Proceedings

Second EEE International Conference on Digital Game and Intelligent Toy Enhanced Learning

DIGITEL 2008

17-19 November 2008
Banff, Canada

Sponsored by
IEEE Technical Committee on Learning Technology
IEEE Computer Society
Athabasca University

Hosted by
Athabasca University

Supported by
The Northern Alberta Institute of Technology

Editors
Mike Eisenberg
Kinshuk
Maiga Chang
Rory McGreal

Los Alamitos, California
Washington • Tokyo
Second IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning

DIGITEL 2008

Table of Contents

Note from the Program Chair..................................................................................................................... ix
Committees.................................................................................................................................................. x

Keynotes

Social Support for Creativity and Learning Online ................................................................. 3
   Amy Bruckman
The Joy of Making ................................................................................................................................. 8
   Dale Dougherty

Full/Short/Poster Papers

A Mobile Phone Based Virtual Pet to Teach Social Norms and Behaviour to Children ................................................................. 15
   Hanno Hildmann, Anika Uhlemann, and Daniel Livingstone
A New 3-Dimensional Comic Chat Environment for On-line Game Avatars .............................................. 18
   Soo-Hyun Park, Seung-Hyun Ji, Dong-Sung Ryu, and Hwan-Gue Cho
A Preliminary Study of Student's Self-Efficacy on Problem Solving in Educational Game Context ......................................................... 23
   Yu-Ling Lu, I-Ing Lee, and Chi-Jui Lien
Adaptive Educational Games: Providing Non-invasive Personalised Learning Experiences ................................. 28
   Neil Peirce, Owen Conlan, and Vincent Wade
Design and Evaluation of a Physical Interactive Learning Environment for English Learning ................................................................. 36
   Jie Chi Yang, Yi Lung Lin, Jia Jia Wu, and Kun Huang Chien
Development of Educational Videogames in m-Learning Contexts ................................................................. 44
   Pablo Lavín-Mera, Pablo Moreno-Ger, and Baltasar Fernández-Manjón
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of a 360 Degrees Panoramic Image System (360 PIS) on the Environment Recognition of Students with Moderate and Severe Mental Retardation in Special Education School</td>
<td>52</td>
</tr>
<tr>
<td>I-chen Cheng and Hwa-pey Wang</td>
<td></td>
</tr>
<tr>
<td>Effects of Collaborative Activities on Group Identity in Second Life</td>
<td>57</td>
</tr>
<tr>
<td>Sumin Seo, Xiangzhe Cui, and Bokjin Shin</td>
<td></td>
</tr>
<tr>
<td>Effects of Object Building Activities in Second Life on Players’ Spatial Reasoning</td>
<td>62</td>
</tr>
<tr>
<td>Jihyun Hwang, Hyungsung Park, Jiseon Cha, and Bokjin Shin</td>
<td></td>
</tr>
<tr>
<td>Evaluation the Efficacy of Computer - Based Training Using Tangible User Interface for Low-Function Children with Autism</td>
<td>70</td>
</tr>
<tr>
<td>Karanya Sitdhisanguan, Nopporn Chotikakamthorn, Ajchara Dechaboon, and Patcharapon Out</td>
<td></td>
</tr>
<tr>
<td>Exploring Learner’s Variables Affecting Gaming Achievement in Digital Game-Based Learning</td>
<td>75</td>
</tr>
<tr>
<td>Jiseon Cha, Youngkyun Baek, and Yan Xu</td>
<td></td>
</tr>
<tr>
<td>From Traditional to Digital: Factors to Integrate Traditional Game-Based Learning into Digital Game-Based Learning Environment</td>
<td>83</td>
</tr>
<tr>
<td>Sheng-Hui Hsu, Po-Han Wu, Tien-Chi Huang, Yu-Lin Jeng, and Yueh-Min Huang</td>
<td></td>
</tr>
<tr>
<td>Games as Skins for Online Tests</td>
<td>90</td>
</tr>
<tr>
<td>Srinivasan Ramani, Venkatagiri Sirigiri, Nila Lohita Panigrahi, and Shikha Sabharwal</td>
<td></td>
</tr>
<tr>
<td>GEOWORLDS: Utilizing Second Life to Develop Advanced Geosciences Knowledge</td>
<td>93</td>
</tr>
<tr>
<td>Donna Russell, Molly Davies, and Iris Totten</td>
<td></td>
</tr>
<tr>
<td>Intergenerational Learning through World of Warcraft</td>
<td>98</td>
</tr>
<tr>
<td>Sri H. Kurniawan</td>
<td></td>
</tr>
<tr>
<td>Investigating the Use of a Robot with Tabla Education</td>
<td>103</td>
</tr>
<tr>
<td>Prakash Persad, Jorrel Bisnath, and Ruel Ellis</td>
<td></td>
</tr>
<tr>
<td>&quot;It is so like Disco&quot; - Dancing on the iTiles</td>
<td>108</td>
</tr>
<tr>
<td>Stine Liv Johansen and Helle Skovbjerg Karoff</td>
<td></td>
</tr>
<tr>
<td>Language Learning in the Palm of Your Hand</td>
<td>113</td>
</tr>
<tr>
<td>Mercedes Rico, J. Enrique Agudo, Héctor Sánchez, and Alejandro Curado</td>
<td></td>
</tr>
<tr>
<td>Learning about Complexity with Modular Robots</td>
<td>116</td>
</tr>
<tr>
<td>Eric Schweikardt and Mark D. Gross</td>
<td></td>
</tr>
<tr>
<td>Learning by Substitutive Competition: Nurturing My-Pet for Game Competition Based on Open Learner Model</td>
<td>124</td>
</tr>
<tr>
<td>Zhi-Hong Chen and Tak-Wai Chan</td>
<td></td>
</tr>
<tr>
<td>Massively Multi-user Online Games: The Emergence of Effective Collaborative Activities for Learning</td>
<td>132</td>
</tr>
<tr>
<td>Iro Voulgari and Vassilis Komis</td>
<td></td>
</tr>
</tbody>
</table>
Micro Adaptive, Non-invasive Knowledge Assessment in Educational Games ...........................................135

  *Michael D. Kickmeier-Rust, Cord Hockemeyer, Dietrich Albert, and Thomas Augustin*

My-Mini-Pet: The Design of Pet-Nurturing Handheld Game .................................................................138

  *Calvin C. Y. Liao, Zhi-Hong Chen, and Tak-Wai Chan*

On the Benefits of Tangible Interfaces for Educational Games .................................................................141

  *Janneke Verhaegh, Willem Fontijn, and Aljosja Jacobs*

Online Videogames in an Online History Class ........................................................................................146

  *Vance S. Martin*

RoboMusicKids – Music Education with Robotic Building Blocks ............................................................149

  *Jacob Nielsen, Niels K. Barendsen, and Carsten Jessen*

The Effects of Digital Games on Undergraduate Players’ Flow Experiences and Affect ..................................157

  *Yu-Tzu Chiang, Chao-yang Cheng, and Sunny S. J. Lin*

The Learning Environment for Stars and Constellations in the Real World with Finger Pointing .................160

  *Masato Soga, Masafumi Miwa, Koji Matsui, Kazuki Takaseki, Kohei Tokoi, and Hirokazu Taki*

The Scope of Adaptive Digital Games for Education ................................................................................167

  *Rikki Prince and Hugh C. Davis*

The Use of Videogames to Mediate Curricular Learning ........................................................................170

  *Begona Gros and José M. Garrido*

ToddlePuff: An Interactive Tangible and Spatial Interface ........................................................................177

  *Ilan Schifter*

Using Posting Templates for Enhancing Students’ Argumentative Elaborations in Learning Villages ..........180

  *Morris S. Y. Jong, Alex W. C. Tse, Yuxia Zhou, Weiqin Chen, Fong-lok Lee, and Jimmy H. M. Lee*

Video Games in the English as a Foreign Language Classroom ................................................................188

  *Tom A. F. Anderson, Barry Lee Reynolds, Xiao-Ping Yeh, and Guan-Zhen Huang*

What Will Happen to Virtual Field Trips? Beyond Classroom ..................................................................193

  *Hyungsung Park, Bokjin Shin, Xiangzhe Cui, and Jihyun Hwang*

**Workshop Papers**

ROBOKID: Let Children Construct Their Own Emotional Kids - Learning by Construction ........................199

  *Gwo-Dong Chen, Mu-Chun Su, Eric Hsiao-kuang Wu, Wu-Yuin Hwang, Tzu-Chien Liu, Eric Zhi-Feng Liu, and Siew-Rong Wu*

Using Humanoid Robots as Instructional Media in Elementary Language Education ..............................201

  *Gwo-Dong Chen and Chih-Wei Chang*
Application of a Learning-Companion Robot in Learning Environments .................................................203

Mu-Chun Su, De-Yuan Huang, Shih-Chieh Lin, Yi-Zeng Hsieh, and Gwo-Dong Chen

A Context Aware Interactive Robot Educational Platform ........................................................................205

Eric Hsiao-Kuang Wu, Hubert Chi-Yu Wu, Yi-Kai Chiang, Yu-Che Hsieh, Jih-Cheng Chiu, and Kuan-Ru Peng

The Effect of MSN Robot on Learning Community and Achievement ......................................................207

Wu-Yuin Hwang, Sheng-Yi Wu, and Hung-Cheng Chen

Human-Robot Interaction Research Issues of Educational Robots .................................................................209

Tzu-Chien Liu and Maiga Chang

Robotics Instruction Using Multimedia Instructional Material .................................................................211

Eric Zhi Feng Liu, Chan Hsin Kou, Ting Yin Cheng, Chun Hung Lin, and Shan Shan Cheng

Humor and Empathy: Developing Students’ Empathy through Teaching Robots to Tell English Jokes ..........213

Siew-Rong Wu

Pedagogy Play: Virtual Instructors for Wearable Augmented Reality during Hands-On Learning and Play ........................................................................................................215

Jayfus T. Doswell

Author Index ............................................................................................................................................217
Note from the Program Chair

DIGITEL 2008

DIGITEL, while still a relatively young conference (this is only its second iteration), seems poised to move out of toddlerhood in a state of excellent health. The community gathering around the conference blends together individual interests in education, advanced technology, children's entertainment, developmental cognitive science, and children's sociology—and that's a fascinating intersection at which to meet. Unlike many school-centric meetings on education, DIGITEL exhibits a healthy respect for children's play and autonomy, and an interest in how they choose to spend their own time. At the same time, the DIGITEL community doesn't focus exclusively on pure entertainment (valuable as that may arguably be), but seeks to find the "sweet spot" where challenge, fun, and personally valued learning support one another. And in that search, researchers feel encouraged to play in their own right—with new technologies, new materials (both physical and virtual), and a still-burgeoning computational infrastructure that seems to change and grow so quickly that it sometimes seems to defy systematic study.

The issues with which DIGITEL concerns itself, though current, are not transient. Children's lives are changing—their toys, their pastimes, their playgrounds, their technological environments; we can help to critique, assess, anticipate, and (on some occasions) redirect those changes, even as we participate in effecting them.

Two additional notes. First, the acceptance rates for the conference this year were 39 percent (for full papers), 42 percent (for short papers), and 71 percent (for posters). And finally, I would like to thank Kinshuk, the conference organizer, for giving me the opportunity to act as program chair this year—in keeping with the DIGITEL spirit, this job has been a challenge, a learning experience, and a whole lot of fun.

Mike Eisenberg
Department of Computer Science and Institute of Cognitive Science
University of Colorado, Boulder
Committees

DIGITEL 2008

Conference Chair
Margaret Haughey, Athabasca University, Canada

Program Chair
Michael Eisenberg, University of Colorado, Boulder, USA

Local Chair
Maiga Chang, Athabasca University, Canada

General Chair
Kinshuk, Athabasca University, Canada

General Co-chair
Tak-Wai Chan, National Central University, Taiwan

Publicity Chair
Demetrios Sampson, University of Pireus & CERTH, Greece

Organization Chair
Rory McGreal, Athabasca University, Canada

Local Administrator
Jill Calliou, Athabasca University, Canada

Finance Chair
Rebecca Heartt, Athabasca University, Canada

Local Advisory Board
Terry Anderson, Athabasca University, Canada
Lisa Carter, Athabasca University, Canada
Steve Schafer, Athabasca University, Canada
Brian Stewart, Athabasca University, Canada
Jeff Taylor, Athabasca University, Canada
Program/Review Committee

Macu Arnedillo, Trinity College Dublin, Ireland
Young Baek, Korea Nat'l Univ. of Education, South Korea
Anup Basu, University of Alberta, Canada
Gautam Biswas, Vanderbilt University, USA
Martin Brynskov, Aarhus University, Denmark
Leah Buechley, University of Colorado, Boulder
James C. Lester, North Carolina State University, USA
Tak-Wai Chan, National Central University, Taiwan
Maiga Chang, Athabasca University, Canada
Gwo-Dong Chen, National Central University, Taiwan
Chryso Chistodoulou, FUNecole Research Institute, Cyprus
Chris Christodoulou, FUNecole Research Institute, Cyprus
Muhammet Demirbilek, Suleyman Demirel University, Turkey
Giuliana Dettori, ITD CNR, Italy
Chris DiGiano, Google, Inc., USA
Stine Ejsing-Duun, University of Southern Denmark
Abdennour El Rhalibi, Liverpool John Moores University, UK
David Gibson, University of Vermont, USA
Mathieu Gielen, Delft University, the Netherlands
Begona Gros, Open University of Catalonia, Spain
Mark D. Gross, Carnegie Mellon University, USA
Asa Harvard, Malmo University, Sweden
Henrik Hautop Lund, University of Southern Denmark, Denmark
Toshihiro Hayashi, Kagawa University, Japan
Richard Huntrods, Athabasca University, Canada
Carsten Jessen, University of Southern Denmark
W. Lewis Johnson, University of Southern California, USA
Jim Laffey, University of Missouri Columbia, USA
Chien-Sing Lee, Multimedia University, Malaysia
Clayton Lewis, University of Colorado, Boulder
Chi-Jui Lien, National Taipei University of Education, Taiwan
Stine Liv Johansen, University of Southern Denmark
Stan Matwin, University of Ottawa, Canada
Rory McGreal, Athabasca University, Canada
David Metcalf, University of Central Florida, USA
Marcelo Milrad, Vaxjo University, Sweden
Hiroyuki Mitsuhara, Tokushima University, Japan
Permanand Mohan, The University of the West Indies, Trinidad
Hoda Moustapha, Carnegie Mellon University, USA
Hiroaki Ogata, Tokushima University, Japan
Martin Owen, Independent eLearning researcher, UK
Ana Paiva, Instituto Superior Tecnico, Portugal
Jim Parker, University of Calgary, Canada
Kylie Peppler, University of Indiana, USA
Eva Petersson, Aalborg University, Denmark
Lydia Plowman, University of Stirling, UK
Clark Quinn, Quinnovation, USA
Donna Russell, University of Missouri-Kansas City, USA
Demetrios Sampson, University of Pireus & CERTH, Greece
Manthos Santorineos, Athens School of Fine Arts, Greece
Eric Schweikardt, Carnegie Mellon University, USA
Kay Seo, University of Cincinnati, USA
Helle Skovbjerg Karoff, University of Southern Denmark
Elliot Soloway, University of Michigan, USA
Daniel Spikol, Vaxjo University, Sweden
Masanori Sugimoto, University of Tokyo, Japan
Jayfus T. Doswell, The Juxtopia Group, Inc., USA
Wen-Kai Tai, Dong-Hwa University, Taiwan
Chin-Chung Tsai, National Taiwan University of Science and Technology, Taiwan
George Tsekouras, University of Brighton, UK
Andrea Valente, Aalborg University Esbjerg, Denmark
Marc Van Gastel, FUNecole Research Institute, Cyprus
Michael VanLent, Soar Technologies, USA
Andrew Vassiliou, FUNecole Research Institute, Cyprus
Uri Wilensky, Northwestern University, USA
David Williamson Shaffer, University of Wisconsin-Madison, USA
Simon Winter, Vaxjo University, Sweden
Ellen Yi-Luen Do, Georgia Tech, USA
Keynotes

DIGITEL 2008
Social Support for Creativity and Learning Online

Amy Bruckman
School of Interactive Computing, Georgia Institute of Technology
asb@cc.gatech.edu

Abstract
In the mid 1990s, we began to ask some hopeful questions about the potential of the Internet to empower the individual: Can users become creators of content, rather than merely recipients? What can people learn through working on personally meaningful projects and sharing them online? If content creation is to some degree democratized, does this have broader cultural or political implications? This enthusiasm faded a bit by the dot-com bust, and many began to wonder: will it be business-as-usual after all?

But then it started happening. On Wikipedia, thousands of volunteers collaborate to create a shared resource that, while not without flaws, is astonishing in its breadth and speed of adaptation. Furthermore, the process of writing this resource is truly collaborative to a degree that should make any Computer-Supported Cooperative Work (CSCW) professional envious. On sites like deviantART and Newgrounds, people collaborate on original art projects and animations. On MySpace, teens create their own web pages, sharing snippets of html and expressing themselves in a quintessentially teenage fashion. Blogs written by ordinary citizens have become influential in politics and culture, almost just as envisioned by science fiction writer Orson Scott Card. Peer production of content, it seems, has arrived.

What has made this explosion of creativity possible is not better tools for production (though those help), but rather social contexts for sharing those products with others. The easy availability of an audience motivates people to create. In this paper, I'll review the history of peer production of content on the Internet, and present current research in the Electronic Learning Communities (ELC) Lab at Georgia Tech that aims to help support this phenomenon. Drawing on work in the fields of online community design, CSCW, and computer-supported cooperative learning, I'll discuss how we can design Internet-based environments conducive to creativity, collaboration, and learning.

1. A medium for peer-to-peer sharing of content
In the early days of the Internet, utopian rhetoric about its ability to empower the individual was common [1]. This new medium, it was said, has the potential to change content from a one-to-many broadcast model to a many-to-many peer sharing model [2]. A new democratization of content creation has potentially profound implications for culture, politics, business and education [3]. Some time in the mid to late 1990s, it became less clear whether that vision would be realized. Maybe, one worried, the Internet will be one big gap.com clothing ad after all. As traditional publishers and manufacturers created presences online, they followed their normal one-to-many transmission of content models. Website development began to be dominated by companies rather than amateurs, and traditional corporations did not yet understand how to involve users in a meaningful way.

However, peer production of content was always still occurring. With the rise in popularity of social networking sites like MySpace and Facebook around 2005, the idea of peer production of content and networking online became a more widely recognized part of popular culture. The term “Web 2.0” has gained popularity to embody these ideas, and has helped to draw attention to perhaps the most important feature of the medium [4]. However, the principles of user-generated content have existed since the days of ARPANET. As the medium has grown, some of the early 90s utopian ideas about its potential have in fact been realized.

2. A natural constructionist learning environment
We can view the Internet as a naturally occurring constructionist learning environment. Seymour Papert presents his constructionist approach to learning as an extension of Jean Piaget’s “constructivism”:
“We understand “constructionism” as including, but going beyond, what Piaget would call “constructivism.” The word with the v expresses the theory that knowledge is built by the learner, not supplied by the teacher. The word with the n expresses the further idea that this happens especially felicitously when the learner is engaged in the construction of something external or at least shareable… a sand castle, a machine, a computer program, a book. This leads us to a model of using a cycle of internalization of what is outside, then externalization of what is inside.” [5]

Particularly inspiring is Papert’s vision of a “technological samba school.” Commenting on the real samba schools of Brazil, Papert writes:

“During the year each samba school chooses its theme for the next carnival, the stars are selected, the lyrics are written and re-written, the dance is choreographed and practiced. Members of the school range in age from children to grandparents and in ability from novice to professional. But they dance together and as they dance everyone is learning and teaching as well as dancing. Even the stars are there to learn their difficult parts.” [6]

Papert goes on to wonder if we could create a kind of technological samba school—a place where a community of people come together to learn about and through technology. Writing in 1980, he of course was thinking of a physical place. However, it almost sounds as if he were talking about the Internet. Online communities provide many of the affordances desirable for a constructionist environment, particularly:

- Social support,
- Technical support,
- Abundant role models,
- An appreciative audience for completed work [7], and
- Situated support for learning [8].

Support that is “situated” is richly connected to other sources of support in the learning environment. Online, examples of good work surround us in our every-day practice. Furthermore, the authors of those examples are frequently accessible, and often willing and eager to answer questions. As we work and play online, we develop a richer and richer set of mental models of what is possible and how to get help to achieve it.


One remarkable example of an online community functioning as a constructionist learning environment is Wikipedia. In 2008, it’s hard to find any regular Internet user who has not used Wikipedia. Versions of Wikipedia exist in more than 100 languages, and as of August 2008, versions in twenty-three languages boast more than 100,000 articles (http://wikipedia.org). The collaboratively written encyclopedia can be edited by anyone—even anonymously. Surprisingly, the content remains relatively accurate [9]. Wikipedia is not necessarily better or worse than professionally written content, but rather different in style and emphasis. For example, comparing professional historical writing to writing on Wikipedia, Roy Rosenzweig finds that Wikipedia “for the most part gets its facts right,” and that in general “Wikipedia’s view of history is not only more anecdotal and colorful than professional history, it is also—again like much popular history—more factualist” [10]. In other words, it is not a replacement for traditional historical writing, but an intriguing complement to it.

While much research has been devoted to analysis of Wikipedia’s content [11, 12], comparatively less has focused on the process of participation, and what might be gained from that process. In a series of interviews with regular Wikipedia contributors, Andrea Forte and I found that many Wikipedia editors explicitly view what they are doing as a learning experience [13]. One editor writes:

“I look up and read books about the subject and I’ll look something up. It’s not that I’m doing all of this in order to develop an encyclopedia, although I am, it’s more that I’m doing this because I want to learn and you have to learn in order to contribute knowledgeably to Wikipedia.”

These interviews further suggested that the process for negotiating content includes features of knowledge building discourse [14] such as proposing new ideas, requesting evidence, and synthesizing divergent points of view:

“What happens is each side starts insisting that the other have clear citations for everything they’re saying and you can end up with some really strengthened articles out of these disputes.”

“The process is really messy. It means there’s a lot of conflict—some interpersonal conflicts, some
conflicts over content, a lot of conflict over emphasis. But in the process it means that people are exposed to ideas and information that they wouldn’t be otherwise."

As editors are writing Wikipedia articles, they are building and deepening their own understanding of the subject matter. They are externalizing ideas, sharing them with others, getting feedback, and revising their understanding based on that feedback.

Wikipedia’s popularity helps encourage individuals to contribute. Wikipedia has consistently been either the 7th or 8th most popular site on the Web. There is a large audience for people’s work on Wikipedia. Wikipedia has every feature Papert imagined for constructionist learning environments, and one more: the ability for individuals to know that they are contributing to a democratic resource of unprecedented scope and global reach.

Newcomers to Wikipedia have an easy path to initial participation: without even logging in, anyone can edit articles. In interviews with twenty-two people who went on to become regular contributors to the site, we found surprisingly similar patterns of participation. Users typically initially find an error in an article on a topic of particular interest to them, and decide to fix it. Finding this process oddly satisfying, they slowly begin to edit more articles. The MediaWiki tools they use also change as they become more experienced users. Over time, they become committed not just to a set of articles, but to the site as a whole.

Wikipedia users may initially see just an encyclopedia, but over time come to see a community. The community includes sources of technical and emotional support for work, and an appreciative audience for good work.

3.1. Legitimate Peripheral Participation (LPP)

When my students and I began studying Wikipedia, we were surprised to find that learning there is a clear-cut case of Legitimate Peripheral Participation (LPP) in a Knowledge-Building Community. Lave and Wenger describe LPP in their studies of traditional craft practice, like tailors in West Africa. They found that a new tailor’s apprentice begins by sweeping the floor. This activity is legitimate because the floor needs to be swept. It is peripheral because it takes place all around the activity of experienced tailors. When the apprentice is finally called upon to sew a seam, he has seen it done many times and is ready to contribute.

Visibility of expert practice is a key feature of successful apprenticeship. Lave and Wenger contrast the tailors’ successful experience with that of apprentice meat cutters, who begin by wrapping meat that skilled butchers have already cut. However, the wrapping typically takes place in a separate room, giving apprentices no opportunity to observe expert practice. This results in a much less successful learning environment.

In a more cognitively oriented task, this same visibility of expert practice remains key to the learning of novice participants. This is a challenge for tasks like writing, where novices have ample opportunity to observe expert products but not the process they go through to create those products. However, on Wikipedia, observing this process is exactly what naturally happens. One key tool for Wikipedia participants is a “watch list.” After you edit an article, you may place it on your watch list. When you check your watch list, you see all recent changes to articles you are watching. As a result, new participants can see every change added and undone, watching an article evolve step by step.

3.2. Knowledge-building communities

Marlene Scardamalia and Carl Bereiter describe most school-based learning environments as “first order.” By this they mean that “adaptation to the environment involves learning, but the learning is asymptotic. One becomes an old-timer, comfortably integrated into a relatively stable system of routines…. In second-order environments, learning is not asymptotic because what one person does in adapting changes the environment so that others must readapt.” They imagine a learning environment could be like a community of scientists, where everyone together is contributing to extending the group’s knowledge. A key feature that makes this possible is peer review—researchers review one another’s ideas for publication, and that review process helps support finding truth as a social process. They imagine that this knowledge-building discourse could be a model for a new kind learning in school. From this point of view, it’s easy to see contributors to Wikipedia as learners—Wikipedia forms exactly the sort of learning environment that Scardamalia and Bereiter imagined.

Wikipedia presents a surprisingly strong example of LPP in a knowledge-building community, and a superb constructionist learning environment. We all can be a bit skeptical about theory sometimes (what does this have to do with the real world anyway?), but here was an example where our theory seemed to be jumping off
the page—predicting exactly what was happening and explaining why.

4. Lessons for designers

Inspired by what we have learned about Wikipedia, Andrea Forte and I created Science Online (http://www.scionline.org), a site for high-school students to learn about science by writing about it. Science Online runs on the same MediaWiki software that Wikipedia uses, but with a set of extensions we created to support strong citation practices, and also teacher tools to make it easier to do this in a traditional classroom [19]. We aim to build on what we have learned about Wikipedia as an informal learning environment to make this kind of learning possible in a formal educational setting.

More generally, our research method in trying to extend the state of the art of constructionist online communities is to study existing successful sites, and then take what we have learned and extend that to building new sites or companion sites that work along with existing sites. Finally, we study sites we create using both qualitative and quantitative methods to try to contribute to both our design knowledge and basic theory of Computer-Supported Collaborative Learning (CSCL) [20].

The challenge for designers of digital games, intelligent toys, and constructionist online communities is to create conditions conducive to learning—especially self-directed learning in informal settings. Give a toddler a set of gears, and some children will be inspired to a lifelong love of mathematics [6], and others will simply chew on them. How can we create environments that encourage more inspiration and less chewing? A harder problem still is how we encourage learners to go beyond a quick and surface engagement to, so to speak, chew on the deeper intellectual aspects.

Engagement is supported by two primary factors: the project and the community. Working on a project the learner cares about can motivate a learner to persevere when difficulties are encountered [21]. In a study of kids programming on a multi-user environment I created called MOOSE Crossing, Elizabeth Edwards and I found that kids who make programming errors are much more likely to resolve those errors if they occurred in a project context. If you care about the end goal, you’ll stick with it. And perhaps the richest learning opportunities occur in that process of working around a difficulty.

Second, engagement is supported by the online community, from beginning to end of the process. The presence of others motivates individuals to create things. One MOOSE participant commented, “the real reason I come to MOOSE Crossing is that I feel needed, and wanted. While programming is a lot of fun, I don’t think I’d do it, if there wasn’t anyone who would appreciate it” [7]. Community members are especially important in moments of challenge. A peer not only may help you solve a technical or design challenge, but can simply provide validation—it’s not your imagination, this stuff is hard.

From studying environments like Wikipedia and creating ones such as MOOSE Crossing [7], Science Online [19], and others [22-25], we hope to develop insights to aid in the design of constructionist online communities. Two insights to highlight are:

1. **Design for Legitimate Peripheral Participation (LPP).**

   A key feature of successful constructionist online communities is their support for LPP. This means that there is an easy first step towards participation that is legitimate. A newcomer has something easy and satisfying to accomplish. From this initial task, there are a series of gradually more challenging tasks available.

2. **Foster social support for participation and learning.**

   From that first visit on, the presence of others sustains an individual’s involvement. In a study of new users on MOOSE Crossing, we found that those who met a regular user or administrator of the system right away were much more likely to stay [26]. Interaction between new and experienced users must be engaging for both groups. In an ideal setup, we create an ecosystem in which what one user contributes helps satisfy the needs of others. To the extent that we have succeeded in creating opportunities for LPP, experienced users will spend time helping new users because new users’ contributions are valued.

   In this sense, Wikipedia has a unique advantage: users feel that they are working together towards a shared goal, the extension of human knowledge. In other constructionist sites, each individual is working towards their own creative product, and this makes it harder to establish the kinds of social support needed. A site has an advantage if participants have a shared over-arching goal and positive interdependence [27].

5. Collaborative creative projects

   Collaboration on projects like Wikipedia articles and open-source software is made easier by the fact that the goal is relatively well defined. Without much
communication, people working on an article about great white sharks or the history of saffron have some sense of what the final product should look like.

An intriguing topic of current research in the Electronic Learning Communities research lab is how we can facilitate collaboration on creative projects where the goal state is initially less defined. One site where this is taking place currently is Newgrounds.com, an animation portal. Most Newgrounds users work individually. However, group projects called “collabs” are also created. We are studying the challenges faced by collab leaders [28], and plan to design a support tool to make this kind of group project easier.

We hope to leverage what we’ve learned about social support for creativity and collaboration online to make new kinds of constructionist learning environments possible.

6. References

The Joy of Making

Dale Dougherty
Make Magazine, O’Reilly Media
dale@oreilly.com

Abstract

Make Magazine connects a generation of hackers to a previous generation of tinkerers. Some of the old and forgotten low-tech skills are being re-discovered and married to high-tech know-how. It’s not only the techniques but also the ethics that are embodied in this work. It signals a cultural shift as creative computing moves beyond the monitor and blends into our physical environment. At Maker Faire, we see individuals and small groups of makers exploring these new ideas.

1. Introduction

Make Magazine started with the observation that people were hacking physical things again. Hacking wasn’t limited to computers, but was including cars, toys, watches, bikes, homes, almost anything you can think of. Hackers were hacking hardware, not just software. The physical world itself was becoming their play space, not just the rectangular LCD screen. It’s a world of senses and sensors. It’s a world of Arduino microcontrollers and open source hardware. It redefines the human-computer interface to include environmental and behavioral interaction. It’s a new way of thinking about the computer’s place in the world.

2. A Brief History of Hackers

I’m going to mention a few remarkable stories about hackers because they give us some insight into the theory and practice of hacking.

2.1 The MIT Tech Model Railroad Club

Steven Levy begins his book “Hackers” with the story of Peter Samson and the Tech Model Railroad Club at MIT in the early Sixties. Levy says that Samson and his friends “had grown up with a specific relationship to the world, wherein things had meaning only if you found out how they worked. And how would you go about that if not by getting your hands on them?”

Levy identifies this as the “Hands-On Imperative,” one of the tenants of the Hacker Ethic. The Tech Model Railroad Club consisted of students who it might be said never grew up. They continued to be fascinated by toy trains and one group of them specialized in the switches for the model train layouts. Out of this group emerges the first hackers who are fascinated by how computers work. They recognize the potential of computers as tools for their own use. They begin forming a set of ideas that computers should be open and accessible systems, and the information about how they worked should be shared freely. The hackers themselves wanted to get their hands on the computers and realize the potential they saw in them. The hackers needed the time to explore on their own; they didn’t want to go through a centralized bureaucracy to have these services performed for them. “Hands-on” was synonymous with access to learning directly how to do things yourself. It’s not a surprise that the free software movement comes out of MIT, based on the people and ideas of the Tech Model Railroad Club.

1.2 Bell Labs: The Vision of Communal Computing

In 1969, a group of researchers at Bell Labs begin building a new operating system, known as Unix. They weren’t building this system to serve an unmet market need. Multics, the system they were current using, was getting phased out and they wanted a system of their own that they could continue working on. They put together a budget for building this new operating system and purchasing new equipment but the proposal was rejected by management.

“What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form. We knew from experience that the essence of communal computing, as supplied by remote-access, time-shared machines, is not just to type programs into a terminal
instead of a keypunch, but to encourage close communication,” wrote Dennis M. Ritchie in The Evolution of the Unix Time-Sharing System. (http://cm.bell-labs.com/who/dmr/hist.html)

Communal computing is something that today we take for granted: that computer users should be connected to one another, initially on the same machine and then across networks of machines.

Undeterred by the lack of support from management, one of researchers, Ken Thompson, found an old PDP-7 computer lying around and began porting a game he wrote called Space Travel to this machine. From there, the team began writing this primitive new operating system for the PDP-7, primarily for themselves to use. Much like the MIT hackers, these researchers began to build tools for their own use. This Unix system becomes the foundation for a generation of academic computing, and eventually it meets with some commercial success with the emergence of “mini-computers”, small multi-user environments. However, the Unix programming environment becomes a de facto standard toolset for developers, giving them the open computing platform that the MIT hackers dreamed of.

2.3 Homebrew Computing

On a weekend in April, 1977, the first West Coast Computer Faire opened and was an unexpected success. Its founder, Jim Warren, called it “a mob scene” with over 12,000 people attending. The goal of the Faire was to bring together hobbyists who were making homebrew computers. Warren says that the West Coast Computer Faire was like one of the “happenings” in San Francisco in the Sixties. “Back then it was power to the people; now it’s computing power to the people.” (Article by David H. Ahl, http://www.atariarchives.org/bcc3/showpage.php?page =98). At the Faire was the Apple Computer exhibit, showing off the new Apple II. Mike Markkula, then VP of Marketing at Apple, said of the Faire: “I’m not exactly sure why so many people are here. A lot of them are just curious about what’s going on.”

Wozniak and Jobs were there, showing off the computer they built in a garage. Wozniak and Jobs met in high school and according to Wozniak, they had “two things in common: electronics and pranks.” Both were also members of the Homebrew Computer Club in the Silicon Valley, which came into existence in 1975. Unlike computer “user groups” that would come later, these hobbyists got together to swap parts and share information about building their own computers.

The origin of the personal computer industry is the story of enthusiasts and hobbyists. Wozniak writes that “The Apple I and II were designed strictly on a hobby, for-fun basis, not to be a product for a company.” He decided against leaving a steady job at HP: “I just loved going down to the Homebrew Computer Club, showing off my ideas and designing neat computers. I was willing to do that for free for the rest of my life.” (http://www.atariarchives.org/deli/homebrew_and_how_the_apple.php) Eventually, Wozniak did leave to start Apple Computer with Jobs. Wozniak estimates that 21 companies could trace their roots back to the Homebrew Computer Club.

The West Coast Computer Faire show that what hackers were doing was not limited to just the members of the Homebrew Computer Club; it was increasingly of interest to more and more people who did not consider themselves hackers. Ordinary people saw the potential for computers in much the same way that hackers did.

3.1 The Meaning of Hacking

Today, the word “hackers” has a positive and a negative meaning. In the media, often a hacker is a miscreant, breaking into computers, and stealing data. I had an email from an official at the United Nations recently asking about the motivation of hackers and why they would want to engage in activities like identity theft. I argued that I don’t use the term hackers in the way she used it but that such criminal behavior can be explained in simple terms: greed. Much like the famous bank robber who said that he robbed banks because “that’s where the money is.”

Hackers were people who made computers or made computers work for them. Yes, they might be mischievous and have a certain taste for pranks, but they had their own ideas about what they wanted to do. In his book “The Cathedral and The Bazaar”, Eric S. Raymond described the motivation of hackers, saying that they primarily wanted to “scratch their own itch.” They saw a problem to solve that was important to them, not necessarily to others. They wrote code to please themselves but the code was something they had a need for.
Hacking also meant to modify something to do what it was not designed to do. Who cared what the intent of the product manufacturer was? If you could make it do something, and figure out a way to do it, more power to you.

While that kind of motivation might make hackers seem self-centered, it explains their persistence and dedication, driven by curiosity coupled with an obsession to get code that worked. However, what saved them from being purely selfish was a desire to share. A coder would share his work, and like a chef who develops his own recipes, he wanted to find others who might use them and in doing so test them. Sharing created community. From the beginning the best coders were ones who made tools to make tools, much like the researchers at Bell Labs. In the community, hackers developed a reputation on the basis of their work. You were known by the code you wrote. It was another tenant of “The Hacker Ethic.”

HACKERS SHOULD BE JUDGED BY THEIR HACKING, NOT BOGUS CRITERIA SUCH AS DEGREES, AGE, RACE, OR POSITION. (Levy)

Hackers had a disregard for credentials but a clear focus on the work itself. Amateurs could succeed on the same terms as professionals. Independents could work alongside those who had corporate or academic titles. Share and share alike.

In “The Cathedral and the Bazaar,” Raymond compared traditional software development to the hacker-inspired open source development practices. He viewed cathedral-building as a top-down, centrally organized activity, symbolized by the IBM mainframe. The alternative was the bazaar, which was decentralized and required little coordination. It was the world of personal computers loosely joined. In the Bazaar, individuals had the freedom to do what they wanted, regardless of what others did. The workers building a cathedral had to work from the same plan. Small projects could be developed independently and the Internet made communication and collaboration much easier, without regard to corporate or academic affiliation or nationality or physical location.

3.2 Watching the Hackers

O’Reilly has made its business to pay attention to what hackers are doing. In the 1980’s, we began writing Unix manuals. Over time, we’ve followed the growing number of hackers. We saw them starting to develop the World Wide Web in the early 1990s. What hackers are doing is important on a number of levels. It’s a kind of countercultural shift in the way we think about how things are made and how people work together.

While the term hacking was initially confined to computing, it has since made a leap into the broader cultural meme-pool. Sometime in the Nineties, people began talking about “hacking” outside of computing; there were food hackers and financial hackers; they were sharing hacks on how to book airline travel or how to parent. In the self-service economy of the Web, hacking was becoming a life skill. Hacking was how you got what you wanted.

Starting in 2003 at O’Reilly, I published a series of books – Google Hacks, Excel Hacks, even Mind Hacks. and we used the term “Hack” to mean “clever or non-obvious solutions to interesting problems.” Hacking is a way to get what you want, even if the maker of the thing didn’t expect that you’d want to do that.

One of the books we did in the Hacks series was TiVo Hacks. It wasn’t a best-seller in the series but the fact that people wanted to hack a consumer electronics product that happened to run Linux and upgrade the hard drive made me think that something was happening.

If people were hacking TiVos, without permission of the manufacturer, what was next? Would they start hacking their cars? Why not look at things in the physical environment as if they were open to hacking? Shouldn’t every car have a Preferences menu? Should you be able to change the sound of your car horn? Shouldn’t you be able to hack the doorbell in your home and in effect replace its ringtone? The ways we’re used to interacting with our computers were going to influence how we interacted in the physical world. We would have the expectation that the physical environment should respond to us, change as a result of interaction with us, and in short be as adaptive as our software environments. The field of hacking had expanded.

4. The Return of the Tinkerers

I could see that hackers were going to become tinkerers who work in the physical world. Tinkerers like to play with things. Tinkerers like tools. They like taking things apart to understand how they
worked. They enjoyed these activities as ends unto themselves.

4.1 Golden Age of Tinkering

As Make grew in my mind, I began exploring the old world of tinkerers. I found a set of Popular Mechanics from the first part of the 20th Century. I also looked at Popular Science and Popular Electronics of the 1950s. What struck me about the magazines, and something the titles that still exist have discontinued, is to show you the details. With great illustrations, they showed you how a thing worked or how to make something. They were willing to show the work, believing that readers might want to act on it or at least learn from it. Popular Mechanics and Popular Science were project-based. They presented a wide variety of projects along with a “can-do” attitude. Almost anything was fair game. Make’s trim size is the same as these magazines of the fifties.

I also found the voice of tinkerers very close to that of hackers. The how-to genre of writing in these magazines is straightforward and plain, but never dull. It’s driven by a shared enthusiasm. To use Ken Thompson’s term, it approaches a sense of “fellowship.” We are all in this together. Whether you worked on a farm or a factory, lived in a city, a suburb or out in the country, the urge to tinker was a source of pride. It defined who you were. Hackers were once tinkers.

4.2 Kit Makers and Builders

I also found the kit-builders. Most of us know about the Heath Kit. A previous generation grew up reading the above-mentioned magazines but they also read the Heath Kit catalog.

For the article, Soul of an Old Heath Kit, I interviewed a man, Howard Nurse, who not only grew up on Heath kits but his father became president of the company. He told me: Electronics was not readily accessible in 1950’s. The only place he could see electronic components was at a local TV repair shop, which he hung around. The Heath kit catalog opened a door to the new worlds of HiFi components, electrical test equipment, ham radios and later television sets.

He recalls the joy of opening up the box. “First, you’d see the Heath kit manual, which was the heart of the kit.” Then you find the capacitors and resistors in brown envelopes. A transformer came wrapped in a spongy paper, a predecessor of bubble wrap. “Before you did anything, you had to go through the errata that came with the kit.” Then he would do an inventory of the parts. He used a muffin tin to sort the parts. Additionally, he’d use corrugated cardboard to arrange the small capacitors and resistors in rows. “After all this waiting and preparation, you’d begin to assemble the parts,” he said. “You started by attaching a few components, and then you got to solder, which was really fun.” “Flux was an aphrodisiac,” he added. When you finished the assembly, and tried it, often it didn’t work. This, too, was part of the process of understanding electronics and learning to fix problems.

This man built his first computer from a Heath Kit, the H8 digital computer. The ironic thing about Heath Kit is that while it’s the culmination of DIY electronics, the rise of the computer kills it off. Computers, even the Apple II, come already assembled and we see an almost 20 year span where the computer itself becomes the Swiss Army Knife – it can do everything we need and we can make it do what we want.

5. DIY: A Bridge Between Hackers and Tinkers

MAKE is a bridge between this new world of hackers and the older world of tinkerers. Now I don’t claim that I knew all this history about hackers or that I knew much about tinkerers before creating Make. Rather it’s the case that as we developed and launched Make, I began seeing more and more connections between tinkering and hacking that made me realize that Make was not just a trend but part of a tradition.

A book by David Edgerton, a British historian, called “The Shock of the Old” makes the point that too much of the history of technology is written with an innovation-centric point of view rather than a use-centric point of view. In other words, we tend to concentrate on what’s new and when it’s new while we ignore the role of older technologies that already exist and which may have more impact. We get caught up in the excitement of the new while much more pervasive technology goes unnoticed.

New technology introduces an alternative that does not always replace existing technology. In fact, usually they co-exist. Edgerton’s point is that we tend not to pay much attention to the old technology, or in this case, the importance of tinkering. We talk about the digital machines but we still live in a physical world, surrounded by mechanical devices and electric machines, many of which are now unfamiliar to us.

There are many ways that this insight is key to starting MAKE magazine. I wanted to create a magazine about all the technology in our lives, not simply the newest. Make is not about what we can buy but about what we can do. Chances are that
launching a water rocket is still more fun than launching a web browser. Flying a kite with a rig attached that holds a camera so you can take pictures from the air is way more cool and a lot more fun to do with other people than taking pictures with a camera phone.

Tinkers and hackers share a DIY mindset, a determination to remake the world and adapt it to their own ideas, with the unstated assumption that this would make the world a better place. There wasn’t a magazine that reflected this DIY mindset around technology. Existing technology magazines viewed technology in a narrow business-driven sense. They mostly covered the release of new products, but they really didn’t suggest satisfying projects for readers to do. There are DIY magazines for cooks, woodworkers, and gardeners but not for hackers. You wouldn’t buy a DIY magazine unless you were engaged in doing things – you want to be a better cook or improve your home garden. I wanted to create a magazine for hackers in the broadest sense possible.

MAKE is not just a print magazine. On Makezine.com, our web editor Phil Torrone posts 30 or so items a day on his blog. He’s not talking about the editors or the magazine; he’s highlighting the cool projects that are happening in the community. It is a conversation where members of the community tell him about what they are doing, and Phil tells the rest of us about it. The result is a fire-hose of amazing DIY projects.

Our Maker Faire is another opportunity to reach new people and create new makers. We just finished our third Maker Faire, a two-day event held south of San Francisco at the San Mateo Fairgrounds where we had 65,000 people come and enjoy the creative and inspiring projects of over 500 makers. Maker Faire not only brings the magazine to life, it brings the community together to celebrate all the different kinds of making. We have hobbyists, enthusiasts, artists, crafters, scientists, engineers, musicians and many more – who in their own way see themselves as makers. You can see the pride and passion of makers in our “I Make” videos that we created at Maker Faire. (http://blog.makezine.com/archive/2008/06/i_make_a_look_at_maker_fa.html)

Maker Faire, like the first West Coast Computer Faire, tells us that the interest in hacking technology and creating new things is not limited to hackers. It’s a seedbed for innovation. We all benefit from it.

5.1 A Love Letter

Finally, I offer this letter from one of our readers as further evidence of what a magazine like Make means to hackers and tinkerers:

Thank you very much, I now understand addiction. I get a hint from the blog that a new issue is coming.

Then, like a kid waiting for the sea monkey packets to arrive, I check my mailbox every day. Is it here? Is it here?

Lies, I tell myself lies. When it comes, I will ration it out. I will only read an article or two every day, I’ll TRY to make it last as long as I can. Total lies.

Is it here yet? Denial. I look in the mailbox, but no, not here yet. I pretend I knew it would not arrive. I deny my excitement.

Just a little, you won’t get addicted. Then one day I get home from work, and there it is. In the mailbox. Wrapped up and shiny. Untouched. YET.

I will ration it out. No, seriously, this time, I can do it.

The plastic bag comes off and goes into the recycling bin. I smell the fresh paper. I examine the cover. I close off all my work. Really, one article, only one.....

I go out to the garage. Move the motorcycles around, clear the model airplanes off the bench, clean up the electronic speedometer I am re-designing from minivan to motorbike, oh, put away the mig welder, that has been out too long. While I am at it, clean up the oxy-acet rig....

Last. I have to make it last.

Brush down the bench. Turn on that florescent overhead.... sit on the shop stool

And it is all over. 4 or 5 hours later, my mind is reeling. I have a million different ideas, six more top-of-the-list projects, 2 people to email, a trip to the hardware store is coming.....

I’ve polished off 2 litres of lemonade and a quarter pound of chips. I have read every page. Some pages twice. My eyes are bloodshot, my butt is sore. Hey, that is not a comfy shop stool

But I am reveling in the wonderousness of Make. There is something about paper. The internet just isn’t the same. I love your magazine. Thank you thank you thank you.
Full/Short/Poster Papers

DIGITEL 2008
A mobile phone based virtual pet to teach social norms and behaviour to children

Hanno Hildmann  Anika Uhlemann  Daniel Livingstone
University of the West of Scotland
School of Computing, 1 High Street
PA1 2BE Paisley, Scotland
hanno@cypherpunx.com  anika_uhlemann@web.de  daniel.livingstone@uws.ac.uk

Abstract

The paper presents a Tamagotchi-like mobile phone game that uses an artificial neural network driven character model and is designed to teach positive moral values to children. The behavioural model is explained and the approach is supported by a proof of concept implementation. Our results suggest the feasibility of the approach.

1. Introduction

The game presented here intends to teach children between 6 and 12 different social values, e.g. taking care of someone or taking responsibility for your own actions. The player has different possibilities to interact with the Tamagotchi to achieve a certain behaviour, but is limited in influence because the creature has its own personality and decision making abilities. Like in real life the player has to take care of the creatures basic needs, as it needs food, sleep and social interactions, but there are also some more advanced needs like affection or intimacy. To keep the Tamagotchi in a healthy condition the player will have to choose actions that please or benefit the virtual creature.

Contemporary mobile phones can easily outperform any computer on which the 70's generation played their first games (e.g. Commodore64, Amiga, Atari) which makes mobile phones an ideal platform for serious games, i.e. for games designed to deliver teaching materials.

Quoting [4], the main benefits to game-based learning (i.e. which skills are developed and which abilities are promoted) are: Problem solving skills, Communication skills, Analytical skills, Discovery skills, Team working skills, Negotiating skills, Social & cultural skills, Logical thinking skills, Critical thinking skills, Visualisation skills. This list is meant to be a comprehensive list of the dominant skills that can be developed or trained through serious games and no game is likely to encompass all of the above to the same extent. The prototype game presented in this paper primarily targets the social and cultural skills of the player.

2. Targeting attitudes of children

Generally the reasons to play a game are to experience fun or challenges, not to learn [2]. If learning does take place it is either incidental or aimed at becoming a better player. A certain drawback to this is that it is very difficult to assess the effect the game has on the player, certainly if there is no controlled evaluation environment.

In the past, games that simulates a virtual creature which is depending on the player to survive have been criticized as being addictive, yet under a certain (our) viewpoint this is a positive aspect of the game. The addictive element of the game is that the user has to interact with the game in order to prevent it from ending. The degree with which children get attached to virtual pets in some cases even matches their affection for real living pets. This attention and care children have been observed to muster for an inanimate toy is unrivaled, up to the point where a deceased Tamagotchi is actually mourned as if it was a living being.

In the field of psychology the theory of planned behaviour [1] provides a model for human behaviour in which the attitude a person has towards some action is a deciding factor for the decision to execute this action. There are results from the literature on behavioural psychology supporting the claim regarding the undesired effect video games can have, especially with respect to increased automatic aggressiveness through violent computer games [6]. While these results claim that computer games can incite behaviour which society as a whole does not condone, they do indicate that the model in question does have merit. Changing someone’s attitude towards a behaviour is to change the likelihood of that person behaving in this way.

In this theory, human decision making is guided by three conceptually different considerations and beliefs:
• **Behavioural beliefs**: Expectations about the likely outcome of actions and the subjective view on them.

• **Normative beliefs**: Also known as peer pressure, normative beliefs are the opinion of others regarding the outcomes of actions, the personal intention to adhere to these peer standards as well as the desire of the individual to live up to these expectations of ones peers.

• **Control beliefs**: The confidence of one’s ability to exercise control over all relevant factors required to successfully perform a task.

The game certainly tries to influence the Control beliefs of the players but the main aim is to confront children with an experience that positively enforces attitudes towards certain behaviours, i.e. to influence the Behavioural beliefs.

3. A simple behavioural model

When presented with a certain perception the Tamagotchi will update all its internal states, using the input weights. This can be done multiple times for various perceptions before the updated internal states are used to calculate a desirability value for each possible behaviour. When the Tamagotchi needs to chose a behaviour these internal states are used one after the other to calculate the (cumulative) desirability or preference for a behaviour.

Once the values for all possible behaviours have been calculated one of them is chosen. In the simplest case this could be the one with the highest value. Another simple approach would be to use these values to bias a random selection. In our case we first filter the behaviour through a list of unlocked behaviours and scale the remaining behaviours according to the degree of autonomy the Tamagotchi has achieved for the behaviour in question. We then chose the behaviour with the highest value.

![Figure 1. The behavioural decision process](image)

Our approach is inspired by [5], where the authors elaborate on how to implement complex behaviour for virtual creatures. This is far more complex than required in our case because the creatures created in [5] exhibit the behaviour of real creatures. Our Tamagotchi however will have far less freedom in its environment and will be restricted to a much smaller number of interactions. Due to this we believe that a simplified version of the approach presented in [5] can be implemented to run efficiently on mobile devices. For preliminary results supporting this assumption see Section 4. In a simplified view we use an artificial neural network to implement the behaviour of the Tamagotchi (see Figure 2). Since we are talking about computer games we know that there will be a finite set of discrete inputs for the virtual creature. We call these perceptions and connect them through weighted connections to update the internal state of the Tamagotchi (\(W^{PI}\)). Once the current values for these internal states are calculated we connect them (again by weighted connections, \(W^{IB}\)) to all behaviours and calculate a value for them. Based on these values we then decide which behaviour the Tamagotchi will exhibit. There is a finite number of perceptions the virtual pet can have, and we reduce all of them to booleans, that is, we assume that any perception is either true or false at any time \(t\). Besides the perceptions we include internal states into our model. These represent the aspects that define the current condition of the virtual creature. We use the internal state of the Tamagotchi to drive its behaviour. By internal states we mean things like hunger or fatigue but also anger and affection. The internal states change according to some outside influences (i.e. perceptions). We use weighted connections to regulate the influence an individual perception has on a specific internal state. The current value of an internal state does not depend on perceptions and weights alone: the calculation of the value for internal state \(I_j(t + 1)\) (\(I_j\) at time \(t + 1\)) takes the previous value (i.e. \(I_j(t)\)) into consideration. The weighted perceptions merely provide an positive or negative update of the value for a state. We can calculate the value for the internal states at time \(t\) but simply summing up the individual inputs (calculated from the

![Figure 2. The input (perceptions) and output (possible behaviour) weights for Hunger.](image)
perceptions and the corresponding weights) to the individual internal states. The tamagotchi has a predefined finite set of behaviours. We again use weighted connections to calculate a preference value for each behaviour from the internal states. We use weights to regulate the influence an internal state has on the preference for a behaviour. The overall preference value of a behaviour is the sum of all weighted inputs from the internal states that behaviour has. Once these values are calculated we only include those behaviours that are available at the time (i.e. unlocked) into our choice. Of those included we give strong preference to those with a high autonomy value (how well the Tamagotchi has learned to autonomously perform a behaviour).

4. Prototype implementation and results

The prototype was implemented using the Eclipse SDK (Version: 3.3.1) and the Java Wireless Toolkit (JWT) 2.5.2 for CLDC with the device configurations set to Connected Limited Device Configuration (CLDC) 1.1 and Mobile Information Device Profile (MIDP) 2.0. The results were obtained from running the code under NetBeans version 5.5.1.

<table>
<thead>
<tr>
<th>Per: 7, IntSt: 3, Behav: 6, $W^{P2}$: 21, $W^{IB}$: 18</th>
<th>$u=1$, $b=1$</th>
<th>$u=10$, $b=1$</th>
<th>$u=1$, $b=10$</th>
<th>$u=10$, $b=10$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.023 ms</td>
<td>0.036 ms</td>
<td>0.150 ms</td>
<td>0.167 ms</td>
<td></td>
</tr>
</tbody>
</table>

The execution times listed in table above show the average time (for 100,000 runs) it took to run the behavioural model on the emulator. The model consists of 7 perceptions, 3 internal states and contains 6 possible behaviours. There were 39 weights in total, 21 connecting the perceptions to the internal states and 18 connecting the internal states to the possible behaviours. In both tables $u$ represents the updates to the internal states and $b$ the calculated behaviours.

The actual value of the weights has no impact on the time it takes to calculate the next behaviour to exhibit. These settings affect only the character of the virtual pet.

The game is a proof of concept implementation and can be easily and quickly adopted to contain larger numbers of all three elements of the behavioural model. To provide a better estimate about the usability of this a second series of tests was run using a model of the size presented in [5], i.e. a model consisting of 47 perceptions, 14 internal states and 77 possible behaviours. A model of this size was used to implement virtual creatures living in an environment which had other creatures to interact with. We argue that a model of this size will likely suffice for the implementation of a type of game proposed in this article as the creatures in [5] are far more complex than we expect our application to get.

5. Conclusion

We presented a Tamagotchi-like mobile phones based virtual pet that uses an artificial neural network driven character model to simulate the behaviour of the virtual creature. We have detailed the behavioural model for such a virtual pet could look like and have provided test results for both the actual implementation as well as a scaled up version of the model that was successfully used to implement virtual creatures with abilities and behaviours far beyond those needed by a Tamagotchi.

References

A New 3-Dimensional Comic Chat Environment for On-line Game Avatars

Soo-Hyun Park, Seung-Hyun Ji, Dong-Sung Ryu and Hwan-Gue Cho
Dept. of Computer Science and Engineering
Pusan National University, Republic of Korea
{shpark, shji, dsryu}@pearl.cs.pusan.ac.kr, hgcho@pusan.ac.kr

Abstract

Chatting is a typical and crucial communication method for on-line gamers. The most popular game chat is based on plain text scripting similar to internet instant messengers. Chat with word balloons is widely used in 3-D avatar agents in virtual space (e.g., SecondLife, IMVU). The current word balloon method with virtual space agents can be improved by exploiting stylized paper-book comics effects. The contribution of our work is twofold. First, we propose a realistic and unified communication interface that only requires typing text. For example, in our system, if an agent/avatar wants to talk to other people, then that agent should approach within a audible and readable distance. We can control virtual loudness of the talking voice by controlling the input text. Second, our system successfully expresses background sound effects. That is we can depict chat atmosphere such as cheerful laughing or loud quarrel, without introducing multimedia features, by manipulating 3-D word balloons.

1. Motivation

As the popularity of Internet services grows, another form of communication - electronic chat rooms - has been introduced [5]. Especially, virtual worlds have recently become successful, due to rapidly improving Information Technologies (ITs). So, recent Internet technology enables us to participate in virtual worlds, ‘Second Life’ is representative of successful virtual worlds [6]. Chat among multiple avatars is the most popular way to communicate, especially for on-line games. The current chat environment in on-line games is very simple. Each avatar has its individual chat text above his head, without consideration of spatial constraints.

Figure 1 shows a snapshot of our system. Seven agents, \( A_i \) are in chat in a conference hall. We can see two groups. In the foreground group (comprising two agents), my agent (a cop) can clearly hear the adjacent agent, since he is close by, within hearing distance. We recognize the group of five agents in the background is chatting, but we cannot distinguish the dialogue, since they are distant from my avatar.

Figure 1. Snapshot of our chat system. My agent (a cop) can clearly hear the adjacent agent, but can only recognize that a distant group (five agents) is laughingly (pink spheres) chatting, but cannot distinguish the conversation (chat texts).

The main thrust of our paper is to apply techniques to transform cinema into a comic book, in which all dialogue and background sounds are depicted in a comic cut with stylized word balloons and background texture [2]. (Figure 3.)

2. Previous Chat Tools

Initially, Internet chat services only supported text-based communication. Fast modems and network connectivity techniques have enabled developers of these chat programs to create a richer user experience via the inclusion of graphics or simple images[14]. Advanced chat software enables us to participate in voice/image chat utilizing web-cameras.
Chat software and component tools are rapidly evolving to adapt to the complicated and user-friendly environments demanded by users (personal agents) in virtual worlds.

The most common Text-based chat is the simplest means of communication, via text messages between people in the same chat room [11]. The oldest form of chat systems are mainly based on this text-based chat system [12]. Advanced graphics technology provided a cartoon-based chat system ‘Comic Chat’ [5] (See Figure 3). As shown in ‘Second Life’ [6] and ‘IMVU’ [4], we cannot express the loudness of a “talking voice”.

An interesting aspect in real world chat is ‘Partial Chat’. For example, assume that we joined a large conference. Then, we may realize there is a group of people chatting near the main door, but we may not be able to clearly hear the dialogue. We can classify real-world chat into two groups, ‘Complete Chat’ and ‘Partial Chat’.

The main goal of this paper is to provide a means of constructing a realistic chat environment in virtual space to simulate the real-world chat using only text.

3. Preliminary

In the following sections, we consider a virtual hall consisting of two small sub-spaces separated by a door. Seven virtual agents (denoted as $A, B \ldots G$) are strolling in the hall. Figure 4 shows a topographical view, including seven avatars. Group $G_1$ consists of Agent $A$ and $B$. Group $G_2$ consists of Agents $D, E, F$ and $G$. Agent $C$ in the passage entrance way is looking at Group $G_2$ and Group $G_1$ in Figures 4(b) and (d), respectively. Figure 4 shows the visibility graph of the chat room and the resulting scene.

When an avatar starts to chat (when an agent types a dialogue text), the corresponding word balloon is created and placed above the agent. It is orthogonal to the viewing vector of the chat agent. That implies that each avatar always has his word balloon above his head in the virtual space. We provide some basic notation and definitions.

Let $A_a$ and $A_b$ be virtual agents and $\vec{N}_a$ be the normal (viewing) vector of $A_a$. Also, let $W_a$ and $W_b$ be the word balloons of $A_a$ and $A_b$, respectively, perpendicular to the viewing vector $\vec{N}_a$ and $\vec{N}_b$. Let $d_{ab}$ denote the distance between $A_a$ and $A_b$, the distance between the centers of
$W_a$ and $W_b$. $\theta_a(\theta_b)$ denotes the right-hand angle between $l_{ab}$ and $W_a(W_b)$.

**Definition 3.1** For two chat agents $A_a$ and $A_b$, we define VCB (Virtual Chat Bandwidth) as the communication capacity bandwidth, computed as follows. If $(\overrightarrow{N}_a \cdot \overrightarrow{N}_b \geq 0)$, then $VCB(A_a, A_b) = 0$. Otherwise let,

$$VCB(A_a, A_b) = C_1 \cdot \frac{(\sin \theta_a \cdot \sin \theta_b)^{k_1}}{dist(A_a, A_b)^{k_2} + C_2}$$

where $C_1$, $C_2$, $k_1$ and $k_2$ are control constants. $\square$ [9]

It is clear that $VCB(A_a, A_b)$ is maximized if and only if $\theta_a, \theta_b = \pi/2$ and $VCB(A_a, A_b) = 0$ if and only if $\theta_a, \theta_b \geq \pi$. This implies that the higher $VCB(A_a, A_b)$, the greater the extent to which two agents $A_a$ and $A_b$ are able to chat with each.

Table 1 shows $l_{ab}$ and $\theta_a$ and $VCB(A_a, A_b)$ shown in Figure 4. In this computation, we set $C_1 = 100$, $C_2 = 1$, $k_1 = 0.5$, $k_2 = 2$, which were empirically determined.

<table>
<thead>
<tr>
<th>Table 1. Chat agent $VCB(A_a, A_b)$ in Figure 4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>E</td>
</tr>
</tbody>
</table>

4. Placing 3-D Chat Balloon

In our system, it is crucial to simulate ‘Partial Chat’ according to the VCB between several word balloons. Previous chat systems utilized artificial chat techniques, such as ‘One-to-One Chat’ and ‘Group Chat’ using ‘Complete Chat’, that were either completely visible or invisible. Rather, we simulated ‘Partial Chat’ utilizing 3-dimensional spatial relationships between agents. Figure 5 shows the difference in results viewed based on the distance between agents. In Figure 5(a), we can clearly ‘hear’ the right-hand agent opposite, while we can read part of the text of the left-hand agent with the blue word balloon. If we are not close to these two agents, then, we can only realize that two agents are conversing, but cannot distinguish the dialogue.

The text printed in each balloon is viewed differently based on the viewing vectors and distances. We can see the chat text clearly at a distance of 0.04 (a virtual space metric) in Figure 5(a), but we can not see clearly at a distance 0.38 in Figure 5(b). For agents who are not looking at each other, sentences are represented as ‘Partial Chat’. Figure 6 illustrates these clearly.

![Figure 5. Readability of chat dialogue.](image)

As shown in Figure 6, each agent has his/her own particular viewpoint based on his/her viewing vectors and distance between agents. Figure 6(e) is a scene from the viewpoint of $D$. Agent $D$ is connected to $E$, $F$, $G$ in Figure 4, so $D$ can see the word balloons of $E$, $F$ and $G$. Figures 6(c), (d) are scenes from $C$’s view point. Agent $C$ is con-
A (red) is chatting with B. B (yellow) is chatting with A. C is looking at D, G. (time $i$) C is looking A, B (time $i+1$) D is chatting with E, G, F. E is chatting with D, G, F. F is chatting with D, G, E. G is chatting with D, G, F.

Figure 6. Different views of each agent depending on the distance between my agent and object agents.

D is connected to D, E, F and G at time $i$, and is also connected to A, B at time $i+1$ in Figure 4. Thus C can see the dialogue of D, E, F and G at time $i$, and the word balloons of A and B at time $i+1$. But C can partially see some balloons based on distances and viewing vectors. We note that C can not ‘hear’ the dialogue of groups $G_1$ and $G_2$. C only realizes that they are conversing.

5. Representing Atmosphere Effect

This section shows a distinct feature of our contribution to virtual chat. If a hearing impaired does not hear sound, he cannot recognize the background sound and noise effects in current virtual spaces, such as SecondLife [6] and IMVU [4]. Previously, plain comics were quite successful in showing real life content on paper, expressing them in terms of various word balloon styles and font types. Our system also adopts this concept in 3-D virtual space chat to express not only the chat text, but also the atmosphere, such as a joyous laughter and a loud quarrels, supporting various types of 3-D word balloons with appropriate placement.

5.1 Depicting Background Sound

In Figure 7, three people (denoted as A, B, and C) are strolling in the hall, and we assume a heavy box was dropped onto the floor making a big sound “BUMP”. How do we represent this sound? The sound word balloon in the plain paper comic book is a good solution. The size of the sound balloon is dependent on the loudness. Figure 7(a) shows the floor plan, including three avatars and a box. In Figure 7(c), A is watching C, B and the box, and if Figure 7(d), B is looking at the box over the fence. Our system expresses background sound (e.g., Bump) using various types of 3-D word balloons.

Figure 7. Background Sound/Noise. (a) A, B, and C are strolling in the hall, and a large box is being bumped heavily. (b) C is looking at the box. (c) A is watching C, B and the box. (d) B is looking at the box over the fence.

5.2 Depicting Shouting and Laughing

We depict various moods by deforming the word balloon’s shape and color. Mood is determined using emoticons and punctuation (e.g., “!” for shouting, or “:-)” for laughing). In our system we represent a laughter (e.g., “ha ha ha”) in the form of pink spheres. The more laughter, the more pink balloons will float over talking people. So we are easily aware of the cheerful mood of a group talking by seeing lots of floating pink spheres.

134
In Figure 8, we consider a virtual hall, including eight people (denoted as A, B, ... H). Group $G_1$ consists of Agents B, C and D. Group $G_2$ consists of Agents E, F, G and H. Chat Agent A is looking at Group $G_1$ and Group $G_2$ in Figure 8(b). A recognizes the moods of the two groups differ. As shown in Figures 8(c) and (d), Group $G_1$ is shouting, and Group $G_2$ is laughing.

Figure 8. Shouting and Laughing. (a) We consider a virtual hall, including eight people (denoted as A, B, ... H). Group $G_1$ consists of Agents B, C and D. Group $G_2$ consists of Agents E, F, G and H. (b) A is looking at Group $G_1$ and Group $G_2$. (c) Agents in Group $G_1$ are quarreling. (d) Agents in Group $G_2$ are laughing.

6. Conclusion and Further Work

Previous chat systems utilized artificial chat techniques, such as ‘One-to-One Chat’ and ‘Group Chat’ using ‘Complete Chat’, that is either completely visible or invisible. In addition, they provide only text transcripts without any explicit relationships tags between them. Rather, we proposed a realistic chat framework. The main contribution of this paper is as follows.

- We proposed a realistic and unified communication framework that enables ‘Complete Chat’ and ‘Partial Chat’ in terms of spatial relationships between agents without the need for additional communication protocol.
- Background sound and atmospheric feeling can be interestingly depicted in the form of a stylized comic book. Currently this system has numerous limitations and drawbacks, which will be studied in future work.

- We need various types of word balloons that are common in comic books. This includes a ‘Thought Balloon’ and more stylized balloon styles.
- It is important to handle sounds from sources beyond the range of view, such as calls from behind and from sources ‘out of the picture’, such as calls from behind and sounds from speakers. This will improve the realism of the virtual world.

7. Acknowledgements

This work was supported by the IT R&D program of MCST/IITA (2008-F-031-01, Development of Computational Photography Technologies for Image and Video Contents).

References

A Preliminary Study of Student’s Self-efficacy on Problem Solving in Educational Game Context

Yu-Ling Lu¹ I-Ing Lee² Chi-Jui Lien³
¹,³National Taipei Univ. of Education, ²Taipei Chin-Tan Elementary School
yllu@tea.ntue.edu.tw; iing@mail.chtes.tpc.edu.tw; cjlien@tea.ntue.edu.tw

Abstract

Problem solving is one of the most important skills in learning and in professional careers. This study explored students’ self-efficacy in an educational game context. A four-stage framework of problem-solving was used in this study. One hundred and nineteen students participated in the study. A questionnaire for assessing students’ self-efficacy was developed and used to collect students’ data. Statistic methods including descriptive statistics, ANOVA, independent T-tests were used. It was found that students show high self-efficacy on problem solving in an educational game context. However, these states of mind fluctuated across the processes of problem solving.

1. Introduction

An important and significant branch of educational gaming is using educational games to train the players to be better problem solvers in science, business, etc. The reason is that problem solving is believed to be a life-long attitude and ability, and is crucial in every professional career. Educational gaming can provide numerous and interesting situations for the player to explore in a costless, but effective way. Previous studies have proved its effectiveness. However, as we have already addressed the nature of problem solving, a good problem solver does not merely know how to solve the problem, more importantly, the problem solver believes that he or she is able to perform and succeed in facing the problem and is willing to taking good care of this problem [1].

Thus, this study’s goal is to investigate students’ self-efficacy on problem solving situations in an educational game context.

Research questions are as followings:
1. What are the self-efficacy levels of learners in regards to problem solving in an educational game context?
2. Does learners’ self-efficacy vary during the course of solving a problem? If so, how does it change?

2. Literature Review

Self-efficacy is one’s belief that he/she is able to organize and apply plans in order to achieve a certain task [1]. People with higher self-efficacy tend to believe that they can succeed and are more likely to expend more effort, and persist longer on the task [2]. Bandura has pointed out that there are four factors affecting self-efficacy: experience, modeling, social persuasions, physiological factors [1]).

Bandura, Barbaranelli, Caprara, and Pastorelli [3] have done a thorough investigation regarding efficacy and academic performance. The study analyzed data which were collected from 279 children and their families. They formulated the network of psychosocial influences through which efficacy beliefs affect academic achievement. It was found that self-efficacy contributes to the success of academic performance. Taking another study that focuses on mathematics as an example, Anjum used 805 students in grade 3 to 5 to study the relationship between self-efficacy and achievement. Their results showed that mathematics self-efficacy and mathematics achievement had a significant correlation and the self-efficacy showed to be a significant indicator of performance [4]. Many studies have also given experiential evidence that self-efficacy has an impact and is an important factor that affects students’ performance [4-7].

3. Methodology

This section will explain the 1. Participants; 2. The Educational Game, 3. Questionnaire, 4. Procedures and data analysis.
3.1. Participants

Five intact classes of fifth-grade, a total number of 119 students from a mid-size elementary school in Taipei, Taiwan, participated in this study. The school is located in a residentially and commercially mixed area. Students represented a variety of socioeconomic statuses and backgrounds.

3.2. The educational game

This research group has developed an educational game, FORmosaHope (FH), for 4th to 7th graders. The rationale used for organizing the learning in the software is to integrate science, technology, and society in the educational game, and to provide a mini-world for the learner to learn. Through the interaction and exploration in the game, the learner will face different challenges and problems that he or she needs to gather information, make judgments, and to solve problems [8-11].

The FH consists mainly of two parts. The first one is a role exploration. A player enters the “Village” for a free exploration (Figure 1).

![Figure 1. Explore and learn in the “Village”](image1)

They (The Tao Tribe people, who live in a small island in the south-east of Taiwan) will discard all flying fishes that they still preserved after September, because they believe that the excess catch will result in misfortune.

Farmer Springer:

(After the paper umbrella is well assembled…) We put persimmon juice on the surface. Then, skillful artists may paint or write poems or inscriptions. After that, wood oil is finally lacquered. By doing these, a fine traditional paper umbrella is born.

![Figure 2. Screenshots of the Touring Taiwan](image2)

3.3. Questionnaire

The Questionnaire of Self-efficacy on Problem Solving in the Educational Game Context (QSEPS-EGC) was developed in this study. The QSEPS-EGC were designed by reviewing stages of problem solving in previous studies and modified based on learners’ playing experience during the courses of action in the educational game, FH. There were 4 facets in the questionnaire. The three facets represented the executing stage of problem solving. The reason for concentrating the problem solving stages to 3 stages was due to the fact that this questionnaire is administrated at the very end of the game. Simplifying the stages from four to three will help students to answer the questionnaire. The three facets were:

1. Knowing the context and sensing the problem
2. Scoping problem and formulating strategies
3. Evaluating strategies and solving problem,

This study agrees that the meta-cognitive experience [12]is important to further improvement of problem-solving skills. So, the 4th facet: Reflective thinking and the improvement of problem solving skills was
developed and added into the questionnaire. There were 12 items in each facet from facet 1 to 3; however, there were only 4 items for the facet 4. The QSEPS-EGC was composed of 40 items.

Examples of knowing the context and sensing the problematic items include “I understand the goals of the game.” Examples of scoping problems and formulating strategies include “I know how to complete missions.” Examples of evaluating strategies and solving problems include “I know the best way of completing missions.” Examples of reflective thinking and improving problem solving skills include “I try to remember how I failed, if I fail to solve a problem.”

Responses were measured on Likert scale from 1 to 5 to represent strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree, respectively. The Cronbach α of this questionnaire was .909. The Cronbach α for each facet was, .829, .792, .866, and .582, respectively. Since there were only 4 items for the facet 4, the alpha coefficient of the 4th facet of the QSEPS-EGC questionnaire is relatively lower than the other facets.

### 3.4. Procedures and data analysis

One hundred and nineteen students of five classes received experimental treatment. During the 8-week treatment period, these students played the FH game one hour per week. After 8 weeks, the QSEPS-EGC was used to collect learners’ self-efficacy on problem solving in the educational game context. The data was then analyzed with the different statistical analysis. For answering the first research question, levels of self-efficacy, the descriptive statistics were used. For answering the second research question, self-efficacy variation during the course of action, repeated measures Analysis of variance (ANOVA) was used to compare the mean differences among students’ self-efficacy in these four faces. The Helmert contrasts were used to identify the pair differences between stages and consequent stages.

### 4. Results and discussion

This section presents the findings of this study.

#### 4.1. High self-efficacy on problem solving in an educational game context

For answering the first research question, this study gathered 119 learners’ data with the QSEPS-EGC. The results are as Table 1.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowing the context and sensing the problem</td>
<td>4.2</td>
<td>.65</td>
</tr>
<tr>
<td>2. Scoping problem and formulating strategies</td>
<td>4.4</td>
<td>.61</td>
</tr>
<tr>
<td>3. Evaluating strategies and solving problem</td>
<td>3.9</td>
<td>.74</td>
</tr>
<tr>
<td>4. Reflective thinking and problem solving skills improving</td>
<td>3.7</td>
<td>.84</td>
</tr>
<tr>
<td>Total</td>
<td>4.0</td>
<td>.55</td>
</tr>
</tbody>
</table>

Table 1 shows that the overall mean is 4.0 (S.D. = .55) and the range of means of each stage is from 3.7 to 4.4. This indicates that learners feel confident and function well throughout the game playing, in terms of the processes of solving problem. This also demonstrates that the virtual problem solving environment provided by the FH educational game is capable of maintaining learners’ self-efficacy on problem solving in an acceptable level.

Some studies have shown that different individuals may use different ways to solve the same problem because each human being has unique knowledge, experiences, attitude, etc. Thus, to teach an individual to learn how to solve a problem is not universal. A computer can fit the niche with its power to attract learners to a problem situation, diagnose learners’ prior knowledge and experience, and guide the exploration that is not possible for a teacher to do when they face dozens of students in a classroom. Maynard’s study has shown that the guidance in the processes of solving a problem provided by a computer can have a high level of fidelity with human expertise [13]. The results of this study, moreover, affirm that the problem solving learning in an educational game context can maintain students’ self-efficacy. Many studies have shown that the educational game is capable of enhancing students’ problem solving skills [14-16], this study adds evidence from psychological aspects to address why the learning achievement can be enhanced. Besides, previous studies’ findings have shown that self-efficacy is helpful to students’ learning achievement [3-7], thus, based on the self-efficacy results of this study, we maintain that problem solving context in educational games can potentially help a student’s learning of problem solving.
4.2. Self-efficacy fluctuated during the problem solving processes

The results in Table 1 have shown that learner’s self-efficacy in each stage ranges from 3.7 to 4.3. This part of study is to examine whether such a fluctuation representing learner’s self-efficacy varies during the problem solving stages with a repeated measures ANOVA. These results are shown in Table 2 and are used to answer the second research question.

<table>
<thead>
<tr>
<th>Sources</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>36.658</td>
<td>118</td>
<td>.311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>127.924</td>
<td>357</td>
<td>.358</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stages</td>
<td>32.636</td>
<td>3</td>
<td>10.879</td>
<td>40.42</td>
<td>.000**</td>
</tr>
<tr>
<td>Residuals</td>
<td>95.288</td>
<td>354</td>
<td>.269</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164.582</td>
<td>475</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P < .01

<table>
<thead>
<tr>
<th>Facet</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 vs. After</td>
<td>3.628</td>
<td>1</td>
<td>3.628</td>
<td>11.668</td>
<td>.001**</td>
</tr>
<tr>
<td>Stage 2 vs. After</td>
<td>40.638</td>
<td>1</td>
<td>40.638</td>
<td>151.027</td>
<td>.000**</td>
</tr>
<tr>
<td>Stage 3 vs. Stage 4</td>
<td>5.646</td>
<td>1</td>
<td>5.646</td>
<td>7.148</td>
<td>.009**</td>
</tr>
</tbody>
</table>

P < .01

From table 3, it shows that students’ self-efficacy in stage 1: knowing the context and sensing the problem is significantly higher than that of subsequent stages, when treating the stage 2 to 4 as a whole for contrasting (F = 11.668, p < .01). Adding the information showed in table 1, that the mean of stage 1 is 4.2, these represent that, in the problem solving context in the educational game, students have a high level of self-efficacy in the beginning stage, then, after the stage 1, they encounter lower self-efficacy in subsequent stages. The second comparison, a statistical significance is also found for the contrast of stage 2: scoping problem and formulating strategies and the rest stages of problem solving (F=151.027, p < .01). This highlights that learners have less confidence in the second half of the problem solving procedures. The third comparison, stage 3 vs. stage 4, shows that there is a statistical significance too (F=7.148, p < .01).

These results imply that learners’ self-efficacy has a tendency of declining, in Helmert’s contrast. It also implies that, to elevate learners self-efficacy on problem solving, the foci shall be put in stage 3: evaluating strategies and solving problems, and especially, stage 4: reflective thinking and improving problem solving skills.

5. Conclusion

The findings of this study point to an important view, that problem solving skills can be trained with a different, non traditional approach. Educational gaming is capable of deploying a problem solving situation and guiding the learner to solve the problem step by step. This study uses empirical data to support that learners may have high self-efficacy in the course of action of problem solving in an educational gaming context. This would have implanted fundamental elements of learning success in an educational game environment about facing and solving problems.

This study also point out that, during the four problem solving stages defined in this study: 1. knowing the context and sensing the problem, 2. scoping problem and formulating strategies, 3. evaluating strategies and solving problem, and 4. reflective thinking and problem solving skills improving, learners’ self-efficacy declines when one compares each stage with its subsequent stages. It concludes that learners feel a lack of confidence in
analyzing and selecting a better strategy from many alternatives as well as to implement a better strategy to solve the problem. Furthermore, the lowest self-efficacy stage, stage 4, has shown that learners are not used to re-examining what they have planned and done in solving a problem. This meta-cognitive process is crucial in improving ones ability. Unfortunately, the data and statistic results clearly showed this deficiency. This result strongly reveals that, both designers of educational games or teachers who teach students to learn how to solve problem need to guide them to reflect their own thoughts or actions from time to time. This would probably be a key to enhancing students’ self-efficacy in stage 4 and a short-cut to enhance students’ problem solving abilities.

6. ACKNOWLEDGMENTS

The authors would like to thank Ms. Chien-ju Li and the supporting team for their special contribution to the project development and support. This study was supported by a grant from National Sciences Council, Taiwan, ROC (NSC93-3111-P-008-001-Y19, NSC92-2524-S-152-001, 152-003, 260-003, NSC94-2515-S-152-002, NSC96-2511-S-152-004-MY3).

7. References


Adaptive Educational Games: Providing Non-invasive Personalised Learning Experiences

Neil Peirce, Owen Conlan, Vincent Wade
Trinity College, Dublin
{peircen, Owen.Conlan, Vincent.Wade}@cs.tcd.ie

Abstract

Educational games have the potential to provide intrinsically motivating learning experiences that immerse and engage the learner. However, the much heralded benefits of educational games seldom consider the one-size-fits-all approach to education they typically embody. The benefit provided by adaptive educational games is that of a motivating environment reinforced with a personalised learning experience. However, adapting a game to enhance its educational benefit endangers its intrinsic motivation and flow. This paper proposes a novel approach for non-invasively adapting a game to enable a personalised learning experience. This is achieved using an innovative, generic and reusable architecture, without mitigating the motivational features of gaming. An implementation of this approach in the form of the ALIGN (Adaptive Learning In Games through Non-invasion) system is detailed and the results of an authentic evaluation are discussed.

1. Introduction

Educational games can be seen as a progression in technology enhanced learning that provides direct support for a learner’s motivation [1]. Although games can provide an intrinsically motivating experience, the complexities of educational game design is considerable [2]. With the full potential of educational games yet to be realized [3] one must consider the existing approaches to technology enhanced learning that have proven fruitful. For instance, adaptation has long proven beneficial in eLearning as is evident in Adaptive Hypermedia [4, 5]. Combining adaptation and educational games can uniquely present a personalised supportive motivational experience. In realising this motivation through appropriate challenge, curiosity, fantasy, and control [6] there remains great potential to address the under-motivated learner.

The continuing progression in educational gaming has seen a move away from the crude separation – or Shavian reversals [7] - of gaming and learning scenarios present in first generation educational games towards a more integrated gaming and learning experience. (e.g. Darfur is Dying, Peacemaker, Brain Training). One notable characteristic of these contemporary games is the emphasis placed on maintaining an enjoyable gaming experience, which is often prioritised over the regularity and frequency of learning content. Whereas this may initially seem a misguided approach in consideration that a positive learning outcome is the ultimate goal, one must consider that the effect of doing the opposite, i.e. prioritising learning content over gaming, is considerably worse. In a scenario where the presentation of the learning content is prioritised over the gaming experience, the possibility of the gaming experience being negatively impacted increases significantly. Without an immersive gaming experience the benefits of using games as a motivational vehicle for learning becomes compromised. It has been identified by a number of authors [3, 8] that an educational game must be a game first and an educational tool second. Without this prioritisation the potential benefits of gaming are mitigated.

Although a learning experience that is intrinsically motivating is advantageous, it is but one of many contributing factors that can lead to effective learning outcomes. The field of adaptive hypermedia in particular has long focused on another factor, the benefits provided by the adaptability and personalisation of the learning experience.

This paper addresses the problem of non-invasively supporting a learner within an adaptive educational game. Through an innovative approach to personalising learning challenge, and meta-cognitive support, it is shown how an immersive 3D adventure game can be personalised in a manner that is not invasive to the player’s gaming experience. Explicitly, the non-invasive adaptations do not compromise the game narrative and character consistency; they are non-invasive to the gameplay experience. This approach promotes augmentation over intervention in
adapting existing educational game content, whilst avoiding the complexity of adaptive narratives by non-invasively providing this augmentation. Additionally through focussing on adapting challenge the approach aims to further aid motivation, a significant factor in positive learning outcomes [9].

This paper details a reusable architecture that supports the approach. A real-world integration and authentic trial of the system with an educational game is evaluated with a discussion on the success of the approach and on future work.

This paper starts with an overview of the state of the art in adaptive educational games, detailing the current approaches and examining existing systems. The paper then details the design of the ALIGN system and the rationales behind our approach to providing educational adaptation. The third section examines the implementation of the ALIGN system and its initial evaluation using the ELEKTRA game [10]. The final section of this paper summarises the findings from the initial experimental evaluation and presents a short discussion on the success of the approach and future work.

2. Adaptive Educational Games

The challenge of integrating personalised learning experiences into educational games provides significant challenges to an area of research that is only now making progress away from earlier ‘Shavian Reversals’[7]. In many instances little was done to blur the boundaries between gaming and learning, something which is considered a desirable feature [11]. Whilst research into the effective integration of gaming and learning is still ongoing [8, 12] the compulsion to provide a personalised educational experience is driven by established research in Intelligent Tutoring Systems (ITS) [13] and Adaptive Hypermedia [14]. The provision of personalisation is long established to be beneficial to learning outcomes and experience [4, 5]. Whereas ITS and AH systems typically have complete control of the learning experience, adaptive educational games (AEGs) are faced with the additional hurdle of maintaining game narratives which potentially may be static and linear. As a result any adaptation performed in an AEG must be appropriately constrained.

The potential thus remains that through the personalisation of the learning experience within educational games, the intrinsic motivation provided by games can be complemented with a tailored learning experience. Artificial Intelligence and adaptation within digital games is in itself an active area of research focussing on such areas as Dynamic Difficulty Adjustment, path finding, and NPC (Non Playing Character) behaviour [3, 15]. Although the burgeoning games industry has spurred such AI in realising commercial applications, the usage of AI techniques within adaptive educational games remains limited. The games that have implemented such adaptations have had to address the same hurdle as faced when integrating education into games, that is, how to integrate education within a game without destroying the gaming experience.

Such games as the DARPA funded Tactical Language & Cultural Training System (TLCTS) [16] have shown that effective learning outcomes can be achieved through the use of adaptive educational games [16]. The realisation of these outcomes however required considerable development costs and the use of sophisticated natural language processing and multi-model adaptation. Such monetary and technical requirements are contributory factors to the scarcity of such games. One attempt to address the associated development cost can be found in the <e-adventure> framework [17] that provides a simplified method of developing adaptive educational games that can also be integrated into existing Learning Management Systems (LMS). Although the <e-adventure> framework simplifies the creation of adaptive educational games, the output game genre is limited to 2D point and click, a limiting feature in consideration of the aptness of particular game genres for particular learning content as is highlighted by Prensky [8].

One of the key motivational factors found within games is a strong storyline [18], a tool which is often utilised within educational games. Whereas integrating educational content within a motivating narrative is a challenging task, the further complexity added when considering adaptive educational content is one of the considerable challenges facing adaptive educational games. Despite the challenges of developing adaptive narratives, such games as Façade [19] have shown how a compelling game narrative can provide an immersive experience. Whilst Façade was not promoted explicitly as an educational game there exist educational examples such as Virtual Team Collaborator (VTC) [20] that adopt a similar approach to adaptive narratives. Although successful in their technical approach, both Façade and VTC exemplify the considerable complexity in implementing adaptive narratives that require the authoring of multitudes of differing narrative strands.

Despite the commonality of narratives in educational games there exist other methods of creating a motivating gaming experience. The Prime Club/Climb game [21] for instance utilises an adaptive pedagogical agent to provide hints, guidance and motivational support in place of a storyline. Through a system of real-time assessment the Prime Club game
ensures that the adaptation provided through the pedagogical agent is always appropriate and is tailored to providing a motivating learning experience.

Whereas the instances of adaptive educational games continue to increase they are still few in comparison to the growing number of non-adaptive educational games. In consideration of this, one approach is to extend existing educational games with adaptive educational content. Such an approach was taken with the Ecotoons 2 [22] game that extended the existing Ecotoons game. Approaches such as this have shown promising results in the feasibility of using adaptation as an enhancing feature to educational games.

While games such as Façade and TLCTS manage to integrate adaptation into the game in a seamless manner, the approaches taken are not without their drawbacks. In both cases the complexity of the implementation was considerable. Not withstanding the benefits of adaptive narratives, an approach to augment existing educational games without adapting narratives is feasible and can present reduced complexity. Further to this a common feature of the existing adaptive educational games is the tight integration of the educational adaptation with the game. As a consequence the educational adaptation becomes tightly bound to a specific game hindering the potential reuse.

3. Design & Architecture

The conceptual separation between gaming and educational adaptation underpins the ALIGN system. Although game logic and adaptation logic can be disparate in nature, overlaps remain in such areas as the preservation of a flow experience [23]. The constituents of a flow experience can be found in both gaming and educational adaptation. In particular the balancing of challenge and skills is a feature important to both games [18] and learning [24].

![Figure 1 – Separation of concerns](image)

Despite this overlap the educational adaptation remains largely agnostic to the underlying game. It is feasible to consider that common axes of adaptation such as motivational support, meta-cognitive feedback, and meta-reflective feedback can all be achieved irrespective of the underlying game. In consideration of this there exists the possibility that adaptation authored at a level abstracted from a particular game could be reused within multiple games.

In order to effectively use abstracted adaptation it is necessary to map between game specificities and the abstracted logic. Within the ALIGN system this is achieved firstly through a process of inference that translates game specificities to abstract educational concepts, secondly through a process of realisation that translates abstract adaptations to game world modifications. A typical example of inference would be the mapping of a player’s failure during a game task to the decrease in the skill related to the task [25]. The process of realisation in this case would translate the abstract desire to aid the player’s skill acquisition into a game world NPC offering verbal guidance.

![Figure 2 – Conceptual separation](image)

The separation of the adaptation and the game features is at the core of the ALIGN system. This approach allows the adaptation and the game logic to operate independently and also to be authored independently. This feature aims to reduce the cost of implementing adaptation through maximising the reuse of domain expert authored adaptation.

Each adaptation is represented as an identifier and a text string describing the envisaged educational outcome. Each one of the adaptations is referred to as an Adaptive Element (AE) and is further annotated with meta-data describing the game scenarios where it can be appropriately used. An example of AE would consist of a description such as ‘motivating hint for skill X’ and would be realised as an encouraging verbal hint being given by an NPC relating to skill X.

This approach allows the educational adaptation to be unconcerned with how an AE is realised and further decouples the ALIGN system from a specific game, thus allowing for greater independent authoring of each.

Whereas rules can be used to select desirable game adaptations, the range of possible AEs must first be constrained. It is this constraint that ensures only appropriate changes are made within the game. The constraint of the Adaptive Elements is conceived as a two stage process based on the game feasibility and on
the game appropriateness. The game feasibility constraints eliminate all AEs that are not available due to the current game state and context. For example if an NPC was not present then many AEs would not be possible. The appropriateness constraint is the crucial component of the non-invasive architecture as it allows for the AEs to be constrained based on factors such as desirable NPC behaviour and game narrative consistency. Typical consistency constraints ensure that NPCs do not repeat or contradict themselves in the dialogs they have with the player. Such repetitive or contradictory actions are identified by maintaining a history of all adaptations used.

The advantage this approach provides is that the adaptation logic is considerably simplified. As the AEs are already constrained by feasibility and appropriateness, the adaptation logic can solely focus on selecting desirable AEs.

Interface Between the Game and the Adaptation.
To achieve non-invasive educational adaptation the game need only satisfy two requirements. Firstly the game must expose all game evidence pertinent to each adaptation offered by the game, such as task success/failure or character movement. Secondly the game must share a set of Adaptive Elements with the system and the game must be receptive to activating an AE when requested.

Architecture. The ALIGN system architecture is divided into four conceptual processes; inference, context accumulation, intervention constraint, and adaptation realisation. The entire ALIGN system operates in a continuous and cyclical manner with data continuously propagating through the four processes. In order to achieve effective non-invasive adaptation the intervention constraint process relies heavily on the game and adaptation context that has been accumulated. Figure 3 illustrates the components of the architecture and their interactions.

The four conceptual processes labelled one to four are detailed below. Details of the key components involved in these processes are also given.

1. Inference of raw game evidence into facts suitable for educational adaptation.
2. Accumulation of inferred evidence, game state, and previous adaptation to develop a temporally holistic view of a learner’s game experience.
3. Refinement of candidate adaptations based on game context, and previous adaptations to ensure the use of non-invasive adaptations.
4. Selection of adaptation based on abstracted pedagogical rules and appropriately refined candidate adaptive elements.

In order to achieve non-invasive adaptation the architecture relies on the inputs of both game designers and learning domain experts. The division of responsibility starts with the game designer having sole responsibility for the ‘Game Constraints’, ‘Consistency Constraints’ components. The learning domain experts having sole responsibility for the ‘Adaptation Rules’. The ‘Evidence Interpretation Engine’ and ‘Adaptive Elements’ requires contributions from both parties.

The following sections detail the functionality provided by each of the architectural components. Importantly each of the components can be modified independently without necessarily requiring modification to other connected components. This

Figure 3 – ALIGN architecture diagram
feature is of particular benefit where new adaptive elements can be authored and automatically used by the adaptation rules.

Evidence Interpretation Engine. This component uses a rule base and other probabilistic methods to translate game specific events to facts that can be used for educational adaptation. Methods such as Knowledge Space Theory (KST) (see first experiment) can be used to infer current learner skills. The collaboration of domain experts and game designers is necessary to effectively translate the significance of game specific data.

Game Constraints. Through the use of rules governing which Adaptive Elements are available in different scenarios, this component ensures that only Adaptive Elements that are possible in the current game context are available for selection.

Consistency Constraints. The importance of this component is in its ability to prevent the selection of Adaptive Elements that would be invasive to the player’s game experience. The rules governing this component are strongly influenced by the game designer to ensure narrative consistency and the appropriate behaviour of NPCs.

Adaptive Elements. In order for game specific adaptations to be made a record of all of the game’s Adaptive Elements is used. Each element is annotated with meta-data describing the game scenarios in which it can be used, and the abstract outcome that is envisaged through using the adaptive element.

Adaptation Rules. This component performs the adaptation based on a set of rules that examine the learner model and determine the desired adaptation outcome. A suitable adaptive element (if available) is then chosen from the already constrained adaptive elements. The Adaptive Elements are selected based on the outcome they are annotated with.

Technical Implementation. The ALIGN system is implemented in Java 1.5 and utilises the JBoss Drools rule engine at its core as an efficient method of executing declarative rules. All communication between game engines and the ALIGN system is currently achieved using TCP/IP sockets. All inferred evidence and Adaptive Elements within the system are inserted into a Drools working memory where they are manipulated by the Adaptation rules, Consistency Constraint rules, and Game Constraint rules. The ordering of rule execution is governed by rule flows, agenda groups, and rule prioritisation. The Learner Data Model, Adaptation Database, and Game State Database are implemented as sets of facts within the working memory. The facts are ordered chronologically allowing them to be accessed as needed for AE constraint and selection. The Adaptive Element descriptions are authored as an XML document which is parsed by the ALIGN system to create facts representing the AEs. These facts are then inserted into the working memory.

4. The ELEKTRA game

The initial experiment using the ALIGN system sought to provide the educational adaptation for the technical demonstrator component of a European Commission funded FP6 project called ELEKTRA [10]. The aim of the ELEKTRA project was to revolutionise technology-enhanced learning through merging expertise in cognitive science, pedagogical theory, computer science and neuroscience with the innovations of computer gaming, design and development.

Figure 4 - Screenshot from the ELEKTRA story

The demonstrator component of ELEKTRA is a first-person 3D role-playing adventure game. It features a motivating storyline, interactive non-player characters, educational adaptation, and a rich visual environment. The educational content of the game focuses on the physics of optics as studied by 13-15 year old students under the French state curriculum. The ELEKTRA game tightly integrates gaming, learning, and storyline to create an immersive experience whereby the boundaries between gaming and learning are blurred.

The ELEKTRA game places the player in the role of George the nephew of a kidnapped scientist. In order to rescue his uncle George must overcome challenges and prove his abilities to an interactive NPC represented by the ghost of Galileo Galilei. The challenges involved are all pertinent to the game’s storyline as well as encouraging learning through experimentation.

Due to constraints within the project the number of learning tasks developed was restricted. For this reason the possibilities for Macroadaptivity, the adaptation of challenge ordering and selection was not practical. As a consequence of this all adaptation provided is Microadaptive, and achieved entirely within learning.
tasks. The adaptation within ELEKTRA focuses on two areas (1) motivational and hinting support, and (2) meta-cognitive feedback. In order to provide motivational and hinting support an additional system component, the Skill Assessment Engine (SAE), was added to the inference process to calculate probabilistic values for the learner’s skills based on their actions. This system utilises a real-time implementation of Knowledge Space Theory (KST) and is further detailed in [25].

The following example illustrates the typical process involved in delivering non-invasive affective/motivational feedback within the ELEKTRA game. In this example the player has been experimenting with an apparatus known as the slope device that is designed to show the effects that magnetism, gravity, and wind can have on materials of varying composition and density. The player must manipulate a magnet and fan to get a marble (wooden, iron or hollow plastic) into a target area under the supervision of an NPC named Galileo Galilei. The stages in the adaptation process are given below.

1. Message received from the game engine indicating a hollow plastic marble has missed the target.
2. The skills associated with this action are inferred and the skill probabilities are updated by the SAE accordingly.
3. The changes in skill probabilities are added as facts to the learner model.
4. The appropriate adaptive elements to be used are constrained in consideration of the presence of Galileo and the previous adaptations given through the Galileo NPC.
5. Using the adaptation rules it is identified that there have been three successive decreases in the probability for the skill “Knowledge of what a hollow object is and that it is less heavy than a solid object”. Based on this, the desirable outcome of encouraging this skill is selected.
6. A suitable adaptive element is chosen from the constrained adaptive elements and is sent to the game engine.
7. The game engine executes the adaptation; in this case the adaptation consists of the Galileo NPC saying “Yes. It isn’t easy, and I’m not sure that I would do any better in your position, but you must persevere.”
8. Feedback that the adaptation was successfully used is sent to the ALIGN system.

Due in part to the flexibility of the ALIGN system it became possible to integrate seven different types of microadaptive interventions being provided to the ELEKTRA game –

- Cognitive feedback
- Instant meta-cognitive feedback
- Tendency meta-cognitive feedback
- NPC Confidence/Prudence feedback
- Affective/motivational feedback
- Knowledge based hinting
- Progression hinting

Given space restrictions it is not feasible to elaborate scenarios for each adaptation type, however further examples of NPC hints include: “You’re successful in finding the solution. But you are not showing me that I can trust your judgment” (Tendency meta-cognitive), “Wood is a medium-weight and non-magnetic material. It is not influenced by the magnet, but can be influenced by the fan” (Knowledge based hinting).

Adaptation Setup. The adaptation setup for the ELEKTRA game required a real-time implementation of KST as part of the SAE [25]. This component calculated the skill probabilities of 25 skills from 12,414 skill states. The setup additionally contained 65 adaptive rules, an 8 stage rule flow, and 197 Adaptive Elements spread over 3 learning scenarios. Through a high performance Java implementation typical response times were less than 50ms providing a responsive gaming experience.

Experimental Setup. The experiment using the ELEKTRA game had the objectives to determine (1) the perceived invasiveness of the adaptation, (2) the effectiveness of challenge personalisation, and (3) the motivational impact of the adaptations provided. Due to the subjective nature of the objectives being
evaluated, a largely qualitative evaluation was appropriate. The one exception to this was for the second objective where a combination of qualitative and quantitative data was used.

In order to achieve the above objectives, the ELEKTRA game was evaluated with 49 students where the learning content formed part of their assessable curriculum. On average the students took 30 minutes to complete the tasks. The experiments took place in late January 2008 at a number of schools in and around Paris under the supervision of the ELEKTRA partner ORT France\(^1\). Each experiment was preceded by a questionnaire designed to gauge the student’s competency in the learning topics covered. A post questionnaire was also used to assess learning impact, and to assess qualitative player experience in terms of game difficulty, flow experience, and the perceived invasiveness of adaptations. Comprehensive logs were also automatically recorded by the ALIGN system that detailed every action taken by the user within the game and every adaptation performed.

5. Experimental Results

In terms of the perceived invasiveness of the adaptation provided the success of the approach was assessed through direct questions relating to the aptness of the adaptations provided and indirectly through the overall flow experience of the learners.

With the majority of the noticeable adaptations being delivered through the Galileo NPC, the perceived appropriateness remained consistent between adaptive hints and static hints. Similarly the flow experience was not adversely affected, indicating that in the least the ALIGN approach maintains the existing flow experience.

To assess challenge personalisation and consequently motivation, the impact of adaptive hints were assessed. In particular, it was found that following an experiment failure by a player, a subsequent adaptive hint improved the player’s subsequent approach to the correct solution, see Figure 6. The metric of approach is the difference in absolute distance to the correct solution based on two subsequent attempts. The attempts were made using the experiments configurable scale of 1-100. For this experiment three groups of students were used, two of which were control groups which received no hints or pre-scripted hints, respectively. The third group received the adaptive hints.

A second aspect of the evaluation used a combined median-split analysis to compare the ‘low adaptivity’ and ‘high adaptivity’ extreme groups. The results of this analysis showed the “High Adaptivity” group reported:

- Higher amount of invested effort and a higher degree of absorbedness
- Higher relatedness with the Galileo NPC
- Higher usefulness of the slope device
- Higher confidence in their own learning achievement
- Easier handling (lower Extraneous Cognitive Load) of the slope device

For this analysis the ‘Low Adaptivity’ group was defined as having 54% or less adaptive interventions and more than 27% counter-adaptive interventions. The ‘High Adaptivity’ group was defined as having more than 54% adaptive interventions and only 27% or less counter-adaptive interventions.

Due to human error in recording dialogues, defining adaptive elements, and inaccurate consistency constraint rules; counter-adaptive hints were given to learners. These hints typically appeared to be somewhat out of context. A typical example would be a hint relating to the density of an iron marble when dealing with a plastic marble. Additionally neutral hints were identified as being hints that did not make reference to the current context but were considered correct.

Despite the evaluation limitations imposed, significant results were obtained for the evaluation of the ELEKTRA game. Whilst not statistically significant the learning outcome and flow experience for the ELEKTRA game with adaptive hints was positive and encouraging with the significance of the results mitigated due to the small sample size.

\(^1\) ORT France is a French non-governmental education and training organisation, http://www.ort.asso.fr/
6. Conclusions and Future Work

The realisation of adaptive educational games presents financial, integration, and technical challenges that have to date hindered the progress of this field of technology enhanced learning. Through the ALIGN system we have demonstrated a novel approach to adaptive educational games that aims to minimize the gaming impact of the adaptation whilst enabling reuse of the adaptation logic. Consequently where reuse can be maximised the development costs of adaptive educational games can be reduced.

The authentic evaluation of the ALIGN system has shown positive results in our initial experimentation and represents a step forward in adaptive educational games. However, the need to examine the generality of the approach in consideration of differing game genres, subject areas, and the feasibility adaptation reuse is required. Due to technical and language constraints the ELEKTRA game presented evaluation difficulties that limited the sample set. Additional experiments using the ALIGN system are currently being developed that will utilise a more portable game platform, in this case Adobe Flash, in order to facilitate the evaluation of the system with a larger sample set. The provision of authoring tools to for the ALIGN system is also a consideration for our future work.

This research was initially funded by the ELEKTRA project as part of the European Commission’s FP6 IST programme, Contract No. 027986 \[10\]. This research is part funded by Science Foundation Ireland through the CNGL project, www.cngl.ie

7. References


Design and Evaluation of a Physical Interactive Learning Environment for English Learning

*Jie Chi Yang, *Yi Lung Lin, *Jia Jia Wu, **Kun Huang Chien
*Graduate Institute of Network Learning Technology, **Department of Computer Science and Information Engineering, National Central University, Taiwan
{yang, nigel, candace}@cl.ncu.edu.tw, jj@axp1.csie.ncu.edu.tw

Abstract

Recently, many researchers believe that learning motivation and interest can be enhanced by participating in educational games. Video capture virtual reality technologies provide a possibility for designing games. However, it has not been widely used in the field of educational games. A digital game-based learning system, called PILE (Physical Interactive Learning Environment), was developed which utilized video capture virtual reality technologies and was applied in educational setting with learning activity design. The learning activity was designed by integrating the PILE system to English learning materials of the third grade of elementary school along with the Phonics in a digital game-based learning design. An experiment of using the PILE system was conducted for examining English learning achievement, motivation and attitude with two groups. The experimental group used the PILE system for English learning. In contrast, the control group used PowerPoint slides for English learning. The result of the experiment shows that students’ English achievement is enhanced by integrating the “game” into learning process with game-based learning design. Positive learning motivation and attitude on English learning was also found.

1. Introduction

In recent years, the development of information technology is rapidly growth under the popularization of Internet. Pedagogy and teaching strategy tend to become the integration of digital learning environment, such as digital game-based learning is an example. Digital game-based learning is a relative new interdisciplinary research field which combines the game theory, learning theory and information technology processing. Various studies pointed out that integrating the “game” into learning process is a great positive and effective way for learning [1][2][3][4][5][6]. It could be taken into account that digital game-based learning is strongly an interactive learning method because most of children like games. Reading and writing are overemphasized in traditional teaching environment. It may decline students’ learning motivation and attitude. Because motivation is one of the most important factors for driving learning and games can encourage motivation. Therefore, digital game-based learning could be integrated into the learning process to construct an interactive learning environment that learning achievement and motivation could be increased. With integrating games to design learning activity, more durable learning motivation [7] and concentration [1] could be generated.

For some years ago, a researcher proposed the 21st century is the generation of games, not only a transition of the technology, but also many changes on education [5]. In educational field, games could be a positive and enlightening way for learning. Traditional educational setting often neglects the influence of motivation by using games in learning. A researcher proposed the ARCS learning motivation theory with four aspects – Attention, Relevance, Confidence and Satisfaction – to demonstrate the importance of the motivation which influences learning [8]. In addition, a researcher proposed motivation with four factors – Curiosity, Challenge, Control and Fantasy [9]. It could be treated as the theoretical foundation of designing educational games in the research field of digital game-based learning [10]. When users are playing games, they may reach an addicted situation. This phenomenon is regarded as “flow” [11]. A study utilized the ARCS motivation theory and the flow theory to design a game-based learning activity, which suggested that a good educational game design can make the learner playing in the game, then entering the flow state, with producing strong motivation, and learning activity was
started to occur [12]. Therefore, it is necessary to arouse learners’ motivation in the design process of digital game-based learning. A study conducted an experiment on elementary school students playing Nintendo’s Game Boy as educational games. The result of the study shows that it was positive support for learning by integrating game design into teaching with fun [13]. A good design for educational games, can not only improve learning motivation effectively, but also benefit to cognition [14].

This study adopts a model of games and learning, called Input-Process-Outcome Game Model which proposed by [1]. This game model has mainly three major parts. The first part is called Input, which means to design an instructional program that incorporates characteristics of games. The second part is called Process, which represents a cycle that includes user judgments (enjoyment or interest), user behavior (greater persistence or time on task), and system feedback (feedback pattern in the interaction between user and system). This cycle results in recurring and self-motivated game play. The third part is called Outcome, which leads to the achievement of learning outcomes. This Input-Process-Outcome Game Model is benefit to the learning activity design of digital game-based learning.

Concerning on related works of video capture virtual reality, there are various categories of applications could be found. In 1996, Vivid Group presented the GX platform game. It uses video capture virtual reality technologies, through video equipment to detect the body motion. It can be played without the traditional input devices such as mouse and keyboard. It was succeeded to be used in the field of rehabilitation [15]. Concerning on the commercial games, Sony Computer Entertainment Incorporated presented the Eyetoy game series on PlayStation 2 platform in 2003. The learner can play the game through the body motion to interact with the system. Besides, Nintendo Company developed the Wiimote of Wii platform which uses Bluetooth technology to perform Human-Machine Interaction game activities. In addition, a study [16] proposed of using video capture virtual reality technologies to design a body-driven multiplayer game system. The characteristic of this system is passing the stages through multiplayer cooperation mechanism. Video capture virtual reality technologies could be also utilized for designing games in education. A study proposed the PILE system [17], which using video capture virtual reality technologies to integrate digital game-based learning for designing English learning activities. The PILE system provides a lot of different interactive methods and integrates the advantages of light weight, easy to get, and low cost of video capture virtual reality technologies for employing the PILE system to an English teaching environment of an elementary school. The system accuracy on video identification was in a tolerable range. The result indicates the feasibility of applying a digital game-based learning system into a real educational setting.

As the above-mentioned background, learning motivation can be improved through the integration of game-based learning design into the learning activity. Video capture virtual reality could be seen as one solution to build a highly interactive learning environment with body motion. Therefore, this study extends the PILE system to integrate English learning activity into game design, and examine the benefit of using the PILE system on English learning achievement, motivation and attitude. The objectives of this study are as follows: First, to integrate the PILE system into game-based learning design for English learning; Second, to design a learning activity in the educational setting by using the PILE system; Third, to evaluate the learning achievement, motivation and attitude of using the PILE system in English courses.

This paper is structured as follows. Section 2 describes system design and learning activity design. Section 3 describes the methods of the experiment. Results and discussion of the experiment is presented in Section 4. Finally, the conclusion and future works are drawn in Section 5.

2. Design of system and learning activity

2.1. System design

The game-based learning model is integrated into the PILE system according to the Input-Process-Outcome Game Model [1]. In the Input part, we adopted English learning material of the third grade of elementary school as learning content, and designed the game stages by learning content. In the Process part, we observed the learners’ interaction and behavior which using the PILE system in the learning activity. In the Outcome part, we examined whether the learning achievement, motivation and attitude are improved or not under the situation of integrating the PILE system into the learning activity. Figure 1 shows a diagram of integrating the PILE system into the Input-Process-Outcome Game Model.
2.2. Learning activity design

Figure 2 illustrates the English learning environment of integrating the PILE system. The learner stands in front of the screen which is equipped with a video camera by using the body motion to interact with objects on the screen. When the learner is playing the game, the other learners are watching the operation and assisting the learner to learn English through passing the stage in the game.

The learning units of the curriculum for designing the game stages were referred to the third grade English text book of elementary school. There are four learning units represent the four game stages. Table 1 shows the four learning units with their corresponding vocabularies and sentences.

The four stages are described as follows. The first stage: The learning unit is Color Understanding, which is designed to understand the usage of different colors. While the game starts, the learner keeps running to move the duck forward. The system randomly changes the color of the object. The learner should answer the question by matching the right color with corresponding object. If the color of the object (balloon) is the same as the vocabulary, the learner should raise the white glove to match the answer, whereas the color of the object is different from the vocabulary of the color, the learner should change to raise the black glove to match the answer. The color of gloves is identified by the system using video capture virtual reality technologies to judge the answer.

The second stage: The learning unit is Possessive Case, which is designed to understand the usage of different possessive cases. The learner uses a “red-touch” object to touch the card on the screen, then the corresponding audio will be pronounced (e.g. “It’s Johnny’s turtle). The learner then drags the card to match the correct answer.

The third stage: The learning unit is Affirmative and Negative, which is designed to understand the usage of different affirmative and negative words. In the beginning, the learner randomly selects a flash card, and then uses the magnet to drag a flashlight object to search a picture. The question is then appeared. The word of the selected flash card is shown at the bottom of the screen, the learner uses the selected flash card to match the picture he/she have searched, and compare whether these two are the same meaning or not. If they are the same meaning, the learner should use the magnet to drag a mallet object to hit the correct answer. For example, if the learner selected the word Yo-yo,
and the picture he/she searched is a toy car, it means that the answer is “No, it isn’t”.

The fourth stage: The learning unit is Review, which is designed to review the key vocabularies appeared in the previous three stages. An object is appeared with its pronunciation in a notice board at the left side of the screen. The learner used the small sharp cap on his/her head to stab the correct answer which is the vocabulary of the object. There are two items to be selected, but only one is correct. The system gives the learner feedback immediately after the answer is selected. Figure 3 illustrates screenshots of the four stages while students are playing the game.

3. Methods

3.1. Participants

49 students were participated in the experiment, which were two classes of the third grade elementary school students. The experimental group includes 18 boys and 7 girls. The control group includes 16 boys and 8 girls.

3.2. Procedure

The experiment contains four courses, with 40 minutes per course which in total for 160 minutes. Every course has one learning unit corresponding to one of the game stages. The experimental group adopts the PILE system for English learning, and the control group adopts the PowerPoint slides for English learning. Both groups took the same pretest on English testing in the beginning of the experiment. The result shows that there is no significant difference between the two groups. The two groups took the posttest and fill out the questionnaire after the experiment.

Figure 3. Screenshots of stages (stage 1-upper left, stage 2-upper right, stage 3-bottom left, stage 4-bottom right)
3.3. Instruments

Instruments used in this study were the English achievement test and the questionnaire. The English achievement test contains a pretest and a posttest, which the items are the same. This test includes listening comprehension and reading comprehension. The reading comprehension contains items of vocabulary and grammar. The English achievement test is made by referring to the third grade English text book of elementary school.

There are 3 types of questions in this test, including multiple choices, dot-to-dot practice and matching words items. The items of the first type are designed for listening comprehension, whereas the items of the second and third types are designed for reading comprehension. The listening comprehension was taken by an English teacher’s pronunciation. The items of dot-to-dot practice are for understanding the vocabularies and the items of matching words are for understanding grammar, these two types of items formed reading comprehension.

The questionnaire is designed as 4-point Likert’s scale, where 1=strongly unfavorable to the concept, 2=somewhat unfavorable to the concept, 3=somewhat favorable to the concept, 4=strongly favorable to the concept. The questionnaire includes three aspects: the system design, the learning motivation and attitude, and the general assessment. The participants in the experimental group have to fill out these three aspects in the questionnaire, whereas the participants in the control group only have to fill out the last two aspects (the learning motivation and attitude, and the general assessment). The items of the questionnaire were made by referring to the SFQ (Short Feedback Questionnaire) [18] and SSQ (Simulator Sickness Questionnaire) [19] by modifying some items with three elementary school teachers who have experienced on teaching.

4. Results

4.1. English achievement test

An independent t-test on the English achievement test in the pretest and the posttest of the experimental group and the control group was analyzed. The results show that there is a significant difference between the pretest and the posttest of the experimental group ($t_{23}=5.966, p<0.001$), as well as there is a significant difference between the pretest and the posttest of the control group ($t_{21}=3.868, p=0.001$). It indicates that the experimental group and the control group had a great achievement in the posttest than in the pretest. However, there is no significant difference on the posttest between the two groups.

Figure 4 shows the result of the English achievement test of the two groups. By looking into the difference between the pretest and posttest of the two groups, although the experimental group’s pretest mean score was lower than the control group’s (10.208>10.818), the experimental group’s posttest mean score was higher than the control group’s (12.458>12.227). The experimental group’s progress score is far higher than the control group’s (2.250>1.409). It indicates that the experimental group had a great achievement on the English achievement test than the control group.

4.2. English achievement test for listening and reading compression

The result of the English listening comprehension is shown in Table 2. From the table, there is no significant difference on students’ English listening comprehension in the pretest and posttest between the two groups. Again, by looking into the difference between the pretest and posttest of the two groups, although the experimental group’s pretest mean score was lower than the control group’s (3.458<4.000), the experimental group’s posttest mean score was higher than the control group’s (4.791>4.681). The experimental group’s progress score is far higher than the control group’s (1.333>0.681). It indicates that the experimental group had a great achievement on the English listening comprehension than the control group.
Table 2. The result of the English listening comprehension

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>24</td>
<td>3.458</td>
<td>1.47</td>
<td>-1.31</td>
<td>.20</td>
</tr>
<tr>
<td>Control Group</td>
<td>22</td>
<td>4.000</td>
<td>1.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>post test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>24</td>
<td>4.791</td>
<td>.508</td>
<td>.604</td>
<td>.55</td>
</tr>
<tr>
<td>Control Group</td>
<td>22</td>
<td>4.681</td>
<td>.716</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The result of the English reading comprehension is shown in Table 3. From the table, there is no significant difference on students’ English reading comprehension in the pretest and posttest between the two groups. Although both of the experimental group’s mean scores were higher than the control group’s in the pretest (6.833>6.818) and in the posttest (7.666>7.545), these scores were very closely. It indicates that the experimental group had a similar achievement on the English reading comprehension with comparison to the control group.

Table 3. The result of the English reading comprehension

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>24</td>
<td>6.833</td>
<td>1.31</td>
<td>.04</td>
<td>.20</td>
</tr>
<tr>
<td>Control Group</td>
<td>22</td>
<td>6.818</td>
<td>1.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>post test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>24</td>
<td>7.666</td>
<td>.64</td>
<td>.48</td>
<td>.55</td>
</tr>
<tr>
<td>Control Group</td>
<td>22</td>
<td>7.545</td>
<td>1.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3. Questionnaire result

The result of the questionnaire was analyzed from the following aspects: system design, the learning motivation and attitude, and the general assessment. Table 4 shows the result of the questionnaire.

4.3.1. System design. A positive result is found in the system design aspect of the questionnaire (Mean=3.59). A high score (Mean=3.63) was gained in the dimension of learning content. On the game design dimension, the score was also high (Mean=3.58, SD=.852). It is found that participants knew rules and goals of the game. They thought that this system provided a clear feedback. In the result of interface design dimension, the score was also high (Mean=3.57, SD=.736). It indicates that participants agreed with the interface design.

4.3.2. The learning motivation and attitude. Positive results are found in the learning motivation and attitude aspect of the questionnaire in the two groups (Mean=3.56 and 3.40 for the experimental group and control group, respectively). Although there is no significant difference for the two groups, the result shows that the experimental group gained a little higher score than the control group in the aspect of learning motivation and attitude.

4.3.3. The general assessment. Positive results are found in the general assessment aspect of the questionnaire in the two groups (Mean=3.23 and 3.24 for the experimental group and control group, respectively). It indicates that the average score in the experimental group is similar to the control group. There are three dimensions in this aspect of questionnaire: classmate interaction, system support learning, and improving self-learning motivation. Positive results are found for all of the three dimensions, but for the first two dimensions, the experimental group’s mean score was lower than the control group’s.

Table 4. The result of the questionnaire

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Dimension</th>
<th>Mean-Exp Group</th>
<th>Mean-Con Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>System design</td>
<td>Learning content</td>
<td>3.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Game design</td>
<td>3.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interface design</td>
<td>3.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.59</td>
<td></td>
</tr>
<tr>
<td>Learning motivation and attitude</td>
<td>English learning motivation</td>
<td>3.59</td>
<td>3.38</td>
</tr>
<tr>
<td></td>
<td>Attitude of technology integrating into English learning</td>
<td>3.58</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>English learning attitude</td>
<td>3.50</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.56</td>
<td>3.40</td>
</tr>
<tr>
<td>General assessment</td>
<td>Classmate interaction</td>
<td>3.00</td>
<td>3.17</td>
</tr>
<tr>
<td></td>
<td>System support learning</td>
<td>3.46</td>
<td>3.65</td>
</tr>
<tr>
<td></td>
<td>Improving self-learning motivation</td>
<td>3.33</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.23</td>
<td>3.24</td>
</tr>
</tbody>
</table>
4.4. Discussion

The results of the study show that there has no significant difference in the pretest and the posttest on the English achievement test, listening comprehension and reading comprehension analyses between the experimental group and the control group. However, in the progress score, the experimental group gained better achievement than the control group. It indicates that participants utilized the PILE system for English learning had a better achievement than those who used PowerPoint slides method for English learning.

Before the experiment, the two classes of the experimental group and control group were accepting the traditional lecturing method in their English courses. The teacher did not use any technology to support students learning. Therefore, participants in both of the two groups had positive attitude and expectation for introducing information technology for learning. It may be the reason for why there is no significant difference in the pretest and the posttest between the two groups. The PILE system for English learning in the experimental group and PowerPoint slides for English learning in the control group gained high achievement after integrating information technology into the learning activity.

In addition, by looking into participants’ background on English learning, the results show that participants in the control group took more time for practicing their English than those in the experimental group, such as extra English lessons after school (experimental group=16%, control group=29%), practicing with some English materials (experimental group=92%, control group=96%). From the above background, the control group’s learning achievement should be better than the experimental group. However, the result was not. From the two groups’ progress score and the posttest average score, it demonstrates that the experimental group was better than the control group. It indicates that the effectiveness of using the PILE system for supporting English learning.

In addition, positive results are found in all of the three aspects – system design, the learning motivation and attitude, and the general assessment – of the questionnaire. Some comments from participants interview could be explained the result. For the game controlling, some participants expressed that the game was hard, because they thought their English is not good and they had no chance to master the skill of game playing, causing the game was not played smoothly. However, participants expressed that they like the stories in the game.

Moreover, different comments are found from different achievement students. High English achievement participants expressed that the content of the game had no challenge to them. In contrast, moderate and low English achievement participants were willing to use the PILE system to support for English learning. They agreed that the PILE system can help their English learning.

Because the learning activity is designed to integrate the PILE system into an English course in the classroom, under the situation of only one computer in the classroom, only few participants had the chance to operate the system. In the classmate interaction dimension of the questionnaire, participants in the experimental group expressed that they were willing to interact with the system. But they hope the learner who is playing the game getting the wrong answer to provide more opportunities for their turns to play the game. This could be a reason for why the lower score in the dimension of classmate interaction. In addition, for the dimension of improving self-learning motivation, the participants answered if they can play the game through the Internet, they would like to use the system at home.

5. Conclusion

This study integrated a game-based design model, Input-Process-Outcome Game Model, to design a physical interactive learning environment for English learning. The third grade elementary school English course was incorporated to design the learning activity. Evaluation on the English learning achievement, learning motivation and learning attitude of the system was conducted. The results demonstrate that students had a great achievement on the English achievement test by integrating the PILE system into English learning activity. Moreover, students had positive learning motivation and attitude by integrating the PILE system into English learning activity.

In the near future, the authors plan to improve the interface design of the system for more flexibility use. A long-term experiment for examining students learning effectiveness on physical interactive learning environment for English learning is also taken into account for a future work.
Acknowledgements

The authors would like to thank the teacher for giving assistance in the experiment. The authors also would like to appreciate all subjects’ participation and cooperation in the experiment.

References

Development of educational videogames in m-Learning contexts

Pablo Lavín-Mera, Pablo Moreno-Ger, Baltasar Fernández-Manjón
Dpt. Ingeniería del Software e Inteligencia Artificial
Universidad Complutense de Madrid, Spain
plavin@e-ucm.es, pablom, balta@fdi.ucm.es

Abstract

The educational gaming field is rapidly growing both in acceptance and variety. Within this variety, the technological evolution of wireless/handheld (W/H) computing devices is opening new possibilities in the so called mobile learning (m-learning). M-learning opens new learning opportunities, but due to the special characteristics of these devices (such as their reduced computing power or the size of the display), some design considerations must be taken into account when creating the games. This project explores both the potential advantages obtained through the m-learning educational videogames and the technological challenges that must be faced in the process. In order to illustrate the challenges, we analyze the process of adapting an existing game-based learning platform (<e-Adventure>) for its use in a mobile environment and discuss how the adapted platform makes it easier to develop m-learning educational videogames.

1. Introduction

In the last few years, the academic and private sectors are focusing on the new possibilities offered by the new portable devices. Some companies consider that these devices, which include PDAs (Personal Digital Assistants), SmartPhones, TabletPCs, iPods or even low costs laptops will play a key role in the future of the of information distribution.

Mobile devices technological evolution has brought in new models with higher computing power and Internet connections. These devices now include new features that blur the barriers between cell-phones and PDAs, and extend their capabilities borrowing from other device families with new features such as GPS (Global Positioning System) receptors, digital cameras, Bluetooth/Wi-Fi connections or audio and video players.

The new possibilities offered by these devices come hand in hand with a broadening market. Buying a last generation cell-phone or PDA is no longer an unaffordable luxury. Even the laptops, which were reserved to the business environment, have become a real alternative to desktops [1]. The cost of the connection services have also been reduced thanks to the development of new technologies like WAP (Wireless Application Protocol), GPRS (General Packet Radio Service), and the WI-FI networks.

From an educational perspective, this allows the students to go one step closer the original e-learning motto, learning anytime and anywhere, because we are not limited by the availability of a connected desktop computer. One of the advantages given by this characteristic is supporting Just-In-Time Learning (JIT-Learning) scenarios. The user can now access the knowledge at the specific moment that it is required, in contrast with the classical way in which the concepts are acquired with the expectancy of eventually being used. Highly specialised tasks can benefit from this approach (a typical example often heard is installing a specific part in an airplane and learning the procedure right when it comes to the installation).

Another view is the distribution of educational contents in third world countries. The use of mobile devices is useful to access these contents in places where no internet connection (or maybe even electricity) is available. Some studies have been done about the use of videogames over cell phones to teach languages and safety knowledge in India [2], and the One Laptop Per Child initiative\(^1\) is certainly a step in this direction.

On the other hand, the rapidly increasing importance of game-based learning [3] can benefit from the advantages of mobility. M-learning systems can be an ideal platform for the distribution of educational videogames and simulations, obtaining more versatile educational systems, and improving the

\(^1\) http://laptop.org/
opportunities for long life learning. However, the mobile field is still young and evolving very fast. This means that integrating games in m-learning scenarios is a significant technological challenge that needs to be studied.

In an attempt to bring together the best of both worlds in a mobile game-based learning approach, we have adapted an existing educational game platform (the <e-Adventure> platform [4]) for its application in mobile environments. In the process, several technical challenges emerged as reported in this paper.

This paper is thus organized as follows: In section 2 we provide a brief overview of the potential advantages of bringing both worlds together and some considerations about the design challenges that this may bring. Section 3 presents a survey of the varied technologies that may support mobile game-based learning. In section 4, as a case study, we present our experience porting the <e-Adventure> educational game platform to a mobile environment, with a reflection about the challenges that emerged and lessons learned. Finally, in section 5 we summarize our conclusions and outline future lines of work.

2. Educational videogames and mobile devices

Using mobile devices as platforms for the execution of educational videogames offers new possibilities for providing better learning experiences. However, these advantages have a price. The special characteristics of these devices affect in different ways the possibilities offered and some design considerations must be taken into account in order to get the most out of these applications.

2.1 The best of both worlds

Using computer and videogames as an educational medium is not a new concept. However, a discussion of the educational benefits of game-based learning is beyond the scope of this paper, with the topic having been thoroughly discussed in the literature [3, 5-8]. Roughly speaking, the usual reasons argued are that videogames are entertaining, immersive and that they stimulate cooperation and competition. All of these aspects of educational gaming can actually benefit from the advantages of mobility:

- Videogames are entertaining: This is the main characteristic of a videogame, and the most used argument in favor of game-based-learning. The belief that some idle moments like the time spent in the public transportation or waiting in lines can be taken as an opportunity for learning. In this context, game-based learning is especially relevant because the original vision of learners using mobile devices to study contents is not nearly as extended as the use of portable gaming platforms. Game-based m-learning can really attract students to learn anytime and anywhere.

- Videogames are immersive: In regular videogames the user gets immersed into the game world through the use of different techniques like the inclusion of a character, which represents him in the game, called avatar or through a first person view of the action. With the use of mobile devices a new method immersion is obtained. Thanks to the different systems which ship with these devices, the users can become an active part of the game. These systems, such as GPS receptors or Bluetooth connections, make the game aware of the location and movements of the users, making them feel really inside the game. This effect is achieved because their actions in the real world have an effect in the virtual world. The use of more senses, the embodiment factor, improves the educational activity [9].

- Videogames stimulate cooperation and competition: The game stimulates the cooperation and competition skills of the users while they play at home, in front of their computers. But the user is experiencing some relationships in the virtual world while getting isolated in the real one. By using mobile devices, the user can move during the activity, interact with other people, related or not to the game. This allows a more embodied interaction and facilitates the effectiveness of collaborative learning because the learners can play together and think cooperatively a common strategy.

In summary, game-based mobile learning not only allows the user to access to the videogame anytime and anywhere. It enhances the attractiveness and effectiveness of m-learning scenarios and offers additional value for the educational advantages of game-based learning.

2.2 Design considerations

Traditionally, mobile devices have been considered as small computers and, in some cases, the contents accessed through these devices have not received any special design consideration. But the advantages offered by mobile devices might be drastically reduced due to the special characteristics of these devices, if some design considerations are not taken in account.
One simple example of these problems comes out when executing a text based application. Long texts may be hard to follow in a small screen, making the user loose interest in the activity. Another example is the interaction method. Trying to emulate the interaction of a mouse using a stylus may become really uncomfortable.

The m-learning systems must be considered as a new research field and the mobile applications must be designed in a specific way. These considerations about content and interaction must be also taken in account while developing m-learning educative videogames. In other words, we must consider the kind of information supplied by the system (videos, text, pictures) and how the user will interact with these contents.

First, the mobile application developer has to take into account which concepts the application display and the way that the whole experience works. This design activity must not be done in the same way that a PC application. The contents displayed easily in a laptop may not be adequate to be displayed in a PDA. The same approach must be taken for the interaction method. Besides this, the mobile devices offer new ways of communication and concepts like the possibility of movement, so it’s necessary new tools and techniques for designing these systems. Parsons et al. [10] propose a conceptual framework which is useful as a script for the analysis and requisites capture phase. They define four perspectives in the design of an application for a mobile platform: generic mobile environment issues, learning contexts, learning experiences and learning objectives. The complete framework is presented in Figure 1.

In the first perspective (generic mobile environment issues) the designer must take into account characteristics common to all this kind of applications. These characteristics are: the mobility, the different users and their role, communication support, media types allowed by the devices, design of the interface, etc. The second perspective centered on the specific application, defining the context where the educational experience takes place, such as the different actors involved, the target social group, the activities which conforms the experience, the resources and facilities supplied and so on.

The third and fourth perspectives get deeper in the concepts related to the design of the specific educational experience, its structure and expected goals. Parsons et al [10] divide the educational experiences in two types: the narrative experience, where the data is provided without any other interaction; and videogames. After this, he chooses the structural elements that Prensky [11] found in videogames: organization of the contents and rules, feedback methods to the user (scores), objectives and goals proposed to the user, representation of the story, conflict and challenges to the user and the social interaction while the experience.

With the use of this framework the designer is supplied with the main points which must be addressed while defining the educative system. Possibilities like the mobility, spatio-temporal awareness or facilities like GPS receptors and Bluetooth connection are not usually considered in the design of desktop applications. Neither are limitations like the media types supported by the devices.

The second issue which must be designed carefully is the interface. The main limitation of these devices is the size of their screens. Usually these screens are 3.5” size and their resolution 320x240 pixels. Albers and Kim [12] study the problems created by small size of the screens. Some of the identified problems are: reading is harder than in a regular screen or paper, the graphical representations are limited by the size of the images, being sometimes too small to be understood. The interaction with the small contents without a mouse makes the activity quite difficult.

Churchill and Hedberg [13] propose a set of good practices in order to obtain high-quality mobile applications. These techniques are also valid for developing videogames and can be summarized with this list:

- The text must be short and formatted in a way that some meta-info about the importance of the content is also supplied. In this way the user can identify the most relevant information.
- The images must be resized without losing their meaning. Images for decorative reasons should be removed.
- Scroll-bars are annoying to work with and must be avoided when possible.
- The educative objects must be designed for being displayed in full screen mode. The navigation

![Figure 1. Design conceptual framework.](image-url)
menus and title bars use some space which should be used by the application (e.g., Internet Explorer for Windows Mobile 5™).

- All data must be displayed at the same time in a single screen. Some alternative methods like audio or video are proposed. Design practices prove that a single screen can accommodate a lot of information elements.

- Design for landscape presentation. Typically the screen of a mobile device is presented in portrait layout. This other presentation method is similar to the one used in television screens or computers.

These good practices do not guarantee to obtain a good mobile application but will avoid a number of common errors and will make the application easier to interact with.

3. Technological issues

M-learning application success is tightly related with the type and number of devices which can execute it and this is very dependent of the implementation technology. Therefore designer should first choose the best technology for a specific application because the development cost and complexity is very different.

These technologies can be group in two general categories: the applications which are executed, at least partially, in the device and those applications which are executed in a remote server.

In the first group comprises the applications developed for specific platforms, Flash Lite based applications and Java ME (Java Micro Edition) based applications. The second category groups: SMS based applications and Web based applications. In this last case, the m-learning application works as a simple front-end of the system.

3.1 Applications for specific platforms

Due to the technological advances, PDAs and cell-phones are closer to the structure of a computer. Typically they come with 32 bits processors and several megabytes of memory. These devices use complete operating systems. Some of the most important platforms are: Symbian, Windows Mobile, Qtopia, BlackBerry and iPhone. At the end of this year, the new platform Android, the new open source platform developed by the Open Handset Alliance (headed by Google), will join them.

Usually these platforms also supply a software development kit (SDK) for application development (Symbian S60 is probably one of the platforms with more variety of development environments). These applications will take full advantage of the platform, with faster execution and better performance because the program is written specifically to be executed over the operative system. The problem of this approach, however, is that the applications written for a specific platform must be rewritten to be executed in another. This implies a bigger cost in order to supply the same contents to a wide range of devices.

3.2 Flash Lite based Applications

Flash Lite is the mobile version of the well-known application Adobe Flash. It is a language with fewer possibilities than the applications written in C or C++ for specific platforms or Java ME. Now it does not provide controls for the GPS receptors or Bluetooth connection what reduces the possibilities offered by the mobile devices. On the other hand the applications developed with Flash Lite are easier to write and provides great visual effects without too much effort.

In the last version of this application typical features of more complex languages are provided. Some of these features are the internet connection for downloading new context or an object oriented language. The applications developed for this platform aren’t executed natively over the operative system but over the Flash engine. This characteristic makes the application more independent of the device and being supported in any Flash Lite device. Kam [2] shows how flash videogames can be useful for spreading educative contents in less favored regions.

3.3 Java ME based Applications

Java ME or J2ME is currently the most important platform for developing applications for mobile devices. It provides a flexible and robust environment where applications for embedded systems or mobile systems can execute. This platform gives support for a number of devices from TV sets, passing by PDA, cell-phones, smart-phones, etc. J2ME promises the same advantages given by Java 2 Platform, Standard Edition (J2SE): “Write it once, run anywhere”. Actually, J2ME platform is a subset of J2SE what implies that a java developer could learn how to program in J2ME pretty easily. Java object orientation properties make the things easier when a complex system must be created.

Java ME provides two different configurations depending on the characteristics of the device where it will be installed. CLDC (Connected Limited Device Configuration) is the configuration for devices with
less memory and processing power. CDC (Connected Device Configuration) is the configuration for more powerful devices and includes a whole virtual machine which can run standard Java byte code and utilize J2SE libraries. Each of these configurations can be complete with profiles and optional libraries which provide control over additional features.

### 3.4 SMS based Applications

The Short Message Service protocol (SMS) has achieved a great acceptance during the last years, especially among teenagers. The low cost of this service has made this technology a daily way of communications. This main limitation for developing games is that SMS is a simple text based technology with a limitation in length messages. On the other hand it is simple but powerful enough for creating quizzes or as a communication method among the users of a ubiquitous game. SMS simplicity is also its main advantage. The SMS protocol is shared by all kind of devices with phone features so the application can be set in a central server and accessed by all the users no matter which device or platform is using. This characteristic reduces considerably the cost of the application.

### 3.5 Web based Applications

Years ago the price of the internet connection via the Global System for Mobile communications (GSM), was too expensive for the average user to use these services. With the Wireless Access Protocols (WAP) the user got the possibility to access Web contents with lower costs. Nowadays the majority of the mobile devices come with features for accessing Web content. With the development of the General Packet Radio Service (GPRS) and the Universal Mobile Telecommunications System (UMTS) the cost of these services becomes inexpensive and affordable by any kind of user (in many cases on a flat rate).

In this kind of applications the problem is the features offered by the devices. Some cell-phones support images, other do not, some devices support video and millions of colors, others only support text based information. The server where the application is running must find out with type of contents is supported in each specific device, and supply only this type of contents, changing the contents not supported by other alternative with the same information. In order to provide this knowledge to the server, some methods of description have been developed: CC/PP, UAProf or WURFL. With these technologies, the server can choose the contents to be displayed to every specific device, but the contents in our application must be organized in a way that conflictive learning content could be exchanged by another.

### 4. Adaptation of <e-Adventure>

*e-Adventure* is a platform designed to allow instructors to develop their own instructional games without any programming knowledge [4]. Thanks to this platform, an expert in any knowledge field can develop his own conversational videogame, with only some little knowledge about computing science. This expert will only need an artist who will help him/her with the game art assets.

The platform focuses on the creation of educational *adventure* games, a well-established videogame genre identified by different authors as one of the most effective genres for learning [14-16].

*e-Adventure* provides a visual editor that simplifies the creation of this type of educational games (see Figure 2). The user can define his/her custom videogame with just some clicks with the mouse. In this way the cost of producing an educational videogame is also reduced because professionals such as videogame designers or programmers are not necessary. The efforts invested in the creation of these applications can focus on the contents instead of programming concerns.

![Figure 2. The *e-Adventure* visual editor.](image)

### 4.1 Objectives of the project

The use of educational videogames in m-learning offers new ways for designing quality educational activities. The knowledge acquisition is enhanced by new methods of immersion and the actual possibility
of accessing to the contents anywhere. But the development of educational videogames which take advantage of mobility is quite complex. The special characteristics and needs coming with mobile devices are added to the intrinsic difficulty of designing a high quality educational videogame.

We think that the adaptation of tool like <e-Adventure> can provide benefits in two ways: this tool will help to create mobile conversational videogames in an easy way because some of the identified design problems are already considered. As a second benefit, some of the main difficulties found while adapting traditional applications to a mobile platform will be exposed.

4.2 Compatibility problems and technical limitations

For the development of the adapted platform we chose Java 2 Micro Edition with its CDC configuration. This configuration provides a complete virtual machine similar to that included in J2SE. Given that <e-Adventure> was developed using Java 2 Special Edition, we expected a reasonably simple transition process.

Within the CDC configuration there are three different profiles which give extra libraries. These profiles are the Foundation Profile, which is the basic profile, the Personal Basic Profile which offers some GUI libraries and some compatibility with AWT, and the Personal Profile which supplies complete support for AWT.

In order to simulate a Java-enabled mobile device, we used Sun’s CDC Toolkit Simulator. This simulator does not ship with the Personal Profile but supports a custom profile based on the Personal Basic Profile and an additional library that completes its AWT support.

During the porting process, however, we found that the current Java implementations for mobile devices were not a match for their desktop counterparts. This is clearly a challenge for the general implantation of game-based m-learning experiences. These are some of the issues that we had to tackle:

- **Version gap.** Given that both Java 1.4 and Java 1.5 are already in their *End Of Service Life* periods, the configuration CDC of J2ME is based on the version 1.4 of the J2SE platform. The <e-Adventure> platform was developed using version 1.6 of J2SE and, therefore, some of its code structures and libraries are not supported by the current mobile devices. This limitation implied changing the improved instructions and structures for obtaining a Java 1.4 compliant version of the code.

- **XML-parsing.** <e-Adventure> uses XML files to annotate the storyboards that define all the features in the game, such as characters, dialogs, interaction with the objects, etc [17]. The original platform treated these files using SAX. However, neither the default libraries, included with the profiles, nor the optional libraries provide an implementation for this API. This aspect remarks another open issue: some libraries included by default in the J2SE platforms are missing from their mobile versions.

- **Compatibility of the interface libraries.** The Personal Profile and the Personal Basic Profile should give a plain support for AWT. This compatibility is based on version 1.3 of AWT so some features and classes are not supported. One of the most concerning examples are the buffer politics. <e-Adventure> uses double buffering in order to avoid the blinking effect caused by repainting elements on the screen, a typical issue in game development. A custom double buffer had to be implemented, which fixed the blinking problem, but slowed down the execution of the application.

- **Media libraries.** <e-Adventure> provides support for several types of audio files like MP3 or MIDI and the display of video clips. As of now, the implementation of the APIs required are still being considered for development, with pre-defined APIs but lacking an official implementation.

After having completed this transition, and as we will discuss later in the conclusions, the choice of a Java-based environment facilitates the creation of game-based mobile learning solutions, but it is still a difficult task.

4.3 <m-Adventure>

In spite of the technical challenges, the first version of our mobile educational game platform, <m-Adventure> is now complete. Given the characteristics of these devices, the mobile version of the engine does not support all the features offered by the original <e-Adventure> platform, especially those related to managing media files, for example, video files.

The editor remains as a desktop application, because it would be very cumbersome for the
instructor to create the materials with the constraints of a mobile device. Once the instructor has finished the creation of the game, he or she can choose whether to export the complete game for execution on the fully-featured <e-Adventure> engine or export a reduced version adapted to the requirements of the mobile implementation of the engine (see Figure 3).

The reduced version of the game, in this iteration, reduces the size of all images proportionally (to fit the smaller screen of a mobile device), performs some technical adjustments (such as reflecting images or resampling sound files) and substitutes the videos for still images when possible.

This workflow, which uses the editor as the starting point and allows the same game to be executed on both platforms, could be extended in the future to include support for more types of devices.

Figure 3. An <m-Adventure> game running on the Sun CDC Toolkit Simulator

4.3 Technical considerations

After the experience of this project, we can deduce that Java 2 Micro Edition is a flexible and robust platform, with an easy learning curve for J2SE programmers. However, the development of applications for mobile devices must take into account some significant differences between the standard and mobile platforms. Even when J2ME is the main platform for developing applications for mobile devices, the CDC configuration of the J2ME platform would need more support in terms of providing implementations for the existing APIs.

The main problem is that, currently, the development of optional libraries is focused on the CLDC configuration which is more extended among the low-end devices such as cell-phones. However, the current increase in the use of the CDC configuration makes us think that in the near future new libraries will be developed in order to support this kind of files.

Some of the initial worries about the limitations of the devices and the possibility of porting this platform to a mobile environment focused on the computing power of these devices. Fortunately, one of the advantages of adventure games is that they have low technical requirements, not needing high speed interactions or complex graphics. The current implementation of the engine can be executed in the current generation of PDAs that implement the Personal Profile of the J2ME CDC configuration. It must be noted that other game types, with higher levels of interactivity and graphical complexity, may be constrained by the current computing power of these devices. However, adventure games are one of the most appropriate game genres for educational contexts [14, 16].

5. Conclusions

Educational videogames in m-learning offers new possibilities for creating high quality educative experiences. However, the actual application of this model has to overcome a number of significant challenges. In order to analyze these issues, we have extended the <e-Adventure> educational game platform, porting the engine for its execution in mobile environments and reported the challenges that we had to face.

Even though most of the work has been focused on solving technical challenges, the resulting platform should facilitate the development of educational adventure games for mobile devices. The creation of the games is based on the already stable <e-Adventure> editor, which takes care of the authoring complexities as described in [4]. Then, the adapted <m-Adventure> engine allows the learners to use these educational adventure games at any moment.

This opens new scenarios for game-based learning without an excessive additional cost. The games can be played during the students’ idle time (in the bus, waiting in a line…), but they will also have the possibility of accessing the contents right when needed...
(Just-In-Time Learning). For example, if the videogame recreated the use of a type of building machine, the user could use the games to solve some doubts standing right in front of it.

Prospective works for this platform include adding features which will use some of the features that ship with next-generation mobile devices. The GPS position of the user might be used to provide different contents depending on the location (context aware games). In the case that the user is moving through a museum, the videogame could change the scene accordingly.

Other future research lines are related to the possibility of adapting the application depending on the preferences and characteristics of the user and the device. As previously stated, having a single editor with multiple adaptation profiles may be a flexible approach to support incrementally an increasing variety of device families. Additionally, the academic community is increasingly concerned with the adaptations needed for users with functional diversity. These adaptations are difficult to implement afterwards and this approach could help to include some of these features from the very beginning.

Acknowledgements

The Spanish Committee of Science and Technology (projects FIT-350100-2007-163 and TIN2007-68125-C02-01) has partially supported this work, as well as the Regional Government of Madrid (grant 4155/2005) and the Complutense University of Madrid (research group 921340 and Santander/UCM Project PR24/07–15865) and by the EU Alfa project CID (II-0511-A).

References

Effect of A 360 Degrees Panoramic Image System (360° PIS) on the Environment Recognition of Students with Moderate and Severe Mental Retardation in Special Education School.

I-chen Cheng   Hwa-pey Wang
National Taiwan Normal University
e14008@ntnu.edu.tw

Abstract

The purpose of the study was to explore if students with moderate and severe mental retardation could take advantage of 360 PIS to enhance action capability in the environment?

The study adopted an experimental design of multiple-probe-across-subject. The targets were four students with moderate and severe mental retardation from a special education school. The independent variable was the teaching system of “The Environment Introduction of Yangming Park by 360° PIS” and the dependent variable were the learning results of the students on the 360° PIS, the ability of the students to recognize the real scenes after learning from the 360° PIS and to act independently in the real environment. Each student had to go through three stages of experiment: baseline, intervention and generalization period.

The results of experiments were as follows:
1. After teaching, students with moderate and severe mental retardation could operate the 360° PIS and reach the learning level of proficiency.
2. Students with moderate and severe mental retardation could recognize the environment on 360 PIS. They could name the scenes and the locations of related passages on the panoramic image. Furthermore, they also could categorize the results from virtual to real environment, named the scenes and found out locations of passages.
3. Students with moderate and severe mental retardation could walk through two trails independently on 360° PIS and generalized the results from cyberspace to not yet experienced environment and walked through two trails.

1. Introduction

For the special education, the virtual world allows its user to be as if in the real place, to know and to understand the place without having any trouble with the transportation costs and dangers, which instead is to be considered a good news for the people with disabilities. Because of their natural imperfection, people with disabilities often have restrictions on experiences and actions. Therefore, with the use of virtual reality technology, the loss caused by such restrictions could be made up for.

This study not only aimed to apply one of the virtual reality technologies, the 360 Degrees Panoramic Image System, to instruct students with mental retardation to recognize the environment of a community but also dedicated itself to understand the relevance of this technology in helping for those special students to get acquainted with the real environment.

2. Literature Review

The individuals with mentally retarded have evident difficulties when adapting into the community life. But, through appropriate education they still have the opportunity to change their style of living [1][2][3]

The Virtual Reality (abbreviated as VR) is to take the advantage of a three dimensional simulation of the environment in which through an unique input and an output equipment it allows interaction with the simulated environment and let the individuals to act as if they are in the real one world [4][5]. The basic characteristics of the virtual reality are “interaction”, “integration” and “three dimensional space” so the individuals could integrate themselves into a “real” world created by the computer.

The present technology used nowadays on the virtual reality could be categorized into geometry-based virtual reality, video-based virtual reality and image-based virtual reality. The 360 Degree Panoramic Image (360°PIS) is considered to be one of the image-based virtual realities that is composted by high real images and considered to be a low cost and of a easy producing method virtual reality when compared with...
After concluding from all the image-based virtual reality related researches mentioned, it evidently shows that the image-based virtual reality has positive effects, but still need to be paid attention to the following: 1. the user does not easily see the transformation/changes of the cursor on the screen 2. an appropriate user’s interface and instruction is requisite, to avoid the users to lose themselves 3. a guide image map is essential 4. the amount of scenic spots influences users’ fluency when using the virtual reality 4. the lack of interaction certainly influences the results.

Special education is considered to be special chiefly for the reason that it needs to attend the special urges of each particular student. In order to satisfy the needs those with special requirements is to use the technology[6]. Virtual reality is based on high resolution level of image in which simulates the real environment, has the function to integrate and interact and contributes tremendous effects on the training education. This particular technology could help the disabled people to overcome their body deficiencies and get into a computerized space without having to encounter any obstacle.

When the teaching is correlated with a special education student’s particular requirements, the virtual reality generated from a computer could help their education, allowing students to experience mistakes, repeat the practices, to be more attracted and interested, to more willing to learn and at the same time to take into account the learning speed of the students, to stimulate the sensorial organs of the students at once, to increase the learning efficiency and make up the deficiencies of those special education students.

In the present, few real models of virtual reality are used in the special education. Neale, Brown, Cobb and Wilson designed an experimental and communicative learning environment for the students with learning disabilities. [7]

To the special education students, the virtual reality is a very helpful learning tool, particularly when the more integration and interaction they have, the lower would be the difficulties they would encounter in the leaning. Though the virtual reality is still under research, related studies based on designs, developments and the effects are also uncommon since most of it is designated for normal individuals and students. Little has been dedicated to special education students either abroad or local. Hence, this study proposes to fully understand how the image-based virtual reality – 360 Degrees Panoramic Image System – would help the moderate and severe mental retardation students to learn efficiently.

3. Research Method

3.1 Participants and Tools

The research targeted four students with moderate and severe mental retardation in a vocational senior high school located in the north of Taiwan. The participants Intelligence Quotient (IQ) leveled between 40-54 (Wechsler Children Intelligence Scale Test III) and had the following features: ability to speak properly, stability in the mood, ability to act by themselves, basic computer skills and experience (to turn on and off the computer and control the mouse cursor) and had never been to the research target location: Yangming Park.

The research used PixMaker to produce the 360° Panoramic Image System of the Yangming Park teaching software. Based on the real environment of the Yangming Park, 5 interactive 360° scene is settled with passage ways connecting all the scenes, demonstrating the complete trails inside the Yangming Park.

At the same time, the teaching software shows the plain map and the 360° panoramic image of the Yangming Park on the computer screen (Figure 1). The students could use the mouse cursor to click on the plain map and connect to the scene of the panoramic environment.

![Map of Yangming Park](image1.png)

After integrating themselves into the scene, they could use the connection and get into the nearby scene. Furthermore, the 360° panoramic image it could be switched into whole screen size allowing the students to move and act even more freely in the virtual world. Within the whole screen size image, by operating the cursor and using the function key, the students could have complete control of it.

3.2 Research Design
The research is a single subjected cross multiple-probe experimental design in which each of the four students is given an one-to-one special instruction under three experimental stages described in the following: baseline, intervention and generalization period.

The independent variable of this research is the teaching system of the environment introduction of Yangming Park by the 360° PIS. The dependent variable are: 1. The student’s capability to operate the 360° PIS including the use of the mouse cursor to do actions, to use the function key to do actions, to click the relative scene on the panoramic image or on the plain map and etc totaling a correct score percentage. 2. the students’ recognition of the environment proving that they should be able to say the right scene name on the computer and find out the correct connection passage ways totaling a correct score percentage in the intervention stage. Then, to say the correct name of the scene and its passage ways in the real environment totaling a correct score percentage in the generalization period. 3. The ability of the students to act independently in the environment such as finding out the two distinctive treasure hidden by following the trails one and two in the computer totaling a score that achieves the correct percentage in the intervention stage. Thus, they should be able also to find out both treasure through trails one and two in the real environment at the generalization period.

The experiment was classified into three stages: baseline, intervention and generalization. In the baseline stage, students’ knowledge on the 360° PIS and the environment is tested. In the intervention stage, the students are instructed and tested directly on 360° PIS manipulation, environment knowledge and ability to act in the environment. And, when the students are in the stage of generalization and they have more stable scores, the students are taken to the real environment and tested to see if their learning was effectively and helpful to them.

4. Result and Discussion

The research results shows that the environment introduction of Yangming Park by the 360° PIS teaching has efficient effects on the environment knowledge of the moderate and severe mental retardation students. The consequences were as showed in the Table 1.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
<th>Student D</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>I</td>
<td>G</td>
<td>B</td>
<td>I</td>
</tr>
<tr>
<td>Cursor control</td>
<td>10%</td>
<td>100%</td>
<td>10%</td>
<td>100%</td>
</tr>
<tr>
<td>Environmental Recognition</td>
<td>0%</td>
<td>100%</td>
<td>83%</td>
<td>0%</td>
</tr>
<tr>
<td>Ability to mobility</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

B: Baseline  I: Intervention  G: Generalization

During the experiment, after continuous try outs on the operation of the 360° PIS, only the student C produced effective results in the baseline stage. The other three students failed to acquire any related knowledge. But after getting into the intervention period, four students learned all the knowledge they would need such as operation skills, knowledge of the five scenes and its passages in the Yangming Park, trails one and two and its perspective hidden treasures. Finally, they became familiar with what has been taught to them after 5-6 times of teaching and testing. At the real environment, the student A had trouble in finding the three passage ways that connects the scenes because of the lost direction. The student B had difficulties to find out the other two passage ways. But, all students could say the five scenes names correctly and indicate the passage ways, to finish the trail one and find out its treasure independently as well as to find the trail 2 and its treasure. Evidently, they successfully used the knowledge they acquired through the computer and effectively generalized into the real environment.

4.1 Learning Effects

According to the research, the mild and severe mental retardation students could operate the 360° PIS and use it to recognize the environment, thus to help them improve their ability to act in a particular environment. Hence, through adequate teaching, they could learn the 360° PIS technology and overcome their deficiencies by involving themselves into the computerized space. Not to mention the improvement that they would have in their acting ability after learning the environment through this technology. The positive results shows and supports the idea that the virtual reality does help students to learn and is an appropriate method to be used in the education and training.\[8\]

Obviously, virtual reality is specially suitable for learning experiences since it is more effective and lasts longer in people’s memory transforming the abstract ideas into a more concrete learning experience. The 360° PIS is a media that links the abstract and the concrete ideas in which provides a direct image
learning, resulting in personal experience which is helpful to the students with mental retardation. All of the four students were familiar with the teaching contents after 5-6 experimental teaching and good in practice.

4.2 The effects of the Generalization

The study results show that the moderate and severe mentally retarded students could effectively generalize into the experiment environment after learning through the 360° PIS. The 360° PIS’s high simulation serves as a concrete learning material for the students, decreasing difficulties generated from the abstract thinking and generalization. Mechling and colleagues used image media to teach the students with mentally retarded to recognize the community and generalize it into the concrete environment.[3]

4.3 Conclusion on the Image-based Virtual Reality Related Research

Although already mentioned in the conclusions of various kinds of virtual reality researches, it is important to restate that: the user does not easily see the transformation of the cursor on the screen, an appropriate user interface and instruction is needed in order to avoid the users to get lost, a guide image map is essential, the number of scenic spot does affect the fluency of the user, the lack of interaction influences the effectiveness of the results. To avoid the above situations, oral instruction is given to the user as well as plain map (guide image map) and whole scene map at the same time followed by a design passage ways that connects the five scenes that are similar to the real environment.

As in the previous researches, the participants of this research also faced the problem of getting lost in the real environment. The 360° PIS provides a continuous running screen without showing the four directions (East, West, South and North). Although the user might know the right location they are and the relative location of the scenes nearby, they have difficulties in knowing the absolute direction. The same situation is found when the participants are on the real environment. When the students get into the first scene, they are able to name it right away, but find troubles in locating the nearby scenes. As the participants were asked to spin themselves around and observe the environment around, the students were able to correlate the image shown in their brain with the reality and find out its relative location.

5. Conclusion and Recommendation

5.1 Conclusion

After adequate teaching, the four students with moderate and severe mental retardation could operate the 360° PIS by themselves and reach the expected learning level of proficiency (Accuracy of 100%).

After adequate teaching, the four students with moderate and severe mental retardation could recognize the environment on the 360° PIS and were able to tell the panorama, names of scenes and the locations of its related passages (Accuracy of 100%). They were able to generalize the results from the virtual into real environment, indicate the names of scenes and find out locations of passages (Accuracy of 83%~100%).

After adequate teaching, the four students with moderate and severe mental retardation could walk through both trails one and two independently on 360° PIS (Accuracy of 100%) and generalize the results from the simulated space to the real environment and successfully walk through the two trails (Accuracy of 75%~100%).

5.2 Suggestion on the Instruction Design

Correspondent to the efficiency, the 360° PIS does help the mentally disabled students to recognize the environment. Through the economic point of view, the software that produces the family version of the 360° PIS has the price averaged about hundreds NT dollars. After shooting in the real environment and have all the taken photos transferred into the computer, a complete panoramic scene image could be produced after a couple of minutes without complicated art designing and related skills. For students with mental retardation, the 360° PIS is easy to operate, displays the real image scene and provides a better interaction than the traditional photography and video taping, and raises learning motive and interest of the users. According to the described advantages, the 360° PIS fits properly in the special education and should be valorized and recommended.

In the pre or post community teaching, the 360° PIS should be used in order to truly present the real community environment so to help those students to recognize the community beforehand and to help avoid difficulties they would face when generalizing into the real community. In the career education, the 360° PIS could be used as a pre-career training which the students could get to know the working environment and the work before involving themselves in it, avoiding any obstacle they might encounter at the beginning and at the same time help them build their career adaptability.
5.3 Recommendation on Future Researches

Although the 360° PIS already showed positive effects when used by the students with mental retardation, the number of researches on this theme is still very limited. Having used the vocational high school students as the target in this research does not mean that only these students need to know the environment and improve their adaptability to the community. The future researches might as well focus on this group or other age levels, different kind of disabilities and levels of disabilities as the research targets.

The environment used in this research is an open and wide space. For this reason, when the students were going into the real environment, the scenes from what they happen to see was more likely to be the same one as what they have seen in the computer screen and the students could easily locate the nearby scenes. For future researches, closed spaces such as the interior of a house or bigger environment such as the entire community area could be used as the research location to further discover the contributions or influences that the 360° PIS would bring to the students.

This study did not leave any test behind when using the three experimental stages -- Baseline-Intervention- Generalization, neither prolonged any of the intervention and generalization stage time when conducting the test in the real environment. At last, it is recommended that after assuring that the students had been under an extensive learning, the students could still remember, keep and generalize all the acquired knowledge.

6. References


Effects of Collaborative Activities on Group Identity in Second Life

Sumin Seo*, Xiangzhe Cui, Bokjin Shin
Korea National University of Education
South Korea
*seosumin@gmail.com

Abstract

The purpose of this study was to analyze the effects of collaborative activities on group identity in Second Life. To achieve this purpose, this study adopted events that promoted participants' interactions using tools inherent in Second Life. The interactive tools given to the control group in this study include: ‘permissions to move, copy, and edit’; ‘give item’; ‘chat’; ‘send instant messaging’. In addition to these tools, special tools of ‘Give Item’ for Praise and ‘Pollster’ were given to the experimental group. The two groups were compared on a score of group identity, which has nine sub-categories. The experimental group showed higher scores in five subcategories than the control group. Thus, we concluded that the use of tools for facilitating participants' interactions is effective for formation of group identity.

1. Introduction

Education in virtual reality has potential as a new method of teaching and learning, supporting interaction among students anytime, anywhere. Students in virtual reality have equal opportunity for participation. They can focus on a specific topic at the same time. Moreover, virtual reality allows students to experience just-in-time learning, access the most updated information, and construct knowledge through communication [1]. Active and frequent interpersonal activities are expected to promote students’ learning, reducing socio-psychological load which they have in the face-to-face environment. Thus, education in virtual reality provides supportive environments for collaborative learning based on interactions among students.

Real-world interactions enable students’ participation and positively affects their attitude toward learning. Interactions also enhance students’ achievements [2] and motivation [3]. Therefore, interactions facilitate students’ learning. In addition, active and frequent interactions among students are conducive to forming group identity. It can also stimulate effective collaboration. However, interaction in a virtual world is not as active and it is not as frequently adopted in virtual reality as expected. Romiszowski and Marson [4] noted the necessity of exploring various strategies to induce students’ interaction in virtual learning.

Many activities in virtual reality are collaborative. Frequently students exchange their opinions on specific topics. In Second Life, they might be performing group work on building houses, offices, and campuses. Advantages of collaborative work in virtual reality include maximized interactions, improved problem solving skills, access to multiple solutions to a problem, and activated higher order thinking [5]. In virtual reality many-to-many interactions are possible, providing simultaneity and equality to communications [6][7]. Access to information is unlimited, providing a way to test one’s knowledge [8][9]. Most important, virtual reality is an environment with a visualized cognitive tool, embodying abstract concepts, showing relations between concepts [10].

While there have been several attempts to introduce new ways of teaching and learning into virtual reality [11][12][13][14], some issues of isolation, lack of friendliness, and a need for various interaction patterns are still to be solved. In order to remove students’ isolation in collaborative learning in virtual reality, the formation of group identity is needed [15]. The strength of the group relies heavily on group identity, a basic building block for social interaction and a means by which individuals define themselves in relation to the group. In particular, group identity shapes the motivation behind voluntary engagement in collaborative behavior, and is linked to a person’s desire to receive feedback from the group and to create, maintain, and enhance a favorable identity for the group.
This study aimed to find effects of using Second Life’s interactive tools in participants’ communications, of giving positive feedback on their collaborative activities, and of allowing opportunities to reflect on their group activities, reinforcing their collaborative work.

2. Collaborative activities in Second Life

Second Life has important educational implications. It provides educational experience originating from engagement, a multitude of ways to be involved, and multi-sensory interactions [16]. Activities in Second Life can support participatory learning and experiences based on interaction [17], and can embody abstracts into concretes.

Collaborative activity in-world has a great potential for building shared memories of enjoyment and fellowship, which strengthens social ties [18]. Collaborative learning is a method of teaching and learning in which students’ group together to explore a significant question or create a meaningful project. Usually, students are working in groups, mutually searching for understanding, solutions, or meanings, or creating a product. Collaborative learning activities vary widely, but most center on students [19]. Research suggests that collaborative learning brings positive results such as deeper understanding of the concept, increased achievement in grades, enhanced self-esteem, higher motivation to continue on task, and an increased willingness to tackle difficult questions [20][21].


2.1. Permissions

‘Permissions’ in Second Life are related to object creation (move, copy, edit). When ‘Move’ permission is given to an object, the object can be rearranged even though it belongs to another player. Thus this ability makes it much easier to rearrange objects when players are in collaboration for building and decorating their spaces. But this permission does not allow modifying the object itself (shape, color, etc.) or the contents.

2.2. Add Friends

‘Add Friends’ gives friends the ability to modify one’s objects: shape, color, and texture. Added friends can use ‘teleport’ to friends and teleport to a location passed to the viewer from a web browser (SLURL). The ‘Teleport’ function calls players into a place for collaboration quickly and easily. Using this feature, a place can be shown to other players without difficulty.

2.3. Give item

Objects can be delivered and shared through this feature. This feature facilitates delivery and sharing of items. Also it expedites interactivity among players. Second Life’s inventory can hold and save documentation of interactions that happen during collaboration as objects for later use. These interactions become a basis of student-centered learning.

2.4. Instant Messaging and Chatting

In Second Life, ‘Group Instant Message’ (IM) allow the players to send a message to all the members belonging to the group. The player must be a member of the group in order to send an IM. Thus they can share a special affinity within a group. In addition, ‘Chat’ allows voice and message communication among players. These features allow students to present their ideas and get feedback synchronously as well as asynchronously.

2.5. Give Item for Praise

Players can give and take a ‘Praise Item’ when they are in interaction. ‘Give item’ in a player’s profile can produce positive effects of praises directed to one another. In order to give ‘Praise Item’, they should observe not only what they are doing but also what the others are doing. In this study a party-hat was used as a symbol to praise.
2.6. Pollster

Another tool for interaction is ‘Pollster’. Players can have a chance to reflect on collaborative work as well as on their own activities. A pollster, consisting of five items for ‘respect’, ‘concern’, ‘contribution’, ‘responsibility’, and ‘collaboration’, was given to the experimental group in order to provide individual reflection as well as group reflection. The experimental group members could respond to five answers of the pollster. Four colors were assigned to each members of a group. They can see the result of their voting by touching the colors.

![Figure 2. Screen shot of ‘Pollster’](image)

Using this tool initiates interactions among players through evaluating their collaboration. It was expected that group identity is formed by players’ reflection on themselves, other members, and group activities.

3. Research Methods

3.1. Participants

Sixty three university students participated in this study, consisting of 22 males and 41 females. The average age of the participants is between 20 and 22. They are from two ‘New Media’ classes taught at the Korea National University of Education in South Korea. One class was used as a control group and the other used as an experimental group. The participants had never visited Second Life before.

3.2. Procedure

Four to five students formed one group. One member of each group was nominated as a leader by the group members. The control group used basic functions (e.g., ‘Permission to move, copy, edit’, and ‘Give item’, ‘Chat’, ‘IM’, etc.) for communication and collaborative activity provided in Second Life. The experimental group was given two more functions in addition to the basic functions: ‘Give item for Praise’ and ‘Pollster’. Two groups conducted group work for four hours.

![Figure 3. Screen shot of ‘Result of Collaborative activity: Construct the Educational Space’](image)

3.3. Group Identity Test

After group activities, the group identity test was administered to participants. The test items presented with a Likert scale in nine subcategories. Among them, seven categories were proposed by Balmer and Wilson [22]: ‘Affection’, ‘Alliance’, ‘Attachment’, ‘Bonding’, ‘Closeness’, ‘Kinship’, and ‘Nostalgia’. Two subcategories for ‘Satisfaction’ and ‘Enjoyment’ were added to the test. ‘Satisfaction’ was added based on the assertion of Chizhik [23], stating that satisfaction with learning is affected by interaction level and quality, in turn, it affects to processes and outcomes of learning. ‘Enjoyment’ was added because it is one of the influential factors to learning motivation and desire to participate.

The reliability (Cronbach’s Alpha) of this test is .77. Reliability is .75 for ‘Affection’, .74 for ‘Alliance’, .74 for ‘Attachment’, .75 for ‘Bonding’, .74 for ‘Closeness’, .75 for ‘Kinship’, .74 for ‘Nostalgia’, .74 for ‘Satisfaction’, and .74 for ‘Enjoyment’.

4. Results and Discussion

Collected data were analyzed using t-test procedure in SPSS. Results and discussions are presented in this section.
According to the analysis presented in Table 1, the mean of group identity for the experimental group is 36.08 and that of control group is 32.16. The difference between two means is about 3.92, which has statistical significance at .05 level.

Table 1. Collaborative activities on group identity for two groups

<table>
<thead>
<tr>
<th>Tool</th>
<th>Use</th>
<th>N</th>
<th>Mean</th>
<th>Std</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>32</td>
<td>3.63</td>
<td>.711</td>
<td>.360</td>
<td>.721</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.54</td>
<td>.884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affection</td>
<td>Yes</td>
<td>32</td>
<td>4.08</td>
<td>.584</td>
<td>2.524</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.58</td>
<td>.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance</td>
<td>Yes</td>
<td>32</td>
<td>4.21</td>
<td>.588</td>
<td>2.091</td>
<td>.042</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.79</td>
<td>.779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment</td>
<td>Yes</td>
<td>32</td>
<td>4.25</td>
<td>.608</td>
<td>2.747</td>
<td>.009</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.71</td>
<td>.751</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding</td>
<td>Yes</td>
<td>32</td>
<td>4.13</td>
<td>.680</td>
<td>1.864</td>
<td>.069</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.71</td>
<td>.859</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closeness</td>
<td>Yes</td>
<td>32</td>
<td>3.75</td>
<td>.737</td>
<td>1.856</td>
<td>.070</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.33</td>
<td>.816</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nostalgia</td>
<td>Yes</td>
<td>32</td>
<td>3.83</td>
<td>.963</td>
<td>2.290</td>
<td>.027</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.25</td>
<td>.794</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Yes</td>
<td>32</td>
<td>4.17</td>
<td>.761</td>
<td>2.121</td>
<td>.039</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.67</td>
<td>.868</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Yes</td>
<td>32</td>
<td>4.04</td>
<td>.859</td>
<td>1.775</td>
<td>.082</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>3.58</td>
<td>.929</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Yes</td>
<td>32</td>
<td>36.08</td>
<td>5.2661</td>
<td>2.364</td>
<td>.022</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>32.16</td>
<td>6.17616</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Five subcategories out of nine showed a significant difference. They are: ‘Alliance’, ‘Attachment’, ‘Bonding’, ‘Nostalgia’, and ‘Satisfaction’.

The result of this study indicates that the interaction tools during group collaboration helped to form group identity. ‘Bonding’ shows biggest difference between groups, next is ‘Alliance’, ‘Nostalgia’, ‘Satisfaction’, and ‘Attachment’ respectively. On the whole, using the interaction tools during the process of collaborative activities contributed to form group identity. However, specifically it did not contribute to forming ‘Closeness’, ‘Affection’, and ‘Kinship’ between the group members and ‘Enjoyment’ to all participants.

5. Conclusion and Suggestions

Interaction among participants has been emphasized in on-line education as it expedites learning among them. However, in virtual reality, interaction does not happen as planned. This study attempted to enhance interaction with an eye to elevate group identity in a collaborative mode of learning. Considering communication as the essence of collaborative knowledge construction [2], it is a best practice to induce active participation of learners in interaction. In collaborative learning, active participation and interaction of every learner are required to ensure successful outcomes. This study adopted five events for positive collaboration in all. Among them, two events, ‘Give Item for Praise’ and ‘Pollster’, were given to the experiment group.

For conclusion, using ‘Give Item for Praise’ in Second Life helped to form group identity. Also, ‘Pollster’, evaluating each other when they are in collaboration, was helpful to form group identity. ‘Give Item for Praise’ induced positive interaction and ‘Pollster’ gave opportunities to reflect on activities of self as well as others and were helpful in forming group identity. This implies that these tools may be effective in promoting achievements through collaboration, and endowing positive attitudes toward subsequent learning in Second Life.

6. References


Effects of Object Building Activities in Second Life on Players’ Spatial Reasoning

Jihyun Hwang*, Hyungsung Park, Jiseon Cha, Bokjin Shin
Korea National University of Education
Republic of Korea
*jihynhwang@gmail.com

Abstract

The purpose of this study is to examine the effects of object building activities in Second Life on players’ spatial reasoning and to explore the relationships between learners’ information perceiving styles and spatial reasoning. The participants of this study included 70 undergraduate students who were taking the class ‘New Media in Education’. For this study, Kolb’s Learning Style Inventory was administered to the participants in advance of activities in Second Life. Also they were given instructions on building objects related to spatial reasoning activities (e.g., analysis and synthesis, deductive reasoning, development and application of visualization methods, systematic approach, and transformation) in Second Life. As a result, it was discovered that Second Life activities are more effective for the abstract conceptualization group than for the concrete experience group. This implies that activities provided in second life were more positively effective to abstract conceptualization learners on their information processing such as spatial reasoning.

1. Introduction

Of the many ways that people think, gather information, process it, and make some meaning out of it, spatial reasoning is a higher order thinking skill which relates entities in space and their relations. Clements and Battista [1] state that spatial reasoning consists of cognitive processes by which mental representations for spatial objects, relationships, and transformations are constructed and manipulated. Thus, spatial reasoning allows people to use concepts of shape, features, and relationships in both concrete and abstract ways and to make and use things in the world [2][3][4]. It is an essential cognitive process of forming ideas through the spatial relationships between objects and of developing spatial abilities. Spatial reasoning covers a broad area of cognition subdivided into several sub domains, “Visualization”, “Spatial Relations” including mental rotation, and “Orientation”, and it can be transferred other subjects [5][6][7].

Spatial cognition and spatial reasoning have recently drawn attention from math and related fields [8][9][10][11] as well as human and machine intelligence [12]. Researchers in this area have made efforts to improve a learner’s spatial reasoning through computer technology. According to Sorby’s [13] and Agogino and His’s study [14], spatial reasoning is a cognitive process and skill that can be learned. CogSketch software developed by the Spatial Intelligence and Learning Center (SILC) [15] is used for creating a computational model of spatial reasoning and learning. CogSketch is a cognitive science research instrument and the NSF granted project "Enhancing Spatial Reasoning and Visual Cognition for Early Science and Engineering Students with 'Hands-on' Interactive Tools and Exercises" [16] that represents the educational value of spatial reasoning and efforts to use techniques for shifting between computational and physical representations about spatial reasoning.

Recently education in virtual reality has become popular in the teaching and learning community. Virtual reality technology is increasingly being recognized as a potential tool for the assessment and rehabilitation of human cognitive and functional processes [17][18][19]. Also researchers in this area agree that virtual reality should allow the development of suitable and extremely useful virtual environments for cognitive functions rehabilitation [20][21][22]. Accordingly, 3-dimensional virtual reality has the appropriate environment to promote spatial cognitive processes.

A number of studies have shown the usefulness of virtual reality in training spatial ability [23][24][25]. Oman et al. [26] conclude that virtual reality is an excellent tool for spatial training. Passing and Eden [27] found that the mental rotation ability can be trained in 3D-stimuli virtual reality. These studies explored the changes of the spatial abilities of players...
through 3-dimensional virtual reality activities and determined the individual variables affecting these changes. More importantly, these studies present the necessity of serious research related to spatial reasoning in virtual reality from the perspective of a cognitive process for promoting a spatial ability.

However, little to no work has been done towards the development of virtual reality applications for spatial reasoning. This is surprising because these emerging technologies can offer innovative and unique tools of research. With 3D virtual reality-technology, it is possible to minimize and overcome some of the problems that occurred in studies on spatial ability with other methods [24]. Virtual reality also allows the experimenter to control the stimulus material and virtual objects which would otherwise be difficult to manipulate and to adapt in the real world. Furthermore, the main advantages of using virtual reality-technologies are their spatial visualization and 3-dimensional interaction capabilities. This should allow creation of very intuitive hands-on training setups that can be very useful for an educational purpose.

Interest in Second Life has been growing. It is a Web-based 3-dimensional virtual reality application which allows players to create their own complex objects in various formats. Thus it is expected to increase a player’s spatial reasoning resulting from operating and constructing 3-dimensional objects. In Second Life, 3-dimensional objects can be created using a built-in tool. It is possible using basic functions to create 3-D images and combine them. The basic object is called prim (for “primitive”) in Second Life. Prims are combined to create more advanced objects. In group work it is also possible to create prims cooperatively. Second Life is an open ended learning environment which can reflect individual characteristics. Thus, learning in Second Life supports a self-directed strategy to process information dynamically. Non linear and self-directed information processing is required in the information-flooded environment. In this environment, an individualized learning strategy is needed for lessening cognitive load. To avoid possible cognitive problems, a learning strategy in virtual space should be in concordance with information perceiving and processing style. Thus, our research team felt it would be interesting to study the relationship between information perceiving style and learning spatial reasoning in virtual space using programs such as Second Life to recognize and apply appropriate learning strategies.

The purpose of this study is to examine the effects of object building activities in Second Life on learner’s spatial reasoning and to explore the relationships between learners’ information perceiving styles and spatial reasoning.

2. The Role of Virtual Reality and Spatial Reasoning

Much effort to use virtual reality for students’ learning has been made recently [28][29]. Virtual reality can facilitate meaningful learning such as knowledge construction, intuitively memorizing and visualizing and drawing analogies and building [28]. Representing in directly visible and manipulable forms, virtual reality can simulate objects, actions, concepts and procedures that are intangible and invisible in the real world [19][30][31][32].

Terlecki and Newcombe [33] explored the differences between males’ and females’ abilities of spatial reasoning, particularly mental rotation ability, as exhibited in the use of computers and digital games. The requirement of spatial reasoning seemed to be a decisive factor in both male and female success and enjoyment of digital games [33][34]. Piagetians [35] emphasize "the part played by overt activities in building up the conceptual machinery of thought" (p. 16). With interactive computer technologies we can simulate contained physical worlds and study people’s actions within them.

Spatial reasoning to solve problems both within and outside of mathematics offers learners ways to interpret and describe physical environments and can serve as tool for other topics in mathematics and science. Spatial reasoning is fundamental in many creative activities such as using maps and design improved by interaction with computer animations and virtual reality [36]. National Council of Teachers of Mathematics (NCTM) calls for geometry and spatial reasoning to be learned using concrete models, drawings, and dynamic software. With appropriate activities and tools and with teacher support, students can carefully make and explore conjectures about spatial reasoning.

Second Life includes the built-in 3-dimensional graphic tool called Atomic Construction. It allows players to create basic shapes and then build more complicated objects combining basic prims. Transformation of prims is a basic skill to create 3-d images. [37] This, as mentioned before, can also be done in group work. What is more, students can interact with these objects and can actively experience phenomena in the virtual world in ways that are more
natural than those normally employed when interacting with computers [38].

Spatial reasoning can be nurtured naturally in Second Life. Through activities to build constructs, participants can exercise spatial reasoning, which is a highly transferrable ability in math, arts, science, and society. Furthermore, learners feel familiarity and close sense to their lives, resulting in active participation and sharing.

3. Information Perceiving Style and Spatial Reasoning

Our research is based on the experiential learning style, in particular, information perceiving style. Kolb [39] stated that once information is perceived, it must be processed which defines two separate experimental learning styles: perceiving and processing. Each of these can be divided into opposites. In information perceiving style, some people best perceive information using concrete experiences like feeling, touching, seeing, and hearing while others best perceive information abstractly using mental or visual conceptualization. Other people process information best by active experimentation like doing something with the information, while still others process best by reflective observation and thinking about it. Accordingly, learners, if they are to be effective, need four different kinds of styles, concrete experience style, reflective observation style, abstract conceptualization style, and active experimentation.

Figure 1. Kolb's Experiential Learning Cycle

Among the many ways to measure learning style, the most commonly used instrument relevant to e-learning is Kolb's Learning Style Inventory (LSI) [41][42][43]. A number of scholars have applied Kolb's learning style theory to study the effects of e-learning and hypermedia learning, and most of them indicate that learning styles are a key factor in the effectiveness of learning [44][45]. Karuppan [46] found that assimilators whose dominant learning abilities were abstract conceptualization and reflective observation were the heaviest users and accommodators whose dominant learning abilities were concrete experience and active experimentation were the lightest users of a course website. A study by McCarthy [47] added the two new views to Kolb’s model concerning the way the brain works (right/left mode). These results show that abstract information processing of students helps to improve academic achievements.

Hirsch and Lloyd’s research of virtual experiential learning related to Kolb’s experiential learning style [48] points out that learners have experiential learning cycles. In addition, Yam and Chit’s study [49] with a focus on developing C-visions, virtual and interactive simulations based on experiential learning style, show that it is necessary to develop learning programs that consider a learner’s information perceiving and processing style when experiencing virtual reality. According to their research, information perceiving and processing style affect teaching and learning. Therefore, it would be important to consider learner’s information perceiving style as an initial step for enhancing spatial reasoning in virtual reality. At the same time, it is a good idea to develop the appropriate instruction programs and activities based on the virtual reality by learner’s characteristic.
4. Methods

4.1. Participants

The experiment group included 73 university students, consisting of 24 males and 49 females. They were selected as subjects for the study because a computer was assigned to each of them and they learned prim production in Second Life. The student’s ages ranged from 20 to 22 years old. They are from three classes taking ‘Media Production for Teaching and Learning’ at Korea National University of Education. Three students, one male and two females were excluded in the study due to their absence either in pre or posttest.

4.2. Research Procedure

The Learning Style Inventory (LSI) by Kolb [50] was administered to measure learners’ information perceiving styles. Based on this test, the participants were divided into two groups in terms of information perceiving styles: The concrete experience group (33 students) and the abstract conceptualization group (37 students). Both groups took the pretest for spatial reasoning test. After Second Life activities, they were also given SRT2 (Spatial Reasoning Test 2) [51] posttest. Each group had performed Second Life activity to improve their spatial reasoning during the session total 18 hours, 6 hours per day for 3 weeks.

4.3. Questionnaire

Two questionnaires are used in this study. One is Learning Style Inventory by Kolb [50] and the other is Spatial Reasoning Test, SRT2 in Technical Test Battery 2 [51]. The Learning Style Inventory consists of 12 items in the Concrete Experience, the Reflective Observation, the Abstract Conceptualization, and the Active Experimentation. This is for adults who are above 18 years old. The reliability (Cronbach’s Alpha) is .62 for concrete experience and .75 for abstract conceptualization. .67 is for reflective observation and reliability for active experimentation is .66.

The SRT2 was used in the study to measure the participants’ level of spatial ability. In detail, this test assesses a person’s ability to manipulate and reason about shapes and spatial relationships. Unlike many spatial tests, the SRT2 assesses the ability to work with three dimensional relationships. This test was administered as both pre and posttest. The items in the pretest were shuffled for the posttest. Cronbach’s Alpha of SRT2 is reported as .84.

4.4. Spatial Reasoning Activities in Second Life

Second Life activities for spatial reasoning consist of five areas: analysis and synthesis, deductive reasoning, development and application of visualization methods, systematic approach, and transformation. These activities were adopted from de Moor [52] who suggested wooden block-building as spatial reasoning activities. Transformation was made in situation and languages used for Second Life. Instead of wooden block-building, prims supported in Second Life were used.

For research, we had taught both groups the needed skills related to using Second Life, including registration, making avatars, walking, hopping, and flying before performing the spatial reasoning activities. Next, they learned several skills and methods for making an object, using the object making tool. We had prepared instructional materials and instruments for using in Second Life such as white boards for showing images, examples made of prims for activities, five notecards for guiding, and task papers for assignment to provide during a player’s learning.

Each of the activities in Second Life is described below:

-**Analysis and Synthesis**: This activity consists of locating the same prim when presented, top view, side view, and front view only; building the prim after top view, side view, and front view presented; drawing the top, the side, and the front shape of the prim; assembling the prim after disassembled.

![Figure 2. Screen of ‘Analysis and Synthesis’ activity](image)

-**Deductive Reasoning**: This activity involves building the object after viewing it in one direction; guessing the number of a prim after viewing it in one direction; and building the prims and drawing the top, the side, and the front shape of the prims after viewing the whole building.
5. Results

For data analysis, a t-test was performed to compare two groups’ mean scores of increased spatial reasoning. The increased mean score was calculated by subtracting pre test score from the post test score. The result of the analysis is presented in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete experience</td>
<td>37</td>
<td>4.95</td>
<td>4.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract conceptualization</td>
<td>33</td>
<td>8.96</td>
<td>4.05</td>
<td>3.59</td>
<td>.001</td>
</tr>
</tbody>
</table>

Table 1 summarizes the result of the t-test for mean scores between the concrete experience group and the abstract conceptualization group. The mean of the abstract conceptualization group is 8.96 whereas that of the concrete experience group is 4.95. This difference is significant (t=3.59, p <.01). Thus, Second Life activities are more effective for the group of the abstract conceptualization style than the group of the concrete experience style.

5. Conclusion and Discussion

Is Second Life an effective environment for enhancing spatial reasoning? Drawing from the results of this study, the answer indicates as positive. Second Life activities are effective for improving spatial reasoning. Supporting the activities for spatial reasoning, the interaction between learner’s cognition and Second Life may enhance the creation of the cognitive processes related to spatial abilities. Experience in building objects in Second Life makes it
possible for participants to express objects in space with mind, not necessarily with real objects.

Why do we need discussions about spatial reasoning in Second Life? Since spatial reasoning as a cognitive process has high transferability, it is important for generating and conceptualizing solutions to multi-step problems in areas such as architecture, engineering, science, mathematics, art, computer games, science robotics and everyday life [12]. Providing opportunities for practicing spatial reasoning in Second Life becomes important to students’ success using virtual reality in the future. Second Life provides an excellent environment for building three dimensional objects similar to real life in math, geometry, construction, and science, engineering education, etc. Thus, Second Life can be a bridge between imagination and reality, providing experiences in patterns, structure, position, and transformation of spaces.

How can Second Life be applied in teaching and learning as an environment for promoting spatial reasoning? Spatial reasoning of participants varies in their information perceiving styles. It is suggested that the information perceiving styles of students should be considered for designing learning in a virtual space such as Second Life. In addition, Second Life activities are more effective for learners with the abstract conceptualization style than the concrete experience style. Thus, learners with the concrete experience style who rely on tangible qualities of immediate experiences are not as likely to make logical or scientific inference as learners who can rely on abstract conceptualization. Therefore, for learners who prefer concrete experience, activities for promoting spatial reasoning may need more detailed instructional methods such as an orientation to learning, exemplary activities, and step by step guidance for their self-directed knowledge construction and for their self-designing of learning.

6. References


[16] Do, E. Y, “NSF DUE-0127579 Project: Enhancing spatial reasoning and visual cognition for early science and engineering students with ‘Hands-on’ interactive tools and


Evaluation the Efficacy of Computer - Based Training Using Tangible User Interface for Low-Function Children with Autism

Karanya Sitdhisanguan¹, Nopporn Chotikakamthorn¹, Ajchara Dechaboon², Patcharaporn Out³
¹Faculty of Information Technology & Research Center for Communications and Information Technology
King Mongkut’s Institute of Technology Ladkrabang, Bangkok, Thailand
s7066005@kmitl.ac.th, nopporn@it.kmitl.ac.th
²Occupation Department
Chiangrai Hospital, Chiangrai, Thailand
³Pediatric Department
Chiangrai Hospital, Chiangrai, Thailand

Abstract

Recently, the number of children having autism disorder increases rapidly all over the world. Computer-based training (CBT) has been applied to autism spectrum disorder treatment. Most CBT applications are based on the standard WIMP interface. However, recent study suggests that a Tangible User Interface (TUI) is easier to use for children with autism than the WIMP interface. In this paper, the efficiency of the TUI training system is considered, in comparison with a conventional method of training basic geometric shape classification. A CBT system with TUI was developed using standard computer equipment and a consumer video camera. The experiment was conducted to measure learning efficacy of the new system and the conventional training method. The results show that, under the same time constraint, children with autism who practiced with the new system were able to learn more shapes than those participating in the conventional method.

1. Introduction

Autism is a disorder of brain function that appears early in life before the age of three. Autism causes impaired social interaction, communication difficulties, and restricted or repetitive activities and interests. People with autism often exhibit abnormal responses to sensory stimulation (e.g., touch, sound, light), usually have moderate mental retardation, and have a higher risk for developing epilepsy. Some autistic patients exhibit aggression and self-injurious behavior (e.g., head banging, biting themselves). About one-third of patients with autism have normal or nearly normal intelligence quotients (IQs).

There is no cure for autism, however, with appropriate treatment and education, children with autism can learn and develop a skill in order to live a normal life in society. Treatment depends on individual need of a patient. In most cases, a combination of treatment methods is required. Among autism treatment methods, occupational therapy and physical therapy are two of the most required autistic trainings. Occupational therapy helps to improve independent function and teaches basic skills (e.g., buttoning a shirt, bathing, basic shape, color). Physical therapy involves using physical exercises and other physical measures (e.g., massage, heat) to help clients control body movements [5].

With explosive growth in general computer usage, many researchers have explored the use of this technology to assist the treatment and interaction with an autistic child. One of the important factors that affect the efficiency of such computer-based training applications is a choice of user interface and interaction style. For example, Dautenhahn et al.[1] in their Aurora project investigated how an autonomous mobile robot can encourage children to become engaged in social interaction, an important aspect of human-human interaction. Bosseler et al. [7] developed and evaluated a computer-animated tutor to improve vocabulary learning and grammar skill in children with autism. Some researchers examined the effectiveness of virtual reality for autism treatment. For example, Dorothy Strickland et al.[8] published two case studies examining whether children with autism would tolerate wearing virtual reality equipment and could respond to the computer-generated world in the meaningful way. Leonard et al. [9] employed a virtual reality system. The system was used to teach children with autism for social skill treatment on how to find a place to sit with a stranger. Mary Barry
and Ian Pitt [6] provided a guideline for designing interactive software based on window icon menu and pointing device (WIMP user interface) for learners with autism. The results of such research show that children with autism may prefer interaction with a computer interface because they can actively control it. Most of these research works, however, mainly focused on high-functioning autism. There has been little research in open literature focusing on using technology to training basic skills in low-functioning children with autism. In [13], the ease of use of WIMP and tangible user interfaces were compared within the context of autistic child training. It was reported that tangible user interface is easier to use for low-functioning autism than standard WIMP interface.

However, how efficient the system is as compared with a conventional training method is not yet explored. In this paper, the TUI training system is studied in term of learning efficiency as compared with a conventional method of training basic geometric shape for children with autism.

2. Autism Treatment

Autism is not treated with surgery or medicine (although some people with autism may take medicine to improve certain symptoms, like aggressive behavior or attention problems). Instead, people who have autism are taught skills required for living a normal life. Best results are usually seen with children who began the treatment when they were very young. Special education programs that are tailored to the child's individual needs are usually the most effective form of treatment by teaching the child to communicate (sometimes by pointing or using pictures or sign language) and to interact with others. A treatment program includes basic living skill as well as any of the following: behavior modification, speech therapy, physical therapy, music therapy, changes in diet, medication, occupational therapy, and hearing or vision therapy. The same specialists who help diagnose the condition usually work together to come up with the best combination of therapies to use in addition to the educational program. [4] There is no single best treatment package for all children with autism. One point that most professionals agree on is that early intervention is important; another is that most individuals with autism respond well to highly structured, specialized programs.

Shape matching Training is one method that has been used to treat basic skill. In conventional geometric shape training, an occupation therapist shows a card containing the picture of one geometric shape or the object that clearly represent geometric shapes (Figure 1) and then asks patients to find and show the card of similar shape. In another method, a board with holes of different geometric shapes is introduced to a patient (Figure 2). Then, the patient is asked to select appropriate shape blocks to fit on these holes. In practice, these conventional treatments are found to be unattractive and boredom to children with autism. Also, such methods require a sufficient number of occupational therapists for the treatment to be effective.

Figure 1 The snapshot of the child with autism during conventional training

Figure 2 The snapshot of the shape block set that use for conventional training

3. Geometric Shape Training

In teaching children with autism to known the basic geometric shapes an occupational therapist shows a card that containing the picture of geometric shape or the object that clearly represent geometric shapes and ask them to pick the appropriate one or using a shape block as describe earlier.

3.1 Design Rationale

Based on observation that autistic children have their own unique learning style they are enjoy playing a computer system equipped with a tangible user interface device such as a steering wheel used in a computer game. Then it is suggested that such device may be better suited to children with autism than a standard WIMP device (a mouse and keyboard). On the other hand, computer game
can exclude the annoying surrounding then helping the children to focus on the task and they can learn from their mistake without the force of occupational therapist. Also, Price et al [14] reported that tangible having the potential for providing innovative ways for children to play and learn, through novel forms of interacting and discovering.

3.2 Tangible User Interface Training System

A tangible user interface is an interface that a computer user uses to interact with digital environment through a tangible input device. The shaping matching training system was developed using this type of user interface. It is aimed to provide similar experience to interaction with other real-world tangible objects such as toys. A system consists of hardware components as shown in Figure 3. Its operation is controlled by custom-made CBT software running on a computer machine. During the training operation, as for the case of conventional treatment, a picture of a geometric shape is randomly chosen and displayed on a semi-transparent glass table top, through a digital projector under the table. A user is asked (through narrative voice) to pick a wood block of appropriate shape and lay it on a table top over an area where an image of the geometric shape is projected (see Figure 5 for a screen shot of the program). A consumer grade digital video camera placed on one side of the table is used to capture the picture of the chosen wood block. Given the picture taken, the color on the edge of the block is then identified by an image processing module (Figure 4), which is implemented as part of the CBT software. The decision is then made by the program whether the chosen block matches in shape with the displayed one. The developed training system responds in real time to children reaction and gains child attention by providing reward if the chosen shape is correct. The reward is given in a form of a cartoon animated figure with applauding sound and music (Figure 6). If the wrong shape is chosen, they are encouraged to "Try again" by the computer narrative voice.

3.2 Implementation Module

4. Experiment and Analysis

4.1 Subjects

Experiment was carried out with sixteen male children with autism at the age of 3 to 7. Participants were recruited with the help of occupational therapists at Chiangrai hospital, Thailand. Male subjects were chosen because boys are 3-4 times more likely than girls to have autism [10]. Subjects were chosen such that they have a same level of learning ability. The subjects were split equally into two
groups. Subjects in each group used only one of the two training (conventional or proposed system). The experiment was taken place at an overtime clinic, so that the test would not interrupt a regular treatment schedule.

4.2 Experiment Design

We performed the experiment by comparing the conventional and proposed systems for basic geometric shape matching skill training. The experiment was divided into 6 sessions. Each session started with an orientation period, where a geometric shape was presented to each subject (using either the conventional method or the proposed system). Each subject was asked to choose an object (a card for a conventional method and a wood block for the proposed system) with a matched shape. In each session, each of the six geometric shapes was presented three times (in non-consecutive order) to each subject.

Figure 7 The snapshot of the child with autism playing the shape matching game during the evaluation session

5. Result and Evaluation

In our previous research [13] we explore the ease of use comparison of WIMP and tangible Uis. The results from the experiment clearly show that tangible user interface is easier to use and suited for low-functioning autism than standard WIMP interface. Then to support these research we compare the ease of use of the two interfaces (WIMP and tangible Uis) as perceived by non-autistic children by using shape matching skill for the case study. The results obviously show that tangible user interface is easier to use for the children with autism than the WIMP interface. The difference between the two UIs is noted to be much more noticeable than the case of non-autistic children.

Then in this paper the experiment was conducted to compare the two training methods in term of learning efficacy. The measurement was done by means of pre-test and post-test. Before the first session the participants were asked to do a pre-test. The test consists of 6 pictures of geometric shapes and the participants were asked to select the matching shape. After completing all training sessions, they were again asked to do a post-test. The same post-test was conducted again a week later. The tests were then analyzed. The difference between the pre-test and post test results was used to measure learning efficiency. The analysis results are shown in Table 1 and 2. From these tables, it was found that the participants from the group where the TUI-based training system was assigned could learn more shapes than those from another group using the conventional training method.

In supporting the hypothesis that the TUI-based system achieves higher learning efficiency (in terms of the number of learned shapes) as compared with the conventional method, the Two-sampling t-test is used (due to a small sample size with the assumption that the population is normally distributed). At the significant level of 0.05, for the pre-test, the calculated value of \( t = 2.457 \). Then the p-value for this upper-tailed test is 0.046. The p-value is less than 0.05. On the other hand, for the post-test the calculated value of \( t = 6.807 \) Then the p-value for this upper-tailed test is 0.000004. Therefore at the significant level of 0.05, the null hypothesis is rejected. It is thus conclude that the tangible user interface training system is more efficient for training basic shape skill than conventional treatment as measured by the number of learning object shapes.

Based on observation during the experiment, we also found that time to complete the task using the TUI-based training system was generally shorter than that of the conventional method. We noticed also that, while strongly expressing unwillingness to use the conventional method, all participants were joyful when training with the new system.

Table 1 The number of correct matching shapes of the pre-test and post-test for the grouped assigned with the TUI-based training system.

<table>
<thead>
<tr>
<th>Name</th>
<th>pre-test score/6</th>
<th>post-test score/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>T2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>T3</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>T4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>T5</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>T6</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>T7</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>T8</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

73
Table 2 The number of correct matching shapes of the pre-test and post-test for the grouped assigned with the conventional method.

<table>
<thead>
<tr>
<th>Name</th>
<th>pre-test score</th>
<th>post-test score</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>C3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>C5</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>C6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C8</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3 The statistics values for the case of the TUI-based training system and the conventional method, as obtained from the pre-test.

<table>
<thead>
<tr>
<th>TUI</th>
<th>Conventional</th>
<th>Sp</th>
<th>t-test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\bar{X}_1)</td>
<td>4.75</td>
<td>2.5</td>
<td>1.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 4 The statistics values for the case of the TUI-based training system and the conventional method, as obtained from the post-test.

<table>
<thead>
<tr>
<th>TUI</th>
<th>Conventional</th>
<th>Sp</th>
<th>t-test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\bar{X})</td>
<td>5.375</td>
<td>1.768</td>
<td>1.5</td>
<td>0.926</td>
</tr>
</tbody>
</table>

6. Conclusion

In this paper, we reported the effective of the tangible user interfaces system to support training basic geometric shape for low-functioning children with autism. The results from the experiment clearly show that the children with autism who study from the TUI training system can learn more shape than conventional treatment. Furthermore, TUI was more attractive and offers a multimedia real time feedback that stimulates children’s learning and also increases their attention span rather than the conventional treatment.

7. References


Exploring Learner’s Variables affecting Gaming Achievement in Digital Game-based Learning

Jiseon Cha*, Youngkyun Baek, Yan Xu
Korea National University of Education
South Korea
*chajiseon@gmail.com

Abstract

This study explored learner’s variables affecting gaming achievement in digital game-based learning. Gender, self-efficacy toward computers, logical thinking, and attitude toward gaming were selected as learner’s variables for the study. Seventy-two elementary school children participated in game-based learning using Zoombinis: Mountain Rescue. Pearson’s correlations coefficient (r) and Regression Analysis in SPSS were used for data analysis. The results of this study include that 1) locus of control, self-efficacy toward computers, and logical thinking were indicated as main variables affecting gaming achievement; 2) Attitudes toward gaming differed by gender; and 3) variables affecting gaming achievement also differed by gender of players.

1. Needs and Purpose of the Study

Video games and computer games have become an important part of young people’s lives particularly in advanced countries. OECD PISA[1] showed that 53% of age 15 students play games with high frequency during a week.

Young people are often called the Net Generation [2][3], the Gamer Generation, [4] and Digital Natives because they have embraced and learned to speak the digital language of computers, video games, and the Internet [5].

However, the impact of growing up with digital technologies is unclear. The assumption is that digital technologies are changing the new generations’ values, learning skills, and educational achievements [6]. Interest is increasing in computer games as the next generation’s educational method, and the research body on learning based on games is growing more than ever before [7]. The focus of the research includes increasing specific abilities of teacher’s in using computer games and the effects of gaming. Recently, some researchers have addressed the learning processes and different individual factors for efficient learning [8].

In this study, we searched for learners’ personalities, cognitive styles, gaming and academic abilities, and demographics (gender, race, and age). Drawing on literature, we found that most studies were unclear about these learners’ characteristics related to games. Of the articles we reviewed, the gender factor was the most frequently reported (n=12), age was second (11), academic ability and race were reported less (n=8 and n=3 respectively). Studies on learners’ characteristics such as personality traits (n=1) and cognitive styles (n=2) were rare. Although much attention was directed at “the learner”, few of the articles dealt with the variables related to learner characteristics [9].

Therefore, the purpose of this study was to explore learner factors on gaming achievement, defined as the achieved level in gaming, and finally suggest implications for the educational use of the games.

2. Selecting and Configuring Learner’s Variables in this Study

Learner’s variables denote traits specific to individual learners, for example, intelligence, cognitive style, learning style, character, motivation to learn, pre-knowledge [10]. These variables are affect learning processes and outcomes. Thus they should be considered as an important factor in designing learning, especially for game-based learning where learners are apt to engage.

Personal characteristics of learners have been examined to some degree although Dempsey et al [9] found that in reality studies are “very unclear in reporting these characteristics.” The most frequently reported variables in the literature were gender, age, academic ability, and race. This is quite interesting as
the early work in the field stresses the importance of individual differences [11], and the importance of examining researched samples to avoid methodological problems when matching samples [12]. Matched sample design is often required as studies are conducted within the existing class structure in schools. The facts that basis factors like age, race, gender, and academic ability are only cited in approximately 25% of the studies indicate the problems are not yet resolved.

One area that has consistently received attention is whether the effects of gaming are in favour of the students with the best academic abilities or if the effects are perhaps a mean to reach the students with weaker academic abilities. According to Coleman et al., [13] games are more effective with high academic achievers than low academic achievers. However, Bredemeier & Greenblat [14] reported more mixed results and pointed out that games might be able to reach less advantaged student groups. They especially pointed out that the prior attitude of the student towards the game plays an important role.

Other indications of personal factors are related to the structure of the group such as size, organization, and relations between students [15]. The argument is that the composition of the group facilitates different learning experiences and dynamics in both the environment and the specific students’ experiences (e.g., being winners and losers of the game) [14].

One area that has received little attention is the importance of previous experiences with games, which could be expected to play an influential role for learning outcomes. Knowledge and experience with playing games would make the student concentrate on playing the game, and to spend less time mastering a new knowledge and skills [16].

It has also been highlighted that a child’s cognitive activities are strongly affected not only by personal skills and attitudes [17], but also by behavioral, affective, and emotional factors [18]. We refer to factors like attention, concentration, motivation (both when connected to play and to computer use) which are universally considered important, and also to transitory factors such as anxiety, tiredness, and need for continuous confirmations by adults.

Learner characteristics are among the most commonly examined variables to predict successful experiences in online learning environments. In the Contreras’ study [20], self-confidence in using computers was predicted by demographic variables, such as age, gender, ethnicity, socio-economic status, and geographic region. In another study, the same construct was used to predict the student’s performance [21]. While these studies are considered valuable to find variable relationships influencing certain dependent variables, the studies need more factors to examine the effect of the important variables in learner and instructional conditions in a holistic way.

Among the demographic variables of learners, gender was one of the most frequently examined variables. In one study, female students reported more feelings of belonging toward peers and the social community, which correlated with greater knowledge gains [22]. More female adult learners of online courses said that their course experiences were positive [23]. In some studies, gender was not a significant factor to predict the learners’ self-confidence in using computers [20] and the use of the computers and the Internet for online learning [24]. Contreras [20] reported that previous computer experiences and the number of online courses taken previously better predicted the students’ confidence in taking online learning.

Also, Lim et al. [25] classified numerous course-affecting variables into four categories: learner characteristics, study habits, instructional variables, and learning motivation and involvement.

In addition, locus of control is one of the important variables. Empirical research findings have implied the following differences between people with internal versus external locus of control:

Internals are more likely to work for achievements, to tolerate delays in rewards and to plan for long-term goals, whereas externals are more likely to lower their goals. These differences relate to differences in achievement motivation (as noted above, Rotter [26]) believed that internals tend to be higher in achievement motivation than externals).

Externals are less willing to take risks, to work on self-improvement and to better themselves through remedial work than internals. Internals derive greater benefits from social supports. Internals make better mental health recovery in the long-term adjustment to physical disability. Internals are more likely to prefer games based on skill, while externals prefer games based on chance or luck.

In summary, relevant literature has showed the following learner’s variables: gender, age, race, academic ability, size organization, earlier experience with game, emotional factor (attention, concentration, motivation), degree of familiarly with the computer, and self-confidence.
Accordingly, learner’s variables we studied in the Zoombinis game-based learning (described below) are in three domains: Cognitive, Affective, and Self. They are as followings:

- **Cognitive: Logical Thinking**
  In order to determine the effects of pre-knowledge and academic ability of players on the game achievement, logical thinking of players is adopted as a learner’s dependent variable. Logical thinking is a target variable of Zoombinis.

- **Affective: Attitude toward gaming and self efficacy toward computers**
  Positive attitude toward gaming and self efficacy toward computers, as affective variables, are expected to affect achievements in gaming.

- **Self: Gender and Locus of Control**
  Gender difference is one of the frequently used variables in computer-related learning environments. This variable is adopted to determine its role in game-based learning in the classroom setting. The authors wanted to know whether a learner’s variables affecting game achievement would differ according to gender.
  Locus of control also is an interesting variable to study in game-based learning, because it is one of the remarkable factors in gaming which most games provide to players.

3. Research Methods

3.1. Participants

Seventy two grade five (i.e. twelve years old) school students, consisting of 39 males and 33 females, participated in this study. They are from two classes selected from Myeongryun elementary school in South Korea. They did not have previous experiences with the Zoombini game before.

3.2. Tools

3.2.1. Zoombinis

‘Zoombinis: Mountain Rescue’ was used for game-based learning in this study. This game is an adventure game and suitable for elementary school children.

It was selected for this study based on the three criteria: It is one of the best-known educational games which provides good learning environment, the achievement level is well reflected as a result of gaming, and lastly, playing with Zoombini helps to develop a players’ thinking abilities.

As gaming proceeds, the kids advance all kinds of theories about how the puzzles worked, and why some Zoombinis went through and others didn’t with different strategies of play.

There is a lot of guessing and testing when playing Zoombini – and surely this is a strategy that games make possible. But even guessing and testing ideally eventually gives way to more systematic hypothesis-based testing.

3.2.2. Tests

Tests for this study are followings:

A. **Logical thinking**
   TOlt (Test of Logical Thinking) by Tobin & Capie [27] was used in this study. It consists of ten items in four domains: controlling variables, proportional reasoning, combinatorial reasoning, probabilistic reasoning, and correlational reasoning. Reliability of this test is .80 (Cronbach’s $\alpha$).

B. **Self-Efficacy toward computers**
   Self-efficacy was tested using CTS (Computer Technologies Survey) type B by Ertmer et al. [28]. This test has been used for perceived self efficacy toward email, word processor, internet, etc [29]. Reliability of this test is .92 (Cronbach’s $\alpha$).

C. **Locus of Control**
   Locus of control test is transformed for Korean students from two tests: A Locus of Control Scale for Children by Nowicki & Strickland [30] and The Student Perception of Control by Wellborn, Conell & Skinner [31]. This test consists of 20 items: ten internal control items and another ten external control items. Reliability of this test is .79 (Cronbach’s $\alpha$).

D. **Attitude test toward gaming**
   Five questions were composed on the usefulness of gaming for computer literacy.

3.3. Procedure

Before playing Zoombinis, the participants took four tests mentioned above. They were informed how to play Zoombinis on the first day of play. They played
it for a total of nine hours during a three week period, one hour three times a week.

Every participant had one ID and password and continued the game sequentially. They restarted the game where they stopped on next day of play.

Achievement scores of gaming were calculated as the number of rescued Zoombinis by the player.

3.4. Statistical Analysis

Mean and standard deviation were calculated for the basic description of each variable, including a gender variable toward to gaming achievement. In addition, Independent-Sample t-test was applied to test gender differences in each variable and gaming achievement. Correlations among variables for all participants of each gender were calculated using Pearson’s correlations coefficient (r). Predicting variables on gaming achievement were analyzed using Regression Analysis in SPSS. The step wise procedure was adopted for relative contributions to the gaming achievement for all participants and for each gender.

4. Results and Discussion

4.1. Overall analysis

Among variables, Locus of control shows the highest correlation. The second highest correlated variable is Self Efficacy and third is logical thinking. Positive attitude toward computers did not show significant correlation to gaming achievement (Table 1).

| Table 1. Correlations between Learner's Variables and Gaming Achievement |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|
|                             | CTS             | Locus of Control| Logical Thinking| Positive attitude|
| -------------------------------------------------------------|
| Gaming achievement                                          | .637**          | .765**          | .379**          | .231            |
| CTS                                                          | .597**          | .296*           | .061            |                 |
| Locus of Control                                             |                 | .253*           | .118            |                 |
| Logical Thinking                                             |                 |                 | -.121           |                 |

* p<.05, **p<.01 (Two-tailed test)

Based on the regression model of gaming achievement, the final model has F value as 36.981 with significance level at .01.

Table 2 presents step wise-analysis of the same Regression Coefficient.

<table>
<thead>
<tr>
<th>Table 2. Stepwise Regression for Gaming Achievement</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locus of Control</td>
<td>.586</td>
<td>.580</td>
<td>.765**</td>
</tr>
<tr>
<td>CTS</td>
<td>.636</td>
<td>.625</td>
<td>.598** .280**</td>
</tr>
<tr>
<td>Locus of Control CTS</td>
<td>.659</td>
<td>.644</td>
<td>.579** .244** .161*</td>
</tr>
<tr>
<td>Logical Thinking</td>
<td>.688</td>
<td>.670</td>
<td>.554** .240** .189* .174*</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01

According to Table 2, the highest predictive variable is Locus of Control, explaining 58% of gaming achievement while Self Efficacy is 4.5% and Logical thinking is 1.8%, Attitude toward gaming is 2.6%.

4.2. Analysis on Gender Difference

Male participants played the game more favorably than female participants and thought more positively than female participants toward game use in learning as in Table 3.

<table>
<thead>
<tr>
<th>Table 3. t-test result according to gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Gaming achievement</td>
</tr>
<tr>
<td>CTS</td>
</tr>
<tr>
<td>Locus of Control</td>
</tr>
<tr>
<td>F</td>
</tr>
</tbody>
</table>
For female participants, Locus of control indicated the highest correlation with gaming achievement, next highest was Self-Efficacy, and the third was Logical thinking. Attitude toward gaming does not show any correlation with gaming achievement (Table 4).

<table>
<thead>
<tr>
<th>Logical Thinking</th>
<th>M  39</th>
<th>6.41</th>
<th>3.39</th>
<th>-1.026</th>
<th>.309</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Attitude</td>
<td>F  33</td>
<td>7.21</td>
<td>3.21</td>
<td>4.871</td>
<td>.000</td>
</tr>
</tbody>
</table>

Similarly, for male participants Locus of Control is the variable showing highest correlation, and the second factor is Self-Efficacy toward computers. However, the third variable is Attitude Toward Gaming and is different from female participants. Logical thinking is the last one correlated to gaming achievement (Table 6).

For female participants, Locus of control indicated the highest correlation with gaming achievement, next highest was Self-Efficacy, and the third was Logical thinking. Attitude toward gaming does not show any correlation with gaming achievement (Table 4).

<table>
<thead>
<tr>
<th>CTS</th>
<th>Locus of Control</th>
<th>Logical Thinking</th>
<th>Positive Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaming achievement</td>
<td>.605**</td>
<td>.759**</td>
<td>.432*</td>
</tr>
<tr>
<td>CTS</td>
<td>.604**</td>
<td>.230</td>
<td>.072</td>
</tr>
<tr>
<td>Locus of Control</td>
<td></td>
<td>.243</td>
<td>.079</td>
</tr>
<tr>
<td>Logical Thinking</td>
<td></td>
<td></td>
<td>-.194</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01 (Two-tailed test)

Based on the regression model on gaming achievement, the final model has F value as 28.299 with significance level at .01. Table 5 presents the step wise-analysis of the same Regression Coefficient. For female participants Locus of Control explains 56.2% of gaming achievement while Logical thinking explains 5.5%.

<table>
<thead>
<tr>
<th>Table 5 Stepwise Regression for Gaming Achievement (female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Locus of Control</td>
</tr>
<tr>
<td>Logical Thinking</td>
</tr>
</tbody>
</table>

Based on the regression model on gaming achievement, the final model has F value with 26.785 at the .01 significant levels. Table 6 presents the step wise-analysis of the same Variable Table 6 Correlations between Learner Variables and Gaming Achievement (female)

<table>
<thead>
<tr>
<th>CTS</th>
<th>Locus of Control</th>
<th>Logical Thinking</th>
<th>Positive Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaming achievement</td>
<td>.665**</td>
<td>.765**</td>
<td>.335*</td>
</tr>
<tr>
<td>CTS</td>
<td>.597**</td>
<td>.332*</td>
<td>.257</td>
</tr>
<tr>
<td>Locus of Control</td>
<td></td>
<td>.246</td>
<td>.311</td>
</tr>
<tr>
<td>Logical Thinking</td>
<td></td>
<td></td>
<td>.056</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01 (Two-tailed test)

Based on the regression model on gaming achievement, the final model has F value as 28.299 with significance level at .01. Table 5 presents the step wise-analysis of the same Regression Coefficient. For male participants Locus of Control is explaining about 57.5% of gaming achievement while Self-Efficacy explaining 5.9% and Attitude toward gaming explaining 4.9%.

<table>
<thead>
<tr>
<th>Table 7 Stepwise Regression for Gaming Achievement (male)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Locus of Control</td>
</tr>
<tr>
<td>CTS</td>
</tr>
<tr>
<td>Locus of Control</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01
5. Conclusion and Suggestions

Gaming achievement in Zoombinis is affected more by learner’s variable of locus of control, self-efficacy toward computer and logical thinking of players than attitudes toward gaming.

This result indicates that cognitive and self variables rather than affective variable are affecting achievement in Zoombinis playing, perhaps because it is a learning game requiring players’ logical thinking. This implies that gaming achievement can be strongly affected by other variables even though attitude toward gaming is highly positive.

Locus of Control, one of the most influential variables, together with intellectual abilities is supported as an influential predictor in learning [32][33][34]. Phares [35] asserted that internal control and academic achievement are correlated positively. Davis and Phares [36] reported that internal control plays more positive role in information pursuit toward outside environment. Also, people who have internal control over themselves are more goal-oriented and show initiative [37][38][39]. Participants in our study with internal control tendency showed higher gaming achievement. This result coincides with previous studies’ results. Namely, players with internal control tendency are higher academic achievers and are curious about pursuing information on the game which they are playing. Thus they are higher achievers in gaming too.

The second influential variable on gaming achievement is self-efficacy toward computers. This indicates that players who are familiar with computer and are good at computing can get a higher gaming achievement. This may result from a relationship with the first variable, locus of control.

The third influential variable is logical thinking. This is mostly likely because Zoombinis requires logical thinking of players.

There are gender differences in variables affecting gaming achievement. For male players, locus of control, self-efficacy, and attitude toward gaming affect game achievement while locus of control and logical thinking affect female’s gaming achievement.

The results of this study implies that game-based learning in the classroom settings can be beneficial to players who are internally controlled and high in logical thinking when these variables are not counted in the learning.

There was no gender difference in gaming achievement. However, the predictive variables on gaming achievement are different according to gender. This suggests that game-based learning should be planned, differentiating players who need detailed guides and instructions from players who don’t need them. Also levels of locus of control should be taken into account when the educational experience is designed and game-based learning is implemented.

Game-based learning is a new instructional trend effective for the gamer generation. However, its effectiveness cannot be guaranteed without planned strategies involving learner’s variables. Further studies on the effects of game-based learning in classroom settings are needed, taking variables such as learning style, age, and motivational level of player.

6. References


From traditional to digital: factors to integrate traditional game-based learning into digital game-based learning environment

Sheng-Hui Hsu, Po-Han Wu, Tien-Chi Huang, Yu-Lin Jeng, Yueh-Min Huang
Department of Engineering Science, National Cheng Kung University
obs945@easylearn.org, cincowu@easylearn.org, kylin@easylearn.org, jeng@easylearn.org, huang@mail.ncku.edu.tw

Abstract

Traditional game-based learning is widely used as pedagogy to motivate students more and attract them in learning process. Digital game-based learning is a new trend in instruction. With high-tech equipments we are able to bring novel experience to learners. Both of game-based learning strategies are with their own advantages. However, the previous difficulty of game-based learning is to integrate these two kinds of learning strategies and strike a balance between them. Therefore, this study aims to utilize activity theory as an analytics tool to analyze the factors of each game-based learning status. After the analysis, we discussed the contradiction of each activity system. Furthermore we had also some suggestions for the instructors and learning activity designers to make game-based learning more useful and meaningful.

1. Introduction

Game has a long history and even scholars cannot investigate the origin of game and when it exists. Psychologists think that the infants start to play game in their childhood and the first game they played is to play with their hands [1]. Most of infants have the habit to suck their hand. It is nature for creatures to observe and use organs. The hand-sucking game not only makes infants to use their tactile and visual ability but also fulfill their physiological and psychological needs. When they grow up, they will find more ways to play their hands, such as: grabbing objects, using hands to make things to other appearance, and so on. Besides the function of game, it is also a method for children to know things.

Many researchers find that games are not only exiting in the human society but also games exist in the life of mammals. Thus Karl Groos the Germany biologist modified Spencer’s conserving mental theory [2], Schiller’s surplus energy [3], and proposed an evolutionary instrumentalist theory of play [4]. He proposed that playing game is not an activity without a purpose but a preparation for the real life in advance. Give examples such as playing house is a game for girls to familiar to the housework, piggyback fight is a game for boys to gain physical power to against enemies for someday, and the kitten grabbing the woolen ball in order to practice hunting mice.

Besides games such as leapfrog and piggyback fight that played with human body, the other games are played with some equipment. These equipment or tools we called them as toy. In addition to above games, there are some classic paper-based game like hang man, crossword, and Sudoku. These games are all popular and famous. The reason why they are successful games is that the game can attract people and lead people to ecstasy state. Maybe players will suffer failure or frustration in the progress, but we can believe that players will finally feel happy in the game process.

By looking back in the game history we can discover that games are naturally created. The usage of these games is approximately to develop skills or just for fun. As time goes by, people know the importance of education and also realize that games can not merely for fun but also can ease the tension atmosphere. And this is the original idea why people combine learning and play together. This is the origin of game-based learning.

2. Traditional game-based learning

The aim of traditional teaching method is to gain the teaching efficiency, enhance the learning performance, and easily managing the whole class. There is few pedagogy whose purpose is just to promote student’s motivation to make students active to learn. For the reason to make students learn knowledge in a joyful atmosphere researchers design the activities with learning material inside and transform the activity into a way of learning with fun. Originally the main issues
we put emphasis on are the learning process and the outcomes. Entertainment and amusements are merely the value-added from game. But in this time we use the additional value to promote student’s learning motivation and increase their engagement. Prensky had gave an example that it is not a difficult thing for children can remember every characteristic of hundreds of Pokemon but a huge challenge to recall the capital, population, and the relation between nations of 180 countries [5].

What kind of factors can make an activity transformed into a way of learning with game? Competition, concentration, and immediate feedback do [6]. We are able to recognize if people are success or failure according to their score in the competition. Individual activity can also become a competition. The competition is to compete with self according to the score of last time. Concentration is to use game make learners involve themselves more in the activity. Lepper and Cordova called this phenomenon as intrinsic motivation. Intrinsic motivation comes from four sources: challenge, mystery, control, and fantasy [7]. The last factor is immediate feedback and the meaning of it is that participant will receive information or hint in the process. Participants will not wait for the end of the activity to get feedback but the feedback mechanism will immediately inform participants.

There is no clear definition of game-based learning (GBL). But we can find something in common among these activities. These activities all have a learning goal, with factors of game, and learners learning things during the activity process. If an activity with these features we can call it a learning process of game-based learning. Maybe people will challenge that Sudoku is not an example of GBL. In fact, Sudoku is a puzzle game. People use their concept of logic to solve the puzzle. Obviously we just see the additional value of Sudoku that kill time in leisure time. But medical reports had indicated that games can slow down aging of brain and Alzheimer's disease. So that if the learner is older people not young people, the main value of Sudoku will be promoted into a higher level and for sure that playing Sudoku is a kind of GBL activity.

Recent years games are widely adopt in the learning activity, such as using poker to teach arithmetic and tangram to teach geometry. We can foresee that children happily learning in the game and no more frustration in the learning process someday in the future.

3. Digital game-based learning

As time goes by, the digital era is coming. It does not mean that analogy is dying out, but means that it is convenient for people to record information in digital way and this is also a trend of technology. Learning is the same as real life, more and more digital products or equipments are used in the instruction. Students learn from books and teachers in past years. Nowadays, they look up information on the internet or learn in the simulation environments. Multimedia and virtual reality help people to simulate a closely real environment and the environment do help teachers to deliver their knowledge to students. Digital learning makes many impossible things which in the traditional learning possible.

In 1946, the first general-purpose electronic computer ENIAC was invented. In 1952, Alexander S. Douglas developed the first computer in the world [8]. In 1983, Nintendo released an 8-bit video game console ‘Family Computer’ (Famicom), and the video game became popular in everywhere. In 1985, Donkey Kong Jr. Math, an edutainment game software was released on Famicom. The short history of digital game tells us that the game used not only for fun but other purpose had been twenty years. Till 2002, Serious Game Initiative proposed that game should not only be used for fun but in a serious purpose [9]. Moreover Roger Smith proposed game impact theory and emphasized that games have the power to affect the society, thus these games should follow the social norm [10]. Thus game is not a game but a power tool to affect the society.

Digital game-based learning was composed by three elements: digital, game, and learning. We are able to treat it as the combination of digital game and digital learning. A complete digital game should with three key elements: storytelling (narrative), core mechanics, and interactivity [11]. This means that if we want to create our own digital game-based learning environment we should take these key elements into consideration. It goes without saying that the core mechanics of digital game-based learning is instruction. Storytelling (narrative) is the factor to attract people in the game process. It usually builds a world or tells a story and makes you believe that you are the character in it. Interactivity affects the length of time that people devote themselves in the game. A well interactivity will also attract people and make them sustain in the game. Once the environment matches these three key elements the learning performance will better than traditional instruction or learning plans.

There are many successful cases of digital GBL. Breakaway Game designed ’24 Blue’ for United Navy to train recruit and make them familiar to the deck [12]. Defense Advanced Research Projects Agency constructed a low price training system ‘DARWARS
Arbush! Convoy Simulator’ in the DARWARS project [13]. And the training system is in a game process to train people. ‘Global Conflict: Palestine’ is a 3D RPG game, you are a reporter in the game. You have to write some articles for your newspaper office and learn history during the game process.

The technology is mature than before therefore new technology will be adopted in the digital game-based learning situation. Harvard and Duke University execute their classes in the internet simulation world of ‘Second life’ [14]. Students play a role in the cyber space and the simulated world. The interaction between people and the simulated places are exactly similar to the real school life. The palm size game console can also be a learning tool nowadays. Both Nintendo and Sony PlayStation released several brain storming games and language learning games on their portable game console. With the mobility, multimedia functions, and computing power people learned knowledge anytime and anywhere. Learners got a whole new experience than before. For example that there are six elementary schools in Chile studied mathematie and took exam via Gameboy [15]; two senior high school in Kyoto treated Nintendo Dual Screen (NDS) and PlayStation Portable (PSP) as formal learning tools to support classroom instruction.

4. Analysis

The method we use in this research is using AT as an analytics tool. The analysis will be described in following sections.

4.1. Activity theory

Activity Theory (AT) was firstly proposed by Russia psychologists Vygotsky, Leon'tev, and Luria during 1896 to 1934 [16, 17]. (Vygotsky, 1978; Engeström, 1999). Main concept of AT is a kind of concept map in order to explain the interaction between the subject and the environment. Engeström (1987) makes the original activity theory to a more complete model and the new model is what we called activity system today.

4.2. Activity system of traditional game-based learning

In traditional game-based learning, students learned in the learning environment and teacher played the role of mentor. The objective of traditional GBL is taking advantage of game to promote students’ motivation to learn, catch their attention, and make them learn better. Using game in the learning process in the first step of
traditional GBL and the second step is to make the learning process efficient, organized, and go smoothly, therefore learning strategy and pedagogy are needed to fulfill to object. The narrative is a key element to make a game like a game, thus we should put emphasis on the construction of the learning environment and context. A good game-based learning environment will not only game success and fun but also student stay in the game flow [18]. Teacher instruct lessons with some equipments and these may be used in the GBL situations as instructional tools. Tools used in the GBL situation is called teaching aid and the toys can also be kinds of instruction supporting tools.

Game is rule-based thus we can extend the meaning that GBL is a rule-based activity [19]. The rules of GBL include the original rules of the game and the norm of the learning process. The game flow and teaching plan are another kind of rules, students cannot learn without these two rules in GBL situation. These two rules are also laws of GBL hence students have to follow the law and cannot against them.

Game-based learning is not a thing for students and teacher but involve lots of people in it and each role has their missions. Everyone in the learning environment have to be responsible to learning process. Teacher designs teaching plans and makes them a GBL activity. Teacher also teaches students and facilitates the learning activity. Teacher plays the role of instructor to teach, the role of helper to help students when they encounter problems, roles of activity designer to design the activity, and a character of the game to facilitate the game. Parents of students should support the teacher during the learning or after the GBL activity. In other words that the parents are the supporters of students and also helping the teacher to watch over the students to know if the students really understanding the knowledge that been taught in the GBL activity.

There are many students in the same GBL activity. The student is not only challenging himself/herself to get a better grades and performance but also to be compared and competed with other students. Students can be teaming up into many teams to participate the activity. It goes without saying that members in the same team will help to each others to emulate other teams. According to zone of proximal theory that students will be affected by peers, team members or opponents and reach a higher level [20]. This is the reason why students played different roles in the activity. Students play the role of team members and peers in the game with each other. At the same time they also play the role of competitor to compete other teams in the activity. After the GBL activity students can take an assessment and know the scores of their team. No matter the score is good or not, the scores of GBL activity and assessment is the outcome of the activity. The score means that how hard working you are in the activity and the level you know about the content of the activity.

4.3. Activity system of digital game-based learning

In digital game-based learning, apart from students and teachers participate in the activity there are many of people behind the scenes. Activity designer, programmer, activity supporter are all parts of the staff of the activity. Sometimes teacher may play two more roles such as activity designer and activity supporter due to the shortage of manpower. The difference between traditional and digital GBL is that the digital GBL uses lots of technologies in the learning process. Due to the using of technology thus we can save time, manpower, and resources in the learning. Besides internet makes learning with the limit of space and time.

The purpose of traditional and digital GBL is to attract student to learn, promote their learning motivation, and make students learn efficiently after all. Pedagogy and learning strategies are the essential tools in the digital GBL, and the technologies here are also tools to enhance digital GBL. With the use of intelligent toys, computers, internet, mobile devices, and other technology, learning will happen in a half-real world (real life with simulation or cyberspace) [21, 22]. The hybrid learning environment also generates some new pedagogy to fit the new learning environment. In the half-real or simulated learning environment, the storytelling will be more considered as an important element. The environment has to provide enough narrative to make learners believing the simulated world is the same as real world and make learners into the flow.

The rules of digital GBL are still consisting of the norm of learning process and the rules of the game. Digital game is the product of computer languages and contents of the code are all conditional expression and regulations therefore the digital game detects what the players do then the game reacts according the rules. However we cannot feel the existence of learning plan in digital game. This does not mean that digital GBL is just for fun without any learning factors in it. As what we say at the beginning, digital GBL is an activity that needs lots of effort before the activity. We cannot exactly beware the learning content in the game but the learning materials have been added in the game already. The activity designer and teacher have to think how to merge the learning materials into the game in advance. This is also an advantage of digital GBL:
learners learning things unconsciously, they do not learn on purpose but in fact they do learn something after the game. This is the evidence that they are in the game flow.

There are many people and staffs involve in the constructing of digital GBL. Teacher has to discuss to learning activity designer and programmer many times for the reason to make a game with education meaning and fun. After a game has been created, teacher has to choose their role in the digital GBL environment to moderate digital GBL in progress. Therefore teacher can become the roles as motivator, debriefer, facilitator, integrator, and so on [19, 23]. A special character has to be told about in digital GBL is non-player character (NPC). Computers and technology are not just creating the cyberspace but also virtual characters. NPC can be classified as tools or a staff of digital GBL. With the pedagogy, NPC becomes a competitor to make learners competing with, a tutor to teach learners in the digital game, and also a tutee to be taught by learners (learning by teaching). The last one staff of digital GBL is database. Database plays the role of recording learners’ profile, status, scores, and everything can be recorded. The summation of these records is the learners’ portfolio. The portfolio will help researchers to analyze the learning style of the learner in order to realize the goal of lifelong learning.

Internet makes learning free from the limitation of time and space. It also makes connections between people. The most impact thing from internet to digital GBL is social community. Standalone game or classic arcade game console can only support one person to play. The internet makes standalone game transform into multi-player game and even massive multiplayer online game (MMOG). The more people interact with each other the more possibility the digital GBL is. People can look up for suggestions or ask for help to make their learning in progress [24]. They can also imitate the exemplar in internet to achieve the learning goal in digital GBL environment. Apart from teacher or tutor teach you knowledge, the relationships between social community provide learners an another medium to learn.

4.4. Factors in the transition

First-order contradiction happens in ‘subject’ and ‘division of labor’ of digital GBL activity system. The contradiction of subject is the cognitive dissonance between staffs. There are students, teachers, activity designer, programmer, and activity supporters participate in the digital GBL activity. But their concepts of digital GBL are totally different to each other. Programmers think all they should do are coding game software according to the request form from teachers. In activity designers’ consideration of the digital GBL activity is the same as the traditional one. Teachers and activity supporters believe that the new technology will help them teach students and make instruction easier. Students look forward to play the game and hope they do not need to study anything. There is no common belief among them. The way to solve this problem is to discuss with each other before constructing the activity. Every staff should construct the activity on the basis of object of activity system.

The division of labor contradiction is about the roles of teacher. Sometimes there is no enough person be able to help teacher to run the activity even the preparation before the activity. Therefore teachers have to design the activity, moderate the activity, teach students, and many other things of the activity. The teachers bear too heavy loading in one activity. Apart from this the unclear roles of teacher will also make students confused in the GBL activity. Solutions of the contradiction are to make more staffs join in the activity or teachers prepare the activity in advance. Sufficient manpower or time is the essential factor to a well operated activity.

Second-order contradictions happen in both traditional and digital GBL activity system. The rules-object conflict and the subject-object-division of labor conflict are the locality of contradictions in the activity systems. The three edges of the triangle are all presenting the same question: save time and manpower but students should also have good performance in learning. There is no best solution to overcome the contradiction. We can add more people in the activity and divide the labors well to save time or use more time to overcome the manpower shortage. The relationship is a like simple machines in the physics domain, either you can save time or save power, you cannot save both of them.

The inner contradiction between rule and object is similar to the other second-order contradiction. Making a learning plan is a time consuming work. But the function of learning plan is to make teachers instruct efficiently and more organized. Therefore we have to strike a balance between learning performance and the consumption of activity preparing time. There is no exact solution of the problem but the thing we can do is making a learning plan and discussing with staffs of the activity in advance. Thus we can save more time in the class and use the saving time to teach students the learning material with game in detail. Students can also have more time to think about the learning material.

Fourth-order contradiction proportion existed between the traditional GBL and digital GBL activity systems. It happens in the rule of the activity system. In traditional GBL environment, teachers draw up the learning plan, prepare the activity, and then execute the
learning plan. In digital GBL environment, there is no learning plan but directly play the game. Therefore, the question is that if the learning plan still be need or not? This is the conflict in the transition of traditional to digital GBL. Actually the learning plan can be treated as the blueprint to integrate traditional GBL activity into digital one. The activity designer and teacher make the learning plan together. After that the programmer started to code the software following the demand of learning plan. The revised workflow of making digital GBL activity will overcome the contradiction.

![Figure 3. Contradictions of the tradition and digital GBL activity systems](image)

5. Conclusions

This paper adapts AT as an analysis tool to describe traditional GBL and digital GBL environment. The analysis reveals the inner conflicts in each activity system and the suggestions to overcome the contradictions also been given after the description of contradiction. However, activity system can change into different of representations while the points of view are changed. Therefore there are still many hidden contradictions in both traditional and digital GBL because the activity system in this research is just constructed according to the view which integrating from traditional to digital GBL. But we are for sure that traditional and digital GBL both are important to education so that we cannot give up any one of them. For the reasons that we want to take advantages from these two learning strategies and the way to make this realize is to integrate traditional GBL into digital GBL. At last, we will achieve the final goal: to make students learn more and better with fun.

6. Acknowledgement

This work was supported in part by the National Science Council (NSC), Taiwan, R.O.C., under Grant NSC 97-2511-S-006-001-MY3.

7. References


Games as Skins for Online Tests

Srinivasan Ramani,
International Institute of Information Technology and HP Labs India, Bangalore
Ramani@iiitb.ac.in

Venkatagiri Sirigiri,
Nila Lohita Panigrahi, Shikha Sabharwal
HP Labs India

Abstract

Games offer a simple form of a reward – the pleasure of playing, without serious consequences for failure. Tests have been converted into simple games to gain this benefit. The focus of this paper is on creating a rich “skin” in which tests can be clothed with no major effort. A number of issues are addressed in the context of designing such a system, including collaboration, content creation and content grading. As multi-player games promote collaboration, we designed a game inspired by the cricket metaphor. We have implemented this as a skin which can clothe any given multiple-choice test.

1 Introduction

Making quizzes into games giving token rewards to encourage learning is a known technique. The idea is to “de-risk” playing, making it enjoyable irrespective of a final “win” or “loss” in terms of scores.

Our focus is on creating a rich “skin”, which is easy to use for clothing objective tests into a multi-player game for promoting collaboration. We also describe a mechanism that motivates students to contribute new questions and hints to a question bank, and grades these contributions.

2 The Use of “Skins”

Most teachers would not like to spend a lot of time creating educational games, but many of them would be willing to use software that takes tests in a standard form and enables students to play games based on the tests.

Design and development of rich “skins” incorporating several techniques is valuable because good skins are likely to be reused with a large set of tests on a large number of campuses. Integration of instruction and testing, and use of an impressive visual environment heightening the pleasure of playing cannot be ignored in games; but these are not always possible, nor necessary. However, a skin designer needs to consider, prior to his design effort, all possible features that could be used in his design, to maximize its impact.

3 Desirable Features of Skins

3.1 Team Structure

Designing on-line educational game skins for supporting a large number of players at a time has significant advantages. It maximizes the returns when these skins are used on one or more large networks, particularly the Internet. It increases the probability that someone would be playing at a time a learner wishes to join in.

It is also desirable to support different tests to run concurrently on the same server, utilizing a common skin. This will avoid regimentation and allow the learners a choice of games.

A game such as cricket has about half the players sitting in the pavilion at any time! Only two players from the batting side are significantly active. Most of the fielders have little to do most of the time! It is best to avoid this and keep as many players as possible in a highly active state.

Sometimes a student may need to use an educational game alone. One way to do this without altering the structure of the skin is to make virtual players available whenever needed.

3.2 Competition

A team structure in a competitive game encourages collaboration and peer learning because team members wish to maximize the team’s performance.

Competition is a major factor introducing affect into what would otherwise be purely cognitive activity, and is a central feature of games. Hence, it is important to promote some degree of competition between individuals or between teams.
An interesting form of competition is the tournament in which teams play against each other pair wise, which is possible in a number of games. A set of such “matches” establishes a useful partial ordering that can be used as a tool to compare the relative merits of teams.

3.3 Feedback

Players get very quick feedback in most games. When they make a mistake or win a few points, they know this immediately. Such immediate “knowledge of results” is essential to make the game enjoyable. Offering real-time feedback through quick evaluation of student responses is easy for objective type questions. In other cases, when the question is not of objective type, teaching assistants could evaluate a student’s response in a game-like situation in real time.

The system could reveal the correct answer to the student if he asks for it after he learns that he has given a wrong answer. The system could also add a short explanation as to how the preferred answer is the right answer.

3.4 Collaboration and Content Creation

Collaborative learning is a widely researched topic [1], with many facets. Test performance of every team member is a matter of concern for the whole team. Skins can exploit this fact to motivate learners to offer their teammates help for preparing for the “game”, consultation and tutorial help as needed. Skins can also encourage learners to contribute content useful to a game skin, improving or extending the question bank, thereby having consumers act as producers.

In our implementation, the system extends content creation by players to useful hints. When a ‘canned’ hint is available, the system displays the ‘canned’ hint after the learner submits the answer, serving a dual purpose. This hint helps the learner who gave a wrong answer by giving additional information, or a simple explanation of why the answer he gave is wrong. The hint enables him to make a second attempt at the question, for earning reduced marks for that question, provided adequate time is available in that time slot.

Display of the canned hint or its absence informs every player of what is available. The player who has given the right answer can choose to help his teammates by giving a hint to make up for the absence of a canned hint. These answers are stored for immediate display after their response, to players who give a wrong answer. Such hints to teammates can be graded on the basis of their success in making teammates score in their second attempts.

Hints given by students and stored in this manner can be transferred, after editing, to an FAQ. The hint FAQ is external to the question database, and merely consists of hints linked to question IDs. This FAQ can be a source of the “canned hints” referred to earlier.

4 Guiz C1: A Skin inspired by Cricket

We have designed a skin, named Guiz C1, which uses concepts familiar to cricket players, but deviates significantly from the rules of cricket. It implements most of the techniques discussed above.

Why cricket? One reason is that bowling and batting are complementary activities that can be mapped on to asking questions and answering them. Other reasons are its multi-player structure, and its international popularity.

![Figure 1. A Schematic for Guiz C1](image)

Guiz C1 is a multi-player competitive game and serves as a test bed for trying out a number of techniques discussed earlier. The game utilizes a bank of questions stored in Moodle.

Our implementation has built-in mechanisms to compute the Facility Index (FI) and the Discrimination Coefficient (DC) [2] of any new question. These mechanisms are used to give appropriate scores to bowlers and batsmen.

4.1 Competition
Currently a competitive situation is created for each player by giving “runs” to the batsman and a bowling score to the bowler. Averages are maintained and displayed for batting as well as bowling. However, there is no notion of the bowler “taking a wicket”, thereby sending the batsman out of the game. Virtual players draw upon questions from the question bank when they bowl. The scores of a virtual player during batting are determined by pseudo-random number generators with specified mean and standard deviations. Specified bowling scores for virtual players makes them ask difficult or easy questions depending on the specified FI expectation.

4.2 Team Structure

Teams of two to four members and individual players are permitted. However, a large number of teams are permitted, thereby supporting a large number of players.

4.3 Learners as Contributors

Having learners create questions [3, 4] for asking their peers supports the learning process and critical thinking. They also give the learner the incentive of being the proud creator of something of value to the others and, of course, opportunity to show off a little!

At any given moment of play, one player is the designated bowler. He would have been identified well in advance of the game by the administrator, giving the bowler time to create his own questions and store them in the database. He submits a list of question numbers to be used in bowling during his turn, and the system does everything else automatically.

All players, other than the members of the bowling team are batsmen, batting simultaneously! There are no fielders.

Early feedback is given to “bowlers” who have designed new questions through real-time “item analysis”. Assume that a current score $S_i$ is available for every player throughout a game. This could also be a cumulative score, such as batting average, from previous games. FI and DC are calculated for any new question using this information and player performance. We use these metrics to give feedback to the designer of the question, immediately after the use of his question.

Giving an incentive to learners in the form of increases in bowling scores motivates them to be creators of high quality content in the form of contributions to the question bank.

5 Conclusion

We have discussed enriching game-skins for making objective tests more interesting to learners. We have argued that a variety of features have to be built into such skins to increase their utility in an educational environment. This includes a mechanism to encourage students to contribute to a question bank. We have described a specific implementation and use of a cricket-like game-skin. We hope to release this skin in the open source form and to offer demos over the Internet.

Under what circumstances are relatively homogeneous teams better? Where do non-homogeneous teams perform better? Should learners be allowed to form teams freely, or should we assign learners to teams systematically/or at random? These issues require further research.

6 Acknowledgements

We thank Kremena Diatchka who was a member of our team when this work was in its planning stages. We acknowledge with thanks the full support given to this project by HP Labs India and the International Institute of Information Technology, Bangalore. This research is funded by HP Labs India.

7 References


[2] Documentation on Quiz reports
http://docs.moodle.org/en/Quiz_reports


GEOWORLDS: Utilizing Second Life to Develop Advanced Geosciences Knowledge

Donna Russell, Ph.D.
University of Missouri-Kansas City
Assistant Professor
School of Education
Curriculum and Instructional Leadership Department
309 School of Education
501 Oak Street
Kansas City, MO 64101
816-235-2232; fax 816-235-5270
russeldl@umkc.edu

Molly Davies, Ph.D.
University of Missouri-Kansas City
Assistant Professor
Department of Geosciences,
420 Flarsheim Hall
501 Oak Street
Kansas City, MO 64101
816-235-1335, fax: 816-235-5535
daviesc@umkc.edu

Iris Totten, Ph.D.
Kansas State University
Assistant Professor
Department of Geology
108 Thompson Hall
Manhattan, Kansas 66506
785-532-2251, fax: 785-532-5159
itotten@ksu.edu

Abstract

In this proposal we describe the design of an advanced geosciences program that uses Second Life Teen World to develop problem-based learning abilities and geosciences concepts in urban students. Geoworlds are complex problem-based scenarios designed into 3-D virtual environments where students can interact with the virtual environment, and each other to develop a solution to the problem space.

1. Introduction

The Geoworlds Project is an innovative integration of collaborative virtual learning environments and problem-based pedagogy to engage students in Earth science while enhancing their problem-solving skills and content knowledge. The Teacher/Facilitators in each classroom will be trained in the problem-based approach with Earth science content based in the national and state science education standards. The impact of problem-based learning in the sciences has been demonstrated to be a successful educational approach to increase knowledge level and student engagement. However, the power of collaborative virtual learning to engage students and increase their problem-solving skills and content knowledge has not been fully researched.

Geoworlds is developed from both cognitive theory and a pragmatic science curriculum centered on national and state science standards. The cognitive theory supporting Geoworlds employs problem-based learning. In Geoworlds the environment is the virtual Second Life platform. This environment has problem-based learning scenarios that emphasize two areas in Earth Science, water and geologic time. Students work their way through the scenarios by solving the earth science problems that occur within Second Life and mirror authentic situations. Cognitive processes such as adaptation, collaboration, and communication are heavily emphasized in the Geoworlds 3-D scenarios and these processes are then applied in the study of real world environmental issues such as global warming in the students’ local community.

2. Goals

The goals of the Geoworlds projects are to 1) engage high school students from minority and under represented populations in Earth science through pedagogical and technological innovations, while simultaneously increasing teacher/facilitator effectiveness in the Earth sciences; and 2) investigate
integrated collaborative virtual learning environments and problem-based learning approaches potential to increase Earth science understanding, advanced problem solving skills and student attitudes towards learning about Earth science. [1]

These goals will be accomplished through the innovative integration of Collaborative Virtual Learning Environments (CVLE), problem-based learning (PBL) pedagogy, and Earth science concepts. The design group includes Dr. Caroline Davies, Department of Geosciences, University of Missouri-Kansas City (UMKC), Dr. Donna Russell, School of Education, UMKC, and Dr. Iris Totten, Department of Geology, Kansas State University. They will design the Earth science CVLE and act as change agents (CA) during the implementation phase of the project. Additionally, these change agents will design and implement a research program that will assess student learning levels, teacher integration of problem-based learning approaches and the use of collaborative virtual learning environments in the Earth sciences.

3. Problem-based learning

Problem-Based Learning (PBL) is an instructional method that addresses the complex knowledge and skill applications that students will face in the future by participating as problem solvers. Students tackle complex, ill-structured problems that resemble if not mirror real world problems. PBL proposes that learning experiences built on the interdependent attributes of meaningful learning including authentic, intentional, active, constructive, and cooperative learning involve meaningful application of knowledge and skills [2]. One of the tenets of PBL is that it is difficult to give meaning to knowledge once removed from its context. PBL immerses students in a context similar to the one in which the problem would normally occur outside the classroom. The students additionally can consider themselves active members of their community of students within the context of the problem, but respond with less risk and intensity than those in actual practice, a phenomena Lave and Wenger called legitimate peripheral participation. [3]

4. Collaborative virtual learning environments

In studies of collaborative virtual learning environments research have shown that learners can develop higher levels of awareness and knowledge as a result of their dialog and interactions in online environments. [4] Integrating a 3-D multi-user learning environment into a science program develops advanced learning processes in students. One aspect of this process is engagement, specifically the engagement of under-represented minorities and females. [5] Growing evidence supports the heavy usage of computer games among boys and girls. [6] Another aspect of these environments is collaboration as students can interact with others in these virtual worlds. These processes are critical for the development of advanced learning processes. [7]

The scenarios and virtual simulations in Geoworlds provide the students with the opportunity to do problem-based learning. Using a curriculum template provided to teachers, the students will interact in Second Life with other students on a global scale who are addressing similar geosciences issues, interact with experts in related fields and gather information for their problem-solving activities. As a result of these collaborative constructivist activities students will develop advanced problem-solving abilities that are needed aspects of functioning in a knowledge-based society. [8] [9]

5. Geoworlds 3-D scenarios

Figure 1: Flyover of Geoworlds main area

Figure 2: Auditorium in Geoworld
The Geoworlds problem-based virtual scenarios will address national and state science standards for Earth Science. These virtual learning experiences will also address the additional standards of Science and Technology and Science in Personal and Environmental perspectives. The design team has designed a Geoworlds classroom curriculum guide to aid the teachers in implementing and assessing their students’ responses.

5.1 Terra world

Terra World is one of the Geoworlds. It is designed to develop an understanding of the origin and evolution of the dynamic earth system. The learning metaconcepts include the geologic time scale and how it relates to the history of the earth, fossils and their documentation of the transitions of life. Using the fossil record and its journey through geologic time as the platform for one of the Geoworlds’s Problem-based scenarios provides a natural connection between what teachers must teach and test in high school earth science classrooms and what many students have already been introduced to through their informal science experiences.

The virtual learning environment of Second Life provides a stimulating place to bring together a vast array of images, video and perspectives on how life transitions through out geologic time. Different periods of time have been virtually recreated and students will navigate through the geologic periods to solve problems that involve real environmental changes that are understood via the fossil record occur at different points in the time scale. As students recognize the clues in each of the environments they will have to resolve the problem in that period before they can enter a portal that brings them to another geologic time. Students will work in teams called Jigsaws in the environment to identify the core concepts for each scenario. [10] Geoworlds will teach students about the index organisms, the ecosystems, the adaptive features to climatic changes, the mass extinctions, and the transitional paths that connect one living organism to another. These concepts and connections can be made real via the three-dimensional platform of Second Life in a way that textbooks and video cannot achieve.

Each scenario includes 15-20 life forms including both plant and animals that were representative of each time zone. Photos and illustrations of the life forms were found and given to the developers to create these for each time period. The developers, a Kansas City company called Iversity, have replicated the representations of the organisms and terraformed each time zone in Terraworld. Additionally there are varied resource kiosks throughout each scenario that will be used by students to complete their activities.

Additonaly there will be pedagogical agents, or AI bots, in Geoworlds. These agents will be designed to be guides for the students and help the student move through the worlds. The developer firm, Iversity, will create these avatars to be self-sustained characters in the virtual worlds that are monitored by a SQL database.

5.2 Terraworld’s curriculum

There are four meta-concepts that serve as the connecting threads between all of the Geoworlds scenarios. The learning goals, objectives, and activities focus on the following meta-concepts; scale, life forms, interconnectedness and change. These concepts are reinforced throughout the world and also provide the link to the problem-based learning, which brings in modern issues such as global climate change and the impact of humans on this change. Each geologic time scenario addresses these concepts and teachers can use them holistically or individually depending upon the classroom curriculum.
There are four main learning goals (climate, life forms, evolutionary change, and paleogeography) and six specific learning objectives that are all tied to the meta-concepts. An example of an objective is: 1) Organisms are interdependent with one another and with their environment and ecosystem. The associated meta-concepts are life forms; interconnectedness.

The main activities in each scenario area are a scavenger hunt and a quest. Rubrics, assessments and accompanying kiosks with supporting information were created throughout the scenarios. Assessments include pre-post surveys, pre-knowledge questions, overall thinker questions, and short quizzes. Summative assessment activities include a Time Sequencing Activity and a student generated creation of a future world that includes representations of the metaconcepts. The student activities are described below.

1. Scavenger Hunt (SH)- introductory activity in each scenario. Each student receives a card that they use to explore the scenario environment. As the student responds to the activity they are encouraged to explore further and discover new aspects of the environment. Aspects of the environment are linked to the four main learning goals of TerraWorld. Student responses are recorded in their field notebook and uploaded to the 2D website for evaluation. This activity assesses learning objectives specific to each scenario.

2. The Quest activities are meant to be a more structured response to the scenario environment. Students will engage in more in-depth responses that require gathering information from the environment itself. They are group activities in which each student chooses an aspect of the environment to investigate such as climate, life forms, evolutionary change, or paleogeography. Students will complete the Concept Mapping exercise and create an interactive map of the scenario linking the information acquired. Students can create and present their ideas in the virtual auditorium.

3. In the Lab Area students will use information gathered from all four scenarios to place moveable objects in a time sequencing activity.

4. The Future World activity also takes place at the end of Terraworld. Students working in groups will design a future world that includes their responses to each of the four learning goals and the metaconcepts.

6. Research goals

The Geoworlds project research goal is to investigate the question: What is the impact of integrative 3-D Geoworlds virtual learning environments on higher order thinking skills of urban high school students? The Geoworlds study will employ a multi-layered assessment approach in order to measure the impacts of the Geoworlds’s collaborative virtual learning environment on the learning and motivational attitudes of the urban student. The following specific attributes will be measured and evaluated.

1. What concept of science and content knowledge is learned using the Geoworlds collaborative virtual learning environments in an advanced geosciences curriculum?

2. How do interactions in virtual geosciences problem-based learning curriculum impact the development of higher-order thinking skills in urban high school students?

3. How does interacting in a collaborative virtual learning environment affect the attitudes and beliefs of urban student about learning in PBL science programs?

A pre/post assessment, based on the Geoscience Content Inventory (GCI), addresses question 1. [11] An analytical qualitative method addresses question 2. The researchers will use NUDIST, a research software program, to categorize and define student responses according to a quantitatively scaled rubric. The rubrics will be scaled from 0-7 using Bereiter’s Scheme of Knowledge. [12] Bereiter’s Scheme of Knowledge provides researchers with a scaled delineation of learning responses that can be used to create scaled rubrics of higher-level thinking skills. A 24-question pre/post survey examines students’ attitudes and beliefs about science and constructivist learning principals in response to question 3.

Geoworlds includes a 2D Internet component, http://geoworlds.org, that includes a login protected learning management system (LMS). This LMS will be used by the teachers to track and assess student interactions and responses in the virtual environments. The LMS will also be used by the researchers to gather data about the environment, the student interactions and the student responses for evaluation of the type and quality of those responses.

As a result of the design team’s efforts to correlate advanced learning processes with the affordances of a collaborative virtual learning environment the Geoworlds environment has the potential to support the implementation of an advanced high school geosciences units as a transformative process in urban classrooms. Additionally the Geoworlds project will develop new understandings about the nature of learning in virtual settings.
7. References


Acknowledgements

The authors would like to thank the Kaufman Foundation in Kansas City, Missouri, USA for funding Geoworld.
Intergenerational Learning through World of Warcraft

Sri H. Kurniawan
Department of Computer Engineering, Baskin School of Engineering, SOE-3, University of California Santa Cruz, 1156 High Street, Santa Cruz CA 95064, USA
srikur@soe.ucsc.edu

Abstract

Although World of Warcraft, one of the most popular multiplayer games, is not traditionally perceived as a learning medium, there is evidence that players teach and learn from each other. This paper reports a series of controlled sessions where strangers of different generations were paired and instructed to learn from each other. Ten pairs participated in 5 one-hour sessions spread over two weeks. The study found that the older players learned about agility and aimless fun from the younger players, and the younger players learned about courteous interactions from the older players. Very few conflicts were observed in those interactions, and when conflicts happened, they were due to difference in playing styles rather than age differences.

1. Introduction

Through recent years, online gaming has taken the online community by the storm. A new expansive community has grown in Massive Multiplayer Online Role-Playing Games (MMORPG); where players take on a role of a fictional character and interact in a virtual world. This has similar characteristics to the old multi-user dungeons such as ‘Dungeons and Dragons’ but with the use of the Internet, millions of players that are spread geographically throughout the world can connect with (and play against) each other.

One of the most popular MMORPG for the past 4 years has been Blizzard Entertainment’s World of Warcraft otherwise know as ‘WoW’. In January 2008 it has surpassed the 10 million subscribers mark. Asia is the biggest market at the moment, with more than 5.5 million players, as compared to North America's 2.5 million and 2 million subscribers in Europe [5].

The success of WoW (and MMORPG in general), apart from a very high quality graphical presentation of the world and the traditional appeal of being a monster slaying game, can be attributed to the player to player collaboration and interaction mechanisms implemented in the game. This ranges from informal short encounters with strangers to organized groups with friends and family as many games require players to collaborate and interact with each other in order to gain better items and better abilities. Some of these mechanics in WoW are in the higher level quests and dungeons where they are purposely made to be too hard for one player and therefore players are required to collaborate with and learn from each other to tackle these quests.

2. WoW and MMORPG as a learning tool

Player interaction in WoW has attracted the research community in recent years, especially as the relationships in the virtual world often translate to the real world, sometimes spanning several geographical zones [6]. WoW has also been used in many creative ways, including as a learning medium, for example as home schooling exercises, and as a shared activity medium between parents and children [3], as the following comment suggests:

“My son is now 13, he started to play WOW on the release. First I was a little against him for buying the game, as I knew everything was in English (we are Danes). Well, for the first 2 month I was sitting beside him to translate the quests and help him to write in English. Sitting there, seeing him play made me want to play too, so I asked him if I could make a char. At that time we only had 1 PC in the house, but last year we got a second PC and I got my own account. After 2 years of playing he is the best in English in his class. I sometimes have to ask him how to spell this and that.”

Ducheneaut and Moore [1] suggested that MMORPG could be used as a social teaching tool, for example an educational-oriented world, where skills like working together, leadership and communication
could be achieved, because the game requires real collaboration for the group to succeed.

Collaborations in the game could act as a “learning environment for training and education in many fields” [3]. This study reported a case of a mother who used WoW to school her children, to teach them math and how to type.

“Moreover the design of MMORPGs fosters the development of social skills by encouraging players to interact with one another. This is done primarily by doing three things: 1) creating tasks, such as quests, that require the participation of multiple players to accomplish (discouraging “solo play”), 2) creating interdependencies between the different character “classes” and combat roles and 3) building periods of downtime into the rhythm of game play.”

Despite evidence of the use of WoW as a learning tool and as an intergenerational communication medium, there is no structured study that aims at understanding at how learning occurs and the role of Wow in the learning process. This study pairs two strangers from different generations (defined as an age difference of at least 20 years old [4]), who are regular WoW players, and instructs them to learn from each other throughout five one-hour sessions spread over two weeks. The participants were aware that they played with a stranger from a different generation.

2. The study

Participants were recruited through posting threads in official WoW forums and dedicated newsgroups and through advertising within the game. The postings did not give any indication of the eligible age group. Once a player replied, they were asked to fill in a short online questionnaire (which includes a question on their age). Only those aged 18 years old or younger or 40 years old or older were contacted for further study; the rest were thanked and informed that enough number of participants had been recruited and no further participation was required. This was done to minimize the possibility of participants lying about their ages as the study involved a draw for an MP3 player.

2.1. Procedure

All of the players performed the whole study in the place of their choice. No reward other than the draw for MP3 player was provided. Arguably, this might have led to a biased sample of dedicated WoW players, but as this study required the players to be committed to participate for two weeks (otherwise we could not use their data) this was the risk that we had to take to ensure low dropout (in this study, we were fortunate that there was no dropout).

The first stage of the study was an online survey, adapted from a questionnaire that aimed at investigating social dynamics of online gaming [2]. The questionnaire consists of three parts:
1. Demographics data (age, gender, geographical location, computer and Internet experiences, etc)
2. Experience and identity in WoW (e.g., whether they tended to play solo, with real-world friends, family and/or strangers, the number of characters created and guilds joined, level of main character, etc)
3. Foreseen problem with intergenerational interaction

Once a participant finished filling in the survey, s/he would be randomly paired with a player in the other age group. Darkspear, a European-based English speaking server, was used for the study.

The pairs were instructed to perform the usual activities that any new player would perform, which includes entering WoW, creating a new character and starting the quests together. The pairs were instructed to play together for five hours spread over two weeks (one hour every 3 days at the time that they agreed as a pair, and they don’t have to be collocated). The players were also instructed specifically to teach each other of game tricks and techniques that they were familiar with, especially if they noticed that their partner was lacking in those skills. To encourage the players to teach their pairs, we informed them that the draw for the MP3 player would be weighted upon how positive their partner’s opinion is on how much s/he had learned from the interaction.

The players’ chats and conversations were logged (using an in-built function within the game); and screenshots of their interaction were recorded. They were asked to use another character if they would like to play and not to interact with their partners outside those hours.

To reduce variability in pair experience, the play type was limited to Player versus Environment (PvE, where player cannot attack or be attacked by another player, players either work alone or in team to slay monsters), players were instructed not to perform Player versus Player (PvP, competitive interaction within a game between two or more live participants, more closely resembling first-person shooters games) or Role-Play (RP, which uses the same ruleset as PvE, with the exception that players must act and behave in character, and must follow "naming rules" when they name their character) interaction. All players were also specified to be of human race in the Alliance faction although they were allowed to choose their own class.
PvE, as opposed to PvP, was chosen to prevent abuse from one player to the weaker partner.

At the end of week 2, online debriefing interviews were conducted, either within WoW, through a messaging service such as MSN Messenger or using VoIP such as Skype, Ventrilio or Teamspeak; essentially the medium that the players chose.

3. Demographics and partnering trends

The teenager group’s average age is 13.8 years (S.D. = 1.87) and the adult group’s average age is 47.7 years (S.D. = 9.13). Seven out of the ten players in the adult group are men, while all of the teenage players are men. Most of the participants were based in the UK (seven teenage players and five adult players) with the remaining coming from Continental Europe (the Netherlands, Italy, Ireland, Belgium and Denmark), most likely due to the server used. The average main level for the adult group (mean = 65.7, S.D. = 4.32) is higher than that of the teenage group (mean = 52.8, S.D. = 12.53). Most players (eight adult and five teenage players) maintained two characters.

3.1. Partners

As Williams et al. [6] suggested, virtual relationships often translate to real-world relationships, and as Nardi and Harris [3] found, it is common for people to play WoW with their family and friends.

Seven of our adult players played with family members but only two teenage players said the same. When asked who those family members were and how old they were, interestingly all of the partners of the adults players were children or teenagers (e.g., children, grandchildren or boyfriend of daughter). One of the two teenagers who played with his family member had a very unique comment: “My mom plays a 63 hunter on my realm, Stepdad’s a level 70 druid. So when at mom’s place Raiding is more important than dinner.” (M, 15).

This comment was unique in several ways; most notably it highlights the extent of WoW as a social game within the familial context.

The teenage players who did not play with family members viewed WoW as a way to escape from real life and family members (interestingly, only parents were mentioned when referring to family members) as suggested by the comments:

“I wouldn't want to include my parents in WoW. It would mean restriction in my gameplay!” (M, 17).

It should be noted that one teenager who did not play with his family member actually commented that he did not mind playing, although it was purely to stop the family member complaining about the time he spent playing, as the following comment suggests:

“I guess I wouldn't mind it if my parents played wow to be honest... at least they would stop nagging at me to stop” (M, 12).

Only four adult players and five teenage players played with their real-world friends. Those who played suggested the potential of WoW for providing topics of conversation in real life, as the comment “always a laugh with a friend from real life cause u can talk about it the next day at work” (M, 41) indicates.

When asked whether the participants had played or joined guilds with people from a different age group - defined as people who are at least 20 years older/younger (for the teenage/adult participants, respectively). Nine adult players said yes while only five teenage players said the same. The comments from those who did not play with players from the other generation seem to refer to being uncomfortable with those other players rather than worrying about skill difference. An adult participant explained why she would not join a teenager-focused guild.

“I do tend to find it easier to team with people nearer my own age, but perhaps that is me being narrow minded. I have quested and done dungeons with my sons and their friends, which is fun but I would not join their guild because I'm sure they don't want mums there” (F, 43).

As for the conversation, the top three topics that almost every player cited were: game-related topics, friends and family, and current affairs.

4. Learning activities

Several types of learning/teaching activities were observed in the sessions. Those are:

4.1. Random acts of fun

While it is uncommon that the pair started playing and chatting seriously (albeit littered with emoticons and short hands), after a while, the younger player usually started teaching the older players to “loosen up” and “have fun”. There were several occasions where the younger players suggested activities that did not go directly toward the goal of going up the level or collecting more points (hence termed ‘random acts of fun’). Some of the examples including suggesting to
protect a randomly chosen low level character or racing to collect bundles of wood that were littered in the forest (which, given that the game is not time critical, getting all the wood bundles faster does not directly contribute to the success of the game).

The older players in general were very positive of these ideas. As one player commented about the race: “I am Having FUN; the race reminded me about an aspect of playing that I’d let slip … just doing it for the sake of it” (M, 48).

4.2. Harmless duels

In some occasions, the younger players also suggested dueling. As the players leveled up, they would gain new skills and abilities and dueling allowed players to test these abilities out. This activity is similar to fighting a horde in a battleground where players can use all skills and ability to try and kill the opponent, except that the players (and their opponents) can only be defeated but would not die (as this is a PvE interaction). Arguably, dueling is a great way of interacting with each other and having fun whilst learning how to use the newly acquired abilities effectively and how to defeat different classes.

Again, this idea was perceived very positively by the older players, who in no occasion was observed to hesitate or object to the suggestion.

4.2. Courteous interactions

In contrast to the way the younger players usually “taught” the older players (which was more straightforward and verbal), the older players were more subtle in their teaching, i.e., through providing examples. One such incidence was related to generosity. It is a common norm for a player who got to the chest first to take whatever items they needed, and then offered the remaining items to their partners. However, in some cases, the older players often went beyond and above this generous behavior by offering their partners to choose the required items first. This generosity did not go unnoticed, as some younger players commented:

“He is kinder and more experienced than most players” (M, 15).
“He is really nice to me” (M, 17).

There was also some occasions where the older players (who happened to be the leader of the pair) placed a marker over a target to “teach” the younger players which monster to attack at any particular instance instead of attracting too many monsters at once.

5. Debriefing interview results

At the end of the two weeks, debriefing interviews were conducted to inquire about the players’ experiences interacting with intergenerational partners and what they felt they had learned from the interaction. Several trends emerged from the interview transcripts:

5.1. Preconception of Intergenerational Interaction

Several of the younger players were quite honest in indicating that at the beginning they did not feel that they could learn anything from their partners. They also felt uncomfortable with the idea of having somebody much older as their partners, as indicated by the comments:

“I thought I wouldn’t have the same kind of normal banter as between me and my friends” (M, 13);
“At the beginning I told myself I wouldn’t tell him the town I live in and family things” (M, 12).

However, in many pairs, within the first session the conversations became very personal. The following is an example of the conversation that was recorded in the interaction log 20 minutes into the first session:

Adult: How old are you??
Teenager: 12
Teenager: u??
Adult: 19 dec 1958
Teenager: lol
Adult: you seem very mature for 12
Teenager: My dad was born in 1958 too....
Adult: lol
Adult: ok sonny
Teenager: =D

5.2. What has been learnt from the interaction

When asked specifically whether they felt they had learnt something new through the interaction with an intergenerational partner, most of the players commented positively. In general, the older players referred to learning about how “fun” the game could be and to be “faster moving”. The younger players usually referred to “mannerism” from the older players. In addition, the players in general complemented their partners, albeit on different qualities, as the following comments indicate:

From the older players:
“I expect him to be faster than me, an oldie, more into the details of the game from a stuff point of view” (M, 48).
“He is faster, quicker learning, more intuitive in his approach to the game” (M, 49);

From the younger players:

“He is kinder and more experienced than most players I played with” (M, 15);

“He seemed very capable for someone as old as my parents” (M, 17).

As the comments indicate, the younger players seemed to refer to experience and kindness as the good qualities in the older players, and the older players attributed speed, learning ability and attention to detail to the younger players. This finding is interesting because nobody seemed to refer to certain techniques or the mechanics of the game as the things they learned from their partners.

5.3. Negative experiences

It should be noted that negative experiences and opinions were recorded although surprisingly, all of the negative comments (regarding one’s partner) came only from the older players such as:

“He is immature, and most of the time either flamed other people or spammed for money” (M, 42);

“He’s so rude, impatient and got no concentration span, pfff sorry but glad he’s gone” (another M, 42).

However, upon further probing in the interviews, it became apparent that the frictions happened due to the difference in playing style rather than age difference. For example, there was one instance where the players could not agree on whether the person who arrived first at the chest should just take the chest or roll for it. This incidence had also been reported in several WoW forums where the players were of similar ages.

6. Discussion and conclusions

This study aims at looking at the use of WoW as a learning tool for social skills in an intergenerational setting. This is unique in many ways. Firstly, no structured study on intergenerational interaction in WoW had been reported. Secondly, although WoW as a learning tool had been mentioned in passing in several studies, those studies recorded observations or comments in forum rather than instrumented specific sessions where the players were instructed to learn from and teach each other.

The results of this small-scale study shed light into some interesting aspects of social skill learning. The study shows that both age groups taught and learned from each other different skills, and appreciated the fact that they learned something new or things that they had forgotten.

The study also shows that in deviance to a stereotype of intergenerational interaction in WoW being undesirable (see for example [6], which reported prejudice against younger players that are perceived to be less mature, therefore spoiling the experience of the game for others), our study did not find age-related prejudices or frictions.

There are several take home messages of this study. First and foremost, for designers of current and future social games for learning, the results of the study should perhaps alleviate their concern that if they design for the younger audience, they might lose the older audience as there might be generational problem to group interaction and learning. This study had shown that age was not a factor in the success or failure of interaction and learning. Secondly, the designers of current and future social games for learning should follow the exemplar of WoW, in which the rules of the games allow for players with strengths in certain areas (in the case of our study in speed and learning abilities as well as in patience and kindness) to exploit their virtues in the virtual world and to teach each other these qualities.

Unavoidably, this study carries some limitations, being a small-scale study and only over 5 hours of interaction. However, this study can be perceived as the first step in using a social game, fittingly, as a social skill learning tool.

7. References


Investigating the Use of a Robot with Tabla Education

Prakash Persad*, Jorrel Bisnath* and Ruel Ellis**
*Mechatronics Group, University of Trinidad and Tobago
**University of the West Indies
prakash.persad@utt.edu.tt
jorrel.bisnath@utt.edu.tt
rellis@eng.uwi.tt

Abstract

This work seeks to examine the basis for using a robot as a tabla tutor. It describes the difficulty associated with playing the tabla and the current methods of teaching. The argument is then put forward for the suitability of the concept. The present state of the project and eventual goal are also described.

1. Introduction

Three major ideas on the structure of learning have pervaded pedagogical thinking in recent times; the traditional behaviourist theory, the cognitive theory and the constructivist theory [1,2]. Learning by repetition or behavioural learning, as it has come to be called, remains one of the more common forms of learning. Although both the cognitive and constructivist learning theories have invoked change in pedagogy in many classrooms throughout the world, their methods have yet to penetrate several traditional learning environments. One example of such a traditionalistic learning environment is classical Indian drumming. Few, if any, changes have been made in the 2000 years of musical history of India pertaining to instruction of this art form [3]. This work aims to describe the relevance of a new form of instruction for the tabla, one of the more popular drums of north India.

2. The tabla

The tabla (shown in figure 1) is one of the most complex drums in the world. It is often used to accompany singers or as part of an Indian musical orchestra or it may be used as a solo instrument [3]. The tabla consists of two hand drums: the dayan, a small wooden drum used to produce treble notes and the bayan, a larger drum made from metal (usually brass) for the deeper bass tones. Both drums are played simultaneously by a performer; the dayan is usually played with the right hand and used to maintain the tempo of the beat while the left hand is used on the bayan to add variation to the music [4,5]. The type of sound which can be created from the combination of both drums is quite distinctive as skilled performers can be known to make the drum, ‘speak’ with a language unique to the tabla [6].

The primary source for this complexity in tonal quality is the design of the drumhead. By combining several layers of material, craftsmen are able to create a membrane which is loaded at certain points; centrally in the case of the dayan and eccentrically in the bayan. The design of the drumhead makes it unique among percussion instruments, since it allows for the creation of harmonic overtones [7]. This forms the basis for musical pitch, meaning that the drum can be roughly tuned. It is not precise to the point of creating a note, but it allows the drum to be tuned to suit a particular singer or mood.

![Picture showing the tabla.](image)

Different sounds may also be created by striking the drumhead at different spots. Each stroke produces a unique sound. There are no fewer than 8 basic strokes which a tabla player must use while playing, and thus 8 basic notes or bols as they are referred to in Indian musical notation [8].
The structure of Indian music is different to that of western music. When a performer accompanies a singer, to the untrained ear, there seems to be very little structure to the flow of the music. This, of course, would be a totally false observation. Tabla has developed certain conventional rhythms for use in accompaniment. However, within these rhythms there is much room for variation. As in western music, there is a concept of tempo, but unlike western music, this tempo is not fixed but rather may be symmetrical or asymmetrical and also not limited to a fixed count e.g. 4/4.

This allows the drummer a lot of room to modify a piece to suit a situation. Notes may be varied within a rhythm as speed or occasion change, as long as the structure of the rhythm remains constant in terms of measure or bar. Filling notes can be added to increase the tempo of the rhythm while maintaining the same speed in the music. And finally notes may be stressed differently in order to better complement a piece being sung.

The musical complexity of the tabla is without question, and proper mastery of the playing technique requires involved control of the musculature of both hands. Both drums are played simultaneously causing the drummer (figure 2) to learn to use both hands independently. New forms of non instinctual muscle control must be developed in order to acquire proper technique and to produce a rhythm of some consistency.

![Figure 2. A trained tabla player.](image)

3. Basis for application

While there are no documented studies done to determine the typical length of time it takes to attain an expert status on the drum, it has been estimated that the average musical expert would have accumulated in the order of 10 000 hours of practice by the age of twenty [9].

There is remarkably very little documentation for playing the tabla despite its long history. To date, anyone wanting to learn to play the instrument must locate a teacher to obtain instruction. A typical tabla lesson is shown in figure 3. As shown, most of the tabla tradition is passed along from teacher to student by oral means. This is facilitated by the structure of the music.

![Figure 3. Typical lesson plan for learning a taal (tabla rhythm).](image)
tabla music to evolve over time, it creates the challenge of not having any set standard for play. There is also no convention for the positioning of the hands, the drums, or the manner of playing the notes. Very often a student is faced with the challenge of having to relearn playing the instrument should the need arise to change instructor, or it may be that the student cannot attain a certain skill level because of faults which stem from the instructor. The system also restricts most instructors to having small classes with just a few students. This tradition is part of the culture involved with learning a tabla and does present a problem if a robot is to be used as a replacement. However, in the initial stages, a robotic tabla tutor may be used in conjunction with a tutor.

As shown in figure 3 after most of the actual knowledge has been imparted, the student in the final stage must practice the taal or rhythm until perfected. This practice time may range from a single hour to a few days depending on the skill level of the student. During the practice session, the teacher must be present to listen for any errors and provide the correction necessary. The teacher also usually plays along with the student to help the student maintain a constant tempo, and help remember the rhythm. This sort of practice is most beneficial on a one to one basis, as each time the teacher has to make a correction, he must stop playing and address the issue, causing any other student who may be practicing to be disrupted. The robot could very easily be introduced at this point in the lesson to assist the teacher. The robot can be set to play the rhythm continuously so that the student will have a continuous visual and audio model to follow. The robot is suited to this task as it is able to maintain the same rhythm at a constant speed. This would also allow the teacher to tutor several students at once, since the teacher can now spend his time examining the students for imperfections and correct each individually while the other students continue to play along with the robot.

Attempts have been made to produce electronic media to attempt to replace the human teacher with very limited success, in the form of instructional DVDs [10]. Novice students have reported that it is extremely difficult to learn from such a medium as basic strokes need to be perfected in order to have proper playing technique. Indeed it has become commonplace to find through empirical studies that often multimedia teaching, is not as effective as it was designed to be [11, 12].

Two theories must be referenced if a successful learning medium has to be developed to correct these shortcomings. The first is presented by Gardener in his work on multiple intelligences [13]. He suggests that different people have different means of relating to information and that some people feel more comfortable in certain environments. While his work talks about seven intelligences, it goes on to say that these afford seven different ways to teach rather than one method for all persons. While a person may be gifted with musical intelligence and may be easily able to understand the complexity of the music of the tabla, this does not mean that someone else would not be able to attain the desired level of skill, but would rather need a different approach to the problem.

The second theory which must be discussed is that of constructivist learning, whereby individuals design their own learning from experiences and interactions [2].

Application of this theory to modern technology has spawned the concept of the learning companion as described in the work done by Chan and Baskin [14]. It is with these theories in mind, that the concept of a robotic tabla tutor is introduced. The robot would be both a tutor and a tabla companion with which the student can play. This robot would be a bio-mimicking object capable of playing the tabla alongside the student. It would be able to act both as an instructor by teaching all the strokes by showing the student exactly how to position the hand and strike the drum, and also give the student a correct idea of how the note should sound. It should be able to say the note while playing to help the student associate all three together. This model should give the student all of the versatility of a live tutor.

If the student chooses to use the robot as a playing companion, he or she could then benefit from having a ‘virtual person’ there with them who they could learn from by imitating. This model seeks to create an open environment for learning, whereby the student can choose how he or she is most comfortable and gains the most benefit.

4. Design

A beta prototype is being utilized to attain the goal of a robotic tabla tutor. The detailed design is described elsewhere [15].

As shown in figure 4, the prototype has the basic stance of a table player, with hands placed in a manner similar to human. The arms of the prototype are fixed in such a way so as to allow for specific positioning on each drum, similar to the drummer. The design caters for adjustability in the horizontal plane as well as in the vertical plane to allow fine adjustments in the prototype.
The prototype created with the tabla

On the dayan, three fingers were used, the first is positioned to strike the outer membrane and play the note, na. The next was placed to strike the black spot, producing the note, ti. A third finger was to provide the damping of the skin necessary to play na. The fingers for the bass drum need to be positioned differently on the drum as observed from the human drummer. Again three fingers were used. Two were joined and bent to strike the surface of the drum flat to produce the note, ka and the other was bent to allow the tip to strike surface and play the note, ge.

A programmable logic controller (PLC) was chosen as the controller and a simple open looped control system used for actuation. A basic program was written on to actuate the fingers in the pattern needed to combine these strokes to play a common rhythm. This was sufficient to test the concept of a robotic tabla player and determine the quality of sound it is capable of. By using the same strokes as a human and the actual instrument to generate the sound, the robot was able to show the ability to create genuine tabla sounds [15].

The current prototype was developed to mimic both the action and the sound of an expert tabla player. This is necessary if proper instruction is to be given to the student. It is intended that replicating proper actions as well as sound will allow the student to benefit from multiple approaches to learning, in essence catering to persons with both musical intelligence and bodily or kinaesthetic intelligence.

5. Testing

Three experiments were done to quantify the viability of the robotic player. Two studies were undertaken to determine the acceptability of the sound quality, which is necessary so that students can adequately gauge what type of sound they should achieve, and the third was to incorporate the robot as a teaching aid in a lesson to determine feasibility.

The first study was an informal survey to compare the sound of a human drummer with accompaniment and the robot with the same accompaniment. Samples of both were recorded and 52 people were chosen at random and each asked to choose the robot after listening to the two recordings. Of the persons surveyed; 28 reported that they could not detect any difference between the two pieces, 15 people chose the wrong piece and 9 chose the right piece.

A programmable logic controller (PLC) was chosen as the controller and a simple open looped control system used for actuation. A basic program was written on to actuate the fingers in the pattern needed to combine these strokes to play a common rhythm. This was sufficient to test the concept of a robotic tabla player and determine the quality of sound it is capable of. By using the same strokes as a human and the actual instrument to generate the sound, the robot was able to show the ability to create genuine tabla sounds [15].

The current prototype was developed to mimic both the action and the sound of an expert tabla player. This is necessary if proper instruction is to be given to the student. It is intended that replicating proper actions as well as sound will allow the student to benefit from multiple approaches to learning, in essence catering to persons with both musical intelligence and bodily or kinaesthetic intelligence.

5. Testing

Three experiments were done to quantify the viability of the robotic player. Two studies were undertaken to determine the acceptability of the sound quality, which is necessary so that students can adequately gauge what type of sound they should achieve, and the third was to incorporate the robot as a teaching aid in a lesson to determine feasibility.

The first study was an informal survey to compare the sound of a human drummer with accompaniment and the robot with the same accompaniment. Samples of both were recorded and 52 people were chosen at random and each asked to choose the robot after listening to the two recordings. Of the persons surveyed; 28 reported that they could not detect any difference between the two pieces, 15 people chose the wrong piece and 9 chose the right piece.
allowed him to concentrate on the students’ technique and provide better instruction.

6. Conclusion

The prototype robotic tabla player has the capability to reproduce the sound and movement of an experienced tabla player, laying the foundation for the development of a robotic tutor. Initial experiments have also proven promising for using the robot as a teaching aid in the immediate future. This was just an initial study and further work will now have to be done on a larger scale with students of varying degrees of skill and thus allow empirical quantification of the validity and utility of this concept.

7. References


[15] Ramkissoon, Narvin A. “DESIGN AND BUILD A ROBOT TO PLAY THE TABLA” (Bsc diss. , University of the West Indies 2006)
“It is so like disco” – dancing on the iTiles

Stine Liv Johansen, Ph.D., Post.Doc, Centre for Playware, University of Southern Denmark.
stlj@litcul.sdu.dk
Helle Skovbjerg Karoff, M.A., Ph.D. fellow, Centre for Playware, University of Southern Denmark
hska@litcul.sdu.dk

Abstract

By presenting a play situation where two girls are dancing to pop music on the digital iTiles, this paper firstly aims to outline some of the changes in play practice among children. Secondly it emphasizes that play is no longer only directly handed down from generation, but is also established in specific situations through the uses of technology, contemporary culture and media. As a conclusion, it seems that the play culture and cultural practice of children is not homogenous, but instead a dynamic practice which is shifting its character constantly through the players’ practice.

Introduction

In recent years, children’s play and play culture has changed and it is possible to understand children’s use of media and play equipment in that light. The characteristics are that younger children and youth’s social lives interact less with children of other age groups and because of that, it seems that the sharing of play inspiration, play expressions and way to organize undergo changes in these years.

At Centre for Playware (University of Southern Denmark) we have been working with different products all referred to as ‘Playware’ in order to provide answers to the changing conditions of children’s play. Playware combines modern technology and knowledge about play culture and aims to produce playful experiences for players.

The specific Playware - called the iTiles - which will be exemplified in this article contains of an arbitrary number of digital tiles in the size of 18*18 cm. In each tile, there is an in-built computer and a light diode in different sizes. The tiles can be connected and built into a large or a small play area. There has been a number of games developed for the tiles, for example ‘Color Race’, which consists of each participant choosing a random color, and when the play begins, each of the tiles will glow alternately with different colors for a short period. The aim for the participants is to hit the tiles the moment your chosen color is glowing. After a sudden period of time the system is counting, the participants’ colors showing the color that has been hit the most [9]. Another game developed for the tiles is ‘Stop dance’; the well known party game in which the players are dancing until the music stops, and then have to stand still. The first one to move must leave the game, which continues until there is only one player left.

In the following, we will present a play situation on the iTiles as an example of both the change in children’s play culture but also the new possibilities provided by both technology itself and the uses of technology by children. Based on the example, we will outline and discuss the changing conditions of children’s play as well as the ways in which children navigate and operate under these conditions. We will be emphasizing children’s active participation and reproduction of play culture. The main point in the paper is that children still play, changes or not, but that play is no longer directly handed down through generations of children, but is established in specific situations via participants’ uses of technology, contemporary culture and media.

Disco on the iTiles

“Everybody, yeah, yeah…” Backstreet Boys are singing while two girls – Julia, the girl with the cap, closest to the camera, and Sarah, the girl further from the camera - are dancing repeatedly. Julia says to Sara “It’s so like disco”, then they dance on. Julia is taking the lead; Sarah is trying to follow her moves. In this particular case, the music origins from a CD player, which is placed in the back of the room, and is as such not directly related to the game on the tiles. The tiles, on the other hand, function as a stage with music and moving lights, and as such it frames the two girls’ improvisations on the theme: disco. The game in itself – Color Race - does not refer to any specific musical genre. Yet, in combination with the lights, the shapes and placement of the tiles (looking like a dance floor in the 1970’s) as and mentioned above, the girl’s previous knowledge of a particular musical genre and the symbols related to it; the tiles, the music and the game forms the basis of a quite different form of play than originally intended.
Girl’s dancing practices refer to a long tradition of dancing and performing. Expressions have changed over times, new genres have arrived and old ones have been forgotten. Dancing to popular tunes while performing specific moves might be taking over as school girls’ preferred activity, leaving traditional clapping games out in the cold. This is an example of the dynamic character of culture, and the fact that culture only exists to the extend to which it is practiced.

The changing face of childhood

Seen from the perspective of play and play culture, the most important change is that large groups of children of all ages, which fifty years ago we would see playing in streets or villages, no longer play the same role in children’s lives. In many places in the western world, large groups of children are almost impossible to find on the street or at play grounds, outside the contexts of institutions or adult organized settings.

In addition, families tend to consist of fewer children, which mean that children grow up with fewer siblings with whom to share their everyday lives. In connection, many women today are working outside the home, which means that the number of children staying at home during the day has fallen drastically. The institutions, in which children are now spending ever more of their daytime, tend to organize children into groups according to age. It is worth noting that pedagogical theories have had an effect on the dissolution of the groups of age-differentiated children, and in schools, children are put into grades according to their age because this approach is considered most conducive to learning. Sports clubs operate with a similar age-group policy.

All together this means that children spend more time with their own age group and less time with children of different ages, and this has a big impact on the play culture. [4, 5, 6, and 12]. Also, adult-organized activities like music classes, sport lessons and so on are growing. It fits very well with parents who do not want their children spend more time with children and less time with children of their own age group [2]. As Cunningham underlines: “Telling parents thaty they are being overprotective and that the roads are becoming safer for their children is, in this context, like telling them that they can let their children play with matches again because deaths from fire have been falling” [1].

As a consequence it means that children are shifting “play domain”, so to say, from time to time, and playing outside becomes an adult arranged and controlled affair as opposed to a spontaneous one, an activity performed by a small group of good friends of a similar age, background and school [8].

There seem to be a lot of reasons why children are spending more time with children and less time accompanied with older children, but in any case it seems to constitute a radical break with historical norms. In human history older children have had a central role in younger children’s lives, and large groups of children have been significant for younger children to reproduce and produce the culture in which they are growing up [3].

What is play?

The changes in childhood – demographically and socially – have a large impact on children’s play. In order to get closer to the impact, we need to clear out our understanding of play. Emphasizing the following three dimensions primarily mean that we understand play as a cultural phenomenon [10, 12] and in reference to the specific example outlined in this paper these seem essential to the definition of play: 1. While the ability to play may be rooted in the human genes, the games we play are certainly not. You need to have insight into the shared culture of techniques and knowledge of play, called the cultural heritage of play, to participate in play with others. As Mouritsen says: “For play to be initiated, the children must already have a preparedness acquired from tradition in the form of skills; a know-how which forms an available store of expressions, genres, aesthetic and organizational techniques” [12]. Play has its values in itself and not outside itself. According to Jessen/Lund, play is “a separate life sphere, which existence cannot and shall not be legitimised with outer purposes” and “a self-sustaining phenomenon which carries its purpose in itself” [10]. This means that play is a voluntary practice – one cannot be forced to play. 3. Play is a social practice, and it is learned, primarily through imitation of other players. Through interaction with its parents the infant child is taught how to play, and from a young age, children learn from other children, as they participate in different communities of play [9, 12, 15].

In order to play, children must know and be conscious of the cultural heritage, which contains a way to organize during the play, the aesthetics and the techniques of playing, all of which are handed down from one generation to the next. Because older children are no longer present in the surroundings of younger children to the same extent as earlier, the traditional “cultural leaders”, i.e. the “masters of play”, who have spent years refining and developing their play capabilities, are more or less gone. They have taken with them much of the inspiration for play, as well as important knowledge about how to organize a game. In that sense we can say that the cultural heritage has been weakened, and this is why it is much less usual for us to find children playing the same games as we played, when we were young.
However, this does not mean that children have stopped playing altogether, or that play culture is no longer passed on from generation to generation. Rather, children are now simply seeking inspiration elsewhere, especially technology, media and medialized toys.

**Play with and within contemporary culture**

Children’s culture – including play culture – is incorporated in contemporary culture. As such, cultural products produced for and used by children, are woven into material, audiovisual and virtual media and culture, mirroring and reflecting a range of cultural expressions. When Julia and Sarah are referring to ‘disco’, they are drawing on their knowledge of the characteristics of a specific musical genre and putting this knowledge into play with the virtual and material reality of the tiles they are dancing on. And by naming the specific genre of reference – disco – they are demonstration not only knowledge but also their ability to reflect upon their own practice. By making this reflection, the situation is framed as play, as something different from ‘regular life’.

Much of children’s – and adults’ – knowledge of genre is generated through media texts [5,6]. Knowledge of the specific disco-genre might be generated through film, television or magazines. Both older (such as the movie ‘Saturday Night Fever’ or the pop band ‘Abba’) and contemporary (such as Madonna’s use of a 70’s Abba tune) media texts might contribute to this passing on of cultural knowledge. This means that it is impossible to deduce the origins of the knowledge of the two girls, which might be understood as a visual culture of mutual references and intertextuality. Swedish cultural researcher André Jansson [3] has defined visual culture as such: “In an ever more complex environment of information specific messages and their social impact have become almost impossible to distinguish. ‘Senders’ and ‘receivers’ seem anything but obvious analytical categories. People produce, consume and are surrounded by information in principle anywhere, in both private and public environments with similar confidence as when they eat, breathe and sleep. Texts melt together, are recreated and flow like clouds of steam into a never ending symbolic universum”.

Also Swedish children’s researcher Anna Sparmann [14] states that children’s media culture must be understood as a complicated circuit, in which it does not make sense to distinguish between original and copy and in which media products are incorporated in a transmedial chain of intertextuality. Through children’s relations with things and texts, this chain is prolonged, since they are woven into children’s and adults interpretive reproduction in communities of practice. These circuits or networks, by Sparmann defined as ‘transmedial intertextuality’, must be seen as dynamic processes. Sparmann writes: “transmedial has to do with the movement. This means how the picture transforms from being inwoven in one medium to appearing in another: from being part of a computer game to becoming a symbol on a sweatshirt, a pen, a back pack, TV or collectors pictures. This movement not only means the building of a network between products, but also that all media refer to and quote each other.” [14:135] (our translation). When discussing these transmedial circuits in relation to children’s play culture it is important to underline the active interpretation and reflection by the children, not to mention the interplay between children, In doing that a new approach to play and the handing over of play between children appears, emphasizing more dynamic flows of cultural practice than the traditional handing down through generations.

**Imitation of play culture**

When playing on the iTiles, Sarah imitates Julia. She is busy keeping an eye with the series of dance movements and her face focuses on the body of the big girl, Julia. The movements of Sarah are a bit behind compared with Julia and the movements are stiffer. She does not know the dancing movements totally, and it is necessary for her to be guided by the bigger girl, Julia. Not even when Julia says “this is so like disco” and looks at the lights in the tiles, Sarah moves her eye from the movements and expressions of Julia. Sarah achieves her knowledge about how to dance by imitating Julia. On one hand it means that her participation in the dance is important in order to get access to the community of dancers, which Julia represents, on the other hand the imitation of practice also becomes crucial to the future dancing.

The question about imitation as access to and participation in the community of dancing and playing can be understood in the light of Jean Lave & Etienne Wenger, who developed the concept legitimate peripheral participation, which “concerns the process by which newcomers become part of a community of practice” [9]. It lays in the concept of legitimate peripheral participation that it is all about how beginners become competent dancers, but also how they reproduce the community of dancers. The idea is that the players move from a peripheral position in the community and the peripheral position in a way is the access to the community. Sarah plays a peripheral role in the community of dancers since she imitates Julia and does not have a personal way of expressing herself in the dance - yet. The stiffness of her movements indicates that she has a way to go. She does not come up with new ideas for the expressions of the movements, just as the decision of stopping the dance is not hers to make.

Julia on the contrary does the dancing practice, but she does a bit more. Notice her slimmer movements, her singing along with the music and her reference to disco music. This also indicates that imitation on one hand is access to dancing practice but on the other hand, it also
consists of the possibility of developing the practice itself. Therefore, it is possible to say that imitation is both the access to the participation and the possibility of developing the dancing practice.

The participation as peripheral can give rise to full participation when she has practiced her dancing skills through participation, and if some other children are going to be introduced to the community of practice, she will be able to act as an introducer to them. Imitation is a reproduction of the dancing community and the community only consists to the extent that it is being reproduced. The tiles support the imitation through its construction. Firstly, it supports the imitation, through the light, because they hold on to the memory of what to do in the series of dance movements. If we imagine the older girl, Julia, walking away from the dance situation and the younger girl Sarah trying to repeat the dancing practice, she just has been doing, the lights will help her remember what to do. The same goes for the music. Both the music and the lights become a kind of materialized memory for Sarah in order to remember what to do. It means that the construction supports players on their way from being beginners to becoming masters of play.

Conclusion

Children’s play culture has undergone major changes during the last 40 or 50 years. Through processes of industrialization and especially because of women’s increased work rate in the Western World, children’s everyday lives have become more fragmented. Children of different age groups spend less time together and hence the handing down of play culture through generations of children has changed. Nowadays children might inspire and imitate each other, but inspirations and knowledge of play and play genres might as well come from media, toys and technology.

Children of the new millennium are drawing on their knowledge of the characteristics of a specific genre – like dancing - and they are putting this knowledge into play with the virtual and material reality they live in. In the particular case described in this paper, the iTiles provide specific materialities and even a specific gameplay, still the girls dancing use these at their own purposes. Instead of sticking to the rules outlined by the game, they use the game and the tiles as a starting point for their own play and performance, whereby the inspiration/imitation process between the two girls is enabled.

The dynamics of their play exist in the interplay between different movements; their knowledge of contemporary culture/musical genre and ‘the stage’/the materiality of the tiles. This means that play culture becomes more heterogenous, since the repertoire and play genres is wider and more changing than it ever was. Still, new relations and communities of practice are occurring,

not based on geographical communities, but more likely on communities of specific practices and interests, and divided by parameters such as age. Furthermore, the girls’ performance can be seen as an updated, present version of folkloristic genres like dancing and hand-clapping. As such, children’s play of today must be understood in the light of a more and more complex and dynamic context of both culture, media and technology.

References

Technical reports. Centre for Playware, University of Southern Denmark


Language Learning in the Palm of Your Hand

Mercedes Rico, J. Enrique Agudo, Héctor Sánchez, Alejandro Curado
University of Extremadura (Spain)
mricogar@unex.es, jeagudo@unex.es, sasahunexesacurado@unex.es

Abstract

Since their availability, audiovisual, multimedia, broadcast and technological devices have been used to promote language learning—to capture language samples, to provide access to authentic speech and material, to enhance worldwide communication, and the like. Likewise, as technologies continue to evolve, the tendency to shrink in size and become more portable is increasingly becoming a more than usual feature. Such portable media—referred to in popular and scholarly literature as mobile, wireless or handheld—include, among others, PDAs, cellular phones, MP3 players, digital dictionaries, etc. [10]. Mobile learning or m-learning could be considered a subdivision of the e-learning initiatives promoted by formative programs and technological development worldwide. Focused on how students perceive mobile technology as an additional language learning practice, and what aspects of their learning were aided by the use of mobile devices, this paper outlines an analysis in progress aimed to explore some of the benefits and challenges for language learning through mobile technology.

1. Framing the Proposal

Mobile technologies are here to stay, from cellular phones, MP3, PDAs or videogame players to wireless communication devices and a great deal of other mobile tools which provide access to data and information how and when the user needs it. The growth in the use of mobile technologies for data transfer, communication, learning and entertainment relies on the need to extend information systems to an increasingly mobile working and learning environment.

Thus, institutions like Duke University, providing free iPods to its entire class [1], firms reporting assessment of traders using GameBoys [5], the potential of cellular phones and SMS messaging for L2 vocabulary learning [4] and mobile-device-supported peer-assisted learning systems for collaborative early EFL reading, among others, are initiatives which have been recently conducted in the emerging area of mobile learning.

Unlike many of those projects focused on assessing the role of technology in particular courses, activities or skills, our proposal aims to examine the possibilities of creating a mobile language environment by the exploration of specific mobile devices in a field in which relatively little research has been conducted. In this case, the research outlines a future in-depth study focused on analyzing how the Nintendo DS and one of its latest products, the so called Practice English, can be used for language acquisition (Figure 1).

Figure 1. Nintendo DS with Practise English

Nintendo DS combines the motivating functions of gaming with the capabilities of an educational learning tool accessible to a great deal of students, researchers and institutions. Among its appealing features we might highlight the Nintendo DS touch-screen, used to test writing skills, dictation exercises given to students to be transcribed into English, and phrases provided to identify mistakes in spelling and grammar. Nintendo DS also works on voice-recognition functions, requesting the users read specific phrases aloud, performance which is then ranked and recorded onto a progress chart which allows users to keep track of their development and see their improvement over time. As for the activities and assessment, the software includes...
competition games, English word tests, dictation, sound identification and the like.

2. Applying the Research

The challenging part of this research is trying to design a study to determine how mobile technology can help our Engineering students improve their English and create a learning environment where the technology would be motivating enough to enhance student performance.

As for the methodology, an inductive approach is devised, in which data and findings will be interpreted in light of the students’ responses.

2.1. Objectives

From the general objective of assessing how students perceived mobile technology for language learning and what aspects of their learning were aided by the use of Nintendo DS, we pose two research questions focused on:

1. Identifying efficient variables to measure student satisfaction with mobile technology for language learning and how Nintendo DS is perceived as fitting in.
2. Gaining insight into the overall role of Nintendo in language acquisition in order to carry out further research in this field.

To conduct the study, we acquired three Nintendo consoles to work with 4 engineering students enrolled in the course English in Computing. Assuming that we could extend the methodology and preliminary conclusions far beyond this pilot study, the research was conducted from April-May, 2008, with a total of three weeks exposure for half an hour daily. The participants worked on an individual basis following the instructions given to them.

2.2. Assessing Objectives

2.2.1. Motivation /Attitude. A primary objective is to keep on discovering the impact technology (Nintendo DS) might have in foreign language learning (student attitudes toward Nintendo DS). Table 1 shows the questions included in the first questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Score Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) I have had previous experience with Nintendo DS for Language Learning</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
</tbody>
</table>

2.2.2. Effectiveness. As stated and in order to carry out further research in this field, the second objective of this pilot study is aimed at exploring the overall role and effectiveness of Nintendo in language acquisition. In table 2 we are shown the questions addressed to gain insights into the benefits derived from mobile technology for language.

<table>
<thead>
<tr>
<th>Question</th>
<th>Score Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) Does the challenge of working with Nintendo DS appeal to you?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(3) My personal attitude towards learning English through technology has increased with Nintendo DS</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(4) How Confusing do you find Nintendo DS?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(5) Do you think it is fun to use Nintendo DS for language learning?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(6) Are the teaching goals of using Nintendo DS clear?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(7) Did using Nintendo during the class increase your motivation?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(8) Has its portability contributed to your English learning by taking advantage of your time during this experience?</td>
<td>A lot  Quite  Not sure  Somewhat  Nothing</td>
</tr>
<tr>
<td>(9) Other (state further advantages /disadvantages)</td>
<td></td>
</tr>
</tbody>
</table>

In general terms, research indicates that gaming and portability of mobile technology can positively impact student motivation, engagement and interest in language learning.

In our case in point, the students surveyed thought that Nintendo DS made learning more fun, kept them engaged with non-stop actions and allowed them to learn beyond the traditional classroom, increasing flexibility and offering new opportunities for interaction.

The need for a more precise identification of goals and the appropriateness of software and tasks are two of the most important aspects to work on in order to achieve an effective integration.
Table 2. Questionnaire 2: Effectiveness

<table>
<thead>
<tr>
<th>Questions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How effective is Nintendo for learning grammar?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. How effective is Nintendo for learning vocabulary?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. How effective is Nintendo for learning pronunciation?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. How effective is Nintendo for learning reading?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5. How effective is Nintendo for learning listening?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6. How effective is Nintendo for learning speaking?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7. How effective is Nintendo for learning writing?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8. My communicative capacity with others has improved</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9. I feel more confident about using my English?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>10. Was the Nintendo DS an effective way to learn English in general terms?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>11. Open comments</td>
<td></td>
</tr>
</tbody>
</table>

As for effectiveness, for games to be properly used in education they must have a clearly defined purpose and a supportive learning structure (software, activities, goals and the like) built around them.

4. References


Learning about Complexity with Modular Robots

Eric Schweikardt
Computational Design Lab
Carnegie Mellon University
tza@cmu.edu

Mark D. Gross
Computational Design Lab
Carnegie Mellon University
mdgross@cmu.edu

Abstract
We present progress with roBlocks, a reconfigurable modular robotic system for education. Children snap together small, magnetic, heterogeneous modules to create larger, more complex robotic constructions. The design of the system is described and the algorithms that handle data transfer and manipulation are explained. Users tend to begin exploring the system through a series of simple robot patterns but quickly progress to more involved constructions. Many years before they learn formally about hierarchy and modularity, children can develop intuitions about these concepts by designing modular robots. Additionally, young users often spontaneously engage in creative debugging practices.

1. Introduction
Our world is a confusing and complex place. Global phenomena emerge as the result of interacting local behaviors. Classical notions of causality that have guided Western thought for centuries continue to serve, but we have come to see that complexity plays an important role in our world. Understanding complexity, and learning to think in terms of complexity, is essential to addressing the problems that face humankind in the twenty-first century: global warming, the management of mega-cities, food, energy, and water for a growing population. This is, of course, not a new idea: the "systems thinking" and cybernetics movement of the mid-twentieth century [1-3] and the scientists and mathematicians who worked on understanding the dynamics of systems such as arms races [4], populations [5], and industrial, urban, and world dynamics [6, 7] laid the groundwork.

We have designed and built a robotic construction kit, called roBlocks, which we intend as a vehicle for conveying the fundamental perspective of complexity: that the behavior of a system need not be programmed from the top down, but may result from the interactions of independent components. Our kit is designed for young learners (roughly ages 10-15) who have no particular technical or computer knowledge.

We share this goal with educational computing environments such as StarLogo and NetLogo [8, 9]. In these screen-based environments, children write programs that describe the behavior of individuals (e.g., a bird) and then explore what happens when the individual program is executed by large numbers of individuals (e.g., flocks and flocking behavior). A different approach but with similar goals is simulations such as SimCity or SimEarth. In these games a player must make decisions in a complex and time varying system. The rules of the system are concealed from the player, so the challenge is to achieve goals without knowing how the system works.

The roBlocks project is based on the idea that the acts of designing and building real objects develops creativity and scientific curiosity. Our work is inspired by Seymour Papert’s idea of constructionism; that building things is a particularly good way to learn since the artifacts are tangible – they can be easily discussed and critiqued [10].

Figure 1. A few roBlocks.
Our approach is inspired by the lovely book Vehicles, by Valentino Braitenberg [11]. Braitenberg shows how, by assembling increasingly complex
robots out of sensors, effectors, and simple neurons, from the ensemble gradually behavior emerges that seems intelligent. Along similar lines is Brooks’s approach to robotics, outlined in his early papers “Intelligence without Reason” and “Intelligence without Representation” [12, 13]. Here again the idea is that rather than resulting from a top-down decision making process, intelligent behavior emerges from communicating local components.

2. The roBlocks construction kit

roBlocks are 40mm plastic cubes that snap together with magnetic connectors [14]. Children as young as nine snap them together to create constructions that drive around on a tabletop, reacting to light and sound. Each roBlock is different. Sensor blocks, including specific blocks for sensing light, sound, touch, motion and (infrared) distance, take in data from the environment and pass it on to connected blocks. Multicolored Think blocks apply functions to those data including sum, maximum, minimum, inverse and threshold. Action blocks translate data passed to them into various types of action. A tread block contains a small motor and drives around on a tabletop according to its given value. Other blocks have rotating faces, bright LEDs and piezoelectric speakers. The fourth block category, utility blocks, includes a block containing a small lithium-ion battery that must be included in each construction, a Zigbee wireless block, and passive data-connection blocks that allow the physical form of a construction to be less constrained by its programmatic layout.

Figure 2. Inside a roBlock.

In a roBlocks construction each block possesses a single dynamic one-byte value, which determines how it operates [15]. Sensor blocks compute this value from environmental input. A light sensor block, for example, has a value of about 5 in a dark room, and a value of over 200 outside on a sunny day. A touch sensor has a resting value of zero but jumps to 255 when it detects contact. blocks, on the other, hand, actuate according to their value, which they derive from data passed to them by their neighbors. A Rotation block with a value of zero does not move, but the same block with a value of 127 would rotate at half speed. roBlocks pass their values to their connected neighbors. Sensors act as sources and action blocks as sinks, and constructions form an implicit directed graph that may have cycles. The blocks operate asynchronously, transferring data with no centralized clock. Each block’s value is determined by the number of steps from each data source in a weighted average. Two sensor blocks at either end of a chain of blocks, for example, create a gradient of block values, with blocks closer to a high sensor reading exhibiting higher values. This weighted averaging scheme allows users to create densely packed 3D lattices of blocks and accurately predict the value at any block.

Each roBlock body is made of two identical three-face halves that screw together enclosing electronics inside. We make the bodies on our 3D printer and using different colors of plastic to indicate type of block. Each face of the blocks is identical, and hermaphroditic connectors allow each block to connect to any other block at any of four possible orientations. Embedded magnets and spring probes on each connector provide both physical and electrical connectivity between blocks. On the back of each connector the magnets are attached with conductive epoxy to the circuit boards shown in Figure 2. Each roBlock has identical electronics: an Atmel AVR microcontroller, programming header, H-bridge motor controller, shift register, and power circuitry.

3. roBlocks robots

The simple robot shown in Figure 3 is built with five roBlocks: two sensor blocks (Light and Knob), a Maximum think block, an LED block and a power block.

Figure 3. A little robot that indicates a number based on the values of two connected sensor blocks.
The network and data flow diagram of this robot is shaped like a “Y”, with the two sensor inputs merged at the think block and passing data to the numeric LED block. Any two sensors could be used here – the Maximum block will cause the output to correspond to the higher of the two sensor values. As we've chosen a Knob as one of our sensors, the user can set its data value manually. With this combination we've created a sort of Threshold robot in which the light sensor value is taken into account only if it becomes greater than the value of the Knob sensor. Braitenberg [11] describes how a simple threshold device can be a key element in creating lifelike, emergent behaviors.

A simple modification illustrates the behavior typical to the think category of blocks. The robot shown in Figure 5 adds a third distance sensor block in front and pointing down, connected through an expand block (which converts a one-byte block value into a binary 0 or 1) and two minimum blocks to the drive subassemblies. Normally, the third distance sensor block would output a high value, allowing the robot to operate just like the robot shown in Figure 2. When encountering the edge of a table upon which the robot is moving, however, the expand block outputs a zero instead of 1, and the minimum blocks immediately stop both drive motors. This robot exhibits interesting and non-linear behavior. Whereas the previous robots suggested a simple action-reaction model, this new robot evokes the notion of rules. Even though we haven’t expressed an explicit if-then statement (“if the robot sees the edge then stop”), the minimum blocks create the effect of a conditional by using only a simple mathematical calculation.

4. Observations of young users

We recently completed a set of informal user test sessions. Each session began with a quick introduction to the kit and a demonstration of how the blocks operate. We demonstrated a couple of simple robot constructions with a single sensor and single action block, and showed how think blocks placed in between change the robot’s behavior. Then, we observed the groups in free play sessions, answering questions and making suggestions when necessary. Often, we would ask subjects to explain their constructions in an attempt to elicit the understanding and mental models they hold concerning the operation of the blocks.

<table>
<thead>
<tr>
<th>Session 1: Sunday, March 9, 2008</th>
<th>Location: Home of User A and B, brothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>User A</td>
<td>11 (6th grade)</td>
</tr>
<tr>
<td>User B</td>
<td>9 (4th grade)</td>
</tr>
<tr>
<td>User C</td>
<td>9 (4th grade)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2: Tuesday, April 8, 2008</th>
<th>Location: Office of User D and F’s mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>User D</td>
<td>7</td>
</tr>
<tr>
<td>User E</td>
<td>7</td>
</tr>
<tr>
<td>User F</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 3: Friday, April 18, 2008</th>
<th>Location: Lunch hour at local middle school</th>
</tr>
</thead>
<tbody>
<tr>
<td>User G</td>
<td>12 (7th grade)</td>
</tr>
<tr>
<td>User H</td>
<td>13 (7th grade)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 4: Friday, April 18, 2008</th>
<th>Location: Lunch hour at local middle school</th>
</tr>
</thead>
<tbody>
<tr>
<td>User I</td>
<td>12 (7th grade)</td>
</tr>
<tr>
<td>User J</td>
<td>13 (7th grade)</td>
</tr>
<tr>
<td>User K</td>
<td>13 (7th grade)</td>
</tr>
</tbody>
</table>
Table 1. User testing sessions.

We conducted six test sessions over two months, each with two or three children working together in each session. Fifteen children participated: 11 male and 4 female. Most participants were between 9 and 13 years old, but we tested with two 7-year-olds and one 5-year-old. Two test sessions took place at the children’s homes, with their parents available and with access to other toys. One session was conducted at the office of the subjects’ mother, and three sessions were conducted at a local middle school during lunch hour with children who had expressed interest when asked by the 7th grade science teacher, who also attended the sessions. The remarks in the following sections draw on our observations of children constructing robots.

5. Learning intuition

It is important to distinguish between familiarity with a particular concept and explicit knowledge of a certain representation of that concept. Claims of educational benefit are often made rather spuriously. One might hear that playing with LEGO bricks teaches kids about physics, or, perhaps more plausibly, that playing with Cuisenaire rods teaches kids about math. While balancing a LEGO construction might involve torque and moment arms, and thereby help students build intuitions about mechanics, students aren’t exposed to the technical language and formal mathematical representations that we use to convey these ideas.

Take, for example, the concept of weighted average, the method each roBlock uses to calculate its one-byte value. Children as young as nine have proven remarkably adept at understanding this calculation, rearranging blocks and noting that data streams are “stronger if they’re closer” when mixed. But they are clearly not learning that:

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

where the x’s stand for data values and w’s stand for their corresponding weights. Some would claim that familiarity with this equation indicates true understanding of weighted average, but this equation is only one representation of the concept. A simple roBlocks robot like that shown in Figure 6 is, in fact, another representation of a weighted average. If the action blocks $A_0$ and $A_1$ were both flashlight or bar graph blocks, a user would notice a gradient of values across the construction. The robot shown in Figure 6 produces a stair-step gradient, but if there were more blocks between the sensors, the gradient would be smooth. This pattern, basically diffusion of data values throughout a construction, is not explicitly contained in the weighted average algorithm, but instead emerges from the interactions between modules. Both the equation and the emergent pattern are valid and interesting ways to think about weighted average.

Figure 6. A simple roBlocks robot illustrating the diffusion algorithm, or weighted average.

We don’t mean to suggest that fiddling with construction toys should supplant traditional mathematics or science education. Yet we do believe that early exposure to STEM concepts in different representations can improve understanding when the concepts are encountered again later in a formal education environment. Specifically, we posit that beginning to learn to think computationally [17] at an early age prepares students well for more advanced subjects in science, technology, and mathematics. In Changing Minds [18], diSessa makes a persuasive argument that early bits of encountered knowledge (or “phenomenological primitives”) lay the groundwork for successful understanding of scientific concepts later on in life.

6. Concepts of complexity

Complex systems are distinguished from those that are complicated or chaotic. A laptop motherboard is complicated, due to its numerous parts, signal paths and different chips, but it is generally predictable and deterministic in its operation. Turbulent flow, by contrast, is chaotic. Enormous sensitivity to initial conditions makes modeling difficult and prediction almost impossible, even though turbulence is just a natural unfolding of physical laws [19]. Complex systems, the subject of this inquiry, are characterized by numerous components, tightly coupled, that simultaneously carry out their own goals or programs. Complex systems are hard to understand. They often give rise to emergent behavior, larger global patterns
that are not easily reduced to the components and interactions that produce them [20].

We discuss the idea of complexity through the notions of modularity, hierarchy, and emergent behavior.

### 6.1. Modularity

Modularity is used to describe a multitude of varying situations. We speak of modular housing that is assembled from prefabricated components, or modular programming, where well-defined interfaces separate chunks of computer code. Lipson [21] defines modularity as the “localization of function,” and this idea is the core concept of roBlocks. Each function, whether sensing, actuating, or computational, is encapsulated within its own sealed plastic cube, accessible but pre-defined. The interfaces between functions are the magnetic connectors, designed so that any two functions can communicate at any of four orientations. Young users are aware that they can remove and replace blocks at will, removing and replacing the programmatic functions at the same time.

A high level of modularity requires loose coupling between modules. In other words, components that are strongly interdependent with their neighbors are not very modular. roBlocks takes loose coupling to an extreme, with each block maintaining a single, dimensionless data value. This block-level modularity seems to resonate with young users. As the blocks were being described to the users at the beginning of Session 2, a seven-year-old commented that the bar graph and numeric block were “the same,” noticing that they both displayed a graphic readout of their value, albeit in different representations. Later, having built a construction that reacted both to ambient light levels and the presence of nearby objects, he began switching out different blocks, noting that “really, all of the white blocks are the same.” While the blocks all have different functions, the modularity and loose coupling of the system create an interface that allows them to be easily substituted for one another.

On a slightly different level, we have been pleased to notice that many users spontaneously begin building meta-modules: assemblies of several roBlocks that can be re-used. These are modules of modules, and users seem to build them naturally, in the process of creating a construction in several steps. In Session 6, for example, an eleven-year-old girl combined a sensor, think, and action block to create a simple mobile robot that would slow down as it approached an object. She used this meta-module in several other constructions, determining along the way that connecting it to other blocks by way of a blocker (a black blocker block transmits power but not data) would ensure that its operation would not be influenced by the other blocks. Eventually, she built a second, identical meta-module, and by attaching the two side-by-side with blocker and power blocks, created a robot that actively turned toward any object before slowing down.

In many systems, such as homo sapiens or even a PC running Photoshop, behavior can seem somewhat separate from physical structure. People often feel that they are something more than their physical being, that there’s an extra little piece of “soul” floating around. And the dividing line between computer hardware and software is strangely dark, with software able to run on many different machine designs. But this is an illusion: bits are bits and neurons are neurons. With roBlocks, however, behavior is directly caused by the physical structure of a construction. It’s clear that the design of the robot’s body gives rise to its behavior, just as it does in biological systems. Pfeifer and Bongard thoughtfully address this issue in their new book [22]. In a certain sense, systems like roBlocks can encourage critical thinking about traditional ideas of mind-body dualism. This mildly subversive notion isn’t a goal of the project, simply a pleasant side effect.

### 6.2. Hierarchy

Modular systems inspire a vision of several encapsulated black boxes, all communicating through specified interfaces. Often, the modules express a certain regularity—this is certainly the case with most modular robots. In real-world systems, however, things are not so simple: modules and meta-modules exist at many different levels of hierarchy. The complex system of world government, for instance, is made up of unions or alliances, which are made up of countries, which are, in turn, made up of states or districts, and eventually, people. Biological systems, with layers ranging from populations down to cells and chromosomes, are even more complex.

roBlocks, with their regular structure and modular functional breakdown, might appear to be restrictive in modeling hierarchical systems. But several children have used meta-modules in very creative ways. During Session 1, an eleven-year old boy used the max, min, and sum think blocks and a variety of sensors to create a complex, hierarchical input chain to a single bar graph (Figure 7). His nine-year-old brother immediately commented that it was “like a ladder,” referring to the common tournament scoring system. It required some discussion to determine exactly how data was flowing through the system, and creating a desired output required a certain amount of thinking. Isaac noted that there were many valid input combinations for a particular output value. Manually manipulating the sensor inputs on even this simple
hierarchy demonstrated the difficulty of determining the root cause of an observed outcome.

![Figure 7. A young user's hierarchical robot.](image)

### 6.3. Emergence

Most of what we observe in the world was never explicitly programmed. Fluctuations in an economy, for example, emerge from millions of local interactions between its component people, businesses, and governments. Almost all of the important systems in the world exhibit some sort of emergence, and this is precisely what makes them difficult to manage. Climate change, war, food shortages—these are not problems that can be solved by blunt decree. They are problems that demand careful probing of causes, patterns, and concurrency.

Cellular automata are a classic model of emergence; the gliders and glider guns in Conway’s *Game of Life* [23] proved a valuable tool for provoking thinking into how intentional-looking behaviors can emerge from several mindless low-level rules. More recently, we have seen several software systems [8, 9] that allow children to create their own rule sets, populating cellular automata worlds with various entities and behaviors, and then watching the ensuing patterns unfold on the computer screen.

While no doubt screen-based simulations can be effective for certain goals, the emergent behavior and patterns displayed in a cellular automata grid are an extreme abstraction from the complexity that we see around us, whether in nature or in societal systems. roBlocks represents an attempt to move these concepts from the computer screen into the real world.

The main challenge children face in assembling a pile of roBlocks into an intended construction involves translating from a *distal* to a *proximal* description [24]. The distal description is the global goal behavior as viewed by an outside observer, like “chase the other robot” or “stop when you see a red object”. The proximal description is the actual set of instructions, or “recipe,” that gets carried out to achieve that goal. For most robots, the recipe is the programming that coordinates its actions, but when children build with roBlocks, the relevant recipe involves the physical configuration of the individual blocks. This is a subtle difference, but one worth elaborating on.

Adding a roBlock to a construction is not the same as adding another function to a body of computer code. A roBlock does represent a particular function, but in a construction, *all* of the modules communicate with *all* the other modules, *all* the time. So in essence attaching a roBlock is more like adding an ingredient to a recipe – one must be mindful of how it will react with all of the other ingredients, combining to create emergent phenomena.

As emergent behavior is often difficult to predict it can be challenging to design a roBlocks construction that behaves according to a particular high-level goal. Novice users are often confounded as they begin to create large constructions—with small sensor variations affecting every other block, it becomes nearly impossible to understand the control structure of the entire construction.

We often prompt our test subjects to build robots that perform some distal behavior, and it is intriguing to hear them talk through their constructions. For “chase” is not as simple as adding a “chase” block – it is a higher-level behavior that must emerge from low-level, mindless interactions. Users as young as nine have been able to clearly explain how certain blocks communicate and function concurrently in order to perform a certain high level behavior, but most of their robots have been fairly simple, made of fewer than eight roBlocks.

It will be interesting to see how users make sense of larger constructions. The behavior that emerges from 6-10 block constructions can be either comprehensible or confounding, depending on the structure of the robot. Children are quick to use hierarchy and modularity to manage the complexity of their robotic constructions—we are curious to see the building patterns they use when given many more modules to design with.

### 7. Debugging

In observation we’ve seen that children are generally capable of building simple robots to meet their design goals, but that a greater number of blocks can begin to confound them. During the first 20 minutes of encountering the system, for example, many users explore the space of constructions that can be built with single *sensor* and *action* blocks: simple robots that respond to a stimulus in a linear fashion.
As they become familiar with the data model, they begin to add more blocks. Since most of the blocks don’t explicitly display their data values, system behavior becomes harder to predict. When writing software, the solution to this problem involves various debugging techniques: we’ve seen children implement a few of these techniques without prompting.

Many users begin to use certain action blocks to examine the data values in the system, stepping through their construction and tracing the data flow. The numeric and bar graph blocks both use arrays of green LEDs to display their value to a user. Snapping one of these blocks onto any other block in the construction displays the data value of that block/ In effect these blocks are probes; the equivalent to printing variable values to the screen when debugging a piece of software. This technique enables kids to step through their constructions and figure out exactly where and how data is changing, so that they can make targeted modifications to their robot.

Most of the roBlocks robots children build are autonomous; their behavior is determined through the sensing of environmental conditions. The absence of a user in control of the robot makes these robots difficult to test. A robot might have light and distance sensor blocks, for instance, and it may be difficult to manipulate both the room’s light level and the position of some other object in order to test the robot’s behavior. Some of our young users have gotten around this difficulty by temporarily substituting a knob block for a particular sensor. This allows them to easily change the sensor value (by adjusting the potentiometer on the block) and simulate conditions that the original robot may encounter. This practice is similar to the programming technique of hard-coding certain variables during debugging to test the operation of others. Indeed, controlling certain variables in an attempt to examine the behavior of others is the fundamental idea of scientific experiment.

We’ve been surprised to see many users begin by trying to build complete robots, finally attaching a power block when the rest of the blocks are in place. On reflection, however, our experience teaching students to write software has shown us that novice programmers often begin by attempting to write a complete program and then run the whole thing. With more experience, programmers learn the value of additive programming; creating functional pieces of code and adding to them makes it much easier to isolate errors. Many of our users have the same experience with roBlocks – they learn that by starting a construction with the power block, they can observe the functionality of their robot as it’s being constructed, instead of only at the end, when it may have become unwieldy to debug.

While many computer scientists recognize the great value of debugging skills for writing software, we imagine these ideas to be much more broadly applicable. The US National Science Education Standards put forth by the National Research Council [25] describe a general theme of inquiry. Chapter Three of the standards specifically recommends less emphasis on “focusing on student acquisition of information” and more emphasis on “focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes”. The standards also recommend less emphasis on “presenting scientific knowledge through lecture, text, and demonstration” and more emphasis on “guiding students in active and extended scientific inquiry”.

8. Conclusions and future work

At DIGITEL2007, we presented a brief survey of toys with multiple nodes of computation [26]. This year, we discuss the ways in which these toys can support notions of how complex systems function. We are currently working on improving the roBlocks kit and creating a programming interface that children can use to modify the behavior of individual blocks.

The informal results and anecdotes we’ve presented are preliminary, but they give us an idea as to the educational affordances of modular robotic kits like roBlocks. Most importantly, we have seen that by providing children with tools to design and build their own physical, concurrent, complex systems, we can scaffold their understanding of difficult concepts like emergence, modularity, and hierarchy. Although these are not the standard “reading, writing, and arithmetic” subjects of secondary education, issues of complexity are paramount in addressing the problems that will face our society in the generations to come.

Acknowledgements

We thank the children who participated in our study, their parents, and their science teacher, Ms. Katie Levedahl of the Sto Rox School District. Ben Wojtyna, Andrew Jones, and Drew Hendrickson contributed many hours of robot assembly help. This work was supported by National Science Foundation Grant ITR-0326054.

8. References


Learning by Substitutive Competition: Nurturing My-Pet for Game Competition Based on Open Learner Model

Zhi-Hong Chen¹, Tak-Wai Chan²

Department of Computer Science & Information Engineering, National Central University, Taiwan¹

Graduate Institute of Network Learning Technology, National Central University, Taiwan²

{hon, chan}@lst.ncu.edu.tw

Abstract

Game competition has promising potential to be a powerful pedagogical strategy. To maximize the benefits and alleviate its possible negative effects, a substitutive competition design is proposed in this paper. The substitutive competition is a kind of mirror competition, a competition of pet-styled virtual characters that represent learners' open learner models. An animal companion system, named My-Pet system, was implemented to realize such concept. A preliminary system evaluation was also conducted in an elementary school to examine the effect of the substitutive competition in the My-Pet system. The results revealed that the substitutive competition was helpful to students' increased motivation and time-on-task that further contributed to improved learning efficiency.

1. Introduction

Game-based learning could be a powerful pedagogy, since digital games have fascinating aspects which could foster people's engagement in the game world [12]. Researchers also reported that digital games could facilitate learning in good ways, when good principles of game design are used in the school learning [27, 15]. Therefore, one of objectives of information technology seems to lies in—incorporating different pedagogical strategies, including game strategy, to help students develop their optimal capabilities.

In addition, from the viewpoint of students, when learning through game-playing, the students might feel that they are just devoted themselves to overcome a series of challenging tasks. In other words, the game pedagogical strategy could enhance students’ engaging level, a crucial factor for an effective learning.

One of key game elements is competition. Competition could be an effective way to motivate students to learn. However, the design of competition should be careful not to harm the learners’ confidence [8]. Therefore, how to design a game-based learning environment that can maximize the power of competition and alleviate the possible negative influences is a significant and challenging issue.

To this end, we attempt to review different categories of commercial games to borrow design experience. Among game categories, the type of nurturing game seems to be suitable for our intention. Since these nurturing games often involve two game elements: nurturing and competition. For example, the famous Pokemon series [26] are typical nurturing games. One of major game goals pursued by players is to become the champion through nurturing monsters for competition.

This observation inspires us to propose the concept of “learning by substitutive competition.” We try to apply the Pokemon game to design an educational learning model. In other words, our intention is to design a substitutive competition of virtual characters by transferring entertainment games into educational games.

2. Substitutive competition

Before the detailed designs are introduced, the characteristics of substitutive competition are identified first. The substitutive competition has two characteristics—indirect characteristic and effort characteristic.

2.1 Not direct competition, but indirect competition

Due to the powerful impact of competition in motivation, some researchers apply competition to learning with careful consideration for preventing possible negative effects: anonymous mechanism and group mechanism.

With respect to anonymous mechanism, although previous research reported that competition might have negative effects on interpersonal relationships and group process [18, 13]. However,
Yu et al. [32] further analyzed these studies and indicated that these studies were conducted in traditional classrooms, which involve face-to-face situations. Consequently, the characteristic of anonymity is taken into account to prevent from negative effects aroused from the competitive context.

In terms of group mechanism, making learners work together is an effective pedagogy to encourage learners to learn, and to help each other [29]. Although the external competition is a useful motivator for individuals, the direct competition of individuals’ performance might damage their confidence. Therefore, the group competition mechanism is recommended [11, 8], since group competition is helpful to member interdependency and member accountability. Some cooperative or collaborative models, such as student teams achievement divisions (STAD), teams games tournaments (TGT), and Jigsaw II, are incorporated with competitive elements [29].

The substitutive competition is another indirect competition model. Each student has an animal companion, a pet-styled virtual character, to serve as competition subjects. Therefore, students need to nurture their animal companions to compete each other. Animal companions serve as “buffers” of direct competition to reduce the possible damages when students fail in the competition.

2.2 Not performance competition, but effort competition

Due to the indirect characteristic, the substitutive competition has another characteristic: positive belief in learning effort. The importance of motivation is always a significant research issue. One perspective towards this issue is whether learning willingness is more important than learning ability. According to attribution theory [30, 31], people’s behaviors are greatly influenced by their perceived causes. Two key factors that dominate people’ perceived causes are—ability and effort.

Dweck [14] further proposes the theory of intelligence, which distinguishes two categories of people: people who believe intelligence is fixed and people who believe intelligence is malleable. The fixed-intelligence people tend to attribute their failures to the inferiority of intelligence. Hence, they gradually become helpless when frequently meeting failures. By contrast, the malleable-intelligence people tend to attribute their failures to the lack of effort. Consequently, they would seek for improvement opportunities.

The substitutive completion provides students with a mechanism to represent their learning effort, and further manipulate them. We hope such learning environment could help students shape their positive belief in learning efforts. That is, the substitute competition emphasizes the effort competition (comparison of learning effort), rather than performance competition (comparison of learning performance).

2.3 Substitutive competition: mirror competition based on open learner model

With the characteristics of indirect and effort, the substitutive competition could be regarded as “mirror” competition. Each student has an animal companion to nurture. The animal companion is an application of representing students’ learning status by virtual pets. Consequently, an animal companion is like a "mirror" to reflect the student’s learning status [9].

Animal companions use open learner model strategy to support the substitutive competition. “Open” learner model means opening the content of learner model to students, instead of hiding this information [4, 21, 5, 6]. The perspective of openness brings several promising benefits, such as being a basis for planning learning goals, improving communication between system and learners, and fostering students’ self-assessment and reflection on learning [7, 33, 23, 24].

On one hand, because animal companions are portrayed as “mirrors” to reflect students’ learning status, animal companions are appropriate candidates to attend the competition for their keepers. Therefore, such mirror competition based on animal companions could be a feasible indirect competition.

On the other hand, the effort-making belief could be emphasized through the “effort” aspect in the process of nurturing animal companions. Nurturing animal companions requires a number of cares for a long period of time. When taking care of animal companions, students actually take care of their learning status. Therefore, such design would imply learners that dedicating time and great effort is the necessary condition for a successful learning.

3. My-Pet system

An animal companion system, named My-Pet, is developed to realize the concept of substitutive competition. The learning flow in My-Pet system could be further divided into two phases: pet-nurturing and pet-competition phases. In the pet-nurturing phase, the student plays the role of keeper; in the pet-competition phase, the student plays the role of cheerleader. That is, in the former
phase, students are provided with opportunity to learn through nurturing-and-training scenario. In the latter phase, the student monitors the comparison of My-Pet with limited participants. The result of competition is mainly dominated by My-Pet’s nurturing status in the nurturing phase.

3.1 Pet-nurturing phase

After registering in the system, a student has a My-Pet to nurture. The nurturing status contains several numerical values that represent the My-Pet status. As shown in Figure 1, the My-Pet inhabits in a backyard, owning the three attributes: energy, experience, and effort. The “energy” and “experience” attributes reflect the interaction between the My-Pet and the student. These two attributes could be improved through feeding and playing with the My-Pet, respectively; the “effort” attribute stands for the effort made by the student. The “effort” attribute could be improved through doing the learning tasks.

In this phase, the student plays the role of keeper in the task-oriented scenario. The subject domain is Chinese idioms. Although an idiom merely consists of four Chinese words, it has a figurative meaning that cannot be deduced from the literal definition. Students master them only through a great deal of practices. Therefore, the learning activity provides five-step practicing stages for students to master these Chinese idioms. As shown in Figure 2, the snapshot illustrates the fourth stage. The students are asked to pick up four words one by one in a correct sequence, avoiding selecting other similar words.

3.2 Pet-competition phase

In the competition phase, a game competition based on the open learner model—particularly for the My-Pet’s “effort” attribute—is held. The competition result is majorly dependent on how much the “effort” attribute of a My-Pet has, as well as a minor lucky element. As shown in Figure 3, after the student selects an opponent who is willing to have a competition, the substitutive competition starts. In each round, the My-Pet has an attack round to get scores according to the value of “effort” attribute multiplied by the value of a dice (the lucky element).

The scores got from the competition follows the given formula: (the “effort” attribute of My-Pet) multiplied by (a percentage got from the dice). In spite of the minor luck element got from the dice, the competition is under a condition that the more the “effort” attribute of My-Pet has, the more probability the learner wins the competition. The competition goes until one of My-Pets wins the game. As shown in Figure 4, a My-Pet is competing against another My-Pet.
4. System evaluation

A preliminary evaluation of the My-Pet system was conducted in an elementary school in Tao-Yuan county. The objective of this experiment focused on the pet-competition effect in terms of two aspects: learning performance and affective feedbacks. For this purpose, a comparative between-subject experiment was designed.

4.1 Participants

The participants were 56 fifth-grade students from two classes. However, due to some participants’ absence from experimental sessions, the remaining participants were 48 participants, including 23 students in the A class (11 boys and 12 girls), and 25 students in the B class (10 boys and 15 girls). Because the policy of randomized class grouping was adopted in the elementary school, we supposed that the participants in the two classes have similar background and learning performance in the language subject.

4.2 Procedure

Two classes were randomly assigned as two groups: control group (without pet-competition), and experimental group (with pet-competition). The difference between two groups lies in whether the pet-competition is involved or not. Participants in the control group (CG) learned Chinese idioms through the light version of My-Pet system (without pet-competition); participants in the experimental group (EG) learned Chinese idioms through the complete version of My-Pet system (with pet-competition). Each group has 4 thirty-minute sessions in the computer laboratory to learn Chinese idioms over the period of five weeks. Table 1 shows the different interventions and participants setting in the two groups.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG   Pet-nurturing</td>
<td>23 (11b:12g)</td>
</tr>
<tr>
<td>EG   Pet-nurturing &amp; pet-competition</td>
<td>25 (10b:15g)</td>
</tr>
</tbody>
</table>

4.3 Measurement

Three measurements were utilized in this experiment: achievement test, time-on-task, and motivational scale. In terms of achievement test, a test about Chinese idioms was conducted twice as pre- and post-test, respectively. The test contains two parts: word-identification and word-sequence (basic part), and idiom context application (advanced part). In terms of motivational scale, a motivational questionnaire developed by authors was employed, including four dimensions of items: attention, relevance, enjoyment, and challenge. In addition, the time-on-task is measured through calculating the time spent in the learning tasks.

4.4 Results

4.4.1 Achievement test

For the result of achievement test, the means and standard deviations for pre- and post-test in CG and EG are listed in Table 2. Two t tests were conducted to examine whether each group has significant improved scores. The results revealed that the score difference between pre- and post-test in each group was statistically significant (t=3.683, p<.01; t=10.084, p<.01 in the CG and EG, respectively). The result means that all participants in two groups had improved their learning performance in Chinese idioms.

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>CG</td>
<td>37.78</td>
<td>9.11</td>
<td>43.22</td>
</tr>
<tr>
<td>EG</td>
<td>36.12</td>
<td>7.98</td>
<td>46.12</td>
</tr>
</tbody>
</table>

* < .05 ** < .01

Furthermore, when the participants’ pre-test scores were treated as a covariance to conduct a one-way ANCOVA, the results showed that the post-test score between the two groups was significantly different (F(1, 46)=3.183, p<.05), as listed in Table 3. Comparing the mean of two groups, we could find that the post-test score of the EG was significantly higher than that of the CG. It means that the improved level of Chinese idioms in the EG was higher than that of the CG. In other
words, participants had a higher learning achievement when they learn idioms through the complete version of My-Pet system (with pet-competition).

Table 3. ANCOVA of achievement for CG&EG

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covar.</td>
<td>2868.5</td>
<td>1</td>
<td>2868.5</td>
<td>82.08</td>
<td>.000**</td>
</tr>
<tr>
<td>Group</td>
<td>222.4</td>
<td>2</td>
<td>111.2</td>
<td>3.18</td>
<td>.048*</td>
</tr>
<tr>
<td>Error</td>
<td>2236.5</td>
<td>64</td>
<td>34.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* < .05  **<.01

4.4.2 Time-on-task

Except that a five-minute introductory activity was conducted in the first session (i.e. participates had twenty-five minutes to use system in the first session), each session has thirty minutes to use the My-Pet system. The spending time on learning task was recorded. Table 4 illustrates the spending time of two groups during the four sessions. It was obvious that the average of spending time in EG (23.15 min) was longer than that in CG (18.55 min).

Table 4. Time spent on learning tasks

<table>
<thead>
<tr>
<th></th>
<th>Ses.1</th>
<th>Ses.2</th>
<th>Ses.3</th>
<th>Ses.4</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>12.7</td>
<td>21.6</td>
<td>20.2</td>
<td>19.7</td>
<td>18.55</td>
</tr>
<tr>
<td>EG</td>
<td>17.4</td>
<td>25.6</td>
<td>24.2</td>
<td>25.4</td>
<td>23.15</td>
</tr>
</tbody>
</table>

4.4.3 Learning efficiency

From the results listed above, it seems that the EG could motivate participants to improve their learning performance more in a shorter period of time. To have a clear understanding about the result, the learning efficiency of two groups is further calculated. The learning efficiency is defined as “improved performance” divided by “spending time.” As shown in Table 5, it is obvious that EG has higher learning efficiency (43.19%) than CG (29.32%). In other words, the presence of pet-competition seems to be helpful to participants’ learning efficiency.

Table 5. Learning efficiency for CG & EG

<table>
<thead>
<tr>
<th></th>
<th>Improved score</th>
<th>Spending time</th>
<th>Learning efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>5.44</td>
<td>18.55</td>
<td>29.32%</td>
</tr>
<tr>
<td>EG</td>
<td>10</td>
<td>23.15</td>
<td>43.19%</td>
</tr>
</tbody>
</table>

4.4.3 Motivational scale

For the result of motivational scale, Table 6 bellow displays the means in terms of four aspects: attention, relevance, enjoyment, and challenge. Four one-way ANOVA were further conducted to validate the difference in the four aspects. As shown in Table 7, the results showed that the relevance and challenge aspects between the two groups was significantly different ($F_{(1, 46)}=3.416, p<.05$; $F_{(1, 46)}=5.654, p<.01$, respectively).

Table 7. ANOVA of motivation between CG&EG

<table>
<thead>
<tr>
<th></th>
<th>CG</th>
<th>EG</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>3.54 .98</td>
<td>3.77 .92</td>
<td>.102</td>
</tr>
<tr>
<td>Relevance</td>
<td>3.87 .96</td>
<td>4.14 .82</td>
<td>.038*</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>4.00 .94</td>
<td>4.23 .76</td>
<td>.065</td>
</tr>
<tr>
<td>Challenge</td>
<td>3.88 .88</td>
<td>4.20 .84</td>
<td>.010**</td>
</tr>
</tbody>
</table>

* < .05  **<.01

According to the post-comparison, we could find that the relevance and challenge aspects in EG were higher than these of CG. This means that the participants’ perception about task relevance and game challenge toward pet-competition were higher than those who did not experience the pet-competition. In addition, the scores in the other two aspects (attention and enjoyment) had no significantly difference ($F_{(1, 46)}=2.323, p=.102$; $F_{(1, 46)}=2.849, p=.065$, respectively).

Table 6. The result of motivational questionnaire for the experimental group

<table>
<thead>
<tr>
<th>Categories and items</th>
<th>S.D.</th>
<th>D.</th>
<th>N.</th>
<th>A.</th>
<th>S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attention &amp; Engagement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This system almost attracts all of my attention</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>6</td>
<td>24%</td>
</tr>
<tr>
<td>I could concentrate my attention on this system</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>14</td>
<td>56%</td>
</tr>
<tr>
<td>I seem to be immersed in the world presented by this system</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>8</td>
<td>32%</td>
</tr>
<tr>
<td>*I can hardly pay my attention to this system</td>
<td>7</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Relevance &amp; Goal-orientation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This system offers a goal worthy of pursuit</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>52%</td>
</tr>
<tr>
<td>I accept this goal, and am progressing for this goal</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>13</td>
<td>52%</td>
</tr>
<tr>
<td>This goal is helpful to my hard study</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>40%</td>
</tr>
</tbody>
</table>
5. Discussion

5.1 Implications on competition

For the affective aspect, the scores of relevance and challenge in EG were higher than these in CG. This reveals that the pet-competition design could enhance these participants’ relevance and challenge which seem to further contribute to the participants’ engaging level. This result tends to support the assumption that enjoyable element is beneficial to engaging learning and time-on-task.

Furthermore, one of the design rationales of substitute competition is to take advantage of competition and prevent from disadvantages. When comparing with the research about competitive model proposed by Yu et al. [32], we could find that multiple competitive models are suggested, since students have various learning preferences.

Along this line of thought, it seems that we could further interpret these competitive models (including substitute competition) through a wider viewpoint—treating competition as a kind of “performance.” In our human society, a drama or sport performance usually involves a stage and a number of audiences. The stage provides performers with a place to perform their trained skills; the audiences offer performers a motive to prepare and improve their skills constantly.

Although the drama or sport performance involves the competitive element, such kind of performance develops a positive value on the effort making. To perform perfectly in the front-stage, the performers would prepare themselves in the back-stage. In other words, the competitive and pressure has been turn into a motivator in performers’ preparation. This driving force is significant since it involves the performers’ self-regulated process [28].

5.2 Application of open learner model

“Open” learner model is a significant application of learner model. With students’ learning profiles, a learning system could adapt its pedagogical strategies to interact with students. However, research of open learner model seeks for a wider viewpoint to treat these learning profiles, such as useful and open learning resources that could be accessed by the student himself, peers, and instructors [6].

Different possible benefits of open learner model have been proposed, but the research of open learner model also meets several challenges, particularly in students’ low motivation to use the open learner model systems [21, 1].

Game competition of My-Pets is based on open learner model. This substitutive competition offers another way to use open learner model. Unlike directly opening the content of learner model to students, the My-Pet system could provide learners with a reasonable cause (e.g. nurturing My-Pet) to use open learner model. Therefore, such game competition of My-Pet might overcome the low-motivation challenge in open learner model research.

5.3 Reflection on the character-enhanced learning

Character-enhanced learning is a research filed that attracts increasing interest recently [19]. Different research directions in educational virtual characters are emphasized, such as educational roles [10], social benefits [16, 17], and communication bandwidth [22, 20]. Through lifelike demonstration by eye gazing, gesture, facial expression, or body language, these educational virtual characters could raise learners’ sense of responsibility [25, 2, 3], keep learners engaged [29, 30], and promote the perception of ease and comfort [16].
In addition to “intelligent” virtual characters designed by artificial intelligence technologies, another “non-intelligent” design is also explored. For instance, the teachable agent simulates the knowledge and behaviors of a tutee, and needs a human student’ teaching [2, 3]. Such “non-intelligent” design of virtual characters is to promote students’ active and responsible learning attitude.

The animal companion system is another example of “non-intelligent” virtual character design. Comparing with the empirical evidence of teachable agent, we could obtain a consistent result about the learning achievement, despite that two studies are applied to different learning subject domains. The teachable agent system is applied to science concept learning; the animal companion system is used for language proficiency.

Further analyzing the underpinning design rationales, we could find that two systems all encourage learners to play different roles from the conventional “student.” That is, learners play the role of “teacher” in the teachable agent system; they also play the role of “keeper” in the animal companion system. The characteristics of teacher and keeper are emotional “learner-initiative” in nature, rather than system-initiative.

These results imply that the emotional learner-initiative approach might be a potential direction in the research of character-enhanced learning, since it involves more student’ active and responsible learning attitudes.

6. Limitation and future work

To take advantage of the pedagogical power of game competition, the concept of substitutive competition is proposed in this paper. Different from previous competition approaches, the substitutive competition emphases on the “indirect” and “effort” aspects based on the open learner model.

Due to this study is our preliminary step toward the issue of substitutive competition, the system evaluation was focused on effect of substitutive competition. However, a number of studies should be further conducted in the future, including a formal experiment to examine the influence of students’ learning confidence, more scaffolding designs to support students’ learning in the pet-nurturing phase.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financially supporting this research under Contract No. NSC95-2520-S-008-003. The authors would also thank the assistance of the school principle and teachers in the elementary school.

Reference


Massively Multi-user Online Games: The Emergence of Effective Collaborative Activities for Learning

Iro Voulgari, Vassilis Komis
University of Patras, Rio Patras, Greece
{avoulgari, komis}@upatras.gr

Abstract

The features and potential of MMOGs to constitute environments for collaborative problem solving activities for learning are the main focus of this paper. Principles from the area of CSCL, problem-solving, cognition and learning can be applied to the design of an educational MMOG so as for effective interactions and collaboration among the players to be fostered. We attempt to propose a framework for the investigation and design of effective collaborative problem solving tasks within MMOGs.

1. Introduction

The potential of computer games as instructional and learning tools has been discussed over the past two decades [1], [2], [3], [4], [5], [6] with the focus of research now shifting to the area of collaborative activities and learning through multi-player games [7], [8], [10], [12], [20].

Massively Multi-user Online Games (MMOGs) constitute highly social virtual environments where the users, through their virtual characters can interact with each other, with the environment and with computer generated characters in order to complete a number of tasks either individually or collaboratively and involving a complex “set of multi-modal social and communicative practices” [7]. The social aspect is strengthened by the fact that the interactions emerging are not a sub-product of the game but they are rather an integral part of successful gaming and attainment of the goal.

The core question of our research is “How can we exploit the inherent features of MMOGs and design effective collaborative problem solving activities for learning?” In this paper we mainly focus on the investigation of communication and interaction in MMOGs. The design of the environment directs the strategies a player employs and the extent and quality of the interactions emerging [19]. We attempt to propose a framework for the design and analysis of the interaction and communication affordances of an environment for the facilitation of in-game collaboration and meaningful communication. A number of studies have focused on the design of games [14], [21]. Our objective, though, is to incorporate collaborative problem solving activities theory into the games design framework, with the perspective to design effective environments for learning.

2. Collaboration and communication in the game environment

Even in the case of multi-user games, players seem to cooperate with others only when they are required to, by the nature of the tasks. Hämäläinen [12] observed that players first attempted to individually solve the problems, before resorting to the help of other players. It seems, therefore, essential that the game mechanics not only encourage but rather require that the players engage in collaborative interactions in order to solve certain problems. For this purpose, he proposed the integration of tasks with higher risk levels and penalties, so as to prevent individual attempts.

After the player has been led to seek the support of a group, it is essential that the links among the members of the group are strengthened and appropriate channels and instances for productive interactions and cooperation rather than aggressive competition are provided. For the promotion of collaborative rather than competitive interactions, Rauterberg [14] introduced the concept of a Shared Social Space (SSS) which summarises the features of a networked multi-player game that promote coalitions. The factors relevant to the promotion of coalitions are the visibility among the characters, the audibility of voice, verbal as well as non-verbal communication and the physical distance of the players. Since physical distance of the players is not always possible in multi-user games, social or virtual nearness is fostered via a number of different mechanisms such as awareness information [13] available to the users through Friend Lists that allow the players to see when their friends are online and invite them for collaborative gaming, or indications on whether other group members are online. In some games, each clan may also have a dedicated Hall, where the virtual
characters may gather, socialise and communicate in virtual proximity.

This unity and sometimes altruism among group members may even be strengthened by seemingly irrelevant, though critical factors, such as the severe death penalties. As Nick Yee reported in his article on Social Architectures in MMOs “Some players felt that the severe death penalties increased the general willingness of players to help each other, because all players understood the burden of death and, more importantly, all players knew that they too would need help one day” [37]. It is not, furthermore, uncommon that people already knowing each other in real life join an MMOG together and form their own teams, or group with players they have become friends with in the game, or even engage in general social chat with other party members. Such conditions seem to also strengthen the affinity of the group.

In the area of collaborative problem solving and learning distributed knowledge and shared goals constitute a defining factor. Knowledge and skills distributed among students seem to positively influence collaboration due to their interdependence [9]. If the players want to attain a common goal and each one of them holds a different piece of the “puzzle”, then they all have to work together for achieving it. This heterogeneity of resources available to the students seems, furthermore to be a positive factor for the quality and quantity of interactions [18]. In MMOGs the available knowledge does not reside in one individual but is distributed across the players [9], [3]. Exchange of information and advice, mentoring and peer-learning are encouraged since new players can take advantage of the experience of older players.

The roles assumed by the collaborating parties appear to constitute an important cognitive dimension for the collaborative problem solving activities and for learning [9]. Different and complimentary roles have a positive effect on collaboration. The characters supplement each other. In specific MMOG cases, for example, fighters have to cooperate with wizards if they want to survive a difficult battle with a strong enemy or a siege.

Once the foundations for cooperative activities have been laid, the next step is the support and promotion of these activities, the support and promotion of player communication and cooperation through appropriate channels and mechanisms. Collaborative interactions are generally distinguished in (a) actions and (b) discussions with Manninen [15] proposing a more detailed taxonomy of verbal and non-verbal interactions used in a Networked Virtual Environment ranging from the appearance of the avatar, the gestures and the body language to the language based communication and the manipulation of the objects and the world. The players act through their virtual selves, their avatars and discuss with other players through text or audio. The main discourse support mechanism in most MMOGs is textual communication through a chat window. In-game verbal communication does not always seem to suffice, though, and therefore the players often rely to external applications (e.g. Skype, TeamSpeak) for elaborating further on an issue. Although this seems to be a solution, it illustrates the emerging need of the players for higher level communication structures, especially when more sophisticated situations and problems rise. Structures for high level questions and explanations seem to also constitute a requirement from a cognitive point of view. An environment which provides communication structures for high level questions, explanations and collaborative problem solving processes such as aggregation, conflict creation, revision and solution, and supports the extent and ease of communication and interaction may more effectively support learning in groups [9].

With respect to the non-verbal players’ interactions, the visual quality of the online presence and of the actions of the players is also important for effective and rich interactions [15]. Manninen focuses on the non-verbal interactions as the key for coping with problems encountered through CMC and argues that features such as realism of the avatars, the gestures and expressions can enhance the gaming experience and promote interactions among players [16], [17].

Research in the area of collaborative learning indicates that there not seems to be an optimal group size but this is rather dependent on the nature of the task and the background of the members of the group [11], [35]. While discussing a modelling framework for the support of collaborative problem solving and learning Hope [9] proposed the implementation of a support function for the formation of the groups according to the given problem. Within an intelligent environment the size of the group may be defined depending on the requirements of the collaborative problem.

Players of MMOGs communicate not only through the integrated tools of the environment, but also through other channels, outside the game. They communicate via websites, newsgroups, discussion fora, chat, messaging and even over the phone or real life [3]. They exchange tips and perceptions on the game, and even develop new strategies for playing. They develop communities of practice. Participation in these virtual communities is intrinsically motivated by the environment as it is linked to the successful completion of the tasks and quests of the game.

3. Conclusions

The new generation of games is far more sophisticated in terms of player-player and player-environment interaction and there is a complex matrix of in-game and
beyond-the-game factors involved in the gaming experience both internal to the design of the system as well as external to the system and relevant to the player or the cultural context [21]. We mainly focused on elements internal to the design of the system in relation to the intended cognitive processes and learning outcomes and more specifically the collaborative problem solving activities as components of an MMOG within a learning context. Our next step will be to examine the design of the tasks as components of the collaborative problem solving interactions and situate them in an analysis and design framework aiming at the effectiveness of the gaming and learning experience.

4. References

Micro Adaptive, Non-Invasive Knowledge Assessment in Educational Games

Michael D. Kickmeier-Rust, Cord Hockemeyer, Dietrich Albert, and Thomas Augustin
Cognitive Science Section, Department of Psychology, University of Graz, Austria
{michael.kickmeier; cord.hockemeyer; dietrich.albert; thomas.augustin}@uni-graz.at

Abstract

Most existing educational games cannot compete with their non-educational counterparts in terms of visual and narrative quality, gameplay, or adaptability. Amongst the most advanced approaches is ELEKTRA, a European project that developed a framework for intelligent educational personalization, enabling games to adapt learning and gaming activities to individual learning progress and pedagogical strategies. In this context, a crucial aspect is an individualized assessment of knowledge and learning progress. The ELEKTRA methodology enables an integrated and individualized assessment by monitoring and interpreting the learner’s behavior within the game in a non-invasive way. The present paper summarizes the theoretical background from the perspective of cognitive science.

1. Introduction

Immersive digital educational games (DEGs) offer a highly promising approach to make learning a more pleasant, engaging, satisfying, inspiring, and probably more effective task. As a consequence, it is not surprising that there is an increasing interest in research on game-based learning and serious games per se. Many of the potential advantages of DEGs (e.g., interactivity, feedback, situated learning) are considered being important for successful and effective learning [1] and games serve the demands of the “digital natives” [2]. Since the 1990s research and development has increasingly addressed learning aspects of playing recreational games and also the realization of computer games for primarily educational purposes. Still, DEGs have major disadvantages, for example, difficulties in providing an appropriate balance between gaming and learning activities or between challenge and ability, in aligning the game with national curricula, or the extensive costs of developing high quality games [3]. Thus, DEGs most often cannot compete with their commercial counterparts in terms of gaming experience, immersive and interactive environments, narrative, or motivation to play. Moreover, most educational games do not rely on sound instructional models, leading to a separation of learning from gaming; often such games provide gaming actions only as reward for learning. In the cold light of the day, most existing DEGs do not differ significantly from other multimedia learning objects or applications.

2. ELEKTRA

The ELEKTRA project (www.elektra-project.org), funded by the European Commission, which ended in February 2008 and had the ambitious mission to fully utilize the advantages of computer games for primarily educational purposes and to address significant drawbacks of DEGs. ELEKTRA developed a sound methodology for designing educational games and a comprehensive game demonstrator based on a state-of-the-art 3D adventure game teaching physics according to European curricula (Figure 1). Furthermore, ELEKTRA addressed important research questions concerning game design, didactic design, or educational interventions.

In the focus of research and development was adaptively generating an appropriate balance of challenges and the learner’s abilities and learning progress. As attempted by conventional adaptive approaches to technology-enhanced education, a learner must not be frustrated by to difficult subject matter but also not bored by to simple challenges. Only if such balance can be achieved on an individual basis, immersion and flow experience can rise, enthralling and captivating the learner. The foundation of such adaptation is a sound assessment of knowledge and learning performance. In contrast to conventional
adaptive tutoring and knowledge testing, within a DEG assessment is restricted by the game’s narrative, the gameplay, and the game flow. Typical and often used quiz-like methods (e.g., test items or multiple choice questions) fail to adapt to individual learners and, most likely, they break the game’s flow and therefore immersion. The ELEKTRA approach attempts to realize micro adaptivity, that is, a continuous assessment by non-invasively interpreting the learner’s behavior in the game and a subsequent adaptation and interventions within learning situations (LeS).

3. Knowledge Assessment on a Micro Level

The foundation of micro adaptive knowledge assessment and subsequent non-invasive interventions is interpreting the learner’s (problem solution) behavior within learning and assessment situations in the game.

To realize such non-invasive assessment of knowledge, ELEKTRA grounds on the formal framework of Competence-based Knowledge Space Theory (CbKST) [4]. Originating from conventional adaptive and personalized tutoring, this set-theoretic framework allows assumptions about the structure of skills of a domain of knowledge and to link the latent skills with observable behavior. It provides an internal cognition-based logic that is quite similar to the logic of ontologies: well-defined entities (the competencies) are in a well-defined relationship (a so-called prerequisite relation).

The domain model, the set of meaningful competence states, and the learning paths are combined with a model of tasks and problems within a LeS, the so-called problem space. For each object in a LeS (e.g., the blind in Figure 1) we assume a set of properties (e.g., location, alignment, or angle) the object can have. Thus, the problem state is the combination of all objects’ states in a given LeS.

The mapping of competence structures and problem spaces enables a continuous and non-invasive interpretation of the learner’s behavior in terms of present and absent competencies within a LeS. This interpretation is probabilistic; for example, if a learner does not turn on a torch, we can assume - with a certain probability - that this learner does not “know that a task requires a light source”.

4. Non-invasive adaptation

ELEKTRA’s methodology allows providing individualized game situations on the basis of the same pool of game assets. For example, a high performer will be provided with fewer but more complex situations than an underachiever. Moreover, based on the presence or absence of certain skills, specific objects can be presented and tasks can be adjusted to the learner’s needs. In the same way, the same learning situation can be presented repeatedly if necessary, for example with an increasing level of difficulty.

In addition to tailoring an entire LeS, the learner can be educationally supported by interventions (e.g., hints) when necessary. The conditions under which a certain adaptive intervention is given are to be developed on the basis of pedagogical rules; however, these rules will apply the micro adaptivity framework and utilize the learner model obtained through the assessment within the framework. Main types of interventions are:

- A skill activation adaptive intervention;
- A skill acquisition adaptive intervention;
- Motivational adaptive interventions;
As summarized in Figure 2, the overall micro adaptive assessment and intervention process is imitated by any action the learner performs in the game (e.g., by switching on a torch). The situation after an event is analyzed in terms of the given problem solution state and, subsequently, the probability distribution over all competence states is adjusted to the problem solution state. This analysis, of course, must occur in real time. By the probability change of specific competencies involved in a situation (e.g., knowing that the torch’s light is necessary), the most relevant/critical competencies can be detected. Depending on an increase (what actually is desired) or a decrease of the probability of specific competencies, pedagogical/ didactic meta-rules are utilized to select a specific interventions and feedback (e.g., "if the probability of a competence v involved in a LeS decreases below a threshold w, and the probability of a competence x is above a value y, then trigger an educational hint z").

5. Conclusions

The aim of micro adaptivity is to enable an assessment of competencies and learning progress during the game, which does not compromise the game flow and therefore does not negatively impact intrinsic motivation. The probabilistic assessment on the basis of interpreting the learner’s behavior and actions within the game is supplemented with “harder” test items, for example the accomplishment of a certain task in order to reach a new level of the game. On the basis of this assessment, non-invasive adaptive interventions can be triggered in order to support the learning process.

Based on sound psychological models for problem solving and for competence structures, we have developed a framework for micro adaptivity within complex learning objects.

In the context of the ELEKTRA project, several empirical investigations and evaluation studies have been conducted (e.g., [5]), particularly concerning the educational effectiveness of adaptive features in assessment and interventions. Generally, analyses revealed that adaptive features result in better learning performance and also superior gaming experience than non-adaptive control groups.

However, micro adaptivity is still in an early stage of research and development. The underlying framework uses some simplifying assumptions like the identity of properties and position categories and actions. Based on the experiences in the ELEKTRA project, the framework will be generalized within and beyond the domain of game-based learning. Future work will also address the integration of meta-cognitive aspects such as confidence ratings into the assessment procedure. In future projects also the realization of adaptive storytelling is envisaged in order to enable educational game technology even a broader range of individualization and adaptation to specific learners.

6. Acknowledgements

The research and development introduced in this work was and is funded by the European Commission under the sixth framework programme in the IST research priority, #027986 (ELEKTRA, www.elektra-project.org) as well as under the seventh framework programme, #215918 (80Days, www.eightydays.eu).

7. References

My-Mini-Pet: The Design of Pet-nurturing Handheld Game

Calvin C.Y. Liao\textsuperscript{1}, Zhi-Hong Chen\textsuperscript{2}, Tak-Wai Chan\textsuperscript{1}

\textit{Graduate Institute of Network Learning Technology, National Central University, Taiwan}\textsuperscript{1}
\textit{Department of Computer Science and Information Engineering, National Central University, Taiwan}\textsuperscript{2}
\{calvin, hon, chan\}@cl.ncu.edu.tw

Abstract

Mobile learning brings us more learning opportunities due to the characteristics of learning devices and wireless computing. Recently, game-based learning also provides promising benefits in children’s learning. Therefore, how to design a game-based learning environment in handheld devices by combining an existing game with different learning activities is a significant research issue. In this paper, we attempt to incorporate game elements with the learning environment design in the PDA for students. Three considerations for the learning environment design in the hand-held devices are discussed: game element design, small screen design, and learner-centered design. According to these three considerations, a pet-nurturing game environment in the PDA, My-Mini-Pet system, is developed, including three components: emotional attachment, learning guidance, and costume show. The design rationale behind the My-Mini-Pet system is that taking good care of the Mini-My-Pet is actually improving the learner’s learning status.

1. Introduction

Game-based learning environments can motivate learners to learn, and provide learners for a great deal of learning opportunities to improve their learning. Malone\textsuperscript{8} suggested that instructors utilize game elements as a pedagogical strategy to benefit student learning. As mentioned above, motivation is a significant aspect to influence a student’s learning. To stimulate a student’s motivation to learn, several researchers have identified significant motivational factors. For example, Malone and Lepper\textsuperscript{9} analyzed key motivational elements for a successful learning environment, including challenge, fantasy, curiosity, and control. Keller\textsuperscript{7} proposed a motivational model for classroom instruction which consists of four factors: attention, relevance, confidence, and satisfaction.

Recently, digital game enhanced learning attracts increasingly attention due to its positive influences on learning. Digital games often own multiple motivational factors, such as fantasy, interaction, conflict, and challenge, and are helpful to motivate people to learn\textsuperscript{[4]}. Gee\textsuperscript{5} pointed out that good learning principles adopted by game designers have much potential for facilitating learning in good ways. Gee\textsuperscript{5} further suggested that human’s learning should adopt good learning principles built in the game design. One-to-one (1:1) technology enhanced learning focuses on the computing support for both formal and informal learning through the available of mobile devices to each student, such as notebook or PDA \textsuperscript{[2]}. Furthermore, as information technologies advance, one-to-one classroom learning, a learning context where every student in the classroom owns a learning device to help him/her learning, potentially brings many positive influences on student’s learning \textsuperscript{[2]}. Because of the characteristics of a hand-held device for student learning, such as small-size, cheap-price, and easy-take, classroom learning might adopt hand-held devices as the first step towards technology-enhanced learning. Therefore, how to design a game-based environment in the mobile device is a significant research issue.

2. Pet-nurturing Game for hand-held device

Among the game categories, the category of pet-nurturing game has one characteristic: the user plays the role of “keeper” to take care of his/her pet for long periods of time. This characteristic is helpful to sustain the motivation to learn. Some studies have noted that pet keeping is naturally attractive to children, because they all share the same attributes, such as cute, simple and straightforward behaviors\textsuperscript{[10]}. Therefore, children’s emotional attachment to pets is easy to elicit \textsuperscript{[1]}. We attempt to apply this emotional attachment to learning design. A framework is illustrated to integrate a pet-nurturing game and learning activities with
different subject domains. As shown in Figure 1, the framework is divided into two parts: pet-nurturing game and learning activity.

First, the pet-nurturing game is a motivation-sustained part which provides the learner with a game environment. While the learner is attracted by the game, the learner’s the desire for game playing will further be translated into the taking-initial-action to learn. For example, the pet needs food and other resources to grow up happily and healthily. Then the learner is guided to attend the learning activities for gaining these game resources. Therefore, the pet-nurturing game makes game-playing relevant to learning, and motivates the learner to learn in the learning activities [3].

Second, the learning activity is a critical part in which learning actually takes place. The learning activity could contain a series of learning tasks designed to improve the learner’s learning in different subject domains. After passing the assessment of learning tasks, the learner could gain the pet resources.

Figure 1. Pet-nurturing game for held-hand device

We attempt to incorporate game elements with the learning environment design in the PDA for students. The three considerations of our environment design: game element, small screen, and learner-centered designs.

2.1. Game Element Design

Prensky[12] indicated twelve useful game elements: fun, play, rules, goals, interactive, adaptive, outcomes and feedback, win states, conflict/competition/challenge/opposition, problem solving, interaction, and representation or story. A game usually includes multiple game elements rather than a single one.

2.2. Small Screen Design

Rosson & Carroll[18] pointed out that the user interface design of the mobile device will be a big challenge of the usage, because people are used to use the desktop computer. Many tasks can simply be completed in the desktop computer, but it’s difficult on mobile device. Norman[11] indicated some possible directions to overcome the design difficulty for the user interface design: conceptual model, making things visible, principle of mapping and principle of feedback. A good conceptual model can make the user think what fit in with actual actions. The user can further know how to use this interface by the principle of “make thins visible”. Furthermore, the principle of mapping could create the nature relation to make the user do something familiar with his experience; the principle of feedback tells the user what is the result of the actions.

2.3. Learner-Centered Design

Software designers usually try to make their software easily for people to use, and a useful approach, user-centered design (UCD), from the perspective of users is developed[11]. Norman[11] described UCD in terms of addressing the conceptual distance between a computer user and the computer. When users use a tool to complete their work, they have specific goals in mind that translate their willing into actions. After executing some sequence of actions on the tool, users evaluate and interpret the result of their goals [13].

3. Animal Companion System: My-Mini-Pet system

The animal companion is a pet-styled virtual character which inhabits in the game environment. Some researchers pointed out that taking care of animal companions might be a powerful game strategy for learning[3]. While learners interact with animal companions, they are actually taking good care of their own learning status in the form of game playing. Therefore, in this paper we adopt animal companion approach in the learning environment design for
handheld device. Meanwhile, an animal companion system in the PDAs, My-Mini-Pet system, is developed according to the three considerations described above: game element design, small screen design, and learner-centered design. Fig. 2 illustrates the snapshot of the My-Mini-Pet system, including artificial attachment, learning guidance, and costume show designs.

3.1. Emotional Attachment

To help the learner establish emotional attachment to his/her animal companion, the My-Mini-Pet system provides the learner with name function to name his/her animal companions. In addition, the learner can nurture the animal companion through buying food and goods in the pet stores while the learner finds the physical value of the pet getting down.

3.2. Learning Guidance

Although game environment could interest the learner, a mechanism is required to guiding the learner to learn. In the My-Mini-Pet system, we design mathematics activity as a necessary part for taking good care of the animal companion by EduCoin. That is, the learner needs to gain EduCoin for buying food or goods in the pet store[3]. Therefore, if the player wants to complete the game, learning must take place in the form of game-playing.

3.3. Costume Show

Kay[6] advocated the usage of learning profiles to promote self-reflection, and stated “it should make it available to the learner for improving their own learning through better self-knowledge.” The costume show provides the learner with a “visible” learning status. Different status of My-Mini-Pet is represented according to the learner’s learning progress and learning performance, and the learner’s awareness of self-reflection might be enhanced.

4. Conclusions

In this paper, My-Mini-Pet system was developed, including three components: artificial attachment, learning guidance, and costume show on hand-held device. The design rationale behind the My-Mini-Pet system was that taking good care of the Mini-My-Pet is actually improving the learner’s learning status. My-Mini-Pet not only attempts to motivate learners to improve their learner’s learning status through the open learner model, but also to promote reflection and helpful interactions among teammates.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financial support (NSC-97-2520-S-008-001).

10. References

On the benefits of tangible interfaces for educational games

Janneke Verhaegh, Willem Fontijn, Aljosja Jacobs
Philips Research Europe
{janneke.verhaegh, willem.fontijn, aljosja.jacobs}@philips.com,

Abstract

Educational games become more effective when the challenge they offer matches the developing abilities of the player continuously. This promotes the motivation of the player and ensures favorable conditions for learning. To achieve a proper match between the player’s abilities and the challenge offered, it is important to minimize any unintended challenge caused by the user interface.

We studied the ease-of-use of a tangible interface for an educational game and of a personal computer based version of the same game. Tangibility of the interface was expected to make the game easier to learn and easier to use than the PC version because it is more direct.

The results from our experiment, in which the interactions of children with the physical interface and the screen-based interface were compared, support this. The results suggest that the tangible version of the game is easier to use than the screen-based version and that it causes less unintended load for the children.

1. Introduction

Educational games become more effective when the challenge they offer is tailored to the current skills and abilities of the player. The importance of a proper challenge in educational materials has been described extensively earlier. See for instance [1]. Ideally, the challenge offered matches the players developing abilities continuously. This would mean that the games never become too easy, which can be boring to the player, but also never become too difficult, which may lead to frustration. Thus, offering a proper challenge promotes the motivation of the player. In addition it ensures that the player is always performing a task that will support the development of new skills and abilities and to improve existing ones. In [2] we described an electronic game with a tangible interface which supports the development of games that assess the skills of a child and tailor the challenge to the assessed aptitude.

To achieve a proper challenge, a precise understanding is needed of the tasks offered in the game and the capabilities required. This also includes those tasks that are due to the user interface. Minimizing the difficulties caused by the interface used, assures that the challenge experienced is mostly based on the intended tasks in the game, which makes the game more effective as the targeted skills can be addressed directly.

It has often been suggested that the use of tangible interfaces in education has clear benefits above non-tangible interfaces such as screen-based computer interfaces [2, 3, 5, 6]. However, a fair comment made, is that there is too little empirical evidence to substantiate these claimed benefits of tangibles for education [4].

To create electronic games for children that merge fun and education, we need to expand and use knowledge on a number of aspects. This paper focuses on the role that the type of interface plays in how easy the game can be learned, but also how well it supports the educational purpose of the game. Ease-of-use is also related to the fun experienced. Any task that is not directly related to the game itself can easily be seen as work, not play, and hard work if this task is difficult.

Figure 1. Tangible version of the game used with several examples of assignment cards.
To gain more insight in the claimed benefits of a tangible interface with regard to usability and how easy it can be learned, and to support this with empirical evidence, we conducted an experiment. An educational puzzle game with a physical interface (condition 1) was compared to the same game with a screen-based, virtual interface (condition 2) in a test with 5-7 year old children. The experiment and its results are described in section 2 and 3. In section 4 we discuss the results and the insights we gained on the use of these interfaces in educational games for children. In section 5 we draw some conclusions.

2. Experiment

2.1 Materials

For the experiment we used the commercially available educational game ‘Passen en Meten 1’ (translates as ‘Fitting and Measuring’) from Jegro [7]. The advertised educational aims of the game are learning to measure and compare different lengths, improving spatial reasoning by exploration, and stimulating logical thinking. The recommended age for this game is five to six years.

The tangible version of the game (Figure 1) consists of wooden blocks and plastic assignment cards. The blocks come in five different colors (red, yellow, blue, orange and green). For every color there are five rectangular blocks in relative sizes 1 to 5. The object of the game is to match a pattern presented on the assignment card using the available blocks.

The object of the virtual version of the game, which is presented in Figure 2, is the same as for the tangible version: to match a pattern using the available blocks. The big difference between the two versions is the user interface. In the virtual version the pattern is shown on a computer screen and the blocks are virtual and need to be selected and manipulated using the computer mouse.

With the virtual version the remaining blocks of only one color are visible at one time, sorted by size (see Figure 3). Pushing a virtual button under the blocks changes the color. By clicking on a block its orientation changes from vertical to horizontal or vice versa. To place a block, it is to be given the correct orientation, dragged to the correct spot on the pattern, and dropped.

With the tangible version all remaining blocks are visible at all times. They are gathered unsorted in a box (see Figure 3). To place a block, it is picked up and put on the correct spot on the assignment card.

Note that the fact that less words are required to explain the tangible version already suggests that the tangible interface is more accessible.

For both games the assignments consisted of the same five types of puzzles, differing in the shape of the pattern (see Figures 1 and 2 for examples), thus yielding five different difficulty levels.

2.2. Participants

The test included 26 participants who all participated individually. They were aged 5 to 7 years, with an average age of 6.6 years. The children were pupils from the second and third grade of a primary school in Eindhoven, the Netherlands. All children had at least some prior experience with using a PC. The written consent of the parents was obtained beforehand.

2.3. Procedure

For the experiment the child was picked up from the classroom and brought to a separate room. First, the child was asked permission to record the experiment on video. The experiment started with explaining the test procedure.

The experiment consisted of two conditions. One condition in which the tangible version of the game was played, and another condition in which the PC based version of the same game was played. The latter we call the virtual version. All participants completed both
conditions. The order of the conditions was counterbalanced. The child was interviewed at the end of each condition, to learn how it had experienced the game.

2.4. Game play

Each participant had to complete four puzzles in each game condition. The four puzzles were randomly selected out of the five pattern types of different difficulty. Each game condition started with a practice puzzle. Children were stimulated to discover on their own how the game worked in each condition. This was done by first giving a short explanation of the game and subsequently letting the child try the puzzle. If the child got stuck a hint was given. Once the child expressed that it fully understood the game, the other three puzzles were played. During the experiment the children we observed continuously.

2.5. Metrics

The following metrics were used in the test:
• Time: the task completion time for each puzzle was measured using a stopwatch.
• Measuring and fitting: the number of measuring and fitting attempts was counted.
• Interview: the child was asked about how it experienced the game and about previous experience with using a computer.
• Observations: observations made during the experiment were written down. The experiments were also recorded with a video camera.

3. Results

3.1. Statistical Analysis

To get a normal distribution of scores, instances of above or below three standard deviations from the mean task completion time were excluded. As a result, the data from one participant were excluded from the analysis. Consequently, the analysis was limited to the data from 25 children.

A paired-sample t-test on the task completion time of the practice puzzles produced a significant result, \( t(24) = -6.079, p < 0.01 \). This means that it took significantly more time to complete the virtual practice puzzles than it took to complete the tangible puzzles.

Finally, the paired sample t-test on the number of ‘measuring and fitting’ attempts made produced a significant result, \( t(24) = 3.321, p < 0.01 \). This means that significantly more ‘measuring and fitting’ attempts were made in the tangible condition compared to the virtual condition.

![Figure 4. Average completion times (Tangible vs. Virtual) for each position in the order of puzzles played.](image)

3.2 Training effects

To assess the presence of any training effects we compared the average completion times for the first, second, third and fourth puzzle played for both conditions. The results are presented in Figure 4. The virtual condition exhibits a clear training effect up to the third puzzle. The tangible condition exhibits only a very slight training effect. The difference in average completion times between the virtual and tangible condition is also clear.

![Figure 5. Average completion times for each position in the order of puzzles played, taking into account the order of conditions. V_T means average completion time for the Virtual condition when started with the Tangible.](image)
A peculiar effect was observed when we took the order of conditions into account (See Figure 5.). Children who first did the tangible condition and then the virtual condition, did worse at the virtual condition ($V_{TV}$) than children who started with the virtual condition ($V_{VT}$). For the average completion times in the tangible condition ($T_{TV}$, $T_{VT}$) it did not matter with which condition the child started.

3.3. Interviews

To the question which version of the game was more fun, 8 children answered that they found the tangible version more fun. 8 children could not choose between the two options and 9 children regarded the virtual version more fun. Some preferred the tangible version because they found it easier. Others preferred the virtual version, because they considered that one easier, in particular because the blocks were sorted already. Others liked the difficulty of the virtual interface, and the fact that they needed to put more effort into the control interface. Some liked the virtual version more, just because it was played on a PC.

With respect to the question which version of the game was most difficult, 7 children regarded the tangible version the most difficult, 3 children could not choose and 15 children found the virtual version the most difficult. This difference can be attributed entirely to the answers from girls. All but two said they found the virtual version more difficult. This was the only question for which there was a clear gender bias.

When asked which version of the game they would choose to play if they could play again, 12 children would play the tangible version, 1 child could not choose between the two version of the game and 12 children would play the virtual version.

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>-</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>more fun</td>
<td>32%</td>
<td>32%</td>
<td>36%</td>
</tr>
<tr>
<td>more difficult</td>
<td>28%</td>
<td>12%</td>
<td>60%</td>
</tr>
<tr>
<td>would play again</td>
<td>48%</td>
<td>4%</td>
<td>48%</td>
</tr>
</tbody>
</table>

Table 1. Interview results for 25 children. ‘T’ means tangible, ‘-’ means undecided, ‘V’ means virtual.

3.4. Observed ways of playing

In the tangible condition, the children seemed to work from the puzzle example and looked which blocks fitted. When playing the virtual version children seem to work from the blocks (or bars), looking at which place in the pattern the block could fit.

The fact that the blocks were already sorted in the virtual version, seemed to make selecting the right block a bit easier. However, finding out how to rotate a block was not easy for many children. Also, switching to another color proved sometimes hard.

A particular problem that occurred when playing the virtual version, was that the children had more trouble deciding which blocks were already placed on the puzzle and which blocks still had to be placed. They did not have such problems when playing with the tangible version. Blocks that are placed onto the pattern, have a black line around them. The empty spots in the pattern have a gray line around them. Once a block is placed on the correct position in the pattern, the gray line is covered by the black one. Once a large part of the blocks is properly placed, it becomes more difficult to see which spots are still empty, as the black lines of the surrounding blocks also cover part of the central block.

Figure 6. Example of the contrast between a placed block (black lined) and empty spot (gray lined).

4. Discussion

Accessibility. The fact that it took significantly more time to complete the virtual practice puzzles than it took to complete the tangible practice puzzles suggests that the tangible interface is easier to learn. Or at least it is easier to understand what needs to be done in the case of the tangible interface. It is more accessible.

Ease of use. The fact that it took significantly more time to complete the virtual puzzles than it took to complete the tangible puzzles suggests that the tangible interface is easier to use. One can point to specific issues with the virtual interface that cause the higher average completion times, such as the problem with assessing which spots are still empty or issues with changing the color or orientation of the blocks. In the end it all points to inaptitude of the virtual interface.

Significantly more ‘measuring and fitting’ attempts were made with the tangible interface compared to the virtual condition. This suggests that the tangible interface invites trial-and-error or a more exploratory
approach. As this was one of the aims of the game, one could say the tangible version is more effective on this aspect.

The observations regarding training effects demonstrate that the children need more time to master the virtual interface than they need to master the tangible interface. In fact, the absence of a training effect with the tangible interface indicates that with this interface it is immediately obvious what needs to be done. With the virtual interface it is less obvious what needs to be done and especially how. Once the children get the hang of it, the virtual interface still takes more time, indicating that the virtual interface is more cumbersome in general.

The peculiar training effect observed when the order of the conditions is taken into account is harder to explain. Apparently transfer of experience from tangible to virtual does not work in this specific case and transfer of virtual to tangible is non existent. One possible explanation is that the strategies a child may develop when using the tangible interface work counter productive when applied to the virtual interface. While strategies developed for the virtual interface are irrelevant for the tangible version.

Many children struggled with click-and-drag mouse actions that were needed to move and rotate the blocks. This suggests that a mouse may not be suitable for children of this age group, which has been suggested before [8]. Conversely, the tangible version of the game may be too easy for our participants and be more suited for younger children. Both points support our assessment of the adverse effects of the virtual interface on the effectiveness of the game.

The first game that children played in each condition was meant to practice. The intention was that children understood the interface and the goal of the game after this practice game. Although most children seemed to understand the game and the interface after the first game, many participants still found it difficult to rotate the blocks and drag them onto the pattern in the virtual condition. More extensive training may have helped here, but the lack of experience with using a PC can not be overcome during the relatively short time frame of the experiment. PC skills also seem to influence strongly the preference for one or the other interface. Some children preferred the PC interface because it was more challenging, but others found it too challenging and preferred the tangible interface.

5. Conclusions

The experiment described in this paper clearly showed that for the game used the tangible interface was both easier to use and easier to learn to use than the virtual interface. It also showed that the tangible interface invites a more exploratory approach.

In our experiment we found specific problems with the virtual interface which detract from the game itself. Next to the task of the game, the children have to learn to cope with the challenge posed by the interface. This is less than optimal, unless handling the interface is a separate and explicit educational goal.

In general we can conclude that the results from our experiment indicate that the tangible puzzle game incorporates less unintended load for children than the screen-based version and that the danger that a virtual interface is less effective should be taken seriously.

6. Acknowledgements

The authors thank the children who participated in the experiment. We also thank Jettie Hoonhout for reviewing an earlier version of this document.

7. References


[7] www.jegro.nl

Online Videogames in an Online History Class

Vance S. Martin
University of Illinois at Urbana-Champaign
vmartin@parkland.edu

Abstract

This study examines use of an online history simulation videogame, Civilization, in an online college history class. Overall findings were that the game complements texts and lectures, aids speakers of English as a second language, creates empathy for past societies, encourages personal research, and creates a sense of community in the online class.

1. Introduction

Videogames have been researched for their effects on children, but only recently has their educational potential been considered with any authority. A major work advocating the learning process involved with videogames was written by James Paul Gee in 2003 [1]. Many have built on his work. For the purposes of this study, the most notable is Kurt Squire.

Squire has been using the videogame Civilization 3 in after school programs with students at the grade and middle school level for several years [2]. This study builds on Squire’s use of Civilization 3 with a few variations. The first is that the game is part of the course curriculum, rather than an after school program. The second is that the students are in an introductory college history class for one semester, rather than a grade school or middle school for a whole year. The final difference is that the class is online.

2. Background

Civilization is a game first created by Sid Meier in 1991. There are now four versions, but the main interaction and basis of the game have not changed. Players begin with a settler in 4000 BC. They start a city and expand it, controlling taxes, trade, treaties, and technology research as they found new cities or conquer those of other players. One can “mod,” or modify, the game to model actual geography or particular historical scenarios.

The theoretical background of this study is constructivist, in that with Civilization students are able to build their own concept or knowledge of history through interaction with the computer and other students in their group. It also creates Vygotsky’s zone of proximal development, in that students, with guidance, can be pushed a little bit past their expertise and learn more by rising to the occasion.

This study was done in an online history class, Western History 1800 to the present, at a community college in the Spring 2008 semester. In addition to traditional assignments, students were asked to post weekly to the discussion board and complete a two part final paper project with peer review. There were two options for the paper: reading a piece of period literature as a primary source document or playing Civilization against classmates.

Students who chose the videogame option were asked to keep a journal of their thoughts and problems. The students were expected to become familiar with the game on their own, then play against other students in the class, and eventually play a time appropriate mod against other students. For this study I used a mod that mimicked the world and main powers in the year 1800. Submission of the journal was the first paper assignment. The second paper required students to reflect on the experience, critically examining the game and comparing it to lectures and readings. They were asked to discuss which helped them understand history more, and any biases in the game or the readings.

This project as initially envisioned had several goals. The first was to engage students in history in a way not possible with books or lectures, but in a way that can complement books and lectures. The second was to create an atmosphere of group learning in an online class. Oftentimes online classes are seen as independent studies, as modern day correspondence courses. The goal was for the online game to create a social network. I believe that the goals were measurably achieved with this study.
3. Methodology

I used qualitative methods for this study. I looked at papers, tests, discussion boards, and emails. It was also possible to interview two of the students who participated in the videogame assignment. I examined the transcripts of the interviews, assignments, emails, and discussion boards looking for common themes. Three common themes were apparent from the data: items that lined up with Squire’s study, impressions about the value of the project, and interesting themes not present in Squire’s study.

4. Findings

Nine students originally signed up for the videogame project, and six of them completed the course. All names are pseudonyms.

Lucy was one of two females in the group. She explained that the videogame gave her a better understanding of how history happens:

Instead of being concerned with events that happened I was able to understand the causes leading up to events. Playing the game along with reading the text and studying history allowed me to make connections between the two…. Instead of “this is how it was and that’s why this is how it is” the video game gave me personal control in how a civilization is formed and how it functions. The videogame allows history to become a more hands on class; which is something I did not think history ever had a chance at becoming.

Lucy felt that the videogames and the other coursework were “two completely different approaches to history” which were valuable together. She indicated that videogames were valuable for students of all ages, preparing them for the future technological environment. Lucy added that it was a valuable assignment, but needs some sort of an in-person introductory session to help students understand how to play the game better.

Michael also learned a lot, and explained that the simulation allowed him to explore and learn. Saving and replaying allowed him to explore options not possible simply through a text:

Having a “redo” at your fingertips is true power. Without the ability to reverse mistakes the task of learning would be near impossible in this game….

The videogame helped me test out my own theories, practice my own total control tactics, and explore possibilities.

As with Lucy, he felt that the lectures and game gave two different ways of looking at and learning about history, and found it useful to compare the two.

Michael also noted the value of the mods, because they allowed one to understand how history happened. In addition, Michael mimicked a behavior seen in Squire’s study, going above and beyond the coursework to see if what was occurring in the game was similar to actual events. While the course focused on only western history, Michael investigated history of other countries, like India, to see if the game was historically accurate.

A group of Korean students, Isaac, Maud, and Kang, played the videogame against each other exclusively. They kept separate journals, but were allowed to do a final group paper that was substantially longer than that required of other students. To test the group play option, they played an American Revolution mod. During this experience they become emotionally involved in the history and plight of the actors:

We were able to realize how the English people felt back when they went to war against the American colonies.

They, like Michael and Lucy, discussed that this was a valuable experience when the game was mixed with the course content. Like Michael, they valued being able to replay to explore the results of different choices.

This group of students also brought to light two unanticipated ideas. As speakers of English as a second language taking classes in English, they may not always have total comprehension of everything they read, and therefore miss certain ideas. However, they were able to play this game using a Korean patch. The game for them was in Korean, which complemented the English text and led to greater comprehension. As Maud said in a personal email, this led to an “unforgettable experience.” They also noted that the game helped them see how history in different locations is related. History is often taught as national history: the history of France, England, and Germany. However, to realize that each of these nations’ histories occurred simultaneously and had some effect on the other is an important concept which students often fail to grasp.

The final student in the project was Robert, who has been playing Civilization for a very long time. However, he has never used the mods before, and was amazed at how accurate they could be. Robert also noted that the game can help one really understand the mindset of people, in a historically accurate, but not necessarily good way. This is similar to the thoughts of Isaak, Maud, and Kang:

What is eerily rude about this game is that you start to form this thinking process that is true to history. Ethnocentrism is prevalent when you travel to a place like Africa, to talk to someone like the Zulu.
who as I put it are “backwards society.” Of course this is how Europeans would of seen them at the time, and it is weird and fitting that that is how I would see them during the game.

Though the others felt that this game was best used in conjunction with texts, lectures, and discussion boards, Robert felt that this game was the way to learn history. This may be indicative of his past playing several versions of the game for many years.

5. Discussion

The first goal of the project was to engage students in history in a way not possible with books or lectures, but complementing these materials. As evidenced by the student comments, this project did convey the content of the class in an informative manner. The videogame and the book helped reach the students using two separate modes of instruction, seemingly leading to greater overall understanding of the content. They better understood the idea of macro history, and were able to better empathize with the way historical agents may have felt: the fear of the American colonists or the racial superiority of the colonizers of Africa.

The students who participated in this project spent twice as much time learning the videogame, playing against each other, and writing their papers than those in the literature project. Not only do I feel that the students did in fact learn history, but they were engaged enough to devote this extra time. I would argue they have learned history in a way that has made it real to them, and much more memorable.

The second goal of the project was to create an atmosphere of group learning in an online class. The students in the videogame project were frequently in contact with each other or myself via email or the discussion board. They contacted each other to set up times to play, and to discuss how to play. For the peer review part of the final paper, each student in the videogame project submitted a paper, and all but one gave feedback. For the literature project, five students were left in the group; only two submitted papers for peer review and each gave feedback. This seems to indicate that the students in the videogame group were more willing to share their papers and give feedback than those in the literature project. A greater percentage of students in the videogame group also finished the class, 6 out of 9 compared to 5 out of 13. Perhaps the students in the videogame project felt a greater sense of community or need to complete the course. These two findings should be explored further in future research.

This study also illuminated some unexpected issues that should be explored in future versions of this project. Students who use English as a second language felt more comfortable using this project, and felt that they learned more than had they not used the videogame. Students were also able to understand the idea that history occurs simultaneously. Finally, the feelings of sympathy with historical actors is interesting and deserving of more research. This study did highlight some similarities with Squire’s study, in that at least one student did independent research to compare the game to history. All of these factors need to be examined in future studies.

A problem raised with this study was the difficulty of becoming familiar with the game. Civilization 4 comes with an in-game tutorial, but even students using this version felt that an in-person session would be helpful. It may be fruitful to examine this option, or application in a blended or hybrid class.

This study should not be read as an argument for videogames as the only method of instruction. Students indicated that it was most valuable in conjunction with readings and lectures. This study illustrates that videogames do have a place in the online environment and should be used as an option for projects or perhaps as part of the curriculum. The game can promote understanding in multiple ways and force students to see history through another lens. This preliminary study shows that there is merit in examining this area of research. A second study will add weight to some of these findings and help us better understand some of the issues that were encountered.

This research was inspired by Squire’s Civilization studies, but was carried out in a different context with different goals. Some of his results were replicated in the new context, but there were other valuable findings that are unique to this environment. This game has fostered understanding with less reliance on English language fluency, created empathy for historical agents, and created a sense of community in an online setting. These provide interesting avenues for future research.

6. References


RoboMusicKids – Music Education with Robotic Building Blocks

Jacob Nielsen, Niels K. Bærendsen, Carsten Jessen
University of Southern Denmark
The Maersk Mc-Kinney Moller Institute
Centre for Playware
Campusvej 55, DK-5230 Odense M, Denmark
raider@mmmi.sdu.dk, mail@nielsk.dk, jessen@litcul.sdu.dk

Abstract

Being able to express oneself musically and experiment with music composition is traditionally determined by one’s ability to play an actual instrument with a certain degree of craftsmanship. The lack of skills often makes it difficult to make children and young people experience the joy of musical creativity, which is an essential element in music education. This paper presents a pilot project where modular robotics is used to create a platform for creative musical expression that allows users to experiment with musical genres without any prior musical knowledge or skills.

1. Introduction

This RoboMusicKids project investigates how music education can be facilitated by the use of elements from the field of modular robotics. The technology used is intelligent blocks, I-BLOCKS, which are able to communicate with each other when physically connected and which are also able to detect the 3D structure that they are part of.

A lot of toys currently exist that can play sounds or music depending on the user’s or the environment’s interaction with them. Most of these have a preset library of sounds and/or tunes, which can be played back in only a few different ways – unless we are talking music instrument toys. These toys, therefore, do not allow the user to really experiment with composition and for instance try out different genres. It is our wish to create a platform for creative musical expression and experimentation, which does not require any pre-learned skills from the user.

Using the I-BLOCKS as a tool for musical experimentation, we allow children to play with professionally created musical pieces and thereby create their own mix and arrangement from a large number of overall possible variations. Our goal is that as the children play with variations of different genres, they thereby learn the characteristics of these, which is an important part of teaching musical comprehension. It is our hope that this hands-on musical experience also will sustain the children’s interest in music creation and first and foremost keep them playing and learning.

The combination of modular robotics and music in RoboMusicKids is in our view a new approach to music teaching that allows children to learn by doing through manipulation with physical objects and gain knowledge about music in the same natural manner as young children commonly learn to know their environment. In relation to learning and technology in general, RoboMusicKids is an example of how learning can be transformed by altering the behaviour of the objects that we allow children to get their hands on.

The project is cross-disciplinary and combines two very different scientific areas, robotics and pedagogical research. In the following we will first introduce the I-BLOCKS technology as a tool for experimenting with music, then describe results from user experiments, and close with a brief discussion of the possible advantages linked to the use of new music technology.

2. I-BLOCKS Technology

The I-BLOCKS (see Figure 1) are cubic modular robotic building blocks that can communicate with each other when connected. Each cube can communicate with up to 4 of its 6 possible neighbours and is fully self-contained with respect to power, connectors and processing. At the edges of the 4 communicating sides of a cube are 4 RGB LEDs, which can light up in 4096 different colours. The I-BLOCKS communicate locally via IR-transceivers.
and can be internally expanded to support global wireless radio (XBEE) communication as well, in order to facilitate ‘structure – structure’ or ‘structure – device’ communication. Each I-BLOCK makes use of a 3D accelerometer to detect its orientation with respect to gravity. This makes it able to detect, for instance, which side is facing down.

The I-BLOCKS connect to each other using magnets, allowing for uni-sex connection at 90-degree angles. At the electronic centre of each I-BLOCK is the Atmel ATMEGA1280 8-bit microcontroller, which takes care of all processing including peripheral device communications etc. The I-BLOCKS hardware is encapsulated by black polyurethane (PUR) shell that has a soft rubber-like feel, with hard plastic plate lids in top and bottom in which charge plugs, programming connectors, sensors and actuators are integrated.

Figure 1. An explained visualization of the I-BLOCK.

An I-BLOCK is assembled as shown in Figure 2. The individual block can be expanded to support sensor, actuator and communication additions of which can be mentioned:

- Sensors: LDR, Flex, Stretch, Sonar, Microphone
- Actuators: LCD Text Display, LCD Graphic Display, Synth Sound, Vibrator
- Communication: USB, XBEE

Figure 2. I-BLOCK explained assembly drawing.

The I-BLOCKS have been developed in several prototypes since year 2000, and are meant as a general platform for exploring physical programming – or “programming by building”. The construction with I-BLOCKS results not only in the development of a physical structure, but also in the development of a functionality of that physical structure. The functionality is a product of the sensor input, the actuator output, the communication and the processing of the individual I-BLOCKS.

There are many possible applications for this type of technology, and some of those explored so far [1][2] include arithmetic, language, neural networks, technology learning, programming, and with this project now also music composition.

We name our technology “modular robotic building blocks” because of our group’s (www.adaptroncis.dk) strong relations to the fields of embodied AI (modular robotics, multi-agent systems etc.) and because of our definition on robotics: “A robot is defined as a programmable machine which autonomously performs a variety of tasks. A robot’s behaviour distinguishes itself from a computer program by its interaction with the physical surroundings via sensors and actuators.”

Our modules do not contain moving actuators, but both the light and sound output are actuators and by using these as feedback to a user’s handling of the I-BLOCKS they do invite the user to act as a “inter-actuator” to the system.

As written above, the I-BLOCKS should be considered a truly distributed system, and even though we use a PC as a generator of the music in the project mentioned here, this PC should just be considered a sound actuator I-BLOCK because it is interfaced in the same way as the other I-BLOCKS. The user does not even need to know about the existence of the PC, all that is needed is the audible feedback.
3. Existing Music-making Technologies and Concepts

There exists numerous music-making technologies on the market today, and a few of these will be mentioned briefly in this section.

If we start on the pure software side, we have products such as Garageband from Apple [3]. This product is extremely user friendly and allows the user to compose music pieces from a large library of loops as well as standard audio and midi recording. The loops are presented to the user in a specific browser and can be dragged and dropped into the current project – even while the music is playing. The new version of Garageband includes a feature named “Magic Garageband” which allows the user to select from different genres of music (jazz, rock, funk, pop etc.) and then a pre-composed piece of music is played for the given genre. The different instruments for a given genre is presented to the user as “icons” on a virtual stage and can be selected to be modified to other variations of that instrument – while the music is playing. For instance the bass instrument in a jazz number can be changed from “walking” to “fretless” to “lounge” to “funky” etc. In this way, the user can setup a suitable accompaniment to her own performance (singing, playing etc.) The functionalities of “Magic Garageband” resemble very much what will be presented in this article, although this is true only from a functional point of view. Other software products that ought to be mentioned is Ableton Live [4], which we also use in this project, and Propellerhed Reason [5], which shares some of the functionalities of Garageband as well as also being very user friendly.

3.1. Technological Products and Concepts

Gil Weinberg, the director of the music technology programme at Georgia Tech, made the Beatbugs [6], which are hand-held percussive instruments that allow the creation, manipulation and sharing of rhythmic motifs through a simple interface. The Beatbugs (Figure 3) can be connected in a network, thereby letting the players form large-scale collaborative compositions.

Sony Block Jam [7] is a musical interface controlled by the arrangement of 25 tangible blocks. By arranging the blocks (Figure 4) musical phrases and sequences are created, allowing multiple users to play and collaborate. The system takes advantage of both graphical and tangible user interfaces.

Figure 4. Sony Block Jam.

Percussa AudioCubes [8] as shown in Figure 5 is a tangible user interface allowing sound designers and music trainers to intuitively explore and create dynamically changing sounds. A new sound is created manipulating cubes, changing their orientation and distance.

Figure 5. Audiocubes.

Besides the technologies mentioned above, a concept named RoboMusic [9] has been developed by Henrik Hautop Lund and Martin Ottesen. In RoboMusic, a number of robotic devices are used as instruments and the tunes are composed as a behaviour-based system. The RoboMusic concept supports the things presented in this article on the behavioural level although in another scenario.

4. Musical Scenario

We wanted to create a scenario where children can experiment freely with music composition, using a set of already composed pieces in different musical genres. As mentioned in the introduction our goal was not to teach children to make their own music from scratch, but instead to teach them the characteristics of different genres as, for instance, jazz genres, rock genres etc. which is an important part of teaching musical comprehension.
Using the specifications described above as a starting point we have tried to design an interaction scenario, where the user identifies the functionality and behaviour of the I-BLOCKS through musical feedback. So it has been a goal for us to make the different musical pieces distinguishable in order to make the user truly perceive the system.

The music created by the user is computed and played back on a PC, using the Ableton Live © music software as a playback unit responding to midi messages coming from the I-BLOCKS. In order to allow the blocks to “talk midi” to a PC we have made a wireless device, named “Midi Box” that converts serial wireless data coming from a XBEE-enabled I-BLOCK into midi signals. By using wireless technology we allow users to manipulate the blocks freely just like conventional building blocks.

The pieces of music that has been made for this project have all been constructed using these rules: There are six predefined instruments (varying according to genre) and within each piece of music there are up to six variations per instrument, and there can be an unspecified number of different instruments. When the user grabs an I-BLOCK, representing an instrument, the block’s orientation - which side is facing down - determines the variation of that specific instrument. The I-BLOCK LEDs change colour depending on their orientation, in order to make it possible for the user to remember and activate specific variations. Each of the instrument I-BLOCKS has been given a colour to represent a specific instrument. For instance, the colour coding for a rock number has been implemented as follows:

- **Red**: Drums
- **Blue**: Bass
- **Green**: Keyboard
- **Yellow**: Guitar
- **Cyan**: Melody
- **Pink**: Human (Vox)

The colours are all easily distinguishable from a user’s point of view.

The musical setup can be seen from Figure 6. Note the black XBEE-enabled I-BLOCK, which communicates wirelessly with the Midi Box, and therefore has to be present in every construction, in order for the PC to generate any music.

![Figure 6. Music setup with I-BLOCKS, Midi-box and PC.](image)

The music style of the pieces created so far includes rock, funk, jazz, reggae, rockabilly, surf-rock, pop and hip-hop of the 80s. The music is mainly loop-based, meaning that when active, each variation of each instrument is playing a certain time and then repeating itself over and over until it is finally deactivated when the user removes the current instrument I-BLOCK from the structure or shifts its orientation.

A short example: A user connects a yellow guitar I-BLOCK to the black XBEE-enabled I-BLOCK. Immediately the PC-music software starts playing one of six guitar tracks depending on how the block is rotated when connected. Another user might then add a red drum I-BLOCK to the structure, which will additionally start a drum track in the music. More instruments can be added, and others removed, and if the user chooses to rotate the entire structure, all the instruments present will start playing a different variation.

This manipulation with musical pieces is a kind of “sampling in real time” which is known from music software on computers (e.g. Ableton Live and Garage Band). The difference between such software and RoboMusicKids is, of course, the physical building-blocks that allow for a more intuitive hands-on approach.

**5. Scenario Extensions**

In order to expand the ways the users can interact with the music to change the general sound of the compositions and also as a means to possibly involve more users in the composition process, we have come up with two extensions to the general scenario described above. Both of these come in the form of XBEE-enabled I-BLOCKS.

The first extension is a guitar-solo instrument I-BLOCK. The user interacts with this block by shaking it and thereby activating solo-tracks in the music. The harder the block is shaken, the more “intense” the sound of the chosen guitar-solo track, increasing in both note speed and tonal range. The level of shaking is also indicated on the I-BLOCK LEDs, which are fading from green to red depending on the shaking...
rate. We make use of the built-in accelerometer to detect the shaking of the block.

This kind of shaking interaction is meant to physically activate the user, making her activity level directly readable from the music as well as giving her the impression of actually being part of the music and thereby enhance the user’s comprehension. This is particular the case in genres like rock and jazz, where solos and improvisation often are significant characteristics.

The second extension is named the effect I-BLOCK, and as its name might indicate, it can be used to turn up and down specified effects anywhere in the music. The effect I-BLOCK is currently influencing the melody part of the music, turning up and down effects such as cut-off frequency, harmony, resonance and portamento, depending on which melody variation is currently playing. Using the effect I-BLOCK, the user has the possibility to alter the music in more or less audible ways, again making her interaction directly influencing the music.

6. User Experiments

During the development of the music integrated in the I-BLOCKS we ran a number of tests and experiments in order to figure out how users responded to the music as well as the way in which the blocks enabled them to navigate this. The following section focuses on two experiments carried out in an after-school centre and presents some of the observations we made in the execution of these.

6.1. After-school experiments

We carried out two user experiments at an after-school centre (see Figure 7) which were of an explorative nature, as our focus was towards discovering ways to improve both the music implemented in the I-BLOCKS and ways to experiment with this as well as discovering the projects’ potential regarding musical comprehension, learning and creativity. The participating children, aged between 10 and 12, were divided into groups of four. Some of these groups consisted of only boys or girls and some were mixed groups. Some of the children had prior experience with formal instrumental music tuition while others had little or no experience. All group sessions were recorded on video.

![Figure 7. After-school experiments in Birkerød](image)

The following is a description of some of the main findings as observed in the participants’ use of the I-BLOCKS. In this description an overall pattern regarding the structure of events observed in each session is presented, serving also as a possible outline of the learning process among the participants.

6.2. Description of the sessions and their overall structure

Reviewing the recorded sessions, we were able to roughly divide each group session into three steps or phases. As hinted above, the mentioning of these steps serves as a description of the actual use of the I-BLOCKS as well as a framework for the later mentioning of perspectives in regard to music-making and musical experimentation with new technology. The three steps observed in the experimental sessions are as follows:

1. **Exploratory use.** Together as a group the children explored different ways of connecting the I-BLOCKS and the different musical segments and variations. This step was characterized by the children’s fascination of the technology itself and the fact that by combining the I-BLOCKS they were able to initiate music. Everyone in the group would at this point actively connect and disconnect blocks and turn the structure around in an exploratory manner. No particular interest in the qualitative musical output and the actual combination of instruments and musical loops was apparent. The main interest among the children at this point was to activate and “checking out” the different loops, and - to a certain degree - find out which colours represented which instrument or sound.

   As in many other regards, exploration of something - for instance a toy that one is not familiar with - is a natural approach. Therefore the explorative way in which the participating children approached this new toy was to be expected. What we saw was children employing the basic learning principles, which leading education theoreticians like Piaget, Dewey, and...
Vygotsky have described as, for instance, “active learning”, “hands-on learning” and “experimental learning”, and which they have pointed to as fundamental for children’s learning. [10]

Of particular interest is the observation of cooperation as well as turn-taking among the participants during their further exploration and music-making, as described in the following.

2. Collaborative music-making. Following the exploratory phase, the children started to pay more attention to the actual musical output of their collaborative use of the I-BLOCKS. Typically this involved discussion among the participants regarding which instruments were audible during their construction of a structure and which variation of this particular instrument they preferred. Typically one participant would start off by connecting an I-BLOCK as a starting point, choosing a loop that they were particularly fond of. Another participant would connect another block, choosing a loop which they felt accompanied the first loop. From here on the group would experiment with the different loops and the structure of the blocks. At times this involved turning the entire structure around and thereby changing the entire musical output, and at other times turning single blocks, changing only the musical output of this particular instrument. The music-making and the learning approach in this phase were still very much a collaborative effort, but did, however, at this point involve a key element of turn-taking allowing the participants to single-handedly control the blocks and the position of the structure, having the other participants suggesting changes and supplying ideas.

3. Individual music-making. In each session we encouraged the participants to create their own musical piece or “mix” (Figure 8), having complete control over the blocks. At this stage it was particularly clear that I-BLOCKS served as a useful tool for musical expression, composition and performance. To a varying degree the participants would examine each block to choose the instrument variation they wanted to use and be very selective in this process. Often they would leave one or two blocks out of the mix in order to receive the output or sound they wanted, avoiding the overall mix getting clustered or “muddy”.

Some participants would start off by creating a combination of instruments and loops that they found fit together and subsequently change the entire structure, serving as another development of the song or tune. This resulted in a series of combinations of loops compromising not just a single mix but several developments of a tune. Also, when experimenting with the ‘rock’ tune, one participant would create an arrangement consisting of several different variations of loops and switching between these by moving the structure of the blocks around, while the other participants took turns to “play” the guitar solo, making up a jam session with the I-BLOCKS.

A striking observation made during these experiments was that every participating child was able to create their own musical piece within the short time of a session (lasting approximately 15 minutes). Everybody participated in collaborative as well as individual music-making and completed the task of creating a mix of their own, regardless of prior experience with instrumental music tuition.

7. Music-making with new technology

Traditionally, being able to express oneself musically and engage in musical activities involving the production of sound, is somewhat determined by one’s ability to play an actual instrument. In order to produce sound with an instrument one must possess a minimum of skills in regard to the actual handling of the instrument. In order to compose or in other ways carry out musical ideas a certain degree of craftsmanship and experience is needed [11][12].

As technological development and research generates different possibilities in approaching music-making and musical experimentation, new paradigms of musical expression, comprehension and creativity are formed. While technology plays an important role among musicians, for example in regard to recording...
music or performing music utilizing different technological tools, the development of sequencer programmes (Steinerg Cubase, Apple Logic etc.) as well as different types of midi controllers (e.g. midi keyboards, electronic drum kits, Korg’s Kaossillator and new interfaces such as Zoundz, The Samchillian, Beat Bugs etc.) has had an important impact in regard to musical play among children and in music teaching in general. In the following we wish to point out some of the possible advantages linked to the use of new music technology, both in music education and out of school.

Norwegian professor of musicology and music education, Petter Dyndahl, has emphasized how “new” technology, for instance sequencing programmes or the midi standard as such, has made new ways of approaching musical creativity possible. According to Dyndahl a digital representation of music on a computer allows us to “mould directly” in the authentic, timbral substance [13], which brings to mind conceptions of music as a physical, mouldable object. Like modelling-wax – flexible and manageable in the hands of the user.

Sequencing programmes, for instance, allow us this kind of flexibility. We can record music of our own, sample existing recordings and manipulate sounds in an infinite amount of ways. Utilizing technology in the creation of music, we may experience a shortening of the distance between an idea and its actual aural representation. In fact, technology may even allow the non-musician access to a creative process involving music in ways previously unimaginable. Of particular interest in regard to musical expression and comprehension is the notion that by utilizing technology, such as musical toys or a computer, we may be able to express ourselves through music, and by doing so reveal skills of aesthetic sensitivity, originality or tonal imagery otherwise hidden as a result of lack of craftsmanship (Webster 1987). The music teacher may realize that pupils who have troubles developing instrumental skills or may lack interest in taking up an instrument, actually possess skills in regard to knowledge of musical genres, having a well-developed sense of aesthetics in music or being very original in their musical expression when utilizing “untraditional” tools in their creation of music.

While projects such as the aforementioned Beat Bugs or the Audio Cubes allow the user to create rhythmic patterns or experiment with harmonic and timbral sound material, the RoboMusicKids project aim to allow children to experiment and manipulate with pre-recorded musical sequences or elements, reminiscent of the way a DJ remixes existing tracks. The I-BLOCKS serve as a multi-track mixer giving the user complete control over the progression and overall mix and arrangement of the track. Furthermore, I-BLOCKS allow the user to isolate the separate elements of a musical piece, making it possible for him or her to understand the sound and musical role of different instruments, both in regard to musical arrangement and mix and in regard to music history, traditions of musical genres and sub-genres, technological possibilities in connection to studio equipment and the recording of music and so forth.

8. Conclusion

I-BLOCKS make it possible for the user to rearrange and manipulate musical elements and create an original musical output. In our experiments we found that the participants were aware of how they wanted their finished musical piece to sound, and were very selective in the process of “building” this. While music technology in some cases holds the risk of allowing us to simply generate a musical product and bypass the actual creative process, our experiments showed that even when utilizing a basic setup of six variations on six different instruments, the participants to a great extent were still able to express themselves creatively. This is not to say that the cubes allow users to make music as if they were composers, but the project does, in our opinion, show a possible direction for future development of musical teaching and learning.

Utilizing music technology in music education and out of school, may give children, or adults, the opportunity to be musically creative and create understanding of musical phenomena and structures. I-BLOCKS represent an intuitive approach to music, both in regard to musical expression as well as musical comprehension and understanding. In the hands of the user, the I-BLOCKS turn music into a mouldable element due to their modular nature, allowing the user to explore its possibilities in a creative and playful way and serve as an intelligent tool that is manageable and flexible in regard to its user’s approach to creativity and learning. Also, the modular nature of the I-BLOCKS ensures that this system is easily expandable and our hope is that this will in turn enable us to provide more flexibility and freedom for the user in his or her experimentation with the music.

9. References


The effects of digital games on undergraduate players’ flow experiences and affect

Yu-Tzu Chiang, Chao-yang Cheng, and Sunny S. J. Lin
Institute of Education National Chiao Tung University, Hsinchu, Taiwan
yuts0913@gmail.com, happyglobe.tw@gmail.com, sunnylin@faculty.nctu.edu.tw

Abstract

The purpose of this study is to investigate the effects of digital games on undergraduate players’ flow experiences and affect. Our findings suggested that both violent and nonviolent digital games would evoke undergraduate players’ flow experiences and positive affect. Digital games may not arouse participants’ real life aggression regardless of playing violent or nonviolent digital games. Undergraduate participants’ flow experiences and positive affect after playing nonviolent digital games were higher than playing violent digital games. The authors suggested that experimental designs and sex in the participants’ composition would have impacts on our results. The limitation was discussed as well.

1. Introduction

The purpose of this study is to investigate the effects of digital games on undergraduate players’ flow experiences and affect. The popularity of digital games is phenomenal, with annual revenues from video games worldwide surpassing those of the film industry [1]. There is no doubt that digital games indeed give players short term relaxation and playfulness. Echoing the advocacy of positive psychology [2], in recent years some researchers have supported positive effects on various digital games, including flow experience [3], intrinsic motivation and positive mood[4]. Ferguson’s [5] studies of video game violence suggested that there were no evidence for the hypothesis that violent video game playing was related to higher aggression. Accordingly, the authors sought to investigate the positive effects of digital games. Csikszentmihalyi [6] supposed that flow, the optimal experience, was one of the phenomena in the field of positive psychology. Flow refers to a state that someone concentrates completely on a pleasant activity. Digital games per se have many features that encourage states of flow, such as providing rich immediate feedbacks to player actions, enjoyment, playfulness and appealing to players’ attention. These characters are inclined to arouse players’ flow experience. Accordingly, the authors attempted to examine the effects of digital game on players’ flow experiences. Csikszentmihalyi [6] suggested flow would arouse people’s positive affect. The authors sought to examine whether flow in digital games would evoke players’ positive affect as well. Chumbley and Griffiths [7] found that different contents in digital games would arouse different affective responses. Accordingly, the present study would like to explore whether the contents of digital games (violent versus nonviolent) would cause negative effects on players’ flow experiences and positive affect.

The purpose of this study is to investigate the effects of digital games: flow experiences and positive affect after playing violent versus nonviolent digital games. We expected that digital games will contribute flow experiences and positive affect to players, but players’ aggression would not be evoked after playing violent and nonviolent digital games. The authors supply a comparative test of two target games: violent versus nonviolent, the participants reported their flow experiences, positive affect and real life aggression after play sessions. In order to ensure the successful manipulate, an advance examination for participants’ initial emotion state and appraisal of the playful traits of target games were conducted. The research questions are in the following section.

Is the pretest of participants’ emotion before playing violent versus nonviolent games different?
Are the playfulness traits of target games and flow experiences in playing two games different?
Are positive affects and aggression thought after playing two games different?

2. Method

2.1. Samples and Procedure

A sample of 30 (11male; 19 female) undergraduates at National Chiao Tung University in Taiwan participated in return for research credit in their educational psychology course. The repeated-measures designs were used to assign each participant to play the target violent and nonviolent digital games. The 30 participants were randomly divided into two groups
(Group A and B). Group A (16 participants) were assigned to play the target violent digital game and group B (14 participants) were assigned to play the target nonviolent digital game. Two weeks later, group A was assigned to play the target nonviolent digital game and group B was assigned to play the target nonviolent digital game. In each experimental process, firstly, they were asked to complete the emotion pretest questionnaire, then to learn how to operate the target games, and finally to complete the other questionnaires after a 30-minute play session.

**Target digital games**

*Violent game*: “Grand Theft Auto”. The game assigns a player to be a criminal in a big city. Various missions are set for completion by the figureheads of the city underworld, generally criminal, which must be completed to progress through the storyline.

*Nonviolent game*: “Super Mario, Crazy Racing”. In the game, the characters from the Mario series of videogames and race go-karts around a variety of tracks.

**Questionnaires**

The authors developed questionnaires consisting of items designed to collect the emotion pretest [8], digital game playfulness traits [9], flow in games [10], positive affect [10], and the real life aggression [11]. The authors used item analysis to delete items to ensure the reliability of the scale. The reliability coefficients (Cronbach’s alpha) of emotion pretest were .78. One item in the scale of was omitted. The reliability coefficients (Cronbach’s alpha) of scale digital game playfulness traits were .83. The reliability coefficients scale of flow in games and positive affect (Cronbach’s alpha) were .91, and .84 for the two scales. Two items in t were omitted, and the reliability coefficients of the scale real life aggression (Cronbach’s alpha) were .88.

### 2.2 Statistical analyses

In order to examine the manipulation, the participants were asked to report their initial emotional state and the appraisal of playfulness for the two target games. The paired t-test measures were used to examine whether means from a within-subjects test group vary over the scores reported from scales of emotion pretest, digital game playfulness traits, flow in games, positive affect, and real life aggression after participants playing violent and nonviolent digital games.

### 3. Results

The T-test of violent and nonviolent games was depicted on Table 1. The participants’ mean scores in emotion pretest were under the midpoints (equal to 4 points) in the scale before playing violent and nonviolent games. The participants reported lower appraisal of playfulness trait for violent games than the midpoints (equal to 4 points) in the scale, but they reported higher appraisal of playfulness trait for nonviolent games than the midpoints (equal to 4 points). The participants reported higher scores than the midpoints (equal to 4 points) in the scale of flow experiences and positive affect.

<table>
<thead>
<tr>
<th></th>
<th>Violent games M</th>
<th>Violent games SD</th>
<th>Nonviolent games M</th>
<th>Nonviolent games SD</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotion Pretest</td>
<td>3.12</td>
<td>0.82</td>
<td>3.20</td>
<td>0.82</td>
<td>-0.58</td>
</tr>
<tr>
<td>Game Playful trait</td>
<td>3.98</td>
<td>1.47</td>
<td>4.38</td>
<td>1.02</td>
<td>-1.26</td>
</tr>
<tr>
<td>Flow Experiences</td>
<td>4.08</td>
<td>1.28</td>
<td>5.38</td>
<td>1.11</td>
<td>-5.22***</td>
</tr>
<tr>
<td>Positive Affect</td>
<td>4.30</td>
<td>1.45</td>
<td>5.67</td>
<td>1.08</td>
<td>-4.07***</td>
</tr>
<tr>
<td>Real life Aggression</td>
<td>2.33</td>
<td>0.95</td>
<td>2.33</td>
<td>0.95</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

* p < .05  ** p < .01  *** p < .001

The findings of paired t test measurements indicated that there were no significantly differences between participants’ emotion pretest and appraisal of playful traits for target digital games. The findings could be used for manipulate check to ensure that participants’ the initial emotion and appraisal of the playfulness traits for the two target games were not different, comparing the follow-up measurement: flow experiences, positive affects and real life aggression.

There were significant differences in flow experiences and positive affect between playing violent and nonviolent target games. Participants reported higher scores in flow experiences (M=5.38 vs. 4.08) and positive affect (M=5.67 vs. 4.30) after playing the target nonviolent game than after playing the target violent game.

Finally, the two group participants reported much less scores (M=2.33 vs. 2.33) in the scale of real life aggression than the midpoints (equal to 4 points). There were no significant differences in real life aggression after playing violent versus nonviolent target games.

### 4. Discussion
The results of study showed that playing both violent and nonviolent digital games could arouse participants’ flow experience and positive affect. In addition, participants reported significant higher scores in flow experiences (M=5.38 vs. 4.08) and positive affect (M=5.67 vs. 4.30) after playing the target nonviolent game than after playing the target violent game. Echoing the findings of Chumbley and Griffiths [7], they found that different contents in digital games would arouse different affective responses. Our finding also appeared that violent digital games could not arouse players’ higher positive affect than nonviolent digital games. The mean scores of real life aggression between the violent and nonviolent games were under the midpoints of responses. In addition, there were no significant differences in real life aggression after playing violent versus nonviolent target games. The results may explain that digital games could not evoke real life aggression regardless of violent or nonviolent digital games. Along with Ferguson’s [5] research, our findings suggested that violent digital games were not associated with aggression and there might be publication bias on negative effects of violent digital games.

5. Limitation

Csikszentmihalyi(1990) suggested scholars to use the experience sample method to explore the human’s flow experiences. In the current study, using an experiment and survey to investigate the flow experiences in digital games may not reflect the delicate and immediate appearance of players’ flow experiences. The participants may report their belief in game experiences, but did not reflect the experiences of the moment while playing. Researchers have suggested violent digital games will produce negative effect on adolescents, our samples were college students: late adolescents. They are possible mature enough to differentiate between good and evil from the digital games. The negative so-called negative effects of violent games were decreased. In addition, although the addicted players were not investigated here, it was possible that few samples were addicted. Addicted players’ short term positive affect aroused by digital games may have impacts on our data analysis. The future research could design another experiments or use experience sample method to improve the construct validity and the reliability.

6. Acknowledgement

This research work is supported by ‘Net and Taiwan Adolescents’ Physical and Mental Development (NeTAPAMD)” (No. NSC 97-2631-S-009-001) which is a branch under national wide project, “Taiwan E-Learning and Digital Archive Program,” of Taiwan.

7. References


The Learning Environment for Stars and Constellations in the real world with Finger Pointing

Masato Soga  
Faculty of Systems Engineering, Wakayama University  
soga@sys.wakayama-u.ac.jp

Masafumi Miwa  
Department of Mechanical Engineering, Faculty of Engineering, Tokushima University

Koji Matsui  
Now Production, Co.,Ltd.

Kazuki Takaseki  
Koza Highschool

Kohei Tokoi, Hirokazu Taki  
Faculty of Systems Engineering, Wakayama University

Abstract

We developed learning environment for stars and constellations with finger pointing under real night sky. This environment has some functions. First function is star name telling function. When a learner points a finger at a star with the sensor on his/her finger top, the system tells him/her name of the star and constellation with voice. Then, second function is star navigation function. If the learner know the name of a star, but he/she does not know where it is in the real sky, the system shows the path from current pointing position to the target star. These two basic functions can be used by single learner, but also used collaborative learners. Third function is constellation tutoring function. The system asks questions about stars and constellations to learners. A learner answers the question by pointing at real star, and then the system corrects it. This function can be used for collaborative learners. Fourth function is collaborative focus point indication. Every learner uses each learning environment for his/her own, and every learning environment communicates each other. Every environment indicates the other learner’s pointed star. Learners can know easily where the other learner points a finger at in the sky, and collaborate learning easily.

1. Introduction

Astronomy is a domain where high technology can assist learners understanding, since learners cannot touch the real celestial bodies in hand. Several learning environments were developed by using web, Internet, computer graphics and so on.

As a learning environment for constellations, a planisphere type astronomy learning environment based on a structured constellation database were developed on web using Ajax [1]. Also, a multi-platform contents management system for online constellation learning is developed [2].

As a learning environment by using telescope, [3] is the first remote telescope in the world that supplies live picture of celestial bodies by Internet. Learners were able to control remote telescope from web user interface. Learners in Germany controlled remote telescope located in Japan, and they watched live picture of the moon by using time difference between Japan and Germany [4].

On the other hand, simulator by computer graphics can assist understanding of astronomy, since the object is too large and too far away to see in the real world. Several simulators were developed for astronomical education. Astronomical VR Contents [5] can simulate traveling from the earth to the universe like traveling by spaceship. Stella Navigator is an astronomical simulator produced by Astroarts co. ltd [6]. It simulates night sky in any time,
at any place. It can simulate astronomical phenomena only from the earth viewpoint.

As research on a method of expression of space phenomena with CG animation, the collision of the comet Shoemaker-Levy 9 with Jupiter in July 1994 is simulated [7].

Mitaka is a simulator developed in 4D2U project by National Astronomical Observatory of Japan [8]. It simulates seamlessly from the earth to the end of the universe at 13.7 billion light years away like traveling in the universe. A learner can select a target celestial body from menu, then, he/she can travel virtually between the target celestial body and the end of universe. Planets, moon, and some famous stars are prepared for the target celestial bodies. Mitaka is very excellent software to understand the universe from the solar system to the end of the universe. It shows distance from the target celestial body, so that the learner can know the size of every structure in the universe.

Such various learning environments can be classified into two group. One is learning environment only in the virtual world. Virtual world here includes not only 3D world in a PC but also 2D contents in PCs. [1][2][5][6][7][8] are classified into this group. On the other hand, the other group is learning environment that enhance observation in the real world. [3] is classified into this group.

It is important to observe real objects and real phenomena to learn science, because learners can understand not only the target objects or phenomena, but also understand the objects or phenomena in the real world with surrounding conditions and sceneries as an experience. The learning environments only in virtual world cannot assist such understanding. Most of developed learning environments use learning contents only in virtual world. The system asks a question to learners by using contents only in PCs, then the learners answer the question by putting in the answer in a blank or select an answer on PC monitor. Such learning environment can help understanding to some extent, however, learners cannot understand it as real experience. Therefore, it is important to learn science with contents in real world.

Although various learning environments are developed, there is few learning environment that connects virtual world and real world. In this background, we developed a learning environment that connects virtual world with real world in the domain of stars and constellations. Specifically, we developed the star learning environment with finger pointing, using real night sky as learning contents. When a learner points at a star with the magnetic sensor on his/her finger top, the system tells him/her name of the star and constellation with voice. Also, the system asks a question to the learner about stars and constellations, and then the learner answers the question by pointing at a star in the real sky.

Furthermore, we developed collaborative learning environment by using two sets of the system and communication technology between them. Two learners use the star learning environments of their own, and each pointed place on the sky is indicated on virtual planetarium on each monitor of their own. They can know where the other learner points a finger at on the sky, and they can collaborate to learn stars and constellations.

Our learning environment can be used novice learners of stars and constellations from elementary school to adults.

2. Virtual planetarium

We developed planetarium that works on PC. We call it virtual planetarium. Virtual planetarium is the basic software module of whole learning environment. We designed it not only for using it independently, but also for using it with finger pointing action described later. Virtual planetarium simulates celestial sphere from the viewpoint of a learner on the earth. It is realized by 3D graphics: stars and constellations are put on 3D sphere. The system calculates rotation angle of the celestial sphere using location data (latitude and longitude), time and date. Then the system displays the virtual planetarium by rotating the celestial sphere appropriately. It results in showing correct sky with constellations in accordance with real sky at that time. The virtual planetarium simulates not only usual stars that consist of constellations, but also planets that move through constellations.

A learner can see a part of the virtual planetarium on PC monitor. He/she can move the virtual planetarium by dragging it with mouse. Virtual planetarium shows a small circle at the center of PC monitor. When a star enters in the circle, virtual planetarium tells its name with text and voice by text-to-speech software. Also the constellation name of the star is announced with voice. Figure 1 shows a scene of the virtual planetarium.

![Figure 1. A scene of virtual planetarium](image)
3. Star name telling function

We developed star name telling function that is presented with magnetic 3D position sensor Isotrak2 produced by Polhemus Co. Ltd. Figure 2 shows the system composition. Isotrak2 is shown in the right part of figure 2. Isotrak2 consists of transmitter and two receivers. Position data of two receivers are transferred to PC in real time. The learner puts one receiver near his/her eye, and puts another receiver on his/her finger top as shown figure 3. When he/she points a finger at a star in the sky, the system calculates the direction vector by subtracting those two position vectors.

![Figure 2. System composition for star name telling function](image)

Figure 2. System composition for star name telling function

Figure 4 shows system modules and workflow. The system has star database that stores position data and names of stars and constellations. The system compares the direction vector with star position data in the star database. Then the system identifies the star pointed out by the learner. After that, the system shows the name of the star and the constellation with text and also with voice by text to speech software.

![Figure 4. Components and workflow of star name telling function](image)

Figure 4. Components and workflow of star name telling function

4. Star Navigation function

If a learner knows the name of target star without knowing where it is in the sky, the system shows path from current position to the target star. The system supports two mode to show the path. One is direct line navigation, and the other is star traveling navigation.

4.1. Direct line navigation

Direct line navigation is the simplest. The system shows direct line from current position to the target star in the virtual planetarium. The learner can easily and rapidly find the target star just by tracing the line (Figure 5).

![Figure 5. Direct line navigation](image)

Figure 5. Direct line navigation
4.2. Star traveling navigation

If the purpose of finding a target star is just finding it, the direct line navigation is the best way. However, if the purpose is not only finding it but also learning relative positions between stars in the sky or learning constellations, the direct navigation is not appropriate. Star traveling navigation can achieve the purpose. In the star traveling navigation, the system shows a path through some bright stars from current star to target star (Figure 6). Since the learner can recognize some bright stars before reaching the target star, he/she can learn names of those stars and those constellations. Also, he/she can learn relative positions between those stars and relative positions between constellations.

5. Constellation tutoring function

A constellation consists of several stars. Some stars in a constellation are connected each other, and forms a shape of the constellation, such as human, animal, bird, tool and so on. It is necessary for a learner to know which star forms which part of the constellation. Constellation tutoring function trains the learner to have such knowledge. This function is used for collaboration by two learners as shown in figure 7. A learner is a novice (learner 1). The other learner is a helper (learner 2). A teacher could play a role of learner 2. The workflow of the function and process of collaborative learning are as follows.

The learning environment shows a problem concerning a star in a constellation on the PC monitor. Specifically, the problem manager of the learning environment requires the learner 1 to point at the star that is adaptive to the explanation shown by the system. Then the learner 2 reads it, and tells it to the learner 1. Learner 1 answers the problem by pointing the target star with finger. The information of pointed star is sent to the module for diagnosis of learner’s answer. The module decides whether the pointed star is correct or wrong, and shows it on the monitor. Learner 2 reads it, and tells it to the learner 1.

Learner 2 can know always where learner 1 points a finger at in the sky by watching the monitor, because virtual planetarium is always displayed on the monitor, and the center of the monitor always accords to the place where learner 1 points a finger at on the sky. So, learner 2 can assist learner 1. If learner 2 knows where the target star is in the sky, he/she can help learner 1 to point a finger at it by watching the monitor.

If the answer is correct, the problem manager shows next problem concerning the same constellation. If the answer is wrong, the system requires the learner to try the same problem repeatedly. If both learners want to give up, learner 1 can find the target star by star navigation function described chapter 4.

By answering the problems, the learner can point a finger at stars in turn that forms the constellation. For instance, constellation Cygnus consists of some bright stars forming a shape of swan. First, the learning environment requires the learner 1 to point a finger at the star located at the bill of Cygnus. Then, when the learner 1 points a finger at the star correctly, the system tells him/her to point a finger at the next star located at the body of Cygnus (Figure 8).

In detail, the learner 1 must push the button of Wii remote controller to fix the star as the target star in the constellation. If the learner points a finger at and fixes wrong star, the system shows that it is wrong star.

Thus, the system always tells the learner information of part in the constellation such as bill, head, tail, etc. By pointing the correct star following the indication, the learner can relate the star to the part of the constellation.

Figure 9 shows the interface for constellation tutoring function. We use not only two sets of receivers of Isotrek2, but also Wii remote controller instead of mouse button. We put a small ring on every receiver to make it easy to keep the eye vector toward the target star. Wii remote controller can communicate with PC by bluetooth. This enables the learner to push buttons of Wii remote controller in any position in the space. Wireless mouse can be also used instead of Wii remote controller. We don’t use orientation sensing function of Wii remote controller, because Wii remote controller has only acceleration sensor. So Wii remote controller cannot measure absolute orientation. Wii remote controller can only measure comparative angle from calibrated orientation. It means that Wii remote controller stores orientation errors as a learner uses it for a long time.

Figure 10 shows a scene of using constellation tutoring function.
6. Collaborative focus point indication function

As described chapter 5, if one of two learners can play a role of helper, they can collaborate learning by using constellation tutoring function. However, if both of them want to use star name telling function simultaneously and they are far away each other, they cannot use constellation tutoring function. In this background, we developed focus point indication function.

Focus point indication function is used by two learners located away each other. Focus point indication function shows direct line from learner’s current pointing star to the other learner’s pointing star in the virtual planetarium. Since it is not easy for a learner to point a finger at target star and watching PC monitor alternately, he/she is recommended to use single head mount display (SHMD). Figure 11 shows one set of the system for focus point indication function.

However, we don’t make an effort to put stars of virtual planetarium onto stars in the real sky precisely, because it is very difficult to do it, since stars are located as points. Even though SHMD only plays a role of showing PC monitor in the learner’s view, it can relieve
the learner of watching desktop monitor and real sky alternately.

Figure 12 shows components and workflow of focus point indication function. In this figure, two sets of star name telling function are prepared, and both virtual planetariums communicate each other, and exchange star numbers of the pointed stars which every learner points a finger at. Then, focus point indication function shows direct line on the virtual planetarium from learner’s current pointed star to the other learner’s pointed star as shown figure 13. Every learner can know which star the other learner points a finger at currently by tracing the line. If they use mobile telephone or voice communication software, they can collaborate to learn stars and constellations using real night sky.

Collaborative focus point indication function can be used in principle by learners even if they are located very far away each other, for instance, 2000km away between Hokkaido and Kyushu. Necessary condition is that both learners must share the same area in the real night sky. So, it is impossible to use collaborative focus point indication between opposite points of the earth, but usually it is possible to use it with high-speed network between neighbor countries located several hundreds kilometers away each other.

On the other hand, collaborative focus point indication function is also useful for learners located only few meters away. It is quite difficult for a learner to know where another learner points a finger in the sky, even if they are standing only few meters away each other. Actually, we evaluated the collaborative focus point indication function by interview with 14 learners who used the function standing few meters away. We used DataGlass2A as SHMD. All learners admit the effectiveness of the collaborative focus point indication.

Figure 13. Views by focus point indication function

7. Evaluation

We evaluated the learning environment. Subjects were 20 students in Wakayama University in Japan. They were novice learners about constellations. After they used the learning environment, they answered questionnaire. The questions were about usability and effects of the learning environment. Questions were as follows.

Q1. Physical feeling of fatigue
Q2. Spiritual feeling of fatigue
Q3. Usability of finger pointing
Q4. Usability of SHMD (Data Glass 2A)
Q5. Effect of direct line navigation
Q6. Effect of star travelling navigation
Q7. Effect of voice guidance
Q8. Effect of collaborative focus point indication
Q9. Effect of star name teller function
Q10. Interest of learning by the learning environment

Students answered every question by selection from five points. Most negative answer is 1 point, and most positive answer is 5 point. 3 point is average.

Table 1 shows the results of the questionnaire. Every number in the table shows the number of students who selected the point. Most right column shows average points of every question.

Q1-Q4 are questions about usability. Results are less than average except Q2. About Q1 result, finger pointing demands to hold out learner’s arm. It makes learners tired. About Q4, we used DATA Glass2A produced Shimazu co.ltd. as single HMD. This SHMD is quite uncomfortable to put on. Also, it cannot adjust brightness of its monitor. Therefore, it made learners tired.

Q5-Q9 are questions about effects. Results are more than 4 point, and it means that most learners thought every function of the learning environment were effective.

Q10 is a question about edutainment. Most of learners thought the learning environment was interesting.
7. Conclusion

In this paper, we described collaborative learning environment for learning stars and constellations by using real night sky with finger pointing.

We developed four functions. First function was star name telling function. When a learner points a finger at a star with the sensor on his/her finger top, the system tells him/her name of the star and constellation with voice.

Then, second function was star navigation function. If the learner know the name of a star, but he/she does not know where it is in the real sky, the system shows the path from current pointing position to the target star. These two basic functions can be used by single learner, but also used collaborative learners.

Third function is constellation tutoring function. We developed guidance and diagnosis function of constellations’ shapes. This function can be used for collaborative learners.

Fourth function is collaborative focus point indication. Every learner uses each learning environment for his/her own, and every learning environment communicates each other. Every environment indicates the line to the other learner’s pointed star. Learners can know easily where the other learner points a finger at in the sky, and collaborate learning easily.

We evaluated the learning environment by questionnaire after using the environment. The results of usability were not so good. Usability will be able to change devices to other ones. On the other hand, the results of effects of the environment were good.

Our future work is to refine pedagogical strategy for constellation tutoring function.

References


<p>| Table 1. Result of the questionnaire |</p>
<table>
<thead>
<tr>
<th>1pt</th>
<th>2pt</th>
<th>3pt</th>
<th>4pt</th>
<th>5pt</th>
<th>Ave (pt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>5</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>Q2</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>Q3</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>2.85</td>
</tr>
<tr>
<td>Q4</td>
<td>0</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>Q5</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>14</td>
<td>4.7</td>
</tr>
<tr>
<td>Q6</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>4.45</td>
</tr>
<tr>
<td>Q7</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>16</td>
<td>4.1</td>
</tr>
<tr>
<td>Q8</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>4.65</td>
</tr>
<tr>
<td>Q9</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>12</td>
<td>4.6</td>
</tr>
<tr>
<td>Q10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>
The Scope of Adaptive Digital Games for Education

Rikki Prince, Hugh C. Davis
Learning Societies Lab
School of Electronics and Computer Science
University of Southampton
{rfp07r,hcd}@ecs.soton.ac.uk

Abstract

In learning technologies, there is a distinct difference between the user sequencing in a system based on IMS Simple Sequencing and an Adaptive Hypermedia system. This range of possibilities is important to consider when attempting to augment educational games with adaptive elements. This poster demonstrates how truly adaptive games could be designed and discusses why this is useful in the field of education.

1. Introduction

This poster presents the concept of fully adaptive digital games for education. Although there have been a number of research papers about educational digital games which adapt to the player, they could be considered quite reserved in the amount of adaptivity they incorporate.

Moreno-Ger et al. [10] demonstrated a system which, based on user information stored in a virtual learning environment (VLE), would select the most appropriate of three levels in the game for the user to start on.

A methodology for generating an environment made up of multiple games adaptively selected from a repository of games was presented by Carro et al. [4].

Conati and Zhao [5] reported on the results of experiments using their pedagogical agent. Their agent augments Prime Climb, which is a two player game used to improve understanding of number factorisation. The agent tracks the player's performance as a Dynamic Bayesian Network, and uses the statistics generated from it to select which of a set of hints to display to the user.

Some reasons why games are not yet adaptive, and how other research fields could inform the design of adaptive digital games is discussed in sections two and three.

Abdullah and Davis [1] presented the differences between using an IMS Simple Sequencing system and an Adaptive Hypermedia system. Importantly, they assert that Simple Sequencing is instructor centred while Adaptive Hypermedia is user centred.

The key differences between the two systems is in how they internally represent the material to be presented to the learner, how they model what the learner already knows and how they use those to adapt the material.

IMS Simple Sequencing [7] is a specification that uses a custom XML markup to organise learning activities in a tree hierarchy, so that the learner can either be guided on a particular route through the sub-nodes and leaves of the tree, or can be given complete freedom to navigate the tree. More intricate behaviours can be created by having conditional rules on the various nodes of the tree, which can enable the learner to skip certain leaves of the tree if they previously met certain objectives.

Adaptive Hypermedia has been an active research area since the early 1990s. Numerous architectures have been suggested for adaptive hypermedia systems, notably de Bra's Adaptive Hypermedia Architecture Model (AHAM) [2] and de Vrieze's Generic Adaptivity Model (GAM) [6]. There are three key components of these architectures. The domain model represents the material which can be presented to the user, in a way that the system understands so it can determine how to adapt it. The user model tracks what the user has done in the past and from this infers their preferences and future needs. The adaption model provides the rules that relate the information about the user to the domain model, and allows the adaption engine to create an experience unique to that user.

Brusilovsky's taxonomy [3] of adaptive hypermedia technologies sets the scope for what can be changed in an adaptive hypermedia system. Fragments of text can be inserted, removed or reordered. Links on a page can be hidden, sorted and annotated. There is even scope for new links and natural language fragments to be generated.

Section four is a discussion of the possible extents of adaption in digital games.

The motivation behind proposing adaptive digital games is to enhance learning and improve accessibility to
educational games. Many adaptive hypermedia applications are in the educational domain, and it is hoped that adaptive games could have a similar impact.

Laurillard’s Conversational Model [9] for tertiary education promotes a learning experience where the tutor can alter their explanation of a concept, the examples they use to demonstrate it and the problems they set the student to help them use the concept. However, the model is impractical when teaching a large number of students. The concept of the teacher changing what they present to the student, based on the student’s apparent understanding of the topic at hand, bears a striking resemblance to the goals of an adaptive application.

Some of the reasons for using adaptive hypermedia could equally apply to adaptive games. For example, Kaplan suggests that HYPERFLEX, an adaptive hypertext system, could improve information retrieval time by up to 40% [8]. Presenting the correct educational material at the right time could prove invaluable in an educational game; otherwise the learner may unnecessarily spend hours playing the game to access what they need to learn.

2. What is not an adaptive game?

The typical modern digital game can be deconstructed into the software engine and the digital content.

The software engine is programming code compiled for the target platform and functions like most regular computer systems. It accepts some input: usually button or key presses, and mouse or joystick movements. These inputs are then processed by the engine by applying some logical rules that are typically specific to the game being played, which updates the internal game state. Finally, the engine produces some output, often including a rendered 3D scene, surround sound and sometimes haptic feedback.

The digital content includes just about everything that is not computer code. The visual output for a game is commonly a 3D scene rendered many times per second. This requires models, which represent the 3D shape, and textures, which form the material of the outer skin, for all the objects within the world. The audio landscape of a game is made up of pre-recorded music and sound effects. From these raw elements, the world is constructed and scripts written to tell a story within the game.

There are elements of adaptivity within some games already. Some games attempt to adjust the difficulty of the game based on the player’s current performance. A simple example of this dynamic difficulty adjustment might be to change the number of opponents the player is faced with in the next stage, in relation to how quickly they dispatched with the opponents in the current stage.

Sandbox games, such as Grand Theft Auto, adapt to what the player has already done. In these games, the player has a choice of which tasks they attempt next, each leading along a slightly different part of the storyline. Rather than having every task available to the player from the start, the majority are only made available to the player based on the completion of other tasks.

However, once the rules and goals within a software engine are written and the art assets are created, the game is essentially fixed in this state. There are a finite number of routes through the game, so given enough time, a player can play the whole game enough to experience every possible storyline and view all of the content. In fact, any adaption that affects events over the whole length of the game are generally based on some very limited choice (of around 2-5 options), while most others are short lived and only affect the current situation the player is in.

3. Towards Adaptive Games

This all leads towards the question: how could a fully adaptive game be created? Having discussed the components of a game and their current adaptability, it is now possible to suggest what would be required to construct a truly adaptive game.

To begin with, the game engine would have to be built with total adaptivity in mind. Where the rules and goals of the game can typically be hardcoded into the program logic, the engine would need to support the ability to alter the rules or generate new ones on the fly. In addition, the engine could flexibly support different control systems (input) and feedback mechanisms (output). This would not only add a level of personalisation whereby the game could automatically identify the player’s preferred method of interaction, but could also allow the game to adapt itself to use less common input devices, improving accessibility to players who cannot use a mouse, keyboard or control pad, while retaining the same basic game.

Content assets are traditionally hand crafted by artists, musicians, level designers and scriptwriters. This creates a fairly rigid game, with any illusion of adaptivity relying on a huge amount of pre-created assets, or clever blending of existing assets to create new ones (as is sometimes performed to create a new animation from two existing complimentary animations). A step towards a solution is the emerging technology of procedurally generated content. This approach involves designing an algorithm to generate a particular asset, in such a way that, by changing the parameter values which initialise the algorithm, a wide range of variations of the asset can be created.

Given the technologies to adapt both the functionality of the game engine and the content assets available, the concept of a fully adaptive game seems more feasible. The system would also require a way to decide what to adapt, when to adapt it and how to adapt it, and some data...
to base those decisions on. On this matter, inspiration can be sought in the field of adaptive hypermedia.

An adaptive game would require some form of model of the player. While some games can store the player's current state for future retrieval, and previous high scores, few store a persistent record of the past actions of the player. Microsoft's Xbox Live stores a form of user model, tracking all of the games a player has played and the 'achievements' they have completed, though this data is limited to games on the Xbox platform.

The next important element is a model of the content, or the parameters within which the content can be procedurally generated. Along with this, a set of rules which specify when and how to perform the adaption, is required. These elements are analogous to the domain and adaption models, respectively, in AHA and GAM.

Finally, it would be necessary to have some form of software engine to detect when the adaption rules are triggered, use the model of the player to decide what to adapt and then process the content into its new form. This would need to be fairly closely integrated with, or else have a well defined interface to, the game engine.

4. Discussion

What, then, is the range of possible adaption in digital games? Can a line be drawn to divide a system which is truly adaptive and one which is just a rearrangement of existing content, based on a finite rule set?

This question somewhat alludes to the answer. If an application just chooses a different order or skips certain segments, based on exposure and performance in previous parts, then it seems it is not fulfilling its adaptivity potential. The information within the segments could be adapted or even generated from scratch to suit the user.

Another area in which a truly adaptive system excels is its user modelling. By storing more details about the player's interactions, previous experience and preferences, there is more data with which the engine can tune the adaption, and potentially improve the player's experience.

5. Conclusion

The concept of fully adaptive digital games for education has been presented here. While existing games have a fairly rigid structure in terms of the rules governing the game and the art content available, a possible design for making games highly adaptive has been suggested.

The scope of adaptability within various forms of adaptive games was discussed, resulting in the conclusion that detailed user modelling and the ability to alter and generate new content based on the model of the user, are key to a fully adaptive system.

Future work on this research will see an attempt to construct a functioning adaptive educational digital game engine, to demonstrate that these ideas are valid.

The concept of an adaptive digital game raises many more questions. How could an adaptive system ensure the game remains fair and balanced? How would an adaptive game affect replayability? How can a tutor author material for an adaptive game?

6. References


THE USE OF VIDEOGAMES TO MEDIATE CURRICULAR LEARNING

Begoña Gros, Open University of Catalonia (Spain)  
bgros@uoc.edu

José M. Garrido, Pontificia Universidad Católica de Valparaíso (Chile)  
jgarrido@ucv.cl

Abstract

A multidisciplinary university team (Chilean-Spanish) and teachers at a a public school in the region of Valparaíso (Chile) carried out an initiative to design and implement an educational sequence that, by including the use of the strategy video game Age of Empires in their activities, could mediate curricular learning in the subject areas of social science and mathematics. The application of this class design involved working with 78 students at K7 level, who made use of the video game in three ways: levelling, inquiry and evaluation. A descriptive case study methodology was used to compile and analyse data in order to identify and describe the sessions and the interaction types occurring in the relationship between peers, the role of the teacher and the contribution of the video game. The main results show, on the one hand, how important it is (i) for teachers to learn how to play, (ii) for them to take part in a co-operative forum to design new settings for learning, and on the other hand, (iii) the types of collaboration and co-operation emerging among students, and (iv) the opportunities offered by the video game to approach the facts of phenomena.

1. Introduction

Research in the fields of sociology, developmental psychology and neurobiology suggests the existence of two profiles of people interacting in modern society. The differences between these two profiles weave together generational, social and cognitive factors. On the one hand are the “Digital Natives,” the “Network Generation,” “New Millennial Students” or people who have grown up from an early age with codes, forms and channels mediated by information and communications technology: computers, internet, mobile phones or video games [4],[5],[6]. On the other are the “Digital Immigrants,” generally adults who were born and educated in non-digital environments, though this does not necessarily involve complete deconstruction of their non-digital forms of understanding and interacting [7] [8],[9].

For these “digital natives”, children and adolescents, digital games on their different platforms are the main setting through which they enter digital culture, involving changes not only in the format of screens but also in the interaction types underlying these formats. In order to understand this, it must be considered that the role of screens as a setting for cultural mediation has changed substantially in recent decades. For many years they were largely something to be looked at. We sit in front of the television or home video to observe, to watch programmes or see a film. Video games, on the other hand, place the emphasis on action and interaction. The player is not passive but becomes the protagonist of the story and must act constantly. The forms of interaction vary depending on the games. They range from very simple interaction based on fast reactions on the player's part (hand-eye games) to responses based on performing strategic and tactical activity (adventure games) or on realistic activities (simulators). With a networked computer the activity also becomes participative, collective and interactive.

As Silva points out, “Learning with the movement of digital technology means getting used to the idea of plentiful, easily-handled information information which can be reformulated freely at the touch of a key and reconstructed at will. The user of digital information is not the classic receiver of a fixed message but the inter-actor who has authorship through their own experience with information, which means that the message can be expressed interactively” [12]. For these reasons, digital games may be considered to be the principal disseminators of the culture of interactivity.

Curiously enough, the informative and communicative features of on-line computers are in tune with the indicators of quality in education: dialogue, exchange of information and opinions, participation, intervention...
and collaborative authorship are essential principles in education for citizenship. However, the (first-generation) television model prevails in classrooms. Pupils cannot choose the channel but have to expect the same information for all. Traditionally, teachers have constructed a route for everybody to follow. The job of teachers today, however, is to build networks, to be able to design territories to be explored – learning occurs precisely through exploration by pupils, just as players learn how to progress through the different screens and attain the constant goals set for them by the game.

Is it possible to build bridges between social practices and classroom practices? How can the settings, learning and social interactions generated and mediated by the ICT media habitually used by the younger generations be used, optimised and given new meaning for use in the context of regulated education? These are issues which educational systems need to engage as part of an effort to foster effective, efficient forms of learning.

This framework of references and concerns was what lay behind this research project. The fundamental purpose of the initiative was to encourage teachers to find out about, consider, reflect upon and agree upon a strategy for designing and implementing learning situations mediated by the use of video games.

The study was carried out by a multi-disciplinary team from the Centro Zonal Costadigital at the Pontificia Universidad Católica, Valparaíso (Chile)\(^1\) in co-operation with the Grupo F9 at the Universitat de Barcelona (Spain)\(^2\). Its aim was to conduct an experiment into incorporating the strategy video game Age of Empires II among the pupils' activities.

This stage began in November 2006 and ended in May 2007. Its aim was to encourage the teachers taking part to define the expected learning they would be aiming at and the consequent learning situations to form a single educational sequence. Four working strategies were used to do this.

The first of these was to create a professional circle of reflection as a regular forum for professional dialogue, exchange and decision-making. This included roles for a specialist in educational technology, an expert player of the game and a mediator responsible for facilitating agreement and decision-making at each stage of the design of the sequence: purposes, activities, tasks and resources.

The second strategy was that of encouraging the teachers to learn to play the video game, which each of them took about a month to become familiar with, to practise and to recognise the game's features. The aims of this strategy were, on the one hand, to resituate the meaning and scope of the fact of gaming as a way of learning and, on the other, to help the individual teachers to identify the opportunities offered by the setting of the video game Age of Empires II in order to link them up with learning within their respective curriculum areas.

The third strategy consisted of collaboratively agreeing upon the curriculum opportunity which could be pursued through the use of the video game, taking into account the features of each subject area involved, in order to build up a structured design of tasks and activities. The professional circle of

---

\(^1\) The Centro Zonal Costadigital [http://enlaces.uev.cl](http://enlaces.uev.cl) is one of six university nodes making up the national technical support network, part of the national educational I.T. Network or Red Enlaces.

\(^2\) The F9 group is made up of a team of university and classroom teachers who have spent over 10 years carry out a range of research and making proposals to incorporate video games in educational settings in Catalonia. See [http://www.xtec.es/~abernat/welcome.htm](http://www.xtec.es/~abernat/welcome.htm).

\(^3\) [http://www.curriculum-mineduc.cl/](http://www.curriculum-mineduc.cl/).

\(^4\) Colegio Manuel Montt. The teachers invited were from the subject areas of mathematics, social science and information technology.
reflection played an important role in this process by mediating a shared framework of beliefs, opinions and ideas.

The product which emerged from these strategies was the preparation of a single plan for classes based on the interactive phase with a central core theme from the unit “The western world: from the mediaeval period to the modern period” from the social science curriculum area on feudalism, which was complemented by content belonging to the unit on ratios from the mathematics curriculum.

Finally, in order to break down the barriers of the experience and time needed by pupils to use the video game properly, a facilitating role was planned for the I.T. Teacher to pursue a strategy of preparing the students with the video game, before the classroom sessions within the curriculum and focusing on ensuring pupils had a similar level in terms of the knowledge and use of the game.

The structure of the strategies used during the design stage is shown in the following figure:

![Diagram showing the strategies used to design the educational sequence](image)

**Implementing the educational sequence**

This stage, devoted to implementing the sequence in the classroom, was carried out between October and November 2007, in accordance with the schedule agreed upon with the teachers. It was put into practice with students in two year groups of basic education (12 to 14 years of age).

The total number of pupils involved was 78, 37 of them belonging to 7A and 41 to 7B. Each group took part in five sessions in the computer lab, for which they were divided into pairs, though one case of individual work was recorded, as a result of the availability of a total of 20 computers. The following table shows the population of pupils taking part:

<table>
<thead>
<tr>
<th>Year</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>7A</td>
<td>16</td>
<td>21</td>
<td>37</td>
</tr>
<tr>
<td>7B</td>
<td>18</td>
<td>23</td>
<td>41</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>34</strong></td>
<td><strong>44</strong></td>
<td><strong>78</strong></td>
</tr>
</tbody>
</table>

The video game was incorporated into learning activities using the William Wallace Learning Campaign as preparation for the work, especially stages 1, 2 and 5: “Marching and Fighting”, “Feeding the Army” and the “Battle of Stirling”, selected by the teachers as the most useful to tie in with the planned curriculum aims.

**3. Analysis of the experience.**

The research was based on a descriptive case study in order to map out a detailed picture of what went on in the classroom. To collect the verbal data a discussion group was organised with 5 pupils from the year groups taking part to assess the experience. The audio-visual data, on the other hand, was gathered by filming 7 out of the 8 sessions conducted in the school's computer lab, as well as making voice recordings of the discourse of the teachers of both subjects.

The data was analysed by observation and by setting up categories for analysis in the light of inductive/deductive interpretation of the evidence, using criteria such as indexicality and reflexivity, to analyse the context, and assessing the learning medium to analyse the role played by the video game.

The result is an analytical description of three aspects: interaction between pupils, the role of the teacher and the contribution made by the video game.
Interaction between pupils

Interaction as used here refers to the set of exchanges, dialogues and actions emerging from pupils' work together while using the video game. The aim was to appraise how relationships were constructed within the setting provided by the strategy game being used. Particular attention was paid to the circumstances and rules of the game channelling how pupils went about performing the activities planned by the teachers. This focus on the indexicality and reflexivity of the phenomenon made it possible to establish the following implications:

The contact and relations between the pairs of pupils were highly-rated in many of their opinions (discussion group), in particular because they became a space for teaching and learning from peers with regard to both the game and the way of organising work together:

"Because she learnt how to play it and I taught her how to play it and what history was like in that period"

Grupo_Discusion_Estudiantes.doc - 6:114 (644:644)

"Ashley and I did something: one of us thought about what might happen if we did something and the other thought about what would happen if we didn't do that thing"

Grupo_Discusion_Estudiantes.doc - 6:119 (660:660)

"So for us, for example, it was, 'Here, what do you think? If I do this it might work, or do you think I should do this other thing?' And we decided between the two of us"

Grupo_Discusion_Estudiantes.doc - 6:120 (664:664)

The class observations (films) corroborate this level of interaction, especially as regards the dialogue taking place between the pupils sitting in front of each computer when they take the steps required to progress in the game. Typical of this interaction is the image of the pupil's finger pointing on the screen as a way of accompanying what they are saying, becoming a pointer and a “technique” for interactive practice between peers which reflects the process of observation, dialogue, exchange and agreement on decision making with the video game.

One aspect which should be noted and which may be interpreted as a result of this level of interaction is the consistently high level of attention and concentration displayed by the pupils working together in front of the screen, making it possible to talk about a degree of involvement which makes the classes work more easily, an impression which is broadly supported by other research work [3], [10], [11].

On the other hand, however, a second type of practice could be observed, characterised by some pupils working individually rather than together with their partners. The evidence shows a way of working in front of the screen whereby progress through levels or achievement of goals was not accompanied by dialogue or explicit agreement with the partner, apart from agreement over turns with the mouse. In this relationship the pupil declines a role in what their partner is doing, merely observing. This practice of “silent observation” is not recorded in the pupils' opinions, though some of them recognised difficulties in pairwork during the activity, due to a lack of expertise with the video game:

"In my case it didn't come out well because I didn't know how to play the game and nor did my partner and I learnt it form the instructions the computer gave me and she didn't do anything, in the end I did everything"

Grupo_Discusion_Estudiantes.doc - 6:117 (654:654)

In no way do these differences between pairs in ways of working place in doubt the value of the video game in providing spaces for co-operation and collaboration between peers as a factor which helped the class to progress; rather, it raises the question of what causes this difference. As an example to confirm how valuable this co-operation between peers was, mention may be made of the only pupil who worked alone during two of the sessions.

Role of teachers

The role played by the teachers throughout the experiment turned out to be a key factor in the research, especially through the possibility of effectively observing how the use of the video game was incorporated into their discourse and classroom activities. Analysis of this made it possible to describe the teaching role on the basis of the practice observed and the image perceived by the pupils:

Observing the activities made it possible to map out some key issues with which the teachers constantly concerned themselves:

- Ensuring everybody worked together for the first 15 minutes of each session (the transition from the Start phase and the Execution phase), preventing pairs of pupils from starting the game early.

- The importance of instructions as a way of guiding pupils' activities, made clear by the
attention pupils paid to what teachers were saying and to the information supplied by the video game during the different stages; and

- Highlighting the difference between playing and learning, as a discourse aimed at the pupils in order to stress participation in a class with curricular aims.

Out of the three observations, the last one was clearly indicative, as despite having designed a teaching sequence centred on the curriculum, the teachers seemed unable to give up, at least in their discourse, the separate images whereby a game is seen as something contradictory to learning.

What the pupils said, on the other hand, revealed two kinds of perception. The first of these was related to the difference between this experiment and the teachers' usual role. By way of interpretation, the difference could be said to lie in the part played by teachers and pupils in the process, i.e. between a focus on teaching and a focus on learning:

"...differences in how they did things, between saying 'Do this and do it now,' and here, where they said 'You try it, try it now,' and then you tried it.'"

Grupo_Discusion_Estudiantes.doc - 6:34 (153:153)

"Normally she explains everything, she presents it all, she says what happened and where the feudal people lived and all that."

Grupo_Discusion_Estudiantes.doc - 6:48 (235:235)

A second perception which emerged had to do with the teachers' nervousness when using an unfamiliar technology medium and type of class. Although no reason for this perception emerges, it is recognised that this “nervousness” is normal behaviour which they also share:

"...because they had never done it before, that's why they were nervous all the time, the first time you were nervous."

Grupo_Discusion_Estudiantes.doc - 6:33 (136:136)

The observed evidence of the sessions, however, does nor corroborate this “nervousness”, so the pupils' opinion may be more a case of their interpretation when faced with the change of context created by the sessions: the presence of monitors and of the I.T. teacher, and the emphasis in the teachers' discourse on following instructions to the letter.

4. Conclusions

The experience of incorporating the video game Age of Empires II into practical classroom sessions in a state school proved to be a good way of approaching the design of a professional, educational path to make it possible to explore the possibilities for dialogue and linkage between digital game settings and the learning of curriculum content that teachers seek to mediate. An experiment like the one conducted here obviously has endless aspects, issues and interpretations which call for further study and deeper analysis. Nevertheless, on the basis of the work done, the following conclusions must be stressed:

From the teachers' point of view:

In the process of resignification of teaching to incorporate the video game, co-operation and support between peers proved to be essential. This means the potential of spaces for dialogue and reflection on decision-making should be emphasised as a strategy for incorporating ICT in the construction of settings for learning.

Exploring the use of the video game in curriculum terms required a strategy to allow (and to a certain extent to persuade) the teachers to learn to play by experiencing the stages and tasks necessary to progress in the game. This became an essential factor which had to come before thinking about what type of educational innovations to make.

The meaning and appreciation of the “game” as a practice to generate learning was one of the greatest challenges in the experiment. This was inconclusive but there was progress which helped the teachers to understand that it was possible to conduct a class with curricular aims but in which pupils actually played.

Constructing a single sequence to be approached from two different subject areas within the curriculum was achieved by establishing a common core topic, in this case from social science, in relation to which mathematics played a complementary role. In other words, content was more important than skills.

During the sessions where the video game was used, the teachers effectively took on a role of mediating and facilitating what pupils had to do. This was reflected in the way in which their attention was focused and in the
three clearly separated phases of interaction in the classroom.

The importance the teachers constantly attached to instructions (whether given directly or indirectly) helped them to mediate the process of autonomous work and focused attention on pupils' part. In this respect the fact that the video game chosen supplied instructions about progressing through the stages was an added attraction.

From the pupils' point of view:

Organising teaching through the use of the video game fostered collaborative work between peers, with a close working partnership emerging between more experienced players and relative beginners, which helped in performing the curricular activities. This interaction was based on observation, dialogue, exchange and agreement, all of which were shown in the recurrent practice of “pointing with a finger on the screen”.

On the other hand, a way of working also emerged in which interaction was replaced by a practice of “silent observation”, unnoticed by the teachers, which did not stop the activities being performed but through an approach which was more one of co-operation to attain a product or end result.

Pupils managed to make the connection between the video game and the curriculum, through the realistic contextualisation and setting it provided, with a very strong link arising between image, action and understanding.

Pupils perceived differences in the teachers' role, leading to more autonomous working, more centred on themselves, which was a change from the habitual practice centring on the content presented by the teachers.

The students provided evidence showing their preference for working in interactive digital settings such as that provided by the video game, as opposed to settings centred on the use of linear rather than digital media.

If these results are compared with previous studies which identify four aspects associated with school organisation (time, content, teachers and concepts) as a problem for incorporating video games in classroom practice [16], the following conclusions may be drawn:

i. **Time.** The experiment took quite a long time to implement, due to the necessary process of resignification for the teachers regarding the contributions to be made by the strategy game and the opportunities identified for its use in the curriculum, and to the need to adjust to the calendar and sequence of units prioritised by teachers in their planning of the year. Quite apart from any possible improvements to enhance processes, it must not be forgotten that using strategy games calls for quite a lot of time to be spent in order to allow pupils to progress through the stages. In this respect the role of the I.T. Teacher was valuable in facilitating and mediating the use of time in the social science and mathematics sessions.

ii. **Content.** While it is true that the experiment helped to link the video game to the curriculum on the basis of dealing with skills and inter-disciplinary decision-making, the teachers' decisions and practice mediated the link to the curriculum on the basis of content existing in it. In this way the school work was organised on the basis of a core topic (feudalism) around which mathematical learning was attached, shaping a form of professional co-operation based around the content.

iii. **Teachers.** In order to mediate the teachers' insecurity concerning the pupils' expertise in playing the video game, the I.T. Teacher's cooperation and support in order to ensure all students were at an adequate level, together with the setting up of a team of monitors chosen from among the best players in the year, assisted the teachers in their work. Nevertheless, this issue needs considering from the point of view that the children have greater experience and instrumental knowledge but lack the degree of reflection and critical thought which needs to be supplied by teachers.

iv. **Concepts.** In some simulation games the concepts being worked on need to be taken into account and points of contact need to be set against academic knowledge. In the case studied here, it is always important to contrast historical knowledge with some of the concepts used in the game.
10. References


ToddlePuff: an Interactive Tangible and Spatial Interface

Ilan Schifter
Interactive Telecommunications Program, New York University
ilans@nyu.edu

Abstract

ToddlePuff is a multi-sensor inflated interface that acts as a game controller for toddlers. ToddlePuff surrounds the child and encourages full body motion. It develops cognitive and sensory-motor skills while teaching symbolic and sequential thinking. It improves speed, spatial orientation and coordination. ToddlePuff incorporates multiple proximity sensors that act as controllers for the game. An animated children’s story is displayed on a screen and told through the speakers. Images of characters from the story are placed on different locations inside the interface. When a character blinks on the screen, the child needs to find the matching image on the surrounding inflated walls and touch it to resume the story. An informal study shows that children responded positively to the concept of spatial interface. They played inside it for a length of time and improved their performance throughout the learning process.

1. Introduction

Spatial functioning—the ability to maintain spatial information while moving [2] or when tracking motion of other objects [3]—is a fundamental process in our ability to survive and move around in the world [1]. It allows us to combine information about distances and angles to form representations of overall spaces [4]. Spatial and visual activities, particularly when accompanied by a motor or tactile component, are especially powerful elements of a truly thorough mathematical and scientific pedagogy [5]. This notion is corroborated by a half century of research in mathematical cognition and education [5]. According to Piaget’s theory of cognitive development [6], children acquire essential spatial abilities during their sensorimotor period. At this stage they learn about their surroundings mostly through touch. In the following preoperational stage children learn to represent objects by images and words. They develop new skills and acquire knowledge through repetition and imitation.

ToddlePuff offers an interactive tangible and spatial experience. It is aimed towards toddlers and introduces a framework for developing both spatial orientation and symbolic thinking. ToddlePuff incorporates multiple sensors and controls a computer game. The interface is a three-dimensional inflated structure that resembles a playpen or a boxing ring and comfortably accommodates the size of a three year-old. Four proximity sensors are located on the inner side of each of the four walls. All sixteen proximity sensors are connected to a microcontroller that sends the data to the computer through a USB connection. A child can enter the interface through horizontal gaps in the walls. An animated children’s story is displayed on a screen and told through the speakers. Each of the characters in the story has an equivalent tangible patch that is located on one of the proximity sensors inside the interface. In the story, characters converse with one another. Before a character speaks, it blinks on the screen to prompt the child to look for its matching patch, located on the surrounding inflated walls. By touching the correct patch, the child resumes the story. It takes at least six minutes for the story to complete.

Figure 1. Playing inside ToddlePuff and watching the animation on the screen
2. Related spatial interfaces

Konami’s Dance Dance Revolution (DDR) was introduced in 1998 and has become a tremendous success. It is a music video game that uses a dance pad as an interface. It typically consists of four arrow panels: left, right, up, and down. The player steps on the panels in response to arrows that appear on the screen. The arrows are synchronized with the general rhythm or beat of a chosen song. Success is depended upon the player's ability to time and position his/her steps accordingly. DDR involves dancing, pattern matching, coordination and speed. It develops the player’s sense of rhythm and requires full body movement.

Cranium’s Hullabaloo game includes a set of pads that are randomly scattered on the floor. The pads show different shapes, colors, pictures and words. An audio recording instructs the children to jump from one pad to another. It is a combination of Twister and Simon Says. Like DDR, it uses full body movement and develops spatial orientation, coordination and speed. Although it does not keep scores or provide any feedbacks to the child, it succeeds in creating a fun and highly engaging game.

3. The ToddlePuff interface

ToddlePuff surrounds the child from all horizontal directions and incorporates interactive buttons (proximity sensors) that control the game. It encourages children to move around and hit the buttons that surrounds them in order to interact with sound and visuals. The interface is designed for use in living rooms. Safety issues were taken into consideration throughout the design process. Due to its inflatable qualities, it is light and foldable. By acting as a stable structure that is able to support a toddler’s weight, the interface provides a safe and cushioned environment to address the child’s tendency to overshoot. The use of proximity sensors makes the child’s hand power insignificant. This enables children with disabilities to play inside the interface.

ToddlePuff’s height equals the average height of toddlers in the U.S. It is designed to block the toddler’s eyesight below the screen, therefore intensifying the immersed experience during play. The interface is wider than an average toddler’s arm span. This requires the child to move her whole body when touching patches on opposite walls.

4. Animated interactive story

In the game, the child is shown a 2D flash animation of a well-known Eastern European folk tale called “Flat for Rent”, put in to writing by Leah Goldberg. An English version was used for the purpose of this project. As mentioned, each of the proximity sensors has attached to it a tangible patch that matches one of the characters in the animation. There are ten animal characters and patches, all of which are in the form of amusing cartoonish images. In addition, there is a patch in the shape of a tower used to initiate the story. The patches act as a logical connection and association between the images on the screen and the buttons on the inflated walls. They are constructed of flexible cloth and offer tactile stimulation.

The story depicts a tower with five floors. On each floor lives an animal: Hen, cuckoo bird, cat, squirrel and a mouse that left his flat for an unknown reason. The tenants decide to rent the empty flat and hang a sign on the wall: “Flat for Rent”. Various animals visit the flat and engage in a conversation with the neighbors. Most visitors like the flat but dislike one of the neighbors. The dove, however, is the last to visit and dislikes the flat but decides to rent it because she likes the neighbors. The animals live together, happily ever after. The animation and conversations held between the tenants and each visitor are repetitive and the entire game is played for approximately six minutes. Before each animal character speaks, it blinks on the screen until the child touches the appropriate...
patch to resume the story. As soon as the correct patch is touched, a unique sound, related to that animal, is produced. To avoid confusion or deliberate false presses, no feedback is provided when touching an incorrect patch.

The method of matching symbolic representations inside the spatial interface encourages children to physically move and become familiar with the three-dimensional space that surrounds them. It teaches them to associate characters on the screen to tactile patches.

5. User testing

Several informal studies were conducted to evaluate ToddlePuff. The main one took place at New York University during the Interactive Telecommunications Program Spring Show, May 2007. A video camera pointed at the interface, recorded all the players during the two-day show. Around thirty people played inside the interface, seven of which were toddlers and preschoolers. The recordings were then analyzed in detail, with noticeable differences amongst the interactions of players at various ages.

At two years old, children, who at this age just begin learning about symbolic thinking are too young to process sequential tasks. Therefore, they memorize one task at a time [6]. For this reason, the possibility that toddlers would not understand the relations between the characters on the screen and the patches on the inflated walls presented itself as a major concern. For example, younger toddlers pointed at the screen when asked to locate inside the interface the equivalent to a blinking character from the animation. The solution, as the creator found, lay in asking the children to search for a similar character, i.e. “the other ant” etc. When presented with this command, all toddlers executed the task correctly. Even though they did not comprehend the symbolic meaning of the patch, they all looked back at the screen immediately after touching the “other animal”, expecting a reaction in the animation. The pre-acquired comprehension of “cause and effect” helped them learn about symbolic representation. After two to three successful matches, toddler acquired an independent ability to execute the task.

The study also demonstrated that recalling locations of previously touched patches presented itself as a difficult task even for grownups. A slight improvement in toddlers’ spatial memory was evident after repetitive hits. However, the attention span of the two-year-old children was extremely short and they paid little attention to the narrative. On the contrary, three year olds were amused by the story and four year olds were mesmerized. Young toddlers tended to pick a favorite character and repetitively touch it. Animations of animals that blinked their eyes proved most popular and young toddlers tended to imitate them with their own eyes. On a separate note, having more than one child simultaneously playing inside the interface resulted in a race to be first to touch the correct patch.

6. Conclusions

Toddlers enjoyed the game to a great extent. They learned symbolic thinking through pre-acquisition of “cause and effect” and improved their performance throughout the learning process. The tangible aspect of the interface proved extremely important for toddlers and preschoolers. The physical and tangible qualities of the three-dimensional space increased the kids’ desire to improve their response time. Adding a timer and a scoring system may intensify the experience even further. Older kids and grownups were evenly excited about playing inside the interface and improved their spatial orientation and coordination skills while playing the game.

In a following project based on ToddlePuff, RFID readers replaced the proximity sensors while RFID tags were placed inside the patches. The original concept of matching symbolic representations of images from the screen to locations on the interface remained the same. In the modified interface, players wore the tangible patches on their bodies and were asked to match different body parts to locations inside the interface.

Experiments based on the present study provide credence to the benefits of using interactive tangible and spatial interfaces with young kids.

7. References

Using Posting Templates for Enhancing Students’ Argumentative Elaborations in Learning Villages

Morris S.Y. Jong  
*The Chinese University of Hong Kong*  
mjong@cuhk.edu.hk

Alex W.C. Tse  
*The Chinese University of Hong Kong*  
alextse@cuhk.edu.hk

Yuxia Zhou  
*The Chinese University of Hong Kong*  
zhouyx@cuhk.edu.hk

Weiqin Chen  
*University of Bergen*  
weiqin.chen@infomedia.uib.no

Fong-lok Lee  
*The Chinese University of Hong Kong*  
fllee@cuhk.edu.hk

Jimmy H.M. Lee  
*The Chinese University of Hong Kong*  
jlee@cse.cuhk.edu.hk

Abstract

Learning Villages (LV) is a game-based computer-supported collaborative learning (CSCL) platform, which facilitates students’ issue-based discussion in a massively multiplayer gaming environment to attain the goal of argumentative knowledge construction. However, such construction can be achieved only if students can make argumentative elaborations properly in order to benefit from CSCL. This paper discusses our research on the use of posting templates to enhance students’ argumentative elaborations in LV. Seventy-four fifth-grade students and two of their teachers from two Hong Kong elementary schools participated in the present study. Results confirm that posting templates, to a certain extent, could assist the students in constructing arguments containing reasons and grounds to rationalize and warrant these arguments. In addition to the provision of the posting templates, we also found students’ face-to-face peer-sharing (facilitated by the teachers) could help them reach and sustain a relatively higher level of attainment of argumentative knowledge construction.

1. Introduction

Sustaining spontaneous players’ engagement [1] and exploiting proactive players’ communities [2] are substantive features of today’s computer games. This emerging attention has been one of the main reasons for the increasing number of educators and researchers worldwide who treat game-based learning as a topic of serious research in the field of education. For instance, Squire [3] studied how to integrate a prevalent commercial game, Civilization III\(^1\), into US high-school classrooms. Instead of utilizing existing commercial games, Shaffer [4], together with his research team, developed a number of self-directed epistemic games for situated learning [5]. Those games engage students in participating in various professional communities, so that they can gain first-hand experience in how members of these professions contemplate and deliberate, behave, and solve problems. Jong et al. [6] proposed the VISOLE (Virtual Interactive Student-Oriented Learning Environment) pedagogy for empowering game-based situated learning, in which they advocated specific teaching and learning roles and tasks for teachers and students. Ip et al. [7] study propose and study the effectiveness of a CSCL style discussion environment embedded in a massive multiplayer online game.

1.1. Game-based CSCL

CSCL refers to the process of a group of students engaging in discussing their perspectives on a problem with the goal of knowledge acquisition through a computer-based communicative platform operated in an asynchronous fashion [8]. Success of a group is attributed to all group members rather than merely the group leader [9]. Each member is responsible for knowing what needs to be known, and ensuring others to know the same.

---

A common critique of some existing CSCL platforms is that their “appearance” and “functions” are just similar to many traditional online text-based discussion boards. Empirical evidence (e.g., [10, 11]) has shown that this kind of platforms fails to promote and encourage students’ proactive participation in CSCL activities effectively. One of the primary aims of the research and development of Learning Villages2 (hereafter refers as LV) has been to address this issue. LV is a massively multiplayer online game (MMORPG) to facilitate a 2-tier issue-based discussion in a CSCL platform. A more detailed description of LV is covered in Section 2.

1.2. Argumentative knowledge construction

One of the foci of CSCL research has been on the facilitation of the process of argumentative knowledge construction. Weinberger and Fischer [8] observed that argumentative knowledge construction can be achieved through CSCL when a group of students elaborates and exchanges arguments on an open-ended issue, by collecting and balancing evidence and counterevidence properly through discourse. Weinberger and Fischer constructed a theoretical framework for analyzing how students structure arguments in CSCL, regarding the relationships between specific components of arguments. This framework has suggested that four categories of argumentative elaborations are often found in CSCL’s discourse, namely, simple claims, qualified claims, qualified and grounded claims, as well as non-argumentative moves.

However, Stegmann et al.’s [12] empirical study has shown that students usually have difficulties in composing arguments in CSCL. For example, their argumentative elaborations often lack supporting data and evidence. This finding coincides with Kuhn et al.’s [13] assertion that the quality of the argumentative knowledge construction without suitable support is insufficient. Stegmann et al. argued that, in order to facilitate the outcome of argumentative knowledge construction, intervention is needed to support students in making argumentative elaborations properly. They advocated for the provision of some sorts of prototypical elaboration scripts (“script components” in Stegmann et. al’s term; “posting templates” in the present study) pre-implemented in CSCL platforms, so as to assist students in formulating and structuring their arguments in a right way.

1.3. Aims of the present study

Even if students are motivated to pursue CSCL in LV, there is no guarantee of success in their argumentative knowledge construction. Students need to compose arguments appropriately in order to benefit from the collaborative learning process. This study aims to echo Stegmann et al.’s [12] proposition, and to investigate how posting templates can facilitate elementary fifth-grade students’ argumentative elaborations in LV. We address two specific research questions: (a) How do students’ argumentative elaborations in LV change in accordance with the provision of posting templates? (b) Is the effect sustainable on students’ argumentative elaborations?

2. Learning Villages

LV [7] is a game-based CSCL platform that operates in a form of massively multiplayer online gaming, in which each student can design his/her own virtual character (an avatar) to participate in this virtual world. There are various entertaining elements in LV. For example, students can earn the “passion” value and upgrade their own status through playing a range of mini-games. Furthermore, there are various “hangout places” for students to meet one another. The interactions include real-time chat, making funny gestures and showing funny emotional icons to draw others’ attention, etc. Figure 1 shows one of the hangout places in LV.

Figure 1. A hangout in LV

Besides the entertainment, LV facilitates students’ 2-tier issue-based discussion for collaborative learning. The first-tier is “village-level discussion,” while the second-tier is “house-level discussion”. Both levels of discussion can take place concurrently.

Each village in LV represents a discussion issue. A student can create a village, taking the role of Chieftain
by initiating an issue for discussion. Any other students in LV who are interested in that issue, can become Villagers by building houses in that village. They can use houses to elaborate, for example, their perspectives, arguments or some related concepts with respect to the issue. In addition, students can build roads between the houses to interconnect different perspectives, arguments or concepts delineated in the village. They can make use of different types of roads, namely, Explanation, Evidence, Problem, My Reply, Solve This First, Another View, Compare With, and Others to reflect the different relationships between the elaborations represented by those houses. This is called village-level (the first-tier) discussion. An example is shown in Figure 2.

In the village, actually, every house is “enterable”, and it functions as an individual forum to facilitate discussion on a specific perspective, argument or concept raised in the village-level discussion. In LV, the term “postings” is used to represent the discussion threads inside houses (see Figure 3). This is called house-level (the second-tier) discussion. The more postings there are in a house, the larger its size and the higher its modernity level will be.

The advantage of the 2-tier design in LV is that, major perspectives, arguments and related concepts, as well as their relationships with respect to a discussion issue can be arranged neatly in the form of mind mapping at the village level. However, it is still handy for students to review the details of a particular perspective, argument, or concept discussed at the house level.

In order to encourage students to participate in quality issue-based discussions, the invest-and-reward mechanism is one of the strategies adopted in LV for the purpose. Every time when a student creates a village, or builds a house in villages created by others, he or she has to pay “donuts” (the virtual money in LV). Nevertheless, when the number of quality houses and postings in the villages (that he or she has “invested” in) reaches a certain amount, the village will be upgraded by either the LV system administrator or their learning facilitators (usually their teachers). Benefits brought about by the upgrade include donut reward, higher social status conferment for enjoying extra privileges in LV, etc.

### 3. Method of the study

Two classes of fifth-graders from two elementary schools (hereafter referred as School A and School B) located in different districts in Hong Kong were the subjects of the present study. It was a convenient sample with 74 students (at the age of 11.2 in average, 35 males and 39 females), 36 students from School A and 38 students from School B.

Preceding the learning experiment, the students in each class were divided into nine roughly equal-size groups so that the groups are equivalent in the distributions in gender and academic performance. After that, every group in School A, on a random basis, was further paired up with a group in School B to form an inter-class collaborative learning team (hereafter referred as a “team”) to conduct issue-based discussion in a collaborative fashion in the experiment. Thus, 9 teams were formed, each composed of around eight students, half from School A and half from School B.
3.1. The posting templates

One month prior to the learning experiment, we formed a working group together with five teachers of General Studies (a core subject in the curriculum of Hong Kong elementary education) from the two participating schools, including two subject leaders who have rich experience in facilitating project-based learning.

In the working group, besides discussing the design and the logistics of the study, we also framed two posting templates to assist students in the elementary fifth grade in making argumentative elaborations in issue-based discussion in LV. The first one was designed for elaborating new arguments (Template 1), while the second one was designed for responding to arguments made by others (Template 2). The two posting templates are shown in Figure 4. Basically, they contain the same three major components, i.e., a claim, a reason, and a source of evidence.

3.2. The learning experiment

The experiment was composed of two phases. The first phase was designed to investigate whether the provision of the posting templates could enhance students’ argumentative elaborations in LV (i.e., the first research question). The second phase was designed to investigate whether the effect of the posting templates on students’ argumentative elaborations was sustainable (i.e., the second research question). In both phases, the students were assigned to work in teams in the inter-school fashion as described previously. All of the learning facilitation activities in the experiment were co-conducted by two teachers, one from School A and one from School B. Within the process, the teachers were allowed to give “just enough” assistance to help the teams to pursue their issue-based discussions when necessary. For instance, at the beginning of a discussion, the teachers would create one or two “initial houses” in each of the villages for stimulating each team to frame the possible directions of inquiries about their own discussion issue.

3.2.1. Phase 1. This phase took four weeks (namely, Week 1, Week 2, Week 3, and Week 4) to complete, in which each team pursued online discussion on a real-life open-ended issue through LV. There were three discussion issues adopted in this phase. Thus, every three teams were assigned to discuss the same issue; however, every team conducted the discussion separately in different villages. Every week, in School A and School B respectively, the teachers conducted a 30-minute face-to-face lesson to facilitate the sharing of their own class’ learning experience in LV. We observed each of the lessons held in the respective schools. After each lesson, we interviewed different students, in a friendly and informal manner, to gain more understanding of their learning process.

At the beginning of Week 2, the teachers introduced the posting templates described previously to the students in the lesson, and displayed the templates on an electronic notice board (a clickable on-and-off window) in each of the villages for the students to have easy reference. The templates were displayed until the end of Week 4.

3.2.2. Phase 2. Three months after Phase 1 had completed, Phase 2 of the experiment was executed. This phase was a delay investigation, in which each team worked in the same way as Phase 1. They were assigned to conduct another discussion on another issue in LV. In fact, this phase duplicated the experimental procedures carried out in Phase 1, except in two aspects. The first aspect is the teachers neither mentioned the posting templates in the face-to-face lessons nor displayed them in the villages. In addition, since one month before the start of Phase 2 and until its end, all of the villages created in Phase 1 were made hidden in LV. Thus, the students were unable to refer to the style of their previous elaborations.

3 The discussion issues adopted in Phase 1 were:
- Should an elementary fifth-grade student bring his/her mobile phone to school?
- Should an elementary fifth-grade student make use of instant messaging software to communicate with others?
- Should we trust the advertisements in electronic media?

4 The discussion issues adopted in Phase 2 were:
- Do you have other suggestions of the form and mode of torch relay in the Olympic Games?
- If it was not the Olympic Equestrian Events, which events could Hong Kong co-host in the Beijing 2008 Olympic Games?
- How should one be qualified to be selected as a torch bearer in the Olympic Games?
The second aspect is the duration. This phase was shortened from four weeks to two weeks. It was because the remaining time of the semester was not sufficient to implement the 4-week phase.

3.3. Analyzing argumentative elaborations

We adjusted Weinberger and Fischer’s [8] framework of argumentative knowledge construction before adopting it to analyze the students’ argumentative elaborations in the experiment. The original framework suggests four categories of argumentative elaborations, namely, simple claims, qualified claims, qualified and grounded claims, as well as non-argumentative moves. We modified the categories that contain the component of “qualifiers” for the present study.

Qualifiers refer to statements that limit the validity of a claim to specific circumstances [8]. In other words, a claim becomes a “qualified” one if the concerned qualifiers are delineated therein. Nevertheless, the purpose of the present posting templates was to assist elementary students in elaborating on arguments with claims, reasons, and evidence properly. Enabling them to make qualified claims was not our current focus. Hence, modification to the original framework was necessary. We revised the categories of “qualified claims” and “qualified and grounded claims” in Weinberger and Fischer’s original framework into rationalized claims, as well as rationalized and grounded claims respectively. The modified framework and the corresponding explanations of the categories are shown in Table 1.

### Table 1. Categories of argumentative elaborations

<table>
<thead>
<tr>
<th>Category</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Claims</td>
<td>Claims that advance one’s position(s), without the provision of reasons and grounds</td>
</tr>
<tr>
<td>Rationalized Claims</td>
<td>Claims that advance one’s position(s), with the provision of reasons to rationalize the claims</td>
</tr>
<tr>
<td>Rationalized and Grounded Claims</td>
<td>Claims that advance one’s position(s), with the provision of reasons to rationalize the claims, and grounds to warrant the claims</td>
</tr>
<tr>
<td>Non-argumentative Moves</td>
<td>Statements that coordinate the discussion moves, such as clarifications, requests for others’ clarifications, etc.</td>
</tr>
</tbody>
</table>

4. Findings

There were 757 and 371 postings in the villages in Phase 1 and Phase 2 of the learning experiment respectively. Within 1 month after each phase, with the use of the modified framework described in Section 3.3, we finished categorizing all students’ postings into the 4 categories—Simple Claims, Rationalized Claims, Rationalized and Grounded Claims, as well as Non-argumentative Moves.

4.1. Effect of the posting templates (Phase 1)

Table 2 shows the number of the students’ postings and their proportional percentage among different categories in the four weeks (Week 1, Week 2, Week 3 and Week 4) in Phase 1. “S” stands for Simple Claims, “R” stands for Rationalized Claims, “RG” stands for Rationalized and Grounded Claims, and “N” stands for Non-argumentative Moves. Figure 5 shows a graphical presentation of their proportional distribution across the weeks. According to the results, we found that the posting templates provided in this phase had positive effect on the students’ argumentative elaborations in LV to a certain extent.

### Table 2. Number of postings among 4 categories in each week in Phase 1

<table>
<thead>
<tr>
<th>Week</th>
<th>Category</th>
<th>S</th>
<th>R</th>
<th>RG</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Count</td>
<td>145</td>
<td>49</td>
<td>11</td>
<td>17</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>65.3%</td>
<td>22.1%</td>
<td>5.0%</td>
<td>7.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2</td>
<td>Count</td>
<td>43</td>
<td>74</td>
<td>46</td>
<td>17</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>23.9%</td>
<td>41.1%</td>
<td>25.6%</td>
<td>9.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>3</td>
<td>Count</td>
<td>27</td>
<td>50</td>
<td>85</td>
<td>26</td>
<td>188</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>14.4%</td>
<td>26.6%</td>
<td>45.2%</td>
<td>13.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>4</td>
<td>Count</td>
<td>11</td>
<td>38</td>
<td>89</td>
<td>29</td>
<td>167</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>6.6%</td>
<td>22.8%</td>
<td>53.3%</td>
<td>17.4%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

In Week 1 (the posting templates had not yet been provided), the majority of the students’ postings were Simple Claims (65.3%). Some of them were able to make claims with reasons to rationalize their arguments (22.1%); however, few students could make arguments with the provision of both reasons and grounds.

The posting templates were introduced to the students in Week 2. Compared to Week 1, the categorical distribution of Week 2’s postings changed. Rationalized-Claim postings dominated (41.1%) in the week. The proportional percentage of the Simple-Claim postings dropped around 40%, whereas the proportional percentage of the Rationalized-and-
Grounded-Claim postings increased by 20% approximately.

In Week 3 and Week 4, the Rationalized-and-Grounded-Claim postings became dominant, with proportional percentage of 45.2% and 53.3% respectively. In addition, compared to Week 1 and Week 2, there were relatively small number of Simple-Claim postings found in these two weeks.

Was the increase of the students’ postings of Rationalized and Grounded Claims in LV in the latter weeks solely due to the provision of the posting templates? In order to answer this question, during the study, we selected and interviewed different students for gaining more understanding of their learning process in LV.

During the interview, Student X who started to create postings of Rationalized and Grounded Claims in Week 2 (but not in Week 1) said, “I started to elaborate on my arguments with reasons, and some sort of evidence after my teacher had introduced the posting templates to us in the face-to-face lesson. When I was creating a new posting in the village, I would look up the templates for reminding myself about what I need to include in this new posting.”

In fact, nearly all of the Rationalized-and-Grounded Claim postings found in this phase were in the style of the templates. Besides, many other students who started to create their Rationalized-and-Grounded-Claim postings in Week 2 gave similar comments as Student X did. This showed that, to a certain extent, the increase of postings of Rationalized and Grounded Claims was facilitated by the posting templates.

Apart from that, we also interviewed students who started to write their Rationalized-and-Grounded-Claim postings in Week 3 or Week 4 (but not in the previous weeks). According to Student Y, “my team didn’t pay much attention to the posting templates at the beginning. We just wrote our postings as what we used to do in other discussion forums … In Week 3’s face-to-face lesson, the teacher invited different teams to share their learning experience in LV with others. We realized that some classmates could make convincing arguments for what they wanted to advocate. They mentioned that the posting templates did help them a lot. My teammates and I started to refer to the templates when composing arguments in our village.”

Student Y’s comment also accords with what we observed in the face-to-face lessons. In fact, not all students could benefit simply from the direct provision of the posting templates. In the present study, the peer-sharing in the face-to-face lessons facilitated by the teachers was another important intervention to enable the students to distinguish between good and bad examples of arguments, and help them to improve their argumentative elaborations.

4.2. Sustainability of the effect (Phase 2)

Table 2 shows the number of students’ postings and their proportional percentage among different categories with respect to the two weeks (Week A and Week B) in Phase 2. The Rationalized-and-Grounded-Claim postings still dominated in Week A and Week B, with proportional percentage of 41.4% and 53.5% respectively. Although the posting templates were not provided in this phase, the format (starting with an argument followed by a reason and then a source of evidence) of most of the Rationalized-and-Grounded-Claim postings were quite similar to that of the templates provided in Phase 1. The proportional percentage of the Simple-Claim postings was at a relatively low level in both weeks (12.4% in Week A, and 11.4% in Week B).

After examining other evidence gathered from the lesson observation and student interviews in this phase, the respective increase and decrease of the Rationalized-and-Grounded-Claim postings as well as the Simple-Claim postings from Week A to Week B could be explained by the effect of the peer-sharing (as described in Section 4.1) facilitated by the teachers at the beginning of Week B.
To further investigate the sustainable effect of the posting templates, we conducted some comparisons between Week 4 and Week A, as well as Week 4 and Week B.

4.2.1. Week 4 VS. Week A. Since Week 4 was the ending week of Phase 1, its categorical distribution of the students’ argumentative elaborations could be treated as the students’ learning attainment in Phase 1. As for Week A, it was the beginning week of Phase 2, and there was a 3-month time lag between Week 4 and this week. Thus, by comparing the categorical distributions of these 2 weeks, we could examine the extent of the sustainable effect of the posting templates on the students’ argumentative elaborations in LV.

Figure 6 shows a graphical presentation of the respective proportional distributions of Week 4’s postings and Week A’s postings among the 4 categories. Although the Rationalized-and-Grounded-Claim dominated in both weeks, Week 4’s proportional percentage was around 12% higher than Week A’s. Concerning the Simple-Claim postings, the proportional percentage in Week 4 was around 6% lower than Week A. A Pearson chi-square test indicated that there was significant difference between the categorical distributions of Week 4’s postings and Week A’s (chi-square = 8.22, p-value = 0.04).

According to the results, without the provision of the posting templates, there was no guarantee that the attainment of the students’ argumentative elaborations in LV, after a period of time (3 months in the present study), could reach “immediately” to a comparable level to the attainment with the introduction of the templates.

4.2.2. Week 4 VS. Week B. Further, we investigated whether the students’ attainment of argumentative elaborations in Week B (the ending week of Phase 2) could reach eventually a comparable level to that they achieved in Week 4 (the ending week of Phase 1). Figure 7 shows a graphical presentation of the proportional distribution of the postings among 4 categories in Week 4 and Week B.

The Rationalized-and-Grounded-Claim postings dominated in both Week 4 and Week B, with the proportional percentage of 53.3% and 53.5% respectively. Also, the proportional percentage of the Simple-Claim postings was at a relatively low level in both weeks (6.6% in Week 4 and 11.4% in Week B). A Pearson chi-square test showed that there was no significant difference between the categorical distributions of Week 4’s postings and Week B’s postings (chi-square = 4.02, p-value = 0.26).

<table>
<thead>
<tr>
<th>Category</th>
<th>Week</th>
<th>S</th>
<th>R</th>
<th>RG</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>23</td>
<td>58</td>
<td>77</td>
<td>28</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>12.4%</td>
<td>31.2%</td>
<td>41.4%</td>
<td>15.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>Count</td>
<td>21</td>
<td>43</td>
<td>99</td>
<td>22</td>
<td>185</td>
</tr>
<tr>
<td></td>
<td>% within Week</td>
<td>11.4%</td>
<td>23.2%</td>
<td>53.5%</td>
<td>11.9%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
According to the results, although the posting templates were not provided in Phase 2, the students could achieve eventually a comparable level of attainment to the level attained with the access to the posting templates in LV. We attribute the resumption to peer-sharing and experience re-collection.

5. Conclusion and discussion

This research investigated the effect of the provision of posting templates for elementary fifth-grade students’ argumentative elaborations in LV—a game-based CSCL platform. The introduced templates contain three major components—a claim, a reason, and a source of evidence. We adjusted Weinberger and Fischer’s [8] original framework so that the modified framework is more suitable to categorize and analyze the students’ elaborations in the present study.

According to the findings, the posting templates could assist the students in constructing arguments containing reasons and grounds to rationalize and warrant their arguments in LV. In the presence of the templates, the students could achieve a certain level of attainment of argumentative elaborations. However, in the absence of the templates, there was no guarantee that all of them could reach “immediately” the same level of attainment (regarding the results of the comparison between the students’ attainment in Week 4 and Week A). Nevertheless, we found that the students’ face-to-face peer-sharing (facilitated by the teachers) and experience re-collection could help them to resume a comparable level of attainment (regarding the results of the comparison between the students’ attainment in Week 4 and Week B).

One of the limitations in the present study is that we did not set up a control group. All of the comparisons were done within the same group of students’ performance in different weeks of the different phases in the learning experiment. Thus, repeating the same experiment with the presence of a control group, i.e., a group in which students have issue-based discussion in LV without the provision of the posting templates in Phase 1, is now on our agenda for further study.

In addition, the quality of the grounds that the students provided to warrant their arguments has aroused our concern. In the present study, it was noticed that a certain portion of the cited grounds in the postings came from Wikipedia and Yahoo! Answers. In fact, the content in these Web 2.0 references has been raising doubts (e.g., [14]) about their authenticity. Our worry is that students use “unwarranted grounds” to substantiate their arguments. In view of the concern, empowering students to evaluate and use “authentic” grounds for participating in CSCL has become another issue which is worth further research efforts.

6. References

Video Games in the English as a Foreign Language Classroom

Tom A. F. Anderson, Barry Lee Reynolds, Xiao-Ping Yeh*, Guan-Zhen Huang*

Graduate Institute of Network Learning Technology,
*Graduate Institute of Learning and Instruction,
National Central University, Taiwan
ta@cl.ncu.edu.tw

Abstract

The purpose of this study was to investigate potentials of and to identify factors relevant to computer games at the center of a course curriculum. In order to improve the English listening ability of foreign language learners in Taiwan, two types of lessons were developed for America’s Army, a free-for-download FPS military game. The current study compared different factors that contribute to the possible success of lessons that use video games as their core material. A deeper impression of the feasibility of using in-game dialogue for language learning was. Assessment of listening comprehension was conducted in pre- and post-tests. The study shows students feel they can learn English through a course that uses computer games and gives directions for further research.

1. Introduction

English, recognized by many as the international language, is taught all over the world in English as a Foreign Language (EFL). Students in an EFL setting lack opportunities for extensive exposure to English, which is necessary for language acquisition [1]. No matter the teaching methodologies that they employ, EFL educators around the globe have been exploiting realia media, enhancing their instruction and giving students exposure to abundant sources of input that are beneficial for improving listening skills [7][8][9]. Throughout the years, language educators have continuously urged students to seek alternatives to static textbook pages and vocabulary lists [3].

Authentic material refers to those media that native speakers are exposed to in English speaking countries. Many EFL educators and researchers advocate the usage of authentic materials as a means of helping students reach native-like fluency in a language [4]. Authentic materials in the EFL classroom can have a positive effect on learning [6]. Authentic language learning materials can increase learner on-task behavior; additionally, overall class motivation to learn class content may increase when using authentic materials [18]. This may be one of the reasons that foreign language movies and culture classes that use authentic media are fast becoming a standard in foreign language departments world-wide [5].

Video games are a form of interactive and engaging authentic materials currently receiving much attention from educators [11]. They offer potentials in improving EFL listening ability [10]. Listening comprehension can be improved by providing audio lessons supplemented by visual input and feedback [22], both of which video games can provide. Research has shown games integrated into mainstream classrooms support higher-level learning and thinking skills [12], and can be especially helpful in developing future professionals [13]. Though research in the area is young, recent investigations probed educators opening up classrooms to video games, video games for language learning, and the changing role of the language teacher in game-based learning environments [15][16][17]. Research has shown that with proper teacher guidance, video games, through the power of simulation, not only promote higher-level thinking skills, but also provide opportunities to delve into the language and knowledge of professionals from other semiotic domains [14].

The game America’s Army (AA) is comprised of in-game tutorials and deployment in simulated missions. The in-game tutorials involve realistic virtual actors speaking hundreds of lines of dialog designed to provide players with an understanding of the training that real soldiers undergo in their training as well as to understand how to play the game. Players are required to initially complete training sessions covering basic rifle marksmanship and movement prior to playing the missions. These training missions involve listening to a virtual instructor (Fig. 1) deliver lectures and instructions, and subsequently performing actions as directed, quickly and accurately.
We selected AA for this current research for a number of reasons: AA provides hours of dialog that teach real-world skills—it taught a man the first aid he performed to save a life [21]; AA is authentic—it has been one of the top ten most popular FPS games for seven years as tracked by GameSpy.com; AA is customizable—it comes with a Mission Editor; and AA is affordable—it is a free-for-download game. We propose an off-the-shelf video game as a source of authentic, engaging, dynamic input for non-native speakers of English.

2. Research Questions

The main aim of this study was to explore possibilities that games, with assistance from English language instructors, can afford for EFL learning. We constructed three research questions to focus our exploration of the possible potentials of AA for foreign language acquisition:

1. What should a teacher do using AA in a Taiwanese EFL environment?
2. How do students feel about using video games, especially AA, for learning English?
3. Can AA increase the listening comprehension of EFL learners in Taiwan?

3. Experimental Methods and Results

The two experiments that appear in this paper were conducted as part of an ongoing investigation of computer games for learning. Two researchers involved in this study were experienced EFL teachers, and they served as the instructors. Students at our university have intermediate to advanced English abilities, and are exposed to English language course textbooks, although lectures are almost always delivered in the lingua franca, Mandarin Chinese. Each student in these experiments was provided with a dual-core Windows Vista OS desktop or notebook PC sufficient for maximum screen resolution and to enable simultaneous screen-capture. America's Army: Special Forces (Overmatch) 2.8.3 for Windows was pre-installed on each computer for each session.

An initial trial experiment probed perceptions and expectations of computer games used for language learning. The trial study generated initial impressions about using AA for teaching EFL and provided direction for the main experiment. Qualitative information gathered from the subjects in the trial study was used to assist the researchers in designing a second experiment. A brief description of the trial experiment is given in the next section, and a more detailed description of the main experiment follows in the subsequent section.

3.1. Trial experiment

Eight subjects (three Taiwanese undergraduate students, 1=M and 2=F; two university exchange students from France, 2=F; and four Taiwanese high school students, 4=M) were recruited to participate in the trial experiment. All participants had studied English for at least six years. All participants expressed a desire to improve their English ability at the time of their recruitment.

The trial experiment was comprised of five sessions; in each, one to three students were guided by a teacher through AA training modules. Direct instruction was not given, but subjects were told they could receive just-in-time assistance on demand. Observations were made by a researcher in a non-teaching role, and screen-captures and video were recorded for subsequent analysis. After completion of a module of AA training, participants were interviewed, with probing and follow-up questions for a deeper understanding of beliefs and feelings.

3.1.1 Trial Experiment: Results. Students expressed that they felt it was possible to improve their English in a class using America’s Army. The most revealing finding of the trial experiment was in response to the open ended question: “How could a teacher help you to learn more English from a class using America’s Army?” All participants shared an assumption that vocabulary lists should be first priority. Such a glossary was created and utilized in one condition of the second experiment. Responses given in interviews were used to generate the questionnaires used in the second experiment.

During one-to-one sessions students were observed to interact more freely with the researchers, asking questions and shouting out unknown vocabulary more frequently.
During paired play, it was determined that headphones were required to prevent interference with the other student’s game play, to allow students to concentrate on the spoken dialogues in the game. During paired play, students appeared to be more isolated, directing their questions to each other more often than to the researchers.

3.2. Second experiment

For this second phase of the study, twenty-nine (17=M; 12=F) non-English major graduate and undergraduate students from a national research university in Taiwan were recruited to participate. The uneven ratio of male to female in this study reflects the population of the engineering university that the participants attend. Non-English majors were recruited to represent average EFL learners in Taiwan. All participants had studied English for at least six years. All participants expressed a desire to improve their English ability at the time of their recruitment.

The trial experiment began to answer our first two research questions, but the third—regarding listening comprehension—was yet unaddressed. Our second experiment was designed to explore more deeply what was revealed in the trial experiment and to begin to fill in the gaps. Listening is perhaps the most difficult language skills to assess [19]. To investigate our third research question, twenty short one or two sentence audio samples were randomly drawn from the initial AA training module, paired with matching multiple-choice questions created by one of the researchers based on Brown’s [19] paraphrase recognition standards listening assessment. Each web-based listening pre- and post-test was comprised of ten questions, randomized: each participant answered a question once, either in a pre- or post-test.

3.2.1 Second experiment: Methods. Subjects were randomly assigned to one of two conditions: Those who received instruction covering the glossary of important terms (vocabulary group) and those who received instruction in how to move and navigate though an AA training module (game tutorial group). The ten vocabulary terms presented to the vocabulary group were words that were used repeatedly in the initial AA training module and appear on the academic word list (a list of 570 words frequently found in academic English language texts [2]). The AA training module presented to the game tutorial group was not the initial training module that was used to generate both the vocabulary word list and the listening tests.

The two teachers took turns, teaching either the glossary or training modes in four different teaching sessions of AA, such that each condition was taught by each teacher an equal number of times. Each subject signed up and participated in only a single session. Blocking was employed to ensure that conditions were balanced: Equal numbers of students from the prominent groups were assigned to each of the conditions. In other words, like numbers of males and female, like numbers from different departments and like numbers from each recruitment method were assigned to each of the two conditions.

The activity flow was as follows. Subjects were first administered a listening comprehension pre-test for 10 minutes. Next, subjects were randomly separated into an instruction group, either for vocabulary or for game tutorial, in which they were given 10 minutes of instruction by one of the two teachers. After instruction, subjects were brought back together and completed the initial AA training module in 30 minutes—subjects who finished before the other students were asked to repeat the module for additional practice until everyone had completed play.

Throughout game play teachers circulated about the classroom providing help to all students and answering questions. Following the completion of the initial training module by all students, students were given the chance to complete another AA training module for an additional 10 minutes as a distracter. At the conclusion of game play, subjects were administered a web browser based listening post-test for 10 minutes. Finally, they were given an additional 10 minutes to complete a paper-and-pencil questionnaire that contained both qualitative and quantitative questions. Actions of participants were observed and videotaped throughout the activity.

3.2.2 Second experiment: Results. Similar listening comprehension abilities were found for both groups (See Table 1). Statistical analysis using a t-test revealed no significant difference between pre- and post-test scores for subjects (p<.05). Despite an apparent small improvement in listening comprehension scores in the game tutorial group, we note no significance was found.

<table>
<thead>
<tr>
<th>Test of Listening Comprehension</th>
<th>Experimental Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vocabulary</td>
</tr>
<tr>
<td></td>
<td>Mean (%)</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>47.33</td>
</tr>
<tr>
<td>Post-Test</td>
<td>47.33</td>
</tr>
</tbody>
</table>

*p < 0.05

Table 1: Vocabulary condition Pre- and post-test

Qualitative data collected from the questionnaires indicate that subjects had a positive attitude towards learning English through a game-based approach.
Subjects compared their learning of English through games to that of virtual movies, most likely because of the interactive features of AA. Most students rated their English ability as being poor. Furthermore, the majority of students felt that the support of an instructor was necessary throughout the game play. They felt that it would be difficult for them to be successful in the game without an instructor to help with problems.

Many students wrote it was difficult to follow the instructions given by the virtual characters because the rate of speech was too fast and they were unfamiliar with the subject area: military English. Some students responded it was difficult to interact inside the simulated world; some had difficulties with the training module. Some students complained about eye strain.

Overall, most males expressed that they felt the game was fun and interesting, whereas many female subjects stressed a general lack of interest in FPS games, evidence that a broad group of students may lack motivation to play games from the military genre.

4. Discussion

The debate on whether authentic materials should be used in the second and foreign language classrooms continues to be a concern for educators [7][18]. One thing that most educators seem to agree is that whether authentic or modified, materials should be targeted according to the comprehension levels of the learners [2][20]. Future research on off-the-shelf games for language learning should take this into consideration matching learners’ abilities to games at the appropriate ability level. Locating games with appropriate content for mature learners with low English abilities is an ongoing challenge—one that could be overcome if more game designers became more aware of the enormous market of language learners.

Playing video games will prepare students for social participation. It is common for groups of friends to play video games in their leisure time. Computer games can provide a natural bond for foreign language learners who would like to become friends with native speakers. However, playing and talking about these games requires a particular frame of reference, a different set of vocabulary than is generally taught in the language classroom. By bringing video games into the forefront of an elective language course, students will learn language from in-game dialogues and textual prompts as well as learning to talk about the games in English.

The role of Asian culture likely played a part in our students’ poor self-perception of their English abilities. Subjects may simply not be familiar with American military culture and thus performed poorly. Past research [4] has indicated that the teaching of culture is essential when utilizing authentic materials for a classroom. Future research in this area of game-based language learning should seek to account for the active role that culture plays in language acquisition.

For playing a game to become a learning process, the teacher’s role—to promote analysis and reflection—is very significant [23]. In our study, though requiring additional preparation time to prepare tests and short (ten minute) lessons, the teaching load was relatively moderate. An improved method of just-in-time help may be beneficial for students if, especially to prepare students for virtual characters with fast paced speech. We are left with the impression that it is feasible to use the dialogue in computer games for language learning.

Educators of all domains hope students spend an abundant amount of time practicing and studying the content. Game-based learning advocates must recognize that extended gaming can possibly lead to eye strain or headache, a point that future designers for game-based learning should take into consideration—preventing students from focusing on one area of the screen for too long while also requiring students to alternate between game play and breaks is a necessity.

![Figure 2. Medic training in a simulated classroom in America’s Army.](image)

Even though AA was initially chosen because it was successful in teaching someone CPR without real-world instruction [21] (see Fig. 2), the determination of games that better appeal to a female audience should be explored. Although students in our study are mature enough to understand the difference between real world and simulated worlds, AA involves shooting of firearms: this type of game play may not be suitable all ages.

We worked under an assumption that paying attention to instructional aspects of the game is important to learning. This assumption was echoed in the responses
made by participants; however, future research should investigate differences in language acquisition between learners who attend to instructional aspects of video games and those who play freely, skipping tutorial elements. Further studies could investigate the role of guidance of language teachers, who may draw the attention of learners to certain language elements, and whether such a direction would lead to an increase in such activities in other situations.

5. Conclusions

Computer games provide language-laden, rich and entertaining vistas onto immersive simulated worlds. We believe properly designed activities for simulated worlds in the classroom is a promising direction for learning, which can result in dramatic improvements to a traditional classroom. Our work demonstrates a possibility that language learning can be supported by digital games. Much like movies and other media, some video games provide a window onto the world, a resource that can and should be tapped for learning.

9. References


What will happen to virtual field trips? Beyond classroom

Hyungsung Park, Bokjin Shin, Xiangzhe Cui, and Jihyun Hwang
Korea National University of Education
Republic of Korea
hyungsung@gmail.com

Abstract

The purpose of this study is to introduce activity for using educational purpose of Second Life based on the model for virtual field to support classroom teaching and teachers’ implementation of curriculum including experiential learning related to cultural assets, field trips, cross-cultural understanding and on the like. In virtual reality, teachers could set a time and place for all the students to meet, such as at a museum, cultural asset, or national treasure, and then plan other activities and discuss them together. For this, we have introduced an extended activity procedure for virtual field trips which focuses on experiential learning and activities to support classroom teaching and learning in second life based on the potential of virtual reality.

1. Introduction

Much effort to use educational games, simulation, and virtual reality for students’ learning has been made in teaching and learning activities. In the words of Jonassen et al. [1], the roles for technologies such as virtual reality in supporting meaningful learning are as follows: as a tool to support knowledge construction; as an information vehicle for exploring knowledge to support learning by constructing; as authentic context to support learning by doing; and as a social medium to support learning by conversing.

Learners learn in various ways, including by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing; and drawing analogies and building. The purpose of these different techniques within teaching and learning activities was to achieve effectively the educational goal of each of them. Learning in schools and in society should be a social context to solve real problems using various tools based on technologies. The idea of socio-cultural learning is based on Vygotsky’s thought that all human activities take place in a cultural context with many levels of interactions; shared beliefs; values; knowledge; skills; structured relationships; and symbol systems [2].

Nood and Attema [3] said that Second Life is a virtual reality where one can interact with the environment that is constructed of quite a realistic graphic representation of our physical world. The first thing a new visitor sees is a modifiable puppet, called an ‘avatar’ that enables the user to move through the virtual world. With this avatar, the user can fly, teleport, or walk to practically any place within Second Life.

Virtual field trips are computer-based simulations of an actual field trip. In this space, it can provide both the teacher and the learner with the opportunity to explore aspects of an actual trip without leaving the classroom. Virtual field trips should include all the elements of a well-designed field trip and provide the students with experiences that are beyond those that could be obtained from a pamphlet about, or a photo display of, the location [4]. Schools have suggested that field experience learning to develop students’ nature and unfold experiential learning is the meaning that can extend instruction-learning activities. For this purpose, virtual field trips for experiential learning can be a great contribution to acquire the knowledge and experience through learning by doing activities in virtual reality because they have good advantages to support classroom learning.

The purpose of this study is to explore the potential of virtual reality and to suggest a model for virtual field trips, practical activities in second life to support classroom teaching and teachers’ implementation of curriculum including experiential learning related to cultural assets, field trips, cross-cultural understanding and on the like.

2. Field experiential learning activities in Second Life

The important distinguishing features of VR are that it is highly immersive, interactive, color visually oriented, fun, and generally exciting. Virtual reality technology is increasingly being recognized as a potential tool for the assessment and rehabilitation of human cognitive and functional processes [5][6][7].

Jonassen et al. [8] argues that technologies can be applications of human knowledge to solve real-world problems. Especially, technology such as virtual reality tools can support human needs and expand the
individual’s functional capacities. This is knowledge construction, informational resource management, and requires producing communication connectives. In the same context, Second Life is a virtual reality tool and new media for exploring communication spaces that may improve mutual understanding between men and women about gender roles. Virtual worlds continue to grow as a significant component of the leisure time of many children and adults. In addition, they are being used in education worldwide and they play an increasingly important part of our culture as a whole.

According to the results of Johnson’s [9] study, the educational potential of virtual reality such as Second Life is as follows: it provides a low risk environment; it has more functions than just chat rooms; it encourages active participation because it has many other options for distance learning; It provides a good learning environment to appropriate accommodate the digital learning generation; it creates the opportunity for more engaging discussions because it reduces the authority of the instructor. Virtual field trips for experiential learning can apply various teaching and learning models to improve higher-order thinking and other learning skills that in turn support classroom learning and other important areas of students’ educational environments. One of the most important missions of educational is to help students develop the knowledge, skills, and attitudes needed to identify, analyze, and solve problems. In this activity process, teachers and learners need to apply appropriate teaching and learning models.

Kolb[10] said that experiential learning is highly suited to the acquisition of practical skills, where trial and error and the opportunity to practice practical techniques related to real tasks is essential. Experiential learning focuses on the learning for the individual, at the same time, learning on the direct process for the individual. In this model, learners must recognize the problem through the impulse phase, observe conditions and situations, get knowledge, make judgments according to the response, and finally achieve the purpose.

We introduce extending the model of virtual field trips based on Dewey’s experiential learning model (see Figure 2). In the planning phase of a virtual field trip, the teacher should guide the goal, topic, activity methods, activity content, and a list of suitable locations for the virtual field trip to learners. In turn, learners can choose an appropriate place to explore for learning. In the next goal of the prior learning phase, learners are to investigate materials related to the topic to achieve the learning objective in virtual reality. For this, we can relate the content to the topic and provide it in Second Life. In addition, Internet content through hyperlinks in WebPages in Second Life can also be used to disseminate content. The virtual field trip phase is a practical activity that features investigation, observation, recording, discussion, and capturing using Second Life’s functionalities. Finally, in the post learning phase, learners must arrange the materials and two post learning papers: a final paper and a reflection paper.

Figure 2. Virtual field trip model for experiential learning

We introduce activities that relate field experiential learning in Second Life through procedures based on virtual field experiential learning and based on the potential ability of virtual reality as stated above.

First, the land in Second Life provides an interesting learning environment that can pique learners’ curiosity and assist student learning.

Figure 3. Solar systems from Science School

For example, Science school land is a place where elementary, middle, and high school learners can learn about the solar system through three-dimensional (3D) environments in Second Life. Second nature land is another example, in which students can learn cellular structure, stellar evolution, human mitochondrial DNA, gallery of human chromosomes, and other similar science-related items.

The second item related to field experiential learning in Second Life is that it can make objects like cultural assets consisted of prims to use for virtual field experiential learning. In Second Life, the residents can make virtual cultural heritage tourism by using their
mouse and keyboard to navigate their avatars through the multiplayer online environment without being there (in the real world). There are many places of historical interest that have been duplicated in Second Life including, China’s Forbidden City and Japan’s Osaka Castle.

Students get involved in these vivid virtual environments, and have unique capabilities, such as the ability to fly through the virtual world, to occupy any object as a virtual body, to observe the environment from many perspectives, and, in some places, to build objects as you see fit. Through this “learning by doing” experience, participants can get a wealth of information and understanding about the place they have visited.

In addition, Second Life can provide places for mutual cross-cultural understanding. A more extensive approach to cross-cultural experiential learning which is now utilized in many schools is foreign field-based travel in which students are immersed for a short period in a foreign culture. The primary reason for the increased popularity of such courses is that the richness of such an experience is difficult to duplicate in the classroom. Students can experience culture shock first hand, see the pervasive influence of culture on business practices, and preview expatriate life. These elements can also be replicated in Second Life.

4. Discussion and Suggestion

There are several ways in which VR technology is expected to facilitate learning. One of its unique capabilities is the ability to allow students to visit environments, and to interact with events that distance, time, or safety factors make unavailable. The type of activities supported by this capability facilitate current educational thinking that students are better able to master, retain, and generalize new knowledge when they are actively involved in constructing knowledge through learning by doing.

Virtual field trips allow learners and teachers to experience those things that cannot be done in the real world. They also provide good experience to support teaching and learning beyond the classroom. In this paper, we have reviewed the advantages, potential power of virtual reality through literature review, and confirmed the roles as the rich learning environment.

Focusing on this point, we have introduced a virtual field trip model based on Dewey’s experiential learning model and introduce a variety of activities that can be applied to virtual field trips for experiential learning. If virtual reality is used for learning to support the classroom, instructional design and other educational parts, we can have effective teaching, learning environments, and good educational ideas and expect learning outcomes.

5. References

Workshop Papers

DIGITEL 2008
ROBOKID: Let Children Construct Their Own Emotional Kids - learning by construction


*Department of Computer Science and Information Engineering, National Central University, Taiwan
Graduate of Network Learning Technology, National Central University, Taiwan
Graduate Institute of Learning and Instruction, National Central University, Taiwan
Center for General Education, National Yang-Ming University, Taiwan
gdchen@db.csie.ncu.edu.tw, muchun@csie.ncu.edu.tw, hsiao@csie.ncu.edu.tw,
wyhwang@cc.ncu.edu.tw, ltc@cc.ncu.edu.tw, totem@cc.ncu.edu.tw, rainbows1114@yahoo.com

Workshop Overview

Bill Gate mentioned in Scientific America that robot will enter every home in ten year the same as personal computers have entered into almost every home in ten year. This project is to response to this trend, and to think about how robot can enhance learning, for example, robot can be as learning tools, teaching tools, learning companions, teaching partner, or some other models to enhance learning. At the same time, emotion interaction, empathy, and story telling capabilities are thought as basic capabilities that students need to learn. Our research group attempts to enhance the completeness and to extend the application about the robot in education. The preliminary research results and findings contain the following elements required for using Robot:

1. develop learning model and theory of using Robot,
2. design learning materials for English, robot programming, and problem solving,
3. evaluation of learning effects [including evaluation from psychology and physiology point of view],
4. design and implement an emotional robot with capabilities of social interaction and emotion interaction.

We also consider the deployment of our research outcome in schools. Therefore, we have demonstration, promotion, and deployment phases. The training program for teachers is designed for this purpose.

Background & Motivation

Education is one of most potential areas to apply and promote robots to the world. Due to its more convenience and more effectiveness to help people build
solid knowledge and make learning more interesting and useful, the first particular workshop of robots on education in Taiwan will be proposed and held with DIGITEL 2008.

Using physical or virtual robots, learning and teaching would become more practical and tangible, and enhance learning motivation and enrich context reality. Learners can build their robots to reach their targets or interact with robots like learning peers or assistants. In building robots, learners construct knowledge by applying various sensors or motor engines to respond different conditions. Students can learn how to solve practical problems in the real world context and apply solid experience and knowledge to solve different similar problems later. In Taiwan, there are more and more researchers and companies concentrated on robot and its application. Meanwhile, many robot contests have been held for long time in Taiwan and attracted many students and teachers to attend them. The governmental organization, National e-learning and digital archives programs, in Taiwan think it will be promising using robot on education and fully support researches on this issue. For bringing forth wider collaboration and sharing, it would become urgent to hold a workshop of robots on education and invite related experts in the world to share their experiences and expertise.

Our workshop focuses on the recent issues and methods of using robot on education in Taiwan. We will introduce National e-learning and digital archives project in Taiwan and its research results of using robot on education. The results include the effects of using robots on cognitive thinking skills, affect, assessment, and motivation. Two main types of researches related robot on education will be presented. First, the researches using physical robots on learning, affect and assessment will be presented their latest results. Second, the researches in virtual robots like learning agents are also discussed. It is hoped that through this particular workshop and discussion with all attendees from all over the world, it can bring forth the further collaboration and impact of this issues to the academics and public.
Using humanoid robots as instructional media in elementary language education

Gwo-Dong Chen, Chih-Wei Chang*
Department of Computer Science & Information Engineering, National Central University, Taiwan
gdchen@db.csie.ncu.edu.tw, gogo@db.csie.ncu.edu.tw

Abstract
As robot technologies have developed rapidly, many researchers have tried to use robots to support education. Studies have shown that robots can help students develop problem-solving abilities and learn computer programs, mathematics, and science. However, few studies discuss the use of robots to facilitate language teaching and learning. It is worth discussing whether language education needs robot support, whether robots present an appropriate medium for language instruction, and what challenges must be overcome. This paper reviews past studies of educational robots, and we designed tested five language instruction scenarios using a teacher and a robot. Based on our empirical experience, we provide suggestions for future research into, and design of, robots for language education.

1. Introduction
Using robots to support teaching and learning, from secondary school to undergraduate courses to graduate education, has become a popular research topic in recent years [6]. The first man to implement an educational robot was Seymour Papert [5], a founding father of this field. He proposed an approach to learning in the classroom that he calls “constructionism”, as opposed to the traditional style of “instructionism”. In this approach, students can learn from designing, and assembling their own robots. Since robots capture the imagination of many younger people, they have been validated as useful aids for the teaching of mathematics and physics [1]. Furthermore, the use of robots is not limited to traditional engineering departments but is distributed across a variety of arts and science courses. The use of robotics by nonengineering, nontechnical instructors has been termed a “robotic revolution” [2].

The development of educational robots is still in the initial stages. Robot technologies bring new developments to education. The literature includes many studies that have tried to use robots to support learning, especially in mathematics and science. However, there are still few papers that discuss the value of robots in language learning. To complete our understanding of educational robots, we should explore potential benefits of using robots for language education, optimal design of language education robots, and limits and challenges that must be addressed. This study explores the possibility of using humanoid robots as instructional media in elementary language education. In this paper, we survey current instructional media for teaching language and roles of educational robots; we also propose five paradigms to realize the implementation of robots in language courses.

2. Related works
The roles of educational robots have some familiar forms. These roles are usually produced by the objects that have existed while learning originally. By reviewing past research, we identified three categories of roles: learning materials, learning companions / pets, and teaching assistants.

Learning materials
The classic example of robots as learning materials is the LEGO Mindstorms for Schools. In 1984, LEGO collaborated with the Media Lab at MIT. They developed instruction kits which combine toys with advanced technologies. LEGO Mindstorms are collectable and programmable teaching tools. Learners can design and develop their own robots in a competition and learn in the process. This results not only in development of motivation but also in improvement of capability in mathematics, science, programming, problem solving, and collaboration [16].

Learning companions / pets
Humanoid robots can naturally be regarded as learning companions. In one field study [4], two robots visited a children’s elementary school in Japan for two weeks, with the purpose of teaching children English. This experiment showed that the children’s recall of new words improved, and that there was a positive correlation between the frequencies of interacting with the robot and learning performance. However, motivation decreased
over time. Although the effects are modest and the study length was short, the results of this study are impressive because this study is the first practical demonstration that students can learn from a humanoid robot.

**Teaching assistant**

While those who use learning companions are mainly students, the robots used as teaching assistants serve teachers to teach in classes. Robot IROBI [3] has been applied as an assistant in a classroom. This instructional medium displays information to students with a monitor in the belly of the IROBI. Moreover, the robot can move its arm to direct students to the key point in the monitor. In 2008, guidelines for designing the proper body feature for a teaching assistant robot in order to provide more effective interaction were proposed [20], such that the interaction between teachers and students could become more varied.

These studies indicate the potential for using robots to support education and suggest a variety of educational robot roles. Currently, many studies focus on applying robots to assist students in learning science or mathematics. However, few researchers have studied using robots to support language education. The goal of this paper is to discover this new research field, to explore the possibility of using humanoid robots as instructional media in elementary language education, to analyze the characteristics of robots in order to facilitate language instruction activities, and to reveal the possible influences to language courses by robots.

### 3. Five paradigms

This study deployed a robot partner for teachers in the classroom in order to realize the effect of robots on learning, and to discuss the optimal use of robots for promoting language education. After conferring with the elementary language teachers, we collaboratively designed five robot modes according to the condition of the classroom and the characteristics of robot that we would specify them in the discussion section. The modes are story-telling mode, oral reading mode, cheer mode, action command mode and Q&A mode.

### 4. Conclusion

As advanced robot technologies have developed rapidly, using robots to support teaching and learning has become a trend. In this decade, researchers have provided much evidence that the robot is a great teaching aid for mathematics and science. Further, educational robots are helpful to students developing collaborative and problem solving abilities. However, there are still few studies which discuss robots in language instruction. What are the advantages and disadvantages of utilizing robots to support language education? How do we design and develop the educational robot to be a practical instructional medium in language education? These are important and fundamental problems for future research. Educational robots will be completed when they can be used for both science and art.

This study does not aim to replace teachers with robots, but attempts to discover a new instructional medium for aiding language education. Using robots in a language classroom to support teaching and learning is now possible. Robots have unique features that distinguish them from human and current media; those characteristics provide robots with great potential to become a useful instructional medium in language education. In the future, we will explore more deeply the relationship between robots and learning performance in language learning.

### 5. References


Application of a Learning-Companion Robot in Learning Environments

Mu-Chun Su, De-Yuan Huang, Shih-Chieh Lin, Yi-Zeng Hsieh, and Gwo-Dong Chen
Department of Computer Science and Information Engineering, National Central University,
Taiwan
E-mail: muchun@csie.ncu.edu.tw

Abstract

In this paper, a learning-companion robot based on a Pleo (a dinosaur-robot) is introduced. The learning-companion robot is equipped with a low-cost Web camera, a computer, and an attention monitoring algorithm so that it can not only monitor a learner’s attention status but also detect whether the learner is too close to a computer screen during an on-line learning activity. The motivation of the development of the learning-companion robot is to alleviate parents’ supervision burdens when they can not personally accompany their children to engage in some learning activities or playing computer games.

1. Introduction

Robots have been developed for many different applications and their designs are changing at an unprecedented pace. Basically, robots can be dichotomized into three categories: industrial robots, professional service robots, and personal service robots [1]-[2]. Industrial robots are the most widespread distributed robots to date and widely applied in welding, assembly, transporting, etc. Professional service robots are developed to assist people in many environments outside factories. As for personal service robots, obviously, they are especially designed to assist or entertain people in domestic environments. Examples are robotic vacuum cleaners, robot-based assistants to elderly and disabled people, intelligent toys, etc.

Recently, researches have been under way for developing robot companions [3], [4]. Such kind of robot companions can be viewed as a special kind of personal service robots. Robot companions are expected to engage in social-human interaction and perform tasks including entertainment, diary duties, educational functions, etc [4]. Although many researchers showed that robot companions may be the next trend of personal service robots, currently, there is no robot that is able to perform a combination of aforementioned tasks efficiently, robustly, and autonomously. Dautenhahn et al. explored people’s perceptions and attributes towards the idea of a robot companion for the home [4]. Hsu et al. investigated the differences of the influences between robot and virtual learning companions on students’ engagement [5].

In our opinion, if a learning companion can not provide some practical or educational functions then it will be just a high-tech digital toy and its worth will be limited since the time spent by the children with the robot will quickly decrease as the novelty of the robot diminishes.

In this paper, we introduce a learning-companion robot which tries to alleviate parents’ supervision burdens when they can not personally accompany their children to engage in some learning activities or playing computer games. The learning-companion robot can not only output a simple learning profile which reveals the degree of the children’s engagement at the end of their learning activities but also issue a warning signal whenever it detects that the learning environment needs better illumination or the distance between the learner and a computer screen is too short.

2. The Learning-Companion Robot

Pleo is an animal appearance robot (a dinosaur-robot) with powerful microprocessors, various sensors, and a lot of motors which enable them move by themselves in a diversity of scenarios [6]. In this paper, we try to implement a learning-companion robot by incorporating a Pleo with a low-cost Web camera, a computer, and an attention monitoring algorithm [7] to endow a Pleo with some practical or educational functions.

Parents would like to know whether their children are really engage in learning activities when they can not sit down beside their children during some learning
activities. To alleviate the parents’ supervision burdens, a Pleo can be placed beside the children to monitor the children’ engagement degree during the learning activities and then output learning profiles to parents (as shown in Fig. 1). Furthermore, parents are always concerned about the vision care problem of their children. To provide an appealing solution to the problem, the learning-companion robot can issue a warning signal whenever it detects that the learning environment needs better illumination or the distance between the learner and the monitor is too short.

![Fig. 1. The learning-companion robot in a learning environment.](image)

Via images acquired by a low-cost Web camera, the attention monitoring algorithm [7] can not only detect the eyelid movements but also give a qualitative measure of facial orientation. Based on the measures a simple learning profile which reveals the degree of the children’s engagement can be real-time or off-line transmitted to children’s parents for reference.

The algorithm starts with extracting visual parameters that typically characterize a person’s level of attention. It locates the face region of the learner and then detects the eye regions. The goal of eye detection is for subsequent eyelid-movement monitoring and facial-orientation monitoring. The facial orientation reveals important information about the learner’s attention. In most of the learning situations the normal facial orientation while learning is frontal. If a learner turns his or her head in another directions (e.g., up, down, right, and left) for an extended period of time, this is a good indicator of inattention. Frequent head tilts may indicate the onset of fatigue. The measures of the attention status are then compiled to generate a simple learning profile to parents for reference.

In addition to the functionality of monitoring the learner’s attention status, the face image acquired by the Web camera can be used to estimate the distance between the user and the computer screen. Via the estimated distance, the system can issue a warning signal to the learner to remind him or her to keep a distance from the screen. By use of a light sensor, the learning-companion robot can also detect whether the learning environment needs better illumination.

3. Conclusion

In this paper, we introduce a learning-companion robot which can alleviate parents’ supervision burdens when they can not personally accompany their children to engage in some learning activities or playing computer games.

Acknowledgement:
This work was partly supported by the National Science Council, Taiwan, R.O.C, under the NSC-97-2631-S-008-003- and the NSC 97-2631-H-008-001-

4. References

A Context Aware Interactive Robot Educational Platform

Eric Hsiao-Kuang Wu, Hubert Chi-Yu Wu, Yi-Kai Chiang, Yu-Che Hsieh, Jih-Cheng Chiu, and Kuan-Ru Peng

Department of Computer Science and Information Engineering, National Central University, Chung-Li, Taiwan

Abstract

Many researches point out that the advantages of peer tutoring, that is also one characteristic of robot education. It is not only a toy, but also your partner. We considered integrating speech, position information and 3G cell phone, to realize a highly-interactive education platform.

Teachers can design different scene with many stages for English or mathematics. Students send out his command to the robot with motions or speech the robot travels within the scene as an adventure. And the students assist the robot to solve any quizzes it meets. If the adventure processes successfully, the robot will interact happily with student otherwise, it will encourage the student to keep trying. The parents or the teacher can observe all these activities with a 3G cell phone to give advises of learning at any time.

1. Introduction

With the rapidly technology development, robots are used in many kinds of places, such as Industrial robot, home service robot, entertainment robot...etc, but rarely appear in education. Therefore, we want to design an edutainment robot with high intelligent and interaction accompany with children. Besides, we imagine the every children will have their own private robot in the future, children will play with robot and learn with robot.

This paper focus on how to design an Intelligent Interactive Robot to help children to learning English and Mathematics at light environment, and use the graphic editor, like LEGO[3] MINDSTORMS and LabView to generator interested scenario scripts, the purpose of using graphic editor is to accelerate the development of game field subcomponent. The users could create different events to increase the interests or learning. The robot in this field will interact with the users actively, and the same command would get different responses with different events. Learning is no longer boring, it would be very interesting with the highly interaction with the robot.

Considering the cost is a very important issue of robot education [1] [2], the price will affect the order of school or parents. So we have done some cost-down procedure for our platform.

2. System Requirement and Architecture

We designed an intelligent interactive robot, which using voice and gesture to control the robot. Besides, instructor could design interesting courses such as Mathematics and English in the robot to attract children’s learning motivation, parents can observe all the activity of leaning via 3G cell-phone. And we prepared a game field to make the learning more interesting. The purpose of our game is as follow: 1) create different events, increase the interests of learning, 2) with different events, the same commands would get different response, 3) using the information about the position of a robot, the robot could interact actively with the user, 4) display different scene with a projector.

To satisfy above requirements, we must have to achieve the following objectives: 1) robot development environment, 2) High interaction including speech recognition, 3) Ubiquitously obverse and care system, 4) An interactive game field.

Figure 1 system architecture
3. System Implement

The activity of learning is performed in the game field by projector. With the tracking system, we can design highly interactive courses within our game field. We give a map file filled with one and zero to produce the environment for playing, the value one stands for the place where robot could move.

After setting the environment, users can put on different events on the map. As the Figure 3, users can set events easily with our graphic user interface.

4. Results and Discussion

Figure 4 show the flow of operating the educational robot. There are three roles in the figure 4. Teacher could use the robot development tool to design some interesting course. Student could interactive with robot via voice and gesture. Last, parent could use 3G cell-phone to observe all the learning activities of children.

5. Conclusion

We developed a highly interactive robot educational platform with aplenty of interactive functions, users can use a remote, speech command, or using a Wii remote by hand waving to control the robot. We believe that highly interactive of a robot could bring out the interesting of learning, which is the most important issue.

With the interactive game field, robots would generate different reaction with different events, which would improve the helpful to increase interests within learning. The cost of education is also one important issue. The cost down procedure is necessary. Choosing a suitable tracking mechanism to implement would be helpful.

6. Reference


The effect of MSN Robot on learning community and achievement

Wu-Yuin Hwang¹, Sheng-Yi Wu², Hung-Cheng Chen³
Graduate of Network Learning Technology, National Central University, Taiwan¹
Department of Digital Media Design, Chinmin Institute of Technology, Taiwan³
wyhwang@cc.ncu.edu.tw

Abstract
Using Instant Messaging to support e-learning will become important because of its instantaneity, speed, effectiveness and low cost. In this study, we developed an MSN robot to mediate and facilitate students’ learning. The students’ acceptance of the MSN robot and its effect on learning community identification and learning were investigated using the Technology Acceptance Model (TAM). The students reported the Perceived ease of use and usefulness of the MSN robot for learning. The finding was that the MSN robot would be beneficial to and acceptable for learning community identification when applied to learning and teaching environments.

1. Introduction and Literature Review
In this paper, we study the use of instant messaging software to build a learning community and to enhance learning in one course. Therefore, we design an MSN robot for one course and recommend students online to help solve problems immediately. In addition, we study its impact on learning by providing the “Human” rather than the “Data” resource.

IM (Instant messaging) is a communication technology which allows a user to find out who is online and available to receive messages[1]. Nardi, Whittaker & Bradner[5] pointed out that IM can allow collaboration, scheduling, impromptu meeting and contact with friends and family.

Besides, there are three important factors. First, Markus[3] thought if enough people use instant messaging, this effect will spread to whole community. Cameron[1] thought instant messaging can succeed in workplace if it has achieved critical mass. Second, social presence means that a medium brings people the same extent of social awareness as face-to-face interaction does. While information is being exchanged, an individual can detect the presence of his or her peers, as in society [5]. Third, Nardi, Whittaker & Bradner[4] indicated people communication has two kinds of interdynamic aspects: “interaction” to exchange actual information, and other is “outeraction” to conduct social talk and negotiate the meeting time and place.

The technology acceptance model (TAM) was proposed by Davis in 1989 [2]. Its aim is to use perceived usefulness and perceived ease of use to explain, diagnose and predict users’ attitude and behavior when faced with new information.

2. Research Design and Implementation
This study was targeted to investigate if the use of an instant messaging robot can facilitate learning and enhance learning community identification. We divide the interaction into three functions (course immediate announcement, discuss board and recommend expert) and the outeraction into three functions (critical mass, social talk and social presence). The operational definition is as below:

- Perceived Usefulness of learning using Interaction: measuring students’ perceived usefulness of these three interaction functions on learning achievement;
- Perceived Usefulness of community using Interaction: measuring students’ perceived usefulness of these three interaction functions on learning community identification;
- Perceived Usefulness of learning using Outeraction: measuring students’ perceived usefulness of these three outeraction functions on learning achievement;
- Perceived Usefulness of community using Outeraction: measuring students’ perceived usefulness of these three outeraction functions on learning community identification;
- Perceived ease of use: Student’s perceived ease of use when using a MSN Robot system;
- Attitude to use system: Students’ attitudes and feelings on MSN Robot;
- System usage: the amount of system usage students used the MSN Robot;
- Identification with learning community: the students’ perceived identification of community;
- Learning achievement: Student’s scores in the post test.

The experimental course, “Introduction of Digital Multimedia Design,” was designed for 83 undergraduates. The experiment was conducted from September, 2007 to January, 2008. One MSN robot
was employed to help students engaged in the forum and discuss their assignments. The assignments were divided into two parts: Multimedia website survey and Q&A session. The MSN robot was online 24 hours a day and delivered instant announcements.

3. Analysis and results
The participants were first-year students in one university of Taiwan. Two classes with 83 students joined this study. Only 77 valid questionnaires were received and used for data analysis. According to the analysis, these results are shown in Figure 1:

![Figure 1 research conclusion map](image)

Besides, according to the statistics results and interview analysis, there are the following found in this research:

- Analysis of the influence of ‘Perceived Usefulness of learning using Interaction’ on Learning community identification and learning achievement: The usefulness of interaction learning was independent variable, and learning community identification was dependent variable. The linear relationship between the two variables was examined.

- Analysis of the influence of ‘Perceived Usefulness of community using Interaction’ on learning community identification and learning achievement: We learned that the presence of experts recommendation made them feel that they belonged to the community because whenever they logged on the MSN, they could get help from experts.

- Analysis of the influence of ‘Perceived Usefulness of learning using Outeraction’ on learning community identification and learning achievement: According to statistics, outeraction failed to have significant influence on learning community identification. The reason could be that many students logged on to MSN just for social talk and were not really intended to join the study community.

- Analysis of the influence of ‘Perceived Usefulness of community using Outeraction’ on learning community identification and learning achievement: They felt like they were part of the community when they found members of the same community online. They thought they could discuss their homework more conveniently and find answers more rapidly.

- Effect of system usage on learning community identification and on learning: The actual system usage had a significant effect on learning community identification. By utilizing MSN robot, students became more involved in their community’s activities and gradually developed a sense of membership.

4. Discussion and Conclusion
Instant messaging and virtual communities could appropriately help with learning achievement. Due to the fact that instant messaging is only an auxiliary technology, the real learning process can only be completed by the learner.

According to the statistics, neither interaction nor outeraction has a significant learning achievement. Instant messaging robot is a mechanism for interaction among community members, enhancing learning community identification. The effect of interaction is greater than the effect of outeraction.

Through this study, students expressed that they had no difficulty in using the robot. On the contrary, they thought it was a fresh idea that would be beneficial and acceptable when applied to teaching.

Reference
Human-Robot Interaction Research Issues of Educational Robots

Tzu-Chien Liu\(^1\) and Maiga Chang\(^2\)

\(^1\)Graduate Institute of Learning and Instruction, National Central University, Taiwan
\(^2\)School of Computing and Information Systems, Athabasca University, Canada

ltc@cc.ncu.edu.tw, maiga@ms2.hinet.net

Abstract

Today’s commercial robots are getting smaller and smaller. The price of robots are also getting close to the mobile phones and becoming affordable to be personal. In order to make the researchers and educationists using the personal robots in the schools and classes, this paper overviews the human-robot interaction factors, e.g. emotions and appearances, and summarizes important things needed to be noted before using the robots for educational purpose. In addition, the paper proposes five possible research directions include gender issues, appearances, humanoid or non-humanoid robots, priority of HRI factors, and interaction issues. Each direction covers several important research topics.

1. Introduction

Nowadays, small-sized and powerful personal robots are getting affordable to ordinary people, for example, Takaratomy Omnibot17mi-SOBOT is around $250 CAD and GeStream Be Robot is around $300 CAD [4][7]. These robots can be programmed to carry out a variety of actions and behaviours, even speaking. Sony also has a wireless card for their AIBO Messenger robots to allow the robot to connect with other computers [6]. Under such circumstance, the robots can be private.

This paper trying to provide researchers and educationists an overview about the human-robot interaction issues which are needed to be considered before the researchers and the educationists start to apply the small-sized and powerful personal robots into their researches and classes.

Before talking about the HRI factors, first of all, we need to know the types of robots. There are different types of robots, including humanoid robots (anthropomorphism), animal-like robots (zoomorphism), caricatured robots, and machine-like robots [3].

2. Emotions

Fong et al. (2003) indicated that emotion is important to a robot’s social development and Billard (2003) considered speech processing to be important in designing robots [1][3]. Woods (2006) also explored the children’s perceptions and evaluations of different robots, and they found that there are two issues that affect children’s choices of robots: behaviour intention and emotional expression [9]. Similarly, Plaisant et al. (2000) developed a storytelling robot with emotional behaviours [5]. They used the robot to help rehabilitate children and found the robot can help the children with therapy. The emotions can be expressed by facial expression, as Breazeal and Scassellati did in 1999 [2]. They built a robot, Kismet, who is a face robot. Emotions can also be expressed by sounds, for examples, laughing when happy, crying when sad, and shouting when angry.

Most of emotions we mentioned can be done by animated agents or virtual characters easily. Robots can perform emotions with another different way, which is “touch”. For examples, when the robot wants to comfort the student, it can pat him/her; when the robot wants to show the student its angry, it can hit him/her; and, when the robot wants to encourage the student, it can use its two arms to pat his/her shoulders. Therefore, when we are thinking how to use robots for educational purpose, we should also think about “body languages” and “body emotions”.

3. Appearances

Beside the perceptions of robots, a much more important thing of using robots for educational purpose is “what kinds of robots can help students learn”. Van Vugt et al. (2007) find that the students’ engagement is
influenced by task-relevance and perceived aesthetics, furthermore, the student’s satisfaction is influenced by his/her engagement and performance [8]. From their research results, we can know that the appearances of educational robots are very important, because of a better looking robot can increase students’ engagement and make students feel satisfy. When we think about a better looking robot, we need to think it with caution. In general, a better looking robot means much more like human beings, but the animal-like robots and caricatured robots, sometimes, are also quite cute and can attract children and young people.

If the humanoid robot is chosen to use, then the Uncanny Valley hypothesis should be taken into consideration. The Uncanny Valley hypothesis made by Mori in 1970, the hypothesis said that users will feel uncomfortable with robots’ whose outlooks are very close to human especially when the robots’ behaviours are not close enough [9]. If the human-like “thing” can walk but not so smoothly like human being, then the “thing” will give people a feeling just like it is a zombie. Similar to the perception of moving zombies, if the human-like “thing” doesn’t move just like a statue but it is so close to human being, then people may think it is a dead body. Both of the perceptions of zombies and corpses are not good to the students.

Woods’ (2006) research results also confirmed the hypothesis really exists after let 159 children score forty robot images and describe their feelings about the robots. If the humanoid robots represent the robots who have legs, arms, and facial expressions. A very interesting finding is the genders of robots, it seems male robots give the children “sad” and “aggressive” imagines. Also, perhaps “wheels” make the robots running fast, the robots with wheels make the children feeling “aggressive”

5. Research Issues

There are five possible research directions of using robots for educational purpose: gender issues, appearances, humanoid or non-humanoid robots, priority of HRI factors, and interaction issues. Due to the page limitation, we only list the details of the gender issues here.

There are several research topics in the gender issues: (1) do male students and female students have different attitudes toward the robots? (2) do male students and female students like different types of robots? (3) do male students and female students have different interaction ways and frequency with the robots? (4) what genders the robots should have for different courses or disciplines?

References

Robotics Instruction Using Multimedia Instructional Material

Eric Zhi Feng Liu\textsuperscript{1}, Chan Hsin Kou\textsuperscript{1}, Ting Yin Cheng\textsuperscript{1}, Chun Hung Lin\textsuperscript{1}, Shan Shan Cheng\textsuperscript{1,2}
\textsuperscript{1}Graduate Institute of Learning and Instruction
National Central University
No.300, Jhongda Rd., Jhongli City, Taoyuan County 32001
TAIWAN
\textsuperscript{2}Department of Information Management
Minghsin University of Science and Technology
No. 1, Hsin Hsin Road, Hsin Feng, Hsinchu
TAIWAN
totem@cc.ncu.edu.tw, janshing04@gmail.com, s901073@gmail.com,
sjohn1202@gmail.com, yes5433@must.edu.tw

Abstract

This study developed a multimedia educational program for teaching robotics. The program was intended to introduce robot adventure, assembly, and programming. Finally, triangulation method was applied in a pilot study to assess user satisfaction with the learning material. The evaluation results indicated that the instructional material was effective and achieved high student satisfaction.

1. Introduction

Robots are now widely used throughout the world for many applications. Accordingly, the robotics field has received increased attention from educators and prospective students in Taiwan. For instance, the number of Taiwanese students participating in the World Robot Olympiad has increased, and they have achieved notable success.

In Taiwan, the LEGO MINDSTORMS NXT system is widely used for robotics instruction because it enables easy assembly and programming. Accordingly, the authors developed the multimedia learning material for LEGO MINDSTORMS NXT. Moreover, in order to test the effectiveness of the material, a formal study was conducted to assess whether users perceived the material as effective for learning robotics. Their feedback was also expected to help researchers improve the material in the future. Therefore, the goal of this research was to develop effective material for teaching robotics and to assess user perceptions of the same.

2. Instructional Design Models

2.1. ARCS Model

Keller developed the ARCS model, which proposes that motivated learners require the following four conditions: attention, relevance, confidence, and satisfaction [1]. However, Keller argued that these four conditions should occur sequentially rather than independently or randomly [2]. We believe that the ARCS model is more effective when combined with the appropriate technology or a human-computer interface. Therefore, the ARCS model was chosen and applied in this study to examine learner motivation.

2.2. ADDIE model

Analysis, design, development, implementation, and evaluation—are the five critical elements of the ADDIE model [3]. Further, the ADDIE model is easier to implement and test. Therefore, in this research, the ADDIE model was applied for the material development as well.

3. Methodology

3.1. Material

The multimedia learning material was developed using FLASH animation software under the frameworks of the ARCS and ADDIE models.

The researchers applied the ARCS model to attract the attention of learners and interest them in an experimental robot adventure, relate it to an everyday task, provide a demonstration video, and decompose the main steps of the task. The designed multimedia material followed the ADDIE model in every phase of development.
3.2. Participants

The six participants in this study were students at a teacher education center in a research university in northern Taiwan. The six students were divided into two groups of three students. All the participants were liberal arts majors. Therefore, none had prior experience in programming or robot assembly. The selected course was introduction to instructional media, which is a 50-minute class that meets twice a week. Therefore, the participants spent 100 minutes learning robotics each week.

3.3. Procedure

The multimedia material, which was developed using FLASH 8, was used to teach the students how to assemble and program a robot. The designed material comprised of three sections: the robot adventure, assembly, and programming. Each part was demonstrated by means of animation. The participants, therefore, learned to assemble, program, and use robots with the assistance of the designed multimedia material. After completing the course, each student answered a questionnaire designed to measure their perceived satisfaction with the designed material. However, on the survey date, one student was absent, while another did not answer the questionnaire for personal reasons. Therefore, only four valid questionnaires were returned to the research team. Triangulation method was used to compensate for the small sample size.

4. Result

The data from the triangulation method were collected and analyzed. Since the median response in each item was 2.5, responses higher or lower than 2.5 indicated satisfaction and dissatisfaction, respectively, with the instructional material.

4.1. Motivation

The mean scores for motivation ranged from 2.67 to 3.75. The students agreed most with the statement that learning is easier with multimedia material than with text-based material.

4.2. Material Design

The mean scores for satisfaction with material design ranged from 2.67 to 3.25. All the students agreed with the statements in each item when evaluating the design element of the material. Some students mentioned in their blog that the arrangement of the multimedia material made learning easy.

4.3. Instructional Material

With regard to satisfaction with material content, the mean scores ranged from 3.00 to 3.75, and indicated that this material is well-designed and helps students learn better.

4.4. Feasibility

The mean scores for satisfaction with feasibility ranged from 3.00 to 3.33. The students responded positively that they were inspired and that they effectively learned the skills needed to construct a robot. Some students mentioned in their blog that they conceived some new ideas on using robots for teaching; another student stated that following the sequences described in the learning material, they could assemble the robot independently.

5. Conclusion

The structures developed for this study material included the robot adventure, assembly, and programming. After the material was satisfactorily developed, the researchers applied it in an educational setting. The students learned, designed, programmed, and assembled the robot. They then debugged the program to successfully overcome the obstacles by using the multimedia materials.

6. Acknowledgement

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract Nos. NSC 96-2520-S-008-003 and NSC 96-2524-S-008-002.

7. Reference


Humor and empathy: Developing students’ empathy through teaching robots to tell English jokes

Siew-Rong Wu
National Yang-Ming University
Center for General Education
Taipei 11221, TAIWAN
srwu@ym.edu.tw

Abstract
Humor and empathy are two important elements in successful communication, especially for medical professionals. To test the hypothesis that implementing humor in EFL students’ English learning would enhance students’ empathy and English proficiency simultaneously, this study was conducted at a medical university in Taiwan from February to June 2008. Humor was implemented in learning activities. Participants’ sense of humor, empathy, and public speaking skills were assessed. All the speaking assessments were recorded and evaluated. The assessment results (n = 28; 15 males and 13 females) show that 92.9% of the participants made progress in English self-introductions, 100% in role-plays, and 71.4% developed a greater sense of humor, 57.1% perceived themselves as having a greater sense of humor, 46.4% had greater desire to become more humorous, and 60.7% had developed greater empathy. These results proved that the use of humor was able to enhance students’ empathy and English proficiency.

1. Introduction
Humor and empathy are vital for medical professionals’ communication with patients. It is also important for these professionals to be humorous because they are facing bitter and stressful situations everyday. Besides, humor is important in learning a foreign language. To test the hypothesis that the use of humor in the training of public speaking can enhance students’ empathy, this study was conducted on 44 participants at a medical university in Taipei, Taiwan, from February to June 2008.

2. Methods
Humor was implemented into the learning activities of public speaking in English, such as self-introductions, searching for English jokes, finding out elements of humor and jokes, participating in joke-telling contest, telling jokes to friends, and role-plays “Teaching robots to tell English jokes.” Students were grouped based on their preference of joke types. They created the stories by themselves and rehearsed together. Their role-plays were videotaped for evaluation and review. All the speaking activities were recorded and evaluated. The participants’ empathy levels were measured by using the Empathy Quotient questionnaire (i.e., The Cambridge Behaviour Scale) which contains 60 items among which 20 are filler items. The EQ has been proved to have highly significant test-retest reliability (Baron-Cohen & Wheelwright, 2004).

Twenty-eight participants’ (15 males and 13 females) data were complete and effective. Jokes found from the Internet were used for the learning of English and the elements of jokes and punch lines. The participants were grouped based on their preference of joke types: linguistic, aggressive, nonsense, and other types of jokes. Besides the self-introductions which were made at the beginning and the end of the semester, respectively, there was also an English joke-telling contest in the middle of the semester, and two role-plays in the last two weeks of the semester. All speaking activities were recorded and evaluated based on five criteria: fluency, content, humor (in self-introductions and joke-telling activities/body language (in the role-plays), articulation, and grammar. The two role-plays were videotaped particularly to examine the participants’ body language in public speaking.

3. Results
All the participants have made progress in role-plays, and that 92.9% of them have made progress in
self-introductions. Their scores in each domain of evaluation were shown in Fig. 1. In the role-play assessment, only one participant did not make any progress, and another one had lower scores in the second self-introduction.

![Graph showing self-introduction scores](image)

Fig. 1. All participants’ performance in self-introductions.

Students’ sense of humor and empathy were both found to have been enhanced after training of humorous public speaking. Fig. 2 shows the sense of humor exhibited in self-introductions. The group of participants who preferred aggressive jokes exhibited a greater sense of humor as they made self-introductions. Overall, 71.4% (males: 60%; females: 40%) of the participants have developed a greater sense of humor in their self-introductions. On the other hand, among the five evaluation domains, humor was the least improved in groups with preferences for linguistic jokes, aggressive jokes, and nonsense jokes, respectively, as shown in Tab. 1.

![Graph showing sense of humor](image)

Fig. 2. Sense of humor exhibited in self-introductions.

Tab. 1. Mean progress in self-introductions.

<table>
<thead>
<tr>
<th>Type of Jokes</th>
<th>Group (n)</th>
<th>Fluency</th>
<th>Content</th>
<th>Humor</th>
<th>Articulation</th>
<th>Grammar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic jokes</td>
<td>7</td>
<td>1.5</td>
<td>2.4</td>
<td>1.5</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Aggressive jokes</td>
<td>9</td>
<td>2.8</td>
<td>3.0</td>
<td>2.3</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Nonsense jokes</td>
<td>7</td>
<td>2.0</td>
<td>2.0</td>
<td>1.2</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Other types</td>
<td>5</td>
<td>0.4</td>
<td>0.8</td>
<td>1.0</td>
<td>0.6</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Besides, 60.7% (males: 58.8%; females: 41.2%) of the 28 participants had developed more empathy after the second role-play. As to whether they wanted to be humorous or not, 46.4% (males: 38.5%; 61.5%) of them have greater desire to become more humorous. Besides, 57.1% (males: 62.5%; females: 37.5%) of them perceived themselves as having become more humorous than before.

4. Discussion

The experimental outcomes proved that implementing humor in the participants’ English learning did enhance their empathy and English proficiency simultaneously. However, in the questionnaire measurement of empathy, there was male superiority. This finding differs from that of the earlier studies in which female superiority is found in the same Empathy Quotient questionnaire (Davis, 1980; Davis & Franzoi, 1991; Hall, 1978; Hoffman, 1977). This entails the need for further research about gender differences of empathy and about whether one’s sense of humor is associated with empathy.

Acknowledgements

This study was supported by two grants from the National Science Council (NSC96-2524-s-008-002, NSC97-2631-S-008-003).

References


Pedagogy Play:
Virtual Instructors for Wearable Augmented Reality
During Hands-On Learning and Play

Jayfus T. Doswell
The Juxtopia Group, Inc.
jdoswell@juxtopia.org

Abstract

This workshop will expose participants to how autonomous Virtual Instructors (VI) can be delivered through wearable augmented reality (AR) to provide a personalized and just-in-time instructional intervention during psychomotor learning and play. Distributing VIs for teaching or improving psychomotor skills through wearable AR, provides individual learners with a continually available personal tutor while, at the same time, keeping their hands free to practice a range of skills. These psychomotor skills may range from children learning basic electronics through robot assembly to learning the proper steps as a master plumber by following a VIs instructions. This workshop will address various pedagogical rules that a VI must follow in order to deliver the best instruction and how the multi-modal instructional intervention of a VI enabled wearable AR system can improve task learning and proficiency during learning and play.

1. Introduction

A virtual instructor (VI) delivered through a wearable augmented reality (AR) display provides a personalized human learning experience by applying empirically evaluated and tested instructional techniques [2]. These instructional techniques combine the art and science of teaching (i.e., pedagogy or andragogy). A VI may be embodied (i.e., 2D/3D character) or non-embodied (i.e., only text or voice) and intelligently considers multiple variables for improving and potentially augmenting human learning. These variables include, but are not limited to, learning styles, human emotion, culture, gender, pedagogical techniques, and disability.

A VI without knowledge of empirical pedagogical techniques or an awareness of how an individual learns does not provide a complete service to the learner. This is especially true with learning psychomotor skills where the consequence of in-adequate skills in the workforce can lead to errors, re-work and significantly increased costs. This workshop will delve into various pedagogies that assist the teaching of psychomotor skills against various methods of learning (e.g., such as Bloom’s taxonomy of learning psychomotor learning [1]).

2. Workshop Objectives

The workshop objectives are to:

- Provide a VI taxonomy that compares and contrasts VIs, robotic VIs, pedagogical agents, and pedagogical embodied conversational agents (PECA).
- Provide a complete understanding of VI enabled wearable AR as an instructional intervention.
- Discuss various pedagogy and learning methods to enhance the comprehension and retention of psychomotor skills.
- Discuss and demonstrate how VI enabled wearable AR instructional interventions can improve psychomotor skills while making it enjoyable for the learner.
- Present the IEEE Virtual Instructor Pilot Research Group and how its research is moving towards an International standard for how VIs will autonomously teach.

Figure 1: First person view of a VI enabled AR display viewing a boat in preparation for the VI to teach about boat maintenance.
3. Expected Outcomes
The main learning outcome of this workshop is that participants will gain a complete understanding of the importance of empirical instructional methods delivered through virtual instructors or pedagogical agents for inclusion in toys, robots, avatars, etc. Additionally, participants are expected to learn how wearable augmented reality works and how the emerging technology is advancing to provide a fun and effective learning experience for a variety of audiences.

Figure 2: 3D Animated Virtual Instructor

Table 1: Workshop format and schedule

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Instructor and Augmented Reality, Defined</td>
<td>30 min.</td>
</tr>
<tr>
<td>This topic will provide the background and classification of virtual instructors, pedagogical agents, and pedagogical embodied conversational agents. This topic will also define wearable augmented reality.</td>
<td></td>
</tr>
<tr>
<td>VI enabled Wearable AR.</td>
<td>30 min.</td>
</tr>
<tr>
<td>This topic will discuss the importance of VI enabled AR as a learning intervention.</td>
<td></td>
</tr>
<tr>
<td>Break</td>
<td>10 min.</td>
</tr>
<tr>
<td>Pedagogy and Learning Methods</td>
<td>30 min</td>
</tr>
<tr>
<td>This topic will present various pedagogy and learning methods to enhance the comprehension and retention of psychomotor skills.</td>
<td></td>
</tr>
<tr>
<td>Demonstration</td>
<td>30 min.</td>
</tr>
<tr>
<td>Presenter will demonstrate how VI enabled wearable AR instructional interventions can improve psychomotor skills while making it enjoyable for the learner.</td>
<td></td>
</tr>
<tr>
<td>IEEE VIPRG</td>
<td>20 min.</td>
</tr>
</tbody>
</table>

5. References
Author Index

Agudo, J. Enrique .................................................. 113
Albert, Dietrich ................................................... 135
Anderson, Tom A. F. ................................. 188
Augustin, Thomas ........................................... 135
Baek, Youngkyun ........................................... 75
Barendsen, Niels K. ........................................ 149
Bisnath, Jorrel ..................................................... 103
Bruckman, Amy .................................................... 3
Cha, Jiseon .............................................. 62, 75
Chan, Tak-Wai ................................................... 138, 124
Chang, Chih-Wei ............................................ 201
Chang, Maiga .................................................... 209
Chen, Gwo-Dong ............................................. 201, 203, 199
Chen, Hung-Cheng ........................................... 207
Chen, Wei Qin ................................................... 180
Chen, Zhi Hong ............................................... 138, 124
Cheng, Chao-yang ............................................ 157
Cheng, I-chen ..................................................... 52
Cheng, Shan Shan ............................................ 211
Cheng, Ting Yin ................................................ 211
Chiang, Yi-Kai .................................................. 205
Chiang, Yu-Tzu .................................................. 157
Chien, Kun Huang ............................................. 36
Chiu, Jih-Cheng .................................................. 205
Cho, Hwan-Gue ................................................ 18
Chotikakamthorn, Nopporn ................. 70
Conlan, Owen .................................................... 28
Cui, Xiangzhe ..................................................... 57, 193
Curado, Alejandro ........................................... 113
Davies, Molly ................................................... 93
Davis, Hugh C ................................................... 167
Dechaboon, Ajchara ........................................ 70
Dowswell, Jayfus T ......................................... 215
Dougherty, Dale ............................................... 8
Ellis, Ruel ......................................................... 103
Fernández-Manjón, Baltasar 44
Fontijin, Willem .............................................. 141
Garrido, José M ................................................... 170
Gros, Begona ..................................................... 170
Gross, Mark D ................................................... 116
Hildmann, Hanno ............................................ 15
Hockemeyer, Cord .......................................... 135
Hsieh, Yi-Zeng ................................................ 203
Hsieh, Yu-Che .................................................. 205
Hsu, Sheng-Hui ............................................... 83
Huang, De-Yuan ............................................. 203
Huang, Guan-Zhen ......................................... 188
Huang, Guo-Chun ........................................... 83
Huang, Yueh-Min ......................................... 83
Hwang, Jihyun .............................................. 62, 193
Hwang, Wu-Yun ........................................... 207, 199
Jacobs, Aljosja .................................................. 141
Jeng, Yu-Lin ..................................................... 83
Jessen, Carsten .............................................. 149
Ji, Seung-Hyun ............................................. 18
Johansen, Stine Liv .......................................... 108
Jong, Morris S. Y .......................................... 180
Karoff, Helle Skovbjerg .................................... 108
Kickmeier-Rust, Michael D ................. 135
Komis, Vassilis ............................................... 132
Kou, Chan Hsin ............................................. 211
Kurniawan, Sri H ........................................... 98
Lavin-Mera, Pablo .......................................... 44
Lee, Fong-lok ................................................... 180
Lee, I-Ing ......................................................... 23
Lee, Jimmy H. M ............................................. 180
Liao, Calvin C. Y ............................................ 138
Lien, Chi-Jui .................................................... 23
Lin, Chun Hung ............................................. 211
Lin, Shih-Chieh .............................................. 203
Lin, Sunny S. J .............................................. 157
Lin, Yi Lung ..................................................... 36
Liu, Eric Zhi Feng ........................................... 211
Liu, Eric Zhi-Feng ......................................... 199
Liu, Tzu-Chien .............................................. 209, 199
Livingstone, Daniel ....................................... 15
Lu, Yu-Ling ....................................................... 23
Martin, Vance S .............................................. 146
Matsui, Koji ..................................................... 160
Miwa, Masafumi ............................................ 160
Author Index

Moreno-Ger, Pablo.............................................. 44
Nielsen, Jacob.................................................. 149
Out, Patcharaporn........................................... 70
Panigrahi, Nila Lohita...................................... 90
Park, Hyungsung............................................. 62, 193
Park, Soo-Hyun............................................... 18
Peirce, Neil................................................... 28
Peng, Kuan-Ru................................ ............... 205
Persad, Prakash............................................. 103
Prince, Rikki................................................... 167
Ramani, Srinivasan........................................... 90
Reynolds, Barry Lee......................................... 188
Rico, Mercedes............................................... 113
Russell, Donna................................................. 93
Ryu, Dong-Sung............................................... 18
Sabharwal, Shikha............................................ 90
Sánchez, Héctor............................................... 113
Schiffter, Ilan................................................... 177
Schweikardt, Eric............................................. 116
Seo, Sumin..................................................... 57
Shin, Bokjin...................................................... 57, 62, 193
Sirigiri, Venkatagiri......................................... 90
Sitchhisanguan, Karanya..................................... 70
Soga, Masato................................................... 160
Su, Mu-Chun.................................................. 203, 199
Takaseki, Kazuki............................................. 160
Taki, Hirokazu............................................... 160
Tokoi, Kohei................................................... 160
Totten, Iris...................................................... 93
Tse, Alex W. C. .............................................. 180
Uhlemann, Anika.............................................. 15
Verhaegh, Janneke.......................................... 141
Voulgari, Iro.................................................... 132
Wade, Vincent.................................................. 28
Wang, Hwa-pey............................................... 52
Wu, Eric Hsiao-Kuang....................................... 205
Wu, Eric Hsiao-kuang....................................... 199
Wu, Hubert Chi-Yu.......................................... 205
Wu, Jia Jia........................................................ 36
Wu, Po-Han..................................................... 83
Wu, Sheng-Yi.................................................... 207
Wu, Siew-Rong................................................. 213, 199
Xu, Yan.......................................................... 75
Yang, Jie Chi................................................... 36
Yeh, Xiao-Ping............................................... 188
Zhou, Yuxia.................................................... 180
IEEE Computer Society
Conference Publications
Operations Committee

CPOC Chair
Chita R. Das
Professor, Penn State University

Board Members
Mike Hinchey, Director, Software Engineering Lab, NASA Goddard
Paolo Montuschi, Professor, Politecnico di Torino
Jeffrey Voas, Director, Systems Assurance Technologies, SAIC
Suzanne A. Wagner, Manager, Conference Business Operations
Wenping Wang, Associate Professor, University of Hong Kong

IEEE Computer Society Executive Staff
Angela Burgess, Executive Director
Alicia Stickley, Senior Manager, Publishing Services
Thomas Baldwin, Senior Manager, Meetings & Conferences

IEEE Computer Society Publications
The world-renowned IEEE Computer Society publishes, promotes, and distributes a wide variety of authoritative computer science and engineering texts. These books are available from most retail outlets. Visit the CS Store at http://www.computer.org/portal/site/store/index.jsp for a list of products.

IEEE Computer Society Conference Publishing Services (CPS)
The IEEE Computer Society produces conference publications for more than 250 acclaimed international conferences each year in a variety of formats, including books, CD-ROMs, USB Drives, and on-line publications. For information about the IEEE Computer Society’s Conference Publishing Services (CPS), please e-mail: cps@computer.org or telephone +1-714-821-8380. Fax +1-714-761-1784. Additional information about Conference Publishing Services (CPS) can be accessed from our web site at: http://www.computer.org/cps

IEEE Computer Society / Wiley Partnership
The IEEE Computer Society and Wiley partnership allows the CS Press Authored Book program to produce a number of exciting new titles in areas of computer science and engineering with a special focus on software engineering. IEEE Computer Society members continue to receive a 15% discount on these titles when purchased through Wiley or at: http://wiley.com/ieeecs. To submit questions about the program or send proposals, please e-mail jwilson@computer.org or telephone +1-714-816-2112. Additional information regarding the Computer Society’s authored book program can also be accessed from our web site at: http://www.computer.org/portal/pages/ieeecs/publications/books/about.html

Revised: 21 January 2008

CPS Online is our innovative online collaborative conference publishing system designed to speed the delivery of price quotations and provide conferences with real-time access to all of a project’s publication materials during production, including the final papers. The CPS Online workspace gives a conference the opportunity to upload files through any Web browser, check status and scheduling on their project, make changes to the Table of Contents and Front Matter, approve editorial changes and proofs, and communicate with their CPS editor through discussion forums, chat tools, commenting tools and e-mail.

The following is the URL link to the CPS Online Publishing Inquiry Form: