KAERA Research Forum

Special Issue:

Current and Future Educational Technology Applications

Volume 1

Number 2

June 2014

Editor

Jung Won Hur, Ph.D.

KAERA

Korean-American Educational Researchers Association

KAERA Research Forum, *1(2)*, 1-2

EDITORIAL

Special Issue: Current and Future Educational Technology Applications

The focus of this edited issue is current and future educational technology applications. More specifically, this issue shares projects that utilize both current technology to solve critical educational issues and future technology to transform how we learn and teach. Advanced technology provides new opportunities to engage and empower all learners (U.S. Department of Education, 2010). The five articles in this issue demonstrate how technologies can creatively help learners ranging from kindergarteners to university faculty. The articles also present important new research areas in which more in-depth studies need to be undertaken to enhance human learning through technology.

In the first article, Yanghee Kim, Diantha Smith, Namju Kim, and Tianyu Chen at Utah State University explain the development process of a robot-based English app. This engaging vocabulary app was designed for a learning robot, *Atti*. A Korean company (SK-Telecom) developed *Atti* for 3-5 year olds, and the authors created the educational app to provide authentic and interactive English learning experiences. In this article, the authors illustrate the iterative cycles of initial design, user testing, and refinement and discuss the potential for educational robots in school and at home.

In the second article, Sungwon Shin and Thomas A. Brush at Indiana University and John Saye at Auburn University introduce the Wise Practice Case Database (WPCD), a project developed to help social studies pre-service teachers understand ways to promote historical inquiry and civic competence. The WPCD addresses the issue of limited field experience in teacher education; the authors developed over 40 web cases of practicing social studies teachers utilizing problem-based learning strategies. Each case consists of classroom videos, teacher reflections, pre- and post- teacher interviews, and supplementary materials. In this article, the authors explain the underlying design framework (technology-enhanced case methods) and provide an overview of the current use of WPCD in U.S. teacher education programs.

In the third paper, Jaesoon An at the University of North Carolina at Charlotte discusses a Large Course Redesign (LCR) program that has been ongoing at UNC Charlotte for six years. LCR aims to help faculty shift existing lecture-based courses to student-centered learning while also reducing instructional costs. In this article, the author discusses the step-by-step redesign process, from grant writing to evaluation, and explains how the changed course differs from the traditional. The author claims that redesigned courses tend to integrate a blended learning model, multimedia resources (e.g., pre-video lectures, electronic textbooks), and a student response system to promote active learning.

In the fourth paper, Taeho Yu at Purdue University examines the reliability and validity of a Korean version of Community of Inquiry (CoI) in online learning. The CoI framework has been widely recognized as a useful tool to examine meaningful knowledge construction online, but only few studies have utilized the instrument in a language other than English. The author developed a Korean version and tested it with 995 Korean undergraduate students. The results demonstrated adequate reliability and validity.

The last paper by Hyo-Jeong So, Heung-Chang Lee, and Sun-Mo Kwon at Pohang University of Science & Technology discuss the trend of future learning technology. The authors provide an overview of future technologies that are likely to have a large impact on teaching and learning based on two major technology trend reports: the Gartner report and the Horizon report. They claim that among many future technologies, learning analytics and 3D printing are particularly promising because of their pedagogical affordance and increasing accessibility and affordability. The authors discuss the potentials and challenges of using each technology in education.

The U.S. Department of Education has observed, “Technology itself is an important driver of change. Contemporary technology offers unprecedented performance, adaptability, and cost effectiveness” (2010, p. 4). The articles in this issue highlight cases in which emerging technology and accompanying pedagogy can enhance our learning environments. We, as educators, should continue to reflect on how new technology can transform our classrooms and how new tools can be appropriately used to empower and engage all learners. It is hoped that each article in this issue will increase understanding of education and technology and provoke new ideas and discussion on improving learning through technology.

Jung Won Hur, Auburn University

REFERENCE

U.S. Department of Education (2010). *Transforming American education: Learning powered by technology.* Washington, D.C.: U.S. Department of Education, Office of Educational Technology.

KAERA Research Forum, *1(2)*, 3-8

RESEARCH ARTICLE

Playing with a Robot to Learn English Vocabulary

Yanghee Kim, Diantha Smith, Namju Kim, & Tianyu Chen

Utah State University

A robot-based English curriculum called *The Missing Code* has been developed to teach English vocabulary to young children whose home language is one other than English. Guided by theories in children's learning and motivation, the curriculum was designed to be developmentally appropriate and engaging for children who were 3-5 years old, carefully balancing the familiar and the new. The development process was characterized by iterative cycles of initial design, user testing, and refinement. Through multiple observations of child-robot play in situ, it was noted that children easily learned how to interact with the robot and showed sustained interest and engagement in the curricular activities with the robot.

Keywords: educational robotics, robot-assisted language learning (RALL), humanoid robots, learning English as a second/foreign language

Atti is a humanoid robot that targets preschool or kindergarten aged children, using the metaphor of a toy friend who does activities with a child. A variety of advanced technological capabilities are embedded in the robot that works in conjunction with a smartphone, including multimedia, bodily movements, optical and proximity sensors, speech recognition, learner interaction logs, and accompanying materials (e.g., physical books and cards). Children can play with Atti and learn educational topics with Atti's assistance.

A next step would be equipping Atti with high quality educational apps to run through the robot. The app development seems to be much more than developing a new mobile app; each part of the curriculum should make use of the robot's unique technical features and social affordance that conventional mobile phones do not have. A collaborative partnership, therefore, was formed between the Atti developer, SK-Telecom (SKT, http://www.sktelecom.com) and the university-based design team (http://create.usu.edu/projects.html), led by Dr. Yanghee Kim, Associate Professor of Instructional Technology and Learning Systems at Utah State University (USU). Sponsored by SKT, the USU team was charged to develop an English learning app for children who learned English as second or foreign language (ESL or EFL). This paper introduces a vignette of this robot-based curriculum development effort.

TRENDS IN EDUCATINAL ROBOTICS

In the recent decade, interest in robotics has emerged rapidly across the world. Robotics is seen by many as offering new benefits in education at all levels (Johnson, 2003). The educational robotics market is also growing. Research by the Japan Robotics Association, the United Nations Economic Commission, and the International Federation of Robotics projects tremendous market growth for personal robots, including those used for both entertainment and educational purposes. Very likely, this trend will continue in the coming decades (Kara, 2004).

The LEGO Mindstorms (http://mindstorms.lego.com) pioneered educational robotics by combining toys with advanced technologies a decade ago. This system was acclaimed by educational researchers and practitioners for its potential to improve motivation and learning of STEM topics with upper-grade students. Since then, the application of robotic technology in public schools has been steadily growing. Nowadays, trends in educational robotics include a wide range of robot applications for engaging young people in learning diverse subject matters (Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). One of those subject matters is English as a Second/Foreign Language (ESL/EFL). In Japan, Korea, China, and other countries pursuing innovations in educational technology, EFL learning is the domain that has most actively used robot assistants.

In those countries, the demand for effective EFL teaching pedagogy has been high. At the same time, the shortage of qualified native English-speaking instructors has been a constant challenge. To solve this problem, many EFL educators have sought to take advantage of advanced technology and have committed to Computer Assisted Language Learning. Recently, some industry partners have developed several humanoid robots and explored opportunities for using the robots to fill the gap in ESL/EFL education. However, the high cost of producing humanoid robots (approximately US $3,000-5,000) has been a major drawback in putting them on the market for the general public. Companies are racing to produce more affordable and feasible robots in school and at home and, also, to develop quality robot apps to assist young ESL/EFL learners. With a new mix of a smart phone, robot toy, and learning tool, SKT's *Atti* seems to open up a whole new field of possibilities for affordable, educational robots.

CHILDREN'S MOTIVATION AND LEARNING

Seminal psychologists have established that children's learning and development is a social and cognitive process. Young children learn in a social context while they play with others (Carpendale & Müller, 2004). Their play is similar to scientific experimentation; they do hypothesis testing while they play with others (Gopnik, 2012). Children's psychological and behavioral changes often occur through vicarious experiences; they learn as they observe and interact with others (i.e., social models) (Schunk, 1991; Schunk & Hanson, 1985). Further, their learning is better promoted when the context is meaningful and relevant to them (Lave & Wenger, 2001). A simple computer screen without social contexts would not be as effective for young children as a technology design that embeds a social and interactive context in its application (Perkins, 2001). With a robot friend, children could learn a language and literacy in a social and meaningful context.

For literacy instruction, Wigfield (1997) has emphasized the importance of understanding both motivation and cognitive process in children's learning. Guthrie and Alao (1997) specified three key aspects of motivation: goal orientation, self-efficacy, and social interaction. Later, Guthrie and other researchers also noted the importance of interest or curiosity in motivation to read (Guthrie et al., 2006). Significantly, Gregory and Chapman (2013) remind us that when we study motivation, we must also remember that "basic needs have to be met first" and two of these important needs include feeling "liked and included." One way to both capture students' interest and help them to feel safe is to infuse learning with elements of fantasy. Fantasy not only captures students' imaginations, but can also help them work through past difficulties (Guthrie & Alao, 1997). During playtime with a robot, a child could be placed at the center of interaction and safely co-explore fantasies.

DESIGN AND DEVELOPMENT PROCESS

The design and development team at USU consisted of multidisciplinary experts in educational curriculum design, graphic design, and software engineering. These experts had had such diverse experiences as consulting with American toy companies and educational television shows and developing applications for public schools and corporate partners. The team was also very culturally diverse; many members of the team had grown up learning English as a second or foreign language and therefore could relate directly to the target population of learners.

The development process incorporates the guidelines of software engineering and design-based research that emphasize the need for highly contextualized data collection. The process is characterized by iterative cycles of design, development, and evaluation and the use of authentic contexts for user testing (Design based research collective, 2003).

The Design phase produced written scripts of the curricular content and robot-child interaction scenarios. Following that, a low-fidelity prototype (a print-based mockup without a robot) was developed. This mockup was taken to three target-aged ESL children, using a Wizard of Oz method, where a designer acts as the missing components of the robot application (Rapp). Our designer played with the children one-on-one at their homes. This mockup test was used to verify the curricular flow, observe the learners' reactions, and determine revision needs in the curricular content and interaction scenarios.

The Development phase began with the refined curricular design. The curriculum was implemented to develop a beta version of the Rapp. This draft app was taken to the target aged children in school. We allowed boys and girls to spend about an hour in playing with the robot on a one-on-one basis at the corner of the classroom. This phase was used to observe seamless interactions between the child and the robot and also to assess coding completeness. The draft Rapp was refined repeatedly as the team continued with the testing.

Evaluation was on going while our team engaged in design and development. At the end of the development, we conducted another round of evaluation, bringing the refined Rapp to school for field-testing. Four to seven-year-old boys and girls spent 30 minutes to an hour individually or in a pair at the corner of a media center. This high-fidelity setting resembled an ordinary classroom, having distractions by peers and environmental noises, leading to further refinement for increased fidelity and completion of the Rapp.

ROBOT-BASED CURRICULAR APP

The curriculum design was focused on learning outcomes and, at the same time, creating learning activities that were developmentally appropriate and engaging for children who are 3-5 years old. The activities and resources were also chosen to carefully balance the familiar and the new. This balance in the materials was achieved with songs and the accompanying book and cards (familiar educational tools), connected to the robot and app (new educational tools). The balance of familiar and new in content also came from having familiar items that are identifiable and easily recognizable (items from home, simple colors and shapes) and new, imaginative content (spaceships, secret labs, etc.).

As presented in Figure 1, three activities (songs, games, and a book) were designed to play a specific role in mastery of three objectives: identifying basic shapes (triangle, circle, square, rectangle); basic colors (red, orange, yellow, green, blue, purple), and initial consonant sounds.

Main Screen

Book

Figure 1. *Examples of the App*

The activities build on each other by introducing, reinforcing, and extending understanding of the target English vocabulary. For introducing, the song portion of the app was designed to expose users to all of the target vocabulary. The songs are based on familiar children's songs (i.e., "Twinkle, Twinkle Little Star"), and after each verse the robot invites the user to repeat target vocabulary or sounds multiple times. For reinforcing, the game portion of the app allows the user to practice all of the target vocabulary introduced in the songs. Users either find the correct matching card (with shapes or colors), or identify the correct initial sound for objects in an OX (true/false) game with both letters and pictures as visual cues. For extending, the book extends what children have already learned by giving new context to the vocabulary. Children see the target words used in the text and hear the robot ask for their help to find shapes, colors, and words in the spaceship.

OBSERVATIONS AND IMPLICATIONS

Easy to Use

In user testing, the team observed that the children were able to work independently and also work either alone or with a peer during interaction with the robot and materials. A big challenge in designing educational software for young children is ensuring that they are able to navigate and use the interface easily. After repeated tests with children as young as three years of age, it was clear that young children could easily figure out how to use each part of the application. The youngest children particularly enjoyed the songs, and the older children (ages 5-7) seemed to particularly enjoy the book. No matter what the activity, however, children were able to participate with minimal instructions from a member of the team.

Sustained Attention and Engagement

It was exciting that children were engaged and focused during their time with the robot. Children were eager to touch the robot and follow it if it moved from one space to another. Even when the robot did not respond automatically (there were a few bugs in the prototype), the children were willing to try interacting again and again until the robot responded. Children normally do not have a long attention span. But the children aged 3 to 7 used the robot app and attended to it for over an hour even after repeated use – a response that cannot be attributed to the novelty effect. Further, as we observed their interactions with the robot, we noticed that even when they were not looking directly at the robot, children would still repeat the English words it spoke and sing along as it sang songs. Overall, we were impressed by the amount of excitement and intensity in children's expressions while they played and learned with the robot. If we returned for repeated testing, the children were always ready to play with the robot again, and even if they were repeating the same activities, they still displayed high levels of engagement.

Rich Learning Experiences

The robot app supplied a variety of learning activities, integrating established strategies and materials into a new environment. Easily recognizable and memorable songs were used to prepare children for more intense practice/instruction. Games helped children get quick practice with concepts and enabled the children to repeat a task again and again until the concepts were mastered. The interactive book was full of context rich sentences. Based on our observations, teachers and parents of young children can expect to see learners engaged with the creative, fun, fantasy-filled world of the robot. Also, the robot app could be used either one-on-one or in small groups of two to three children. In individual use, the child had a time to build confidence with a friend-like robot; in small-group use, the robot served as a center for collaborative work among human peers. Overall, the robot app helped the children with explicit, systematic, and personalized instruction to learn English, as well as building their confidence in the use of English.

CONCLUSION

As a result of our design, development, and evaluation, the USU team is confident in the potential of future educational robots. Due to the relatively low cost of the robot Atti and the relatively short time it takes to develop new apps, this could be a scalable, educational resource for children both in school and at home. There are many other curricular areas that could be created in future apps: English instruction in a wide variety of subjects at a wide variety of levels and instruction connecting early mathematical or scientific concepts and language development, and so on.

The diversity of the design team could be an asset to make the curriculum for market that targets a wide audience of learners. Based on our conversations with the teachers and parents in testing, once a school or parent has observed a child's engagement in a robot, it is very likely that they would continue to obtain new materials and applications that teach students English. Because the robot interacts with them like a friend, children may be more likely to use English to interact with others rather than learning English by decontextualized, rote memory. Particularly, the fantasy that a humanoid robot can afford might open up endless creative opportunities for future designers and developers. In the future, there could be an entire universe where Atti and children zip from place to place to learn English from unique friends in new worlds.

REFERENCES

Carpendale, J. I. M., & Müller, U. (Eds.). (2004). *Social interaction and the development of knowledge*. Mahwah, NJ: Lawrence Erlbaum Associates.

Design based research collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Gopnik, A. (2012). Scientific thinking in young children: Theoretical advances, empirical research, and policy implications. *Science, 337*(6102), 1623-1627.

Gregory, G. H., & Chapman, C. (2013). *Differentiated instructional strategies: One size doesn't fit all*. Thousand Oaks, CA: Sage Publication.

Guthrie, J. T., & Alao, S. (1997). Designing contexts to increase motivations for reading. *Educational Psychologist, 32*(2), 95-105.

Guthrie, J. T., Wigfield, A., Humenick, N. M., Perencevich, K. C., Taboada, A., & Barbosa, P. (2006). Influences of stimulating tasks on reading motivation and comprehension. *The Journal of Educational Research, 99*(4), 232-245.

Johnson, J. (2003). Children, robotics and education. *In Proceedings of 7th international symposium on artificial life and robotics* (pp. 16–21), Oita, Japan.

Kara, D. (2004). *Sizing and seizing the robotics opportunity, RoboNexus*. This text can be accessed online at Robotics Trends Inc. (http://www.roboticstrends.com/).

Lave, J., & Wenger, E. (2001). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Perkins, D. N. (2001). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.), *Distributed Cognition: Psychological and educational considerations* (pp. 88-110): Cambridge University Press.

Rusk, N., Resnick, M., Berg, R., & Pezalla-Granlund, M. (2008). New pathways into robotics: Strategies for broadening participation. *Journal of Science Education and Technology, 17*(1), 59–69.

Schunk, D. H. (1991). *Learning theories: An educational perspective*. New York: Macmillan.

Schunk, D. H., & Hanson, A. R. (1985). Peer models: Influence on children's self-efficacy and achievement. *Journal of Educational Psychology, 77*(3), 313-322.

Wigfield, A. (1997). Reading motivation: A domain-specific approach to motivation. *Educational Psychologist, 32*(2), 59-68.

KAERA Research Forum, *1(2)*, 9-16

RESEARCH ARTICLE

Technology-Enhanced Cases for Teacher Preparation: The Use of the Wise Practice Case Database in Social Studies Teacher Education

Sungwon Shin and Thomas A. Brush
Indiana University

John Saye
Auburn University

This paper introduces the Wise Practice Case Database (WPCD) project, an effort to support technology-enhanced case methods as a means to overcome the issue of limited field experiences in teacher education programs. As part of a larger project to promote problem-based learning and technology in K-12 settings and teacher education programs, this project focuses on creating and disseminating technology-enhanced cases of practicing social studies teachers who utilize student-centered instruction in their every day classroom. Various social studies cases with different school settings, grade levels, and topics are presented in the form of text, image, sound, and video within this online database. A brief overview of the current use in U.S. teacher education programs, as well as future directions for the database are also discussed in this paper.

Keywords: Technology-enhanced case, Teacher education, Social studies

A thousand hearings are not worth one seeing. (Chinese Proverb)

Many novice teachers struggle to implement teaching strategies to promote critical thinking and active participation, while they are simultaneously dealing with management issues in the classroom (Darling-Hammond, 2010). Scholars argue that live classroom experiences during their teacher training may not only help them develop teaching competency, but also allow them to reason through issues they face in the classroom (McDonnough & Matkins, 2010). Indeed, previous studies have suggested that field experiences have positive influences on pre-service teachers, and can impact their abilities, such as their classroom management skills (Watzke, 2003), their self-efficacy, and the connections they make between theory/pedagogy and classroom practice (McDonnough & Matkins, 2010). Accordingly, many teacher educators have emphasized the role of field-based experiences that provide "learning from the wisdom of practice" (Darling-Hammond, 2010, p. 40) and the need for an increase in quality-based field experiences for pre-service teachers (Wilson & Floden, 2003).

Unfortunately, many prospective teachers lack experience in practice during their teacher training. There are numerous obstacles to providing prospective teachers with sufficient field experiences, such as finding placements for pre-service teachers, working with limited funds and time for supervision, and a lack of high-quality classroom settings; these challenges are coupled with the most important obstacle, a disconnect between what is learned in methods courses and how teaching is performed in real-world classrooms (Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005; Hudson & McRobbie, 2004; Weber, 2012; Wilson & Floden, 2003). Even if pre-service teachers are provided with multiple field-based experiences, there is no guarantee that those experiences will provide examples of good teaching models. Meuwissen (2005), for example, reported pre-service social studies teachers' frustrations regarding field experiences that did not reflect what they learned in their methods courses. He argued that, while social studies teacher education focused on preparing teachers for student-centered pedagogies, real-world classroom practices remained teacher-centered with limited opportunities for pre-service teachers to observe the application of what they learned in their teacher education program.

Accordingly, the purpose of this paper is to introduce the Wise Practice Case Database project, an effort to support technology-enhanced case methods in teacher education programs in order to address the issue of limited field experiences. First, this paper will discuss the concept of technology-enhanced case methods that was used as a design framework for the Wise Practice Case Database. Then, this paper will provide information on the Wise Practice Case Database, a Web-based case database specifically designed and developed for the purpose of supporting case methods-related instruction in social studies teaching methods courses. Brief information on how the cases in the database have been used in teacher education programs across the U.S. will also be provided.

THE CALL FOR TECHNOLOGY-ENHANCED CASE METHODS IN TEACHER EDUCATION

In order to overcome the issue of limited field experiences in teacher education, many scholars have discussed the use of technology-enhanced case methods. Cases are narratives of real-world classroom problems or issues, and case methods enable novice teachers to develop "knowledge of specific, well-documented, and richly described events" (Shulman, 1986, p. 11) by providing examples of actual classroom practice, opportunities to practice decision making and problem solving in K-12 classrooms, and stimulants to encourage personal reflection and supplements to the lack of field experiences (Merseth, 1996). Technology-enhanced learning environments can be defined as "technology-based learning and instructional systems through which students acquire skills or knowledge, usually with the help of teachers of facilitators, learning support tools, and technology resources" (Wang & Hannafin, 2005, p. 5). In these types of environments, information associated with complex, authentic issues and contexts can be displayed in various forms (e.g., text, image, sound, video images) while learners situate themselves in the course of events (Dunlap & Grabiner, 2012; Hannafin, Land, & Oliver, 1999; Spiro, Collins, & Ramchandran, 2007). The Web environments also provide easy access to a myriad of information to help learners construct and revise their knowledge.

Taking the cognitive flexibility theory into consideration, Spiro and colleagues (2003, 2007) suggest that a combination of case methods and a technology-enhanced learning environment can support complex learning and knowledge transfer into real-world contexts. They argue that most novices struggle to perceive the abstract third dimension of a problem (or case, example), while experts easily comprehend this same space based on their compiled experiences. The researchers claim that this abstract dimension can be better conceptualized and structured when a case is presented in the form of text, image, sound, and video, as these tools are generally utilized within authentic contexts (Brown, Collins, & Newman, 1989; Spiro et al., 2007). In this respect, technology-enhanced case methods can serve as a powerful venue for supporting novice teachers who lack experience in the profession, and who struggle to understand the complexities of teaching and learning in K-12 classrooms.

Numerous studies in fact have demonstrated the usefulness and effectiveness of technology-enhanced case methods in the field of teacher education. In particular, the use of video case-based learning has been found to be successful in mathematics and science teacher education; it has provided examples of authentic teaching practices and helped prepare prospective teachers for real-world classrooms (e.g., Beck, King, & Marshall, 2002; Kurz, Llama, & Savenye, 2005; Santagata, & Angelici, 2010; Santagata & Guarino, 2011; Santagata, Zannoni, & Stigler, 2007). Studies have also shown that technology-enhanced case methods promoted teacher reflection and discussion on inquiry-based learning (Barab, Makinster, Moore, & Cunningham, 2001; Moore & Barab, 2002). Considering the increased emphasis being placed on promoting student-centered instruction in K-12 classrooms, these studies show the potential of technology-enhanced case methods in preparing future teachers for these types of classroom environments.

Among different programs within teacher education, the social studies teacher education program exists as perhaps the one subject area that is in great need of technology-enhanced case methods. Social studies education has emphasized the importance of promoting historical inquiry (Barton & Levstik, 2004; Saye & Brush, 2004), deliberation in the classroom (Hess, 2009; Parker, 2003, 2006), and other student-centered practices as a means of preparing students for a participatory, pluralistic democracy. This makes it even more important for future social studies teachers to gain meaningful, field-based experiences that model pedagogical approaches which require a high level of understanding concerning classroom dynamics. Although not many empirical studies related to social studies teacher education programs that utilize technology-enhanced case methods can currently be found, there exist promising research and projects in the field. Hess (2004), for example, discussed her own experience using video cases in her social studies methods courses, while Brush and his colleagues (2009) revealed in their study that social studies pre-service teachers demonstrated a positive attitude towards the use of video cases and recognized their potential as a means of supporting their learning experiences. Indeed, there has been a continuous, collaborative effort of teacher educators and educational technology researchers to create and disseminate social studies-specific technology-enhanced cases for more meaningful teacher preparation experiences among pre-service teachers.

THE WISE PRACTICE DATABASE PROJECT

The Wise Practice Case Database (WPCD) in the Persistent Issues in History Network (PIHNet; http://www.pihnet.org) has been developed as an effort to support technology-enhanced case methods in social studies teacher education programs. This on-going project is part of a larger project called the Problem-based Learning and Technology project (PBL-Tech; http://www.pbl-tech.org), which focuses on developing Web-based resources and tools to facilitate problem-based learning in both K-12 and teacher education programs and settings. Specifically, the cases in the database aim to support the understanding of how social studies, and in particular, history, should be taught to promote historical inquiry as well as civic competence (Brush et al., 2009).

The first version of this case database was launched in 2009, and recently, the development of the second version has been completed. Currently, the WPCD project team is in the process of migrating the users of the first version to this newer iteration. The decision to update the database was made after receiving feedback from the database users through a survey.

As the main issue of the first version was interface design, the project team redesigned the entire case database to allow for easy viewing of each case material as well as less clicking on the part of the user to find relevant information. Several iterations of a usability test and an ensuing redesign of the space followed, as the platform (i.e., the Drupal module system) of this new database allowed for quick and easy modification of the design. Also, from an administrator's perspective, it has become much easier to create a case using the newly developed Case Construction Tool within the PIHNet website.

The WPCD is basically a Web-based collection of wise teaching practices enabling direct access to different resources associated with each case included on the website, as well as external Web resources related to the cases. It consists of more than 40 video- or text-based cases of authentic K-12 social studies classrooms, as well as teachers' reflections on their own practices. As the core of each case, there are classroom videos which run from between 20 to 40 minutes in total length; each classroom video is divided into 4 to 8 smaller video clips to support different instructional activities in university classrooms. Each case also includes pre- and post-interviews of the teacher, and related informative resources such as lesson plans, academic standards, downloadable teaching materials, and background information on teachers and schools. Users can access the database through the PIHNet website, and find the list of cases; they can then select a case to open in the Case Viewer (See Figure 1.) so that they can view all the related materials.

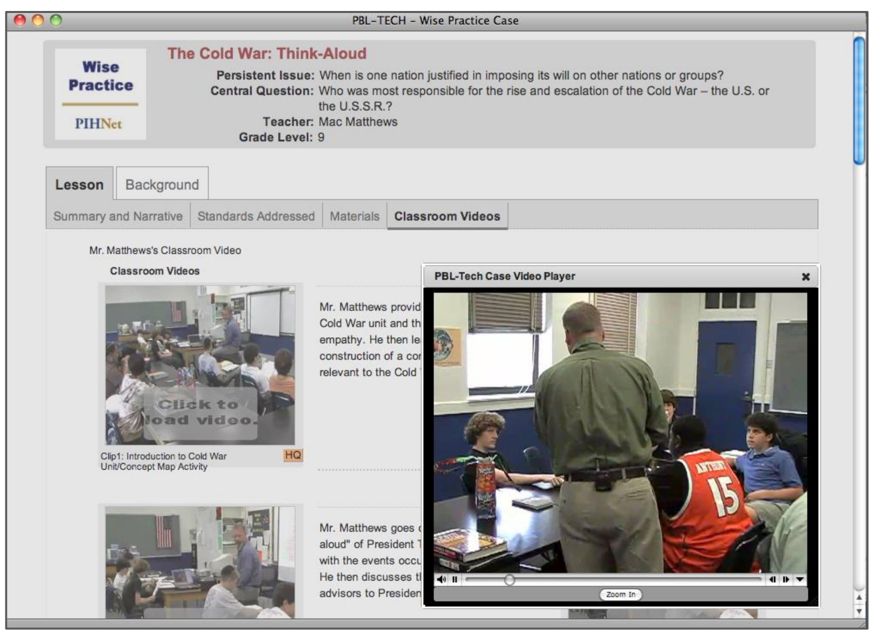

Figure 1. *The Wise Practice Case Viewer*

Many teacher educators, educational technology researchers, practicing teachers, and students participated in creating these cases. At the initial stage, teacher educators and researchers identified experienced teachers who had utilized student-centered instruction in their classrooms, and worked with them to create authentic cases in their own classrooms. Once the instructional materials and case information were collected, and the classroom implementations were video-recorded and edited, researchers organized all the information and uploaded them to a virtual server that could store large files using the Case Construction Tool. This tool enables researchers to upload easily various forms of files to the Web environment as well as hyperlink Web-based resources so that users can view them through the Case Viewer.

Various cases with different school settings, grade levels, and topics are presented in the database to enable users to observe and engage in different classroom experiences. The topics come from U.S. and world history, including events as diverse as the U.S. Civil War, Washington's presidency, the Civil Rights Movement, the Cold War, and the War in Iraq. A civic case related to religious freedom is also included in the database. The cases depict a myriad of instructional strategies within the Problem-based Historical Inquiry (PBHI) framework (Brush et al., 2009). This framework is a "hybrid mode of inquiry as the means to study [enduring societal] problems" (Saye & Brush, 2004, p. 128) that includes instructional strategies and activities designed to encourage K-12 students to examine persistent societal questions that revolve around fundamental values of constitutional democracy through a process of historical inquiry. Specific examples include structured academic controversies, concept discovery, analogous case study, jigsaw strategy, and congressional hearing. All of the cases in the WPCD present particular segments of a PBHI unit that has been implemented in a real social studies classroom to support technology-enhanced case methods in teacher education programs. Some cases include an entire unit plan as a reference to novice teachers (See Table 1. for the complete list of cases in the WPCD).

TABLE 1
Complete List of Cases

Case Title
• Seminar Discussion: Civil Rights
• Interactive Slides Lecture: Civil Rights Movement
• Structured Academic Controversy: U.S. Foreign Policy
• Historical Detection (Document Analysis): Civil Rights
• Concept Discovery: Justification for Military Action
• Congressional Hearing: The U.S. in the 1920s
• Think Aloud: Cold War
• Analogous Case Study: Washington's Presidency (Little Rock)
• Cartoon Analysis: The U.S. 1920s
• Deliberation: Civil Rights Movement (Little Rock)
• Disciplined Discussion: Civil Rights Movement (Little Rock)
• Introductory Grabber: Civil War
• Persuasive Presentation: Civil Rights
• Public Meeting: Civil Rights
• Think Aloud: Washington's Presidency (Text-only case)
• Billboard Activity: Virginia Religious Freedom Model (Text-only case)
• Introductory Unit Discussion: Civil Rights
• Presentation and Deliberation: Civil Rights Movement
• Press Conference: Washington's Presidency
• Response Groups: Religious Freedom 20th Century Cases
• Role Play: Religious Freedom (Patrick Henry)
• Talk Show: The Future of Iraq

THE WISE PRACTICE CASE DATABASE IN SOCIAL STUDIES TEACHER EDUCATION PROGRAMS

The WPCD project team conducted a survey study to gather information on how the case database had been used in teacher education programs in the U.S. (See Shin et al., 2013 for a complete report). It was reported that over 20 social studies instructors in the U.S. were using the WPCD in their teacher education programs at the time the research was being conducted. A few instructors outside the U.S. such as the U.K. and Singapore, had also used the database in their programs. There also were a few university instructors outside social studies education who frequently used the database; they had used the cases in law courses or other educational technology courses. Currently, the number of instructors who have access to the first versions of the database was 58, and they are in the process of migrating to the new database. The total number of users for both versions has been gradually increasing since the release of the second version of the database.

According to Shin, Brush, and Saye (2013), the majority of social studies teacher educators had used the database in their teaching methods course, while a few had also implemented them in their social studies content, education technology, and/or educational foundation courses. All of the instructors reported that they used the cases mostly in class, by facilitating discussion during and after watching the classroom video clips of each case. A few instructors also reported that they had asked their pre-service teachers to access the cases outside of class to complete simple lesson analysis assignments. However, they were not particularly impressed with the results they obtained, due to the lack of scaffolding present during the learning process outside the classroom.

Most of the instructors reported that they had used an average of two to four cases per semester for an average of 45 minutes in class, while a few used more than five cases; this latter group tended to spend more time dealing with the cases. It was also reported that, while teacher educators focused on watching the classroom video clips more than other materials associated with each case during the class sessions, they did also use the other materials available (e.g., lesson summary, teaching materials, teacher reflection, school information) to prepare for their own instruction and to provide contextual information to their pre-service teachers.

The most frequently used cases are those depicting student-centered instructional strategies that involved inquiry and deliberation, such as Seminar Discussion, Interactive Slide Lecture, Structured Academic Controversies, Congressional Hearing, and Document Analysis. These are all instructional strategies that have been continuously endorsed by many social studies teacher educators. It is noteworthy that these cases also provide good models of how teachers enact classroom management strategies. Indeed, this topic was also a frequently discussed purpose of using real-world classroom cases in teaching methods courses by the participants. In addition, it is also clear from the report that teacher educators preferred to use cases with classroom video clips, instead of using text-based cases.

From the survey report and recent conversations with teacher educators, it is possible to conclude that a number of pre-service teachers who are currently in their field observation or student teaching are using the case database as their teaching reference. They download and tweak the materials for their own use, as well as watch classroom video clips to prepare for their own instruction. The WPCD project team has also provided access to pre-service teachers who completed the methods course experience and moved forward to their student teaching. In addition, there are practicing teachers who requested access to the database and are currently using the cases as part of their professional development.

LOOKING AHEAD

The WPCD project has a long journey ahead. More cases are needed to accommodate the needs of teacher educators and pre-service teachers – different grades, topics, strategies, teachers, students, schools, and more. Finding ways to support different types of case methods is another task that the project should pursue. The development of a mobile application that allows teacher educators or pre-service teachers to easily access the project without logging into the PIHNet website may also facilitate different ways to use cases in teacher education courses. It would also be beneficial to have a personalized database for each pre-service teacher so that they can video document and reflect on their own teaching from teacher training to actual classroom practices. A tool to support their reflection process is something worth developing as well. One day, their teaching stories might be a part of the WPCD that would help forthcoming prospective teachers. It is truly the time to reap the benefits of using technology-enhanced case methods in preparing future teachers.

REFERENCES

Barab, S. A., MaKinster, J. G., Moore, J. A., & Cunningham, D. J. (2001). Designing and building an on-line community: The struggle to support sociability in the inquiry learning forum. *Educational Technology Research and Development, 49*(4), 71-96.

Barton, K. C., & Levstik, L. S. (2004). *Teaching history for the common good*. New York: Routledge.

Beck, R. J., King, A., & Marshall, S. K. (2002). Effects of videocase construction on preservice teachers' observations of teaching. *The Journal of Experimental Education, 70*(4), 345-361.

Brown, J., Collins, A., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. *Cognition and Instruction: Issues and Agendas*, 453-494.

Brush, T., Saye, J., Kale, U., Hur, J., Kohlmeier, J., Yerasimou, T., Guo, L., & Symonette, S. (2009). Evaluation of the Persistent Issues in History Laboratory for Virtual Field Experience (PIH-LVFE). *Journal of Interactive Online Learning, 8* (1), 41-62.

Darling-Hammond, L. (2010). Teacher Education and the American Future. *Journal of Teacher Education*, 61(1-2), 35-47.

Darling-Hammond, L., Hammerness, K., Grossman, P., Rust, F., & Shulman, L. (2005). The design of teacher education programs. In: L. Darling-Hammond & J. Bransford (Eds.), *Preparing teacher for a changing world* (pp. 390-441). San Francisco: Jossey-Bass.

Dunlap, J., & Grabinger, R. S. (2012). Hypermedia learning environments: Instructional design and integration. Mahwah, NJ: Lawrence Erlbaum Associates.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. M. Reigeluth (ed.), Instructional-design theories and models: A new paradigm of instructional theory Vol. II (pp. 115–140). Mahwah, NJ: Lawrence Erlbaum Associates.

Hess, D. (2009). *Controversy in the classroom: The democratic power of discussion*. New York: Routledge.

Hess, D. E. (2004). Using video to create a vision for powerful discussion teaching in secondary social studies. In J. Brophy (Ed.), *Advances in Research on Teaching: Vol. 10. Using Video in Teacher Education* (pp. 53-71). Oxford, UK: Elsevier.

Hudson, P., & McRobbie, C. (2004). Evaluating a specific mentoring intervention for preservice teachers of primary science. *Action in Teacher Education, 17*(2), 7-35.

Kurz, T., Llama, G., & Savenge, W. (2005). Issues and challenges of creating video cases to be used with preservice teachers. *Tech Trends, 49*(4), 67-73.

McDonnough, J. T. & Matkins, J. J. (2010). The role of field experience in elementary preservice teachers' self-efficacy and ability to connect research to practice. *School Science and Mathematics, 110*(1), 13-23.

Merseth, K. (1996). Cases and case methods in teacher education. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp.722-744). New York: Macmillan.

Meuwissen, K. W. (2005). Maybe someday the Twain shall meet: Exploring discussions between methods instruction and "Life in the Classroom". *Social Studies*, *96*(6), 253-258.

Moore, J., & Barab, S. (2002). The inquiry learning forum. *TechTrends, 46*(3), 44-49.

Parker, W. C. (2006). Public discourses in schools: Purposes, problems, possibilities. *Educational Researcher, 35*, 8-18.

Parker, W. C. (2003). *Teaching democracy: Unity and diversity in public life*. New York, NY: Teachers College Press.

Santagata, R. & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *Mathematics Education, 43*, 133-145.

Santagata, R., & Angelici, G. (2010). Studying the impact of the lesson analysis framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education, 61*(4), 339-349.

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Math Teacher Education, 10*, 123-140.

Saye, J.W. & Brush, T. (2004). Promoting civic competence through problem-based history learning experiments (pp.123-145). In G.E. Hamot, J.J. Patrick, & R.S. Leming (Eds.), *Civic Learning in Teacher Education*, Vol. 3. Bloomington, IN: The Social Studies Development Center.

Shin, S., Brush, T., & Saye, J. (2013). *The use of technology-enhanced cases in social studies teacher education programs*. Paper presented at the College and University Faculty Assembly of the National Council for Social Studies, St. Louis, MO.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2). 4-14.

Spiro, R. J., Collins, B. P., & Ramchandran, A. (2007). Reflections on a post-gutenberg epistemology for video use in ill-structured domains: Fostering complex learning and cognitive flexibility. In R. Goldman, R. D. Pea, B. Barron, & S. Derry (Eds.), *Video Research in the Learning Sciences* (pp. 93-100). Mahwah, NJ: Lawrence Erlbaum Associates.

Spiro, R. J., Collins, B. P. Thota, J. J., & Feltovich, P. J. (2003). Cognitive flexibility theory: Hypermedia for complex learning, adaptive knowledge application, and experience acceleration. *Educational Technology, 44*(5), 5-10.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23.

Watzke, J. L. (2003). Longitudinal study of stages of beginning teacher development in a field-based teacher education program. *The Teacher Educator, 38*(3), 209-229.

Weber, C. A. (2012). *Student teachers' use of historical controversial issues in secondary social studies*. (Unpublished doctoral dissertation). Indiana University Bloomington, Bloomington, IN.

Wilson, S. M. & Floden, R. E. (2003). Creating effective teachers: Concise answers to hard questions. An addendum to the report "*Teacher Preparation Research: Current Knowledge, Gaps, and Recommendations*." Eric Document Reproduction Service # ED476366.

KAERA Research Forum, *1(2)*, 17-23

RESEARCH ARTICLE

Large Course Redesign Program at UNC Charlotte

Jaesoon An

University of North Carolina at Charlotte

The Center for Teaching and Learning (CTL) at UNC Charlotte is administering a Large Course Redesign (LCR) program. It is a faculty development program infused with instructional design initiative to address mission-critical institutional issues of student learning and instructional cost. After a successful completion of the pioneering project, the program evolved into a grant program funded by the provost office. This paper describes the methods and procedures CTL employed to redesign large-enrollment courses and shares one specific course redesign example. In a LCR project, faculty members who teach multiple sections of a large-enrollment course work as a team to redesign the whole course. Compared to the traditional faculty development approach of delivering workshops, this approach is project-based. Instructional designers work collaboratively with faculty who actually redesign the course and attempt to achieve faculty development in the process of the project. Compared to the traditional instructional design approach of working with subject matter experts to develop the curriculum and deploying it, this approach is faculty-centered where instructional designers provide consultations and support on the side.

Keywords: Large-enrollment course, Course redesign, Faculty development, Teaching grant

The Center for Teaching and Learning (CTL) at UNC Charlotte is administering a Large Course Redesign (LCR) program as an effort to enhance the university mission of teaching and learning excellence. Although lecture-based class format had long been considered to be ineffective for facilitating student learning, it had been the most prevalent class format among large-enrollment courses. Both administrators and faculty members of the university recognized the need for incorporating more student-centered active learning pedagogies into large-enrollment courses. Within the boundary of the traditional course format, however, it was not easy to apply active formats in large-enrollment courses compared to small classes.

Another need that several LCR projects aimed to address was related to the cost dimension of college classes. With increasing student enrollment to the university, most large-enrollment courses were faced with the need to increase the number of sections and instructors. Educational budget situation, however, could not meet the demand for additional human resources and classroom space. Also, the student body of the urban university showed increasing demand for online courses or more flexible class format.

The LCR program was launched as a faculty development program infused with instructional design initiative to address such critical needs relating student learning and instructional cost. After a successful completion of the pioneering project started in 2008, the program evolved into a grant program funded by the provost office. This paper describes the methods and procedures CTL employed to administer the LCR program and shares one specific course redesign example.

REDESIGN METHOD

In a LCR project, faculty members who teach multiple sections of a large-enrollment course work as a team to redesign the whole course. It is a faculty-led course design project where the owner of the project is the faculty teaching the course (Dee, Henkin, & Hearne, 2011). CTL facilitates the project process by providing guidance on the general process, facilitating team work, and providing resources such as templates and training in addition to the funding necessary for the development work. Compared to the traditional faculty development approach of delivering workshops, this approach is project-based. Instructional designers work collaboratively with faculty who actually redesign the course and attempt to achieve faculty development in the process of the project. Compared to the traditional instructional design approach of working with subject matter experts (i.e., faculty members in a university setting) to develop the curriculum and deploying it, this approach is faculty-centered where instructional designers provide consultations and support on the side. Along with the ownership, the outcomes of the project belong to the faculty and their program.

The pioneering LCR project, *Hybrid Elementary Spanish*, was a collaborative effort between CTL and the Spanish program of the Department of Languages and Culture Studies. While the Spanish program took the ownership of the project, CTL provided support on grant writing, project management, and training. Extending the internal collaboration into the national level, the project was invited to participate in a national course redesign program, Colleagues Committed to Redesign (C2R) of National Center for Academic Transformation (NCAT). NCAT had been leading large course redesign efforts across the U.S. since its first course redesign program in 1999. The two main goals of NCAT's course redesign programs were: improving student learning and reducing instructional cost. (Twigg, 2003) These goals were directly relevant for UNC Charlotte and many other higher education institutions in the U.S. One hundred and fifty nine institutions worked with NCAT to redesign their courses as of February 2014 (NCAT, 2014).

NCAT's redesign methods are similar to traditional instructional systems design method, ADDIE (Molenda, 2007). The analysis phase takes place in the form of responding to the Readiness Criteria. An important readiness criterion is whether curriculum redesign decisions will be made collectively beyond an individual faculty member level, and the redesigned class format will be adopted across all sections of a large-enrollment course. To accomplish this goal of redesigning a whole course, it is imperative that all instructors are willing to participate in the redesign process or at least stay in close touch with the process to be able to adopt a new format in the full implementation stage.

Another important analysis task is cost estimation. Using NCAT's Cost Planning Tool, instructional cost of the current format is calculated in terms of the cost per student. Then, the cost per student is compared to that of the redesigned format. Typically the goal is reducing the cost per student to be able to accommodate increasing enrollment with existing degree of resources. To maintain academic rigor while achieving the cost reduction, resource re-allocation that will help maximize the utility of the faculty time is planned typically. Common strategies include employment of diverse supplementary personnel such as teaching assistants and tutors.

Adoption of learning technologies is another common strategy to enable online delivery and learning activities.

Along with the above analyses tools, CTL provides a template for the course redesign plan to guide the planning phase. This template includes components corresponding to NCAT's guidance on various course design aspects such as models of course, principles of successful redesign, models of student learning assessment, cost reduction strategies, and critical implementation issues. Such adapted versions of NCAT's methods became the common methods of all large course redesign projects at UNC Charlotte (CTL, 2014).

REDESIGN PROCESS

Typically, a redesign project starts with the writing of a project proposal for the LCR grant using a template provided by CTL. The proposal process is comprised of two phases, pre-planning and full proposal. The pre-planning phase is intended to help the core project members to initiate the project quickly by describing the essence of the project briefly. It also allows CTL to offer feedback and suggestions for the full proposal. The full proposal includes more complete description of the redesign plan building upon the pre-planning. In the process of writing the full project proposal, the faculty team builds consensus on the goal of the project and how they will proceed to achieve the goal. Initial decisions must be made regarding the amount of class seat time and overarching pedagogy, tools, and resources of the course. All of the stakeholders such as the instructors of multiple sections and providers of campus resources including the department chair are included in the decision-making process. During this process, the faculty team enhances their readiness for a change in the way they teach the course. The faculty members also get a sense of how they can work together as a team and what kinds of personnel and resources they will need to complete the redesign project. The budget planning of the LCR fund is conducted accordingly.

Facilitating teamwork among faculty members is an important aspect of the LCR program administration. Several strategies are used to facilitate collaboration among faculty members. First, the team is encouraged to build a community of the project by using an online project site (Cowan, 2012). Moodle course management system at UNC Charlotte allows project sites and development courses. Through a project site, the faculty team communicates and stores common course materials. In the process of building a development course for the redesign course, the faculty members also practice using Moodle and other learning technologies and seek out necessary technology training proactively. This integration of technology training into the redesign project occurs very naturally and is usually demanded by the faculty members, demonstrating effectiveness of course redesign projects in achieving technology training objectives. Second, diverse kinds of meetings are organized to allow the faculty members to discuss project issues and ideas while enhancing the sense of community. Regular team meetings enable the team to sustain teamwork over an elongated project period which spans over 2 years typically. Meetings between a CTL staff member and the faculty project lead also occur to move the project forward. Additionally, project presentations across multiple redesign teams offer chances to receive feedback and ideas from other teams. Faculty members who have completed a redesign project are asked to serve as redesign scholars for new redesign teams. Cross-team presentations occur at major milestones such as in the beginning of the project with redesign scholars, after completing a pilot course with the provost, and after full implementation at a symposium with the general faculty.

An important step of the redesign process is conducting a pilot and collecting data for formative evaluation (Maslowski & Visscher, 1999). After teaching resources for the redesigned course are developed or arranged as planned, the next step is trying them out in one or more sections of the course for a semester. By the midterm of the pilot semester, a student survey is conducted to gather students' opinion about the redesigned course. The survey questions are usually comprised of both quantitative and qualitative questions. While the quantitative questions provide student opinion on specific questions the faculty members have, the qualitative questions provide data on unspecified course aspects that work well for the students and those who do not work as well as intended. At the end of semester, student grades of pilot sections are compared with those of traditional sections to assess effectiveness of the redesigned format in terms of student learning outcomes. The results from the pilot semester provide input for the revision of the course design before the new course format gets implemented across all sections of the course. Some redesign teams continue collecting data each semester even after the full implementation is completed. This continual research and improvement on the course design demonstrates the lasting effect of course redesign project on faculty development and enhancement of the Scholarship of Teaching and Learning (SOTL).

NATURE OF REDESIGN

As of February 2014, ten large-enrollment courses have participated in the LCR program, including Spanish, General Education, Psychology, Physics, Chemistry, Political Science, Sociology, Africana Studies, Math, and First Year Writing courses. These projects have been transforming the learning experience of the majority of student population for the past six years but with the recent onset of the First Year Writing courses redesign, all UNC Charlotte students will be impacted by the LCR program.

Although each of the above redesign projects had distinctive set of project goals, there were several changes common to all projects. Most LCR projects at UNC Charlotte adopted the blended format although a couple of large-enrollment courses were redesigned into the 100% online format. The faculty teams were more open to the idea of mixing online work with some classroom-based activities than moving to 100% online instruction. This preference was supported by education studies showing better student learning outcomes in blended format than in 100% online format in general (Dziuban, Hartman & Moskal, 2004).

Another common change was that all courses tried to deliver preparatory or introductory content through the use of learning technologies. Electronic textbook assignments were given in addition to or in place of traditional reading assignments. Lecture notes and video micro-lectures (Shieh, 2009) were provided in advance as pre-class assignments. The purpose was to prepare students for the class where active, deeper learning took place, such as clarification of misconception, application, discussion and problem-solving. The general pedagogy of most redesigned courses seemed to resemble that of the flipped classroom (Fulton, 2012).

Another pedagogy-related common change was that more emphasis was given to student-centered teaching (Eliason & Holmes, 2012). Most courses made before-class work accountable through assignments or quizzes. Using a student response system during class (Bruff, 2010) was common to assess the level of understanding. Out-of-class resources such as the resource center and tutors were more tightly integrated with the coursework. The instructor promoted the use of out-of-class resources actively by integrating them into their teaching or assignments. In addition, most redesigned courses reduced the lecture time or the class seat time (deNoyelles, Cobb, & Lowe, 2012) to offer small group discussion or problem-solving sessions (Ferreri & O'Connor, 2013). Graduate or undergraduate teaching assistants were hired to facilitate the small group sessions. The use of undergraduate assistants proved to be effective in both UNC Charlotte and other institutions (Weidert, Wendorf, Gurung, & Filz, 2012) that the university is now providing funding for hiring "preceptors" for large-enrollment courses.

Another common goal of the redesign projects was aiming to facilitate common student learning across multiple sections. Most of multi-section courses did not have a course coordinator who would facilitate common materials and policies across sections, leaving every component of the course up to the discretion of individual instructors. This lack of commonality across multiple sections was considered to be problematic for student learning especially when coupled with the reality that some sections were taught by adjunct faculty members and graduate teaching assistants. This situation resulted in uneven learning experiences for students depending on the section they were enrolled in. While academic freedom must be cherished, there was a need for some degree of standardization for introductory level large-enrollment courses. Many redesign projects developed common materials and shared them through the project site or a course coordination site in Moodle.

In terms of the cost saving aspect, most LCR projects achieved cost saving or increased the utility of the current level of cost. By reducing lecture time, some projects reduced the use of large lecture halls while increasing instructional capacity of the faculty members. Faculty time was freed up to teach more students in the same number of sections or more sections. Some projects enhanced their undergraduate or graduate programs by hiring more teaching assistants and enriching learning experiences for them through the assistantship opportunities. Most importantly, some projects reduced the instructional cost per student by improving on DFW rates and reducing the need for repeat-taking the course.

Figure 1 below illustrates how Physics courses have been transformed through the redesign project. Before the redesign, instructional techniques were very simplistic. Lecture was given twice a week. Students were asked to do homework, and two midterm exams and one final exam were given. After redesign, the weekly instructional sequence and methods became diversified to facilitate diverse ways of learning. One of the significant changes was that students were held accountable for their pre-lecture study through the pre-lecture quiz. This was to ensure that students come to the lecture with adequate reading. After the lecture, students were asked to do interactive homework on the electronic textbook. Another significant change was that the second lecture was replaced by TA-led small group problem-solving session. Students were asked to work on hands-on problem-solving questions while the TA was present to help them. Students were also given one-question weekly tests in the problem-solving session. This low-stakes weekly test not only ensured attendance but also gave students an increased confidence in their ability to learn physics. By being tested on one problem per week, students had an ongoing opportunity to assess their progress and chances to recover from failed tests. Ongoing assessment and prompt feedback is one of the five principles of successful course redesign suggested by NCAT. As a result, the DFW rates of the redesigned Physics courses were better than those of the courses in traditional format. The TA-led small group session was adopted by the Political Science redesign project. In this case, students were asked to engage in discussion and their learning was made accountable by requiring them to write reflection papers on the discussion. In terms of the cost saving, the Physics faculty members achieved savings not only by improving DFW rates but also by increasing their capacity to teach more sections and reducing the use of large lecture halls. They were able to hire more TAs in return. The project was immensely successful in both student learning and cost saving aspects that it was showcased to the university board of trustees.

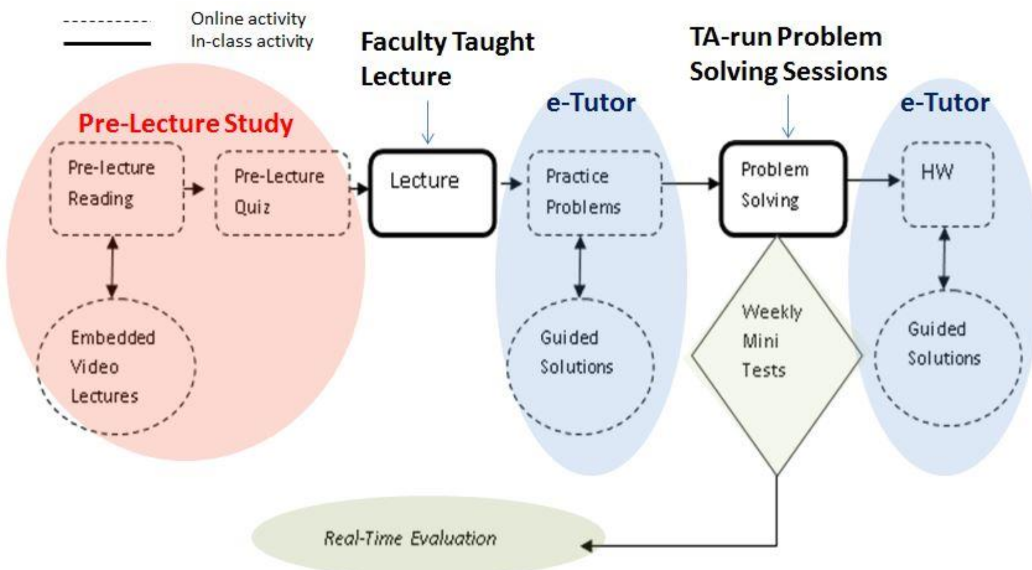

Figure 1. *Redesign Process of Physics Courses*

IMPLICATIONS OF REDESIGN PROJECTS

The use of diverse technologies in redesigned blended course formats usually creates a need for technology training and adoption support. For example, the process of electronic textbook adoption tends to involve the issue of compatibility with campus course management system. When micro-lectures are used, a set of needs arise related to the equipment and the support for the video production and editing. Also, there comes an influx of pedagogy questions such as facilitating team-based learning effectively, facilitating meaningful discussion, grading forum discussions in time-efficient ways, and coping with the perception of cheating in online activities. The reduction of class seat time and the division of the large class into small groups tend to require changes in the registration system and classroom assignment. The issues include, for example, how to utilize the large lecture halls freed up through the redesign, how to assign classrooms to accommodate multiple number of small groups per course, and what kinds of course designators are needed to clearly indicate course formats and classroom requirements in the registration system. Lastly, as the faculty incorporates more active techniques, the need for flexible classroom space arises. In terms of methods, there are several administration strategies that need more research. For example, stepwise proposal process, integration of technology training with course design project, and effect of course design project on SoTL and faculty development would benefit from further investigation.

REFERENCES

Bruff, D. (2010). Multiple-choice questions you wouldn't put on a test: Promoting deep learning using clickers. *Essays on Teaching Excellence, 21*(3). Retrieved from http://podnetwork.org/content/uploads/V21-N3-Bruff.pdf

Center for Teaching and Learning (CTL, 2014). Large course redesign, UNC Charlotte. Retrieved from: http://teaching.uncc.edu/services-we-provide/large-course-redesign

Cowan, J. (2012). Strategies for developing a community of practice: Nine years of lessons learned in a hybrid technology education master's program. *TechTrends, 56*(1), 12-18.

Dee, J., Henkin, A., & Hearne, J. (2011). Enabling initiative and enterprise: Faculty-led course redesign in a STEM discipline. *Educational Research Quarterly, 35*(1), 34-64.

deNoyelles, A., Cobb, C., & Lowe, D. (2012). Influence of reduced seat time on satisfaction and perception of course development goals: A case study in faculty development. *Journal of Asynchronous Learning Networks, 16*(2), 85-98.

Dziuban, C., Hartman, J. & Moskal, P. (2004) Blended learning. *ECAR Research Bulletin, 2004* (7), 1-12.

Eliason, S. & Holmes, C. (2012). A course redesign project to change faculty orientation toward teaching. *Journal of the Scholarship of Teaching and Learning, 12*(1), 36-48.

Ferreri, S. & O'Connor, S. (2013). Redesign of a large lecture course into a small-group learning course. *American Journal of Pharmaceutical Education, 77*(1), Article 13. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3578326/

Fulton, K. (2012). Upside down and inside out: Flip your classroom to improve student learning. *Learning & Leading with Technology, 39*(8), 12-17.

Maslowski, R. & Visscher, A. (1999). Formative evaluation in educational computing research and development. *Journal of Research on Computing in Education, 32*(2), 239-55.

Molenda, M. (2007). In search of the elusive ADDIE model. *Performance Improvement, 42*(5), 34-36.

Shieh, D. (2009). These lectures are gone in 60 seconds. *Chronicle of Higher Education, 55*(26), A13. Retrieved from http://chronicle.com/article/These-Lectures-Are-Gone-in-60/19924

The National Center for Academic Transformation (NCAT, 2014). Retrieved from http://www.thencat.org

Twigg, C. (2003). Improving quality and reducing cost: Designs for effective learning. *The Magazine of Higher Learning, 35*(4), 22-29.

Weidert, J., Wendorf, A., Gurung, R., & Filz, T. (2012). A survey of graduate and undergraduate teaching assistants. *College Teaching, 60*(3), 95-103.

KAERA Research Forum, *1(2)*, 24-35

RESEARCH ARTICLE

Examining Reliability and Validity of a Korean Version of the Community of Inquiry Instrument Using Exploratory and Confirmatory Factor Analysis

Taeho Yu
Purdue University

This study examines the reliability and validity of a Korean version of the Community of Inquiry (CoI) instrument in online learning. The measurement consists of 34 items to evaluate social presence, teaching presence, and cognitive presence and was translated from English into Korean for this study. One Cyber University in Seoul, South Korea was selected to test the reliability and validity of the CoI measurement in Korean. Data were randomly split into two groups. Three factor-structures of the CoI framework explained 63.82% of the variance in the pattern of relationships among the items using the first split-half sample. All three presences had high reliabilities (all Cronbach's $\alpha > .913$). The three-factor structure of the CoI framework with social presence, teaching presence, and cognitive presence confirms the Korean version of the CoI measurement by deleting two items which cross-loaded on multiple factors. Confirmatory factor modeling approach was used to assess the validity of the Korean version using the remaining half sample.

Keywords: community of inquiry, online learning, factor analysis

Scholars in the distance education field consider the Community of Inquiry (CoI) an effective and efficient framework of learning within online learning platforms (Akyol & Garrison, 2008; Burgess et al., 2010; Shea & Bidjerano, 2009). Based on the CoI framework, a varied spectrum of online learning contexts has been analyzed in order to understand implications for online learning practices (Jézégou, 2010; Ke, 2010; Morris, 2011; York & Richardson, 2012). The CoI framework reflects the dynamic nature of online inquiry and provides researchers with useful guidance when exploring how a sense of community for knowledge construction can be created online and significantly impact students' learning processes (Rovai, 2002; Shea, 2006). The large body of the literature on the CoI framework focuses generally on online environments in the United States since the CoI instrument is in English. However, a lack of research utilized the CoI measurement in a different language although online learning became popular in many different countries.

Online learning in Korea has been developed rapidly with the wholehearted support from Ministry of Labor of Korea (Lee et al., 2009; Lim, 2007). Due to high speed internet and nation-wide broadband infrastructure, high quality VOD (Video on Demand) typed online learning content has been provided for online learners in Korea (Communications Workers of America, 2009; Misko, Choi, Hong, & Lee, 2005). Therefore, the purpose of this study is to examine the reliability and validity of the CoI instrument in Korean as a starting point of expanding its research area to various languages and online learning environments.

THE COMMUNITY OF INQUIRY (CoI) FRAMEWORK

The Community of Inquiry (CoI) framework consists of three core elements of collaborative constructivist learning required to sustain a purposeful learning community: social presence, cognitive presence, and teaching presence (Garrison, Anderson, & Archer, 2010, see Figure 1). Cognitive presence is defined as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry" (Garrison, Anderson, & Archer, 2001, p. 11). Social presence is defined as the level of recognition of other people in the process of communicating with them in online environments (Garrison & Arbaugh, 2007). Teaching presence is described as "the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" (Anderson, Rourke, Garrison, & Archer, 2001, p. 5).

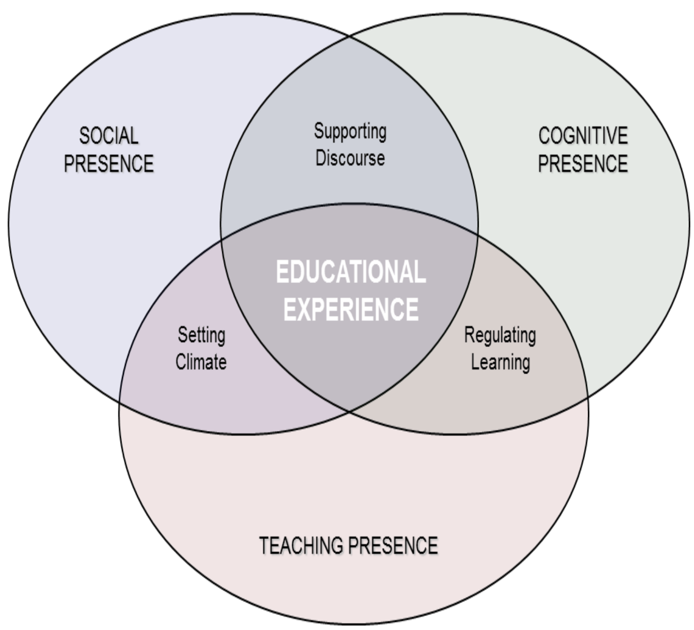

Figure 1. Community of Inquiry Framework

The Community of Inquiry (CoI) instrument consists of 34 items: 13 items for teaching presence, 9 items for social presence, and 12 items for cognitive presence (Garrison, Anderson, & Archer, 2001). This instrument has been tested to establish a reliable measurement for three presences (Arbaugh, 2007; Arbaugh et al., 2008) and was validated using a multi-institutaional data set (Swan et al., 2008). The internal consistency reliability of the 34 items of the CoI framework was high with Cronbach's Alpha of 0.91 for social presence, 0.95 for cognitive presence, and 0.94 for teaching presence (Swan et al., 2008).

METHODS

Research Context

The Cyber University in South Korea selected for this study consists of six departments and 19 programs. Over 11,000 students were enrolled in 2012 and the majority of students were between 19 and 23 age years old. All courses in the Cyber University are provided through online education and there is no face-to-face component. Most online courses were in VOD format; however a few were structured as including Problem Based Learning (PBL) and discussion based courses. An online survey link to the CoI instrument in Korean was posted on the front page of the Cyber University Homepage for three weeks from April 15, 2013 to May 3, 2013. All survey results were collected electronically and coded for analysis.

Participants

The participants for this study were 995 Korean undergraduate students: 440 (44.1%) male and 555 (55.9%) female students enrolled in the Cyber University. There were 235 freshmen (23.6%), 150 sophomores (15.1%), 325 juniors (32.7%), and 273 seniors (27.4%). In terms of the locations of residency, the majority of participants (78.2%) lived in urban areas such as Seoul, Incheon, and Gyung-gi.

Data Collection

Community of Inquiry (CoI) Survey. The CoI Survey Instrument (Swan et al., 2008) was administered to students to gather data using an online survey. The 34 CoI survey items were measured on a 5 point Likert scale (Strongly Disagree = 1 and Strongly Agree = 5). The online CoI survey in Korean was created by using a recognized online survey tool and the students could access to the survey link from the front page of the Cyber University Homepage. This study was approved by the Purdue University Human Subjects Institutional Review Board, and informed consent was waived.

Data Analysis

The total sample (N=995) was randomly divided into two split-half samples by using Statistical Package for the Social Sciences (SPSS, version 21). Exploratory factor analysis (EFA) was performed on the first split-half samples (n=498) and confirmatory factor analysis (CFA) was performed on the second split-half samples (n=497).

RESULTS

Descriptive Statistics

Table 1 shows the descriptive statistics including means, standard deviations, Skewness, Kurtosis, minimums, and maximums of the three elements of the Community of Inquiry (CoI).

It reveals that participating students perceived high social presence (M=3.46), teaching presence (M=3.87), and cognitive presence (M=3.76). The minimum and maximum values were the same in three presences as 1 and 5 respectively. In addition, the result presented that the data in this study were normally distributed based on the degrees of Skewness and Kurtosis because both were less than the absolute value 1.

TABLE 1
Descriptive Statistics of Each Element of the CoI

	Mean	Std. Deviation	Skewness	Kurtosis	Min	Max	N
Teaching Presence	3.87	.85	-.549	.385	1	5	498
Social Presence	3.46	.95	-.203	-.285	1	5	498
Cognitive Presence	3.76	.80	-.366	.220	1	5	498
Total	3.72	.86	-.393	.150	1	5	498

Exploratory Factor Analysis (EFA) for Validity

An exploratory factor analysis was conducted on the 34 items with promax rotation using SPSS 21. Exploratory factor analysis is a statistical method to increase the reliability of the scale by removing inappropriate items and to identify the dimensionality of constructs by examining relations between items and factors when the information of the dimensionality is limited (Netemeyer, Bearden, & Sharma, 2003). In this study, the three factors of social, cognitive, teaching presences were used to determine the pattern of structure in the 34 item measurement of the CoI framework along with a scree plot and eigenvalue (Thompson, 2004). The scree test introduced by Cattell (1966) plots eigenvalues against the number of factors to determine where a significant drop presents within factor numbers (Netemeyer, Bearden, & Sharma, 2003).

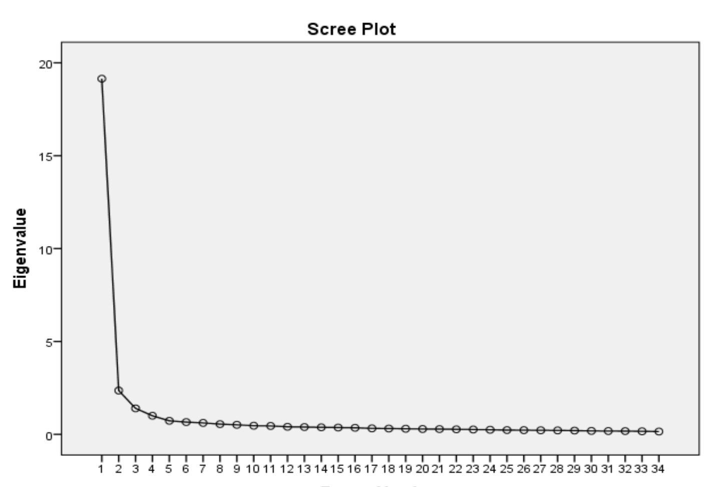

Figure 2. *Scree plot for the Korean version of the CoI instrument*

TABLE 2
The Items and Three-Factor Structure of the CoI after factor reduction procedures

	Factor		
	1	2	3
TP_The instructor helped to keep course participants engaged and participating in productive dialogue.	.882		
TP_The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	.805		
TP_The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	.789		
TP_The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.	.788		
TP_The instructor helped to keep course participants engaged and participating in productive dialogue.	.786		
TP_The instructor provided feedback that helped me understand my strengths and weaknesses.	.782		
TP_The instructor encouraged course participants to explore new concepts in this course.	.764		
TP_Instructor actions reinforced the development of a sense of community among course participants.	.708		
TP_The instructor clearly communicated important course goals.	.696		
TP_The instructor provided clear instructions on how to participate in course learning activities.	.683		
TP_The instructor clearly communicated important course topics.	.673		
TP_The instructor provided feedback in a timely fashion.	.602		
CP_Learning activities helped me construct explanations/solutions.		.778	
CP_I utilized a variety of information sources to explore problems posed in this course.		.762	
CP_Combining new information helped me answer questions raised in course activities.		.736	
CP_I can apply the knowledge created in this course to my work or other non-class related activities.		.707	
CP_Brainstorming and finding relevant information helped me resolve content related questions.		.670	
CP_Problems posed increased my interest in course issues.		.659	
CP_I felt motivated to explore content related questions.		.654	
CP_Reflection on course content and discussions helped me understand fundamental concepts in this class.		.628	
CP_I have developed solutions to course problems that can be applied in practice.		.624	
CP_Course activities piqued my curiosity.		.580	
CP_Online discussions were valuable in helping me appreciate different perspectives.		.570	
CP_I can describe ways to test and apply the knowledge created in this course.		.538	

SP_I felt comfortable interacting with other course participants.	.887
SP_I felt comfortable participating in the course discussions.	.755
SP_I felt that my point of view was acknowledged by other course participants.	.702
SP_I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	.653
SP_I felt comfortable conversing through the online medium.	.606
SP_I was able to form distinct impressions of some course participants.	.556
SP_ Online or web-based communication is an excellent medium for social interaction.	.538
SP_ Online discussions help me to develop a sense of collaboration.	.532

TABLE 3
CoI Survey Instrument in Korean

	Presences	Items
Teaching Presence	Design & Organization	1. 교수자가 주요 강의 내용들을 명확하게 전달했다. 2. 교수자가 주요 강의 목표들을 명확하게 전달했다. 3. 교수자가 강의 내 학습 활동들에 어떻게 참여해야 하는지 명확하게 설명했다. 4. 교수자는 내가 강의에서 배워야 하는 내용과 불필요한 내용을 구별하는데 도움을 줬다.
	Facilitation	5. 교수자는 내가 주요 강의내용들을 이해하기 위해 내 생각을 명확히 하는데 도움을 줬다. 6. 교수자는 학생들이 수업에 적극적으로 생산적인 대화에 참여하도록 도움을 줬다. 7. 교수자는 내가 학습을 하는데 도움이 되는 방향으로 수업 내 과제들을 수행할 수 있도록 도움을 줬다. 8. 교수자는 학생들이 수업에 관련된 새로운 개념들에 대해 탐구해 볼 수 있도록 장려했다. 9. 교수자는 학생들이 수업 내 학습공동체를 형성하는 걸 강화하는 역할을 수행했다.
	Direct Instruction	10. 교수자는 내가 학습을 하는데 도움이 되는 방향으로 수업과 관련된 주제들에 대한 토론에 집중할 수 있도록 도움을 줬다. 11. 교수자는 내가 나의 강점과 약점을 이해하는데 도움이 되는 피드백을 제공해 줬다. 12. 교수자는 제때 피드백을 줬다.
Social Competency	Affective expression	13. 나는 수업에 몇몇 학생들에 대해서 특별한 인상을 형성할 수 있었다. 14. 온라인 또는 웹 기반 의사소통은 사회적 교류를 위한 최고의 매체이다.
	Open communication	15. 나는 온라인 매체를 통해서 대화를 나누는데 익숙하다. 16. 나는 수업 토론에 참여하는데 익숙하다. 17. 나는 수업 내 다른 학생들과 교류하는데 익숙하다.
	Group cohesion	18. 나는 다른 학생들과 신뢰를 쌓아가는 과정 중에 다른 학생의 의견에 반대하는 것에 불편함이 없다. 19. 나는 내 관점이 다른 학생들에게 인정받고 있다는 걸 느꼈다. 20. 온라인 토론은 내가 협업에 대한 감각을 키우는데 도움을 준다.

Cognitive Competency	Triggering event	21. 제기된 문제들은 수업 내 이슈들에 대한 내 관심을 증가시켰다. 22. 수업 내 활동들은 내 호기심을 자극했다. 23. 나는 수업 내용 관련된 질문들에 대해 탐구하고자 하는 동기부여를 느꼈다.
	Exploration	24. 나는 수업 내 제기된 문제들을 탐색하기 위해 다양한 정보를 활용하였다. 25. 브레인 스토밍 과 관련된 정보를 찾는 과정은 내가 수업 관련 문제들을 해결하는데 도움을 줬다. 26. 온라인 토론은 내가 나와 다른 관점들을 받아드리는데 큰 도움을 줬다.
	Integration	27. 새로운 정보를 통합하는 과정은 내가 수업 활동 안에서 제기된 문제들에 답하는 것에 도움을 줬다. 28. 학습 활동은 내가 설명이나 해결책을 구성하는데 도움을 줬다. 29. 수업 내용과 토론에 대해 재조명은 내가 수업의 구조적 개념을 이해하는데 도움을 줬다.
	Resolution	30. 나는 수업에서 얻게 된 지식을 어떻게 평가하고 활용하는지에 대해 묘사할 수 있다. 31. 나는 일상 생활에 적용가능 한 수업 내 문제들에 대한 해결책을 발전시켰다. 32. 나는 이번 수업에서 내 과제와 연결되었거나 수업과는 별도의 활동을 통해 얻게 된 지식을 활용할 수 있다.

An initial analysis was run to obtain eigenvalues for each factor in the data. The Kaiser-Meyer-Olkin Measure verified the sampling adequacy for the analysis, KMO=.969. Bartlett's Test of Sphericity, $\chi 2$ (561) = 15023.45, $p < .000$, indicated that correlations between items were sufficiently larger for EFA. Three factors had eigenvalues over 1 as the scree plot shows clearly in Figure 2.

The final three-factor structure in this study is composed of 32 items after deleting two items which cross-loaded on multiple factors. As shown in Table 2, 12 items for factor 1 represent teaching presence, 12 items for factor 2 represent cognitive presence, and 8 items for factor 3 represent social presence. The first item that was deleted was *SP_Getting to know other course participants gave me a sense of belonging in the course* because it had factor loading of .511 on social presence and a cross-loading of .424 on teaching presence. Then, the second item, *TP_The instructor clearly communicated important due dates/time frames for learning activities*, was deleted because it had factor loading of .493 on teaching presence and a cross-loading of .422 on cognitive presence. Finally, this 32-item structure explained 63.82% of the variance in the pattern of relationships among the items. The percentages explained by each factor were 53.61% (teaching presence), 6.70% (cognitive presence), and 3.50% (social presence) respectively.

Item Analysis for Reliability

An item analysis was conducted to test the reliability of each element as well as an entire instrument of the CoI. According to Blunch (2008), satisfactory internal consistency ranges from 0.7 to 0.9. All three elements in this study had high reliabilities. Cronbach's α of teaching, social, and cognitive presence was .954, .913, and .956 respectively. In addition, Cronbach's α of the instrument overall was .972 (See Table 4).

TABLE 4
Cronbach's Alpha for Each Element of the CoI

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of items
Teaching Presence	.954	.955	12
Social Presence	.913	.914	8
Cognitive Presence	.956	.956	12
Total	.972	.973	32

Confirmatory Factor Analysis (CFA) for predictive validity

Following EFA, Confirmatory Factor Analysis (CFA) was conducted to verify the Korean CoI instrument by using Linear Structural Relations (LISREL, version 8.8). Two items that were cross loaded on multiple factors were removed from the original 34 item in order to identify a stronger model, which can increase the percentage of variance explained and reduce the $\chi 2$ goodness of fit statistic after initial EFA. The main purpose of running CFA is to examine the relationships among the latent and manifest variables supported by logic or theory (Schreiber, Stage, King, Nora, & Barlow, 2006). Multiple goodness of fit indices have been developed such comparative fit index (CFI), the goodness of fit index (GFI), and root mean square error of approximation (RMSEA). The interval of CFA and GFI between 0 to 1, and closer to 1 means there is higher relations between variance and covariance (Schreiber et al., 2006). According to the previous research, above .95 of CFA, 0.90 of GFI (Hu & Bentler, 1999) and below .05 of RMSEA (Browne & Cudeck, 1993) indicate the excellent model fit respectively. Hu and Bentler (1999) also recommended reporting Incremental Fit Index (IFI) to identify the degree of model fit.

The CFA results presented that the hypothesized model of 32-item structure of the CoI instrument was verified as an excellent fit for the data ($\chi 2$ (461, N=995)=1925.88, $p<.001$, IFI=.98, CFI=.98, GFI=.79, RMSEA=.084). The obtained *t* values were significant at $p<0.001$ because the ranges were between 14.75 and 24.16 which are greater than 3.29 (Hatcher, 1994). As shown in Figure 3, the completely standardized loadings are ranged between 0.68 and 0.88. Finally, the results of the CFA confirmed that the model fit is excellent between the proposed model and the observed data.

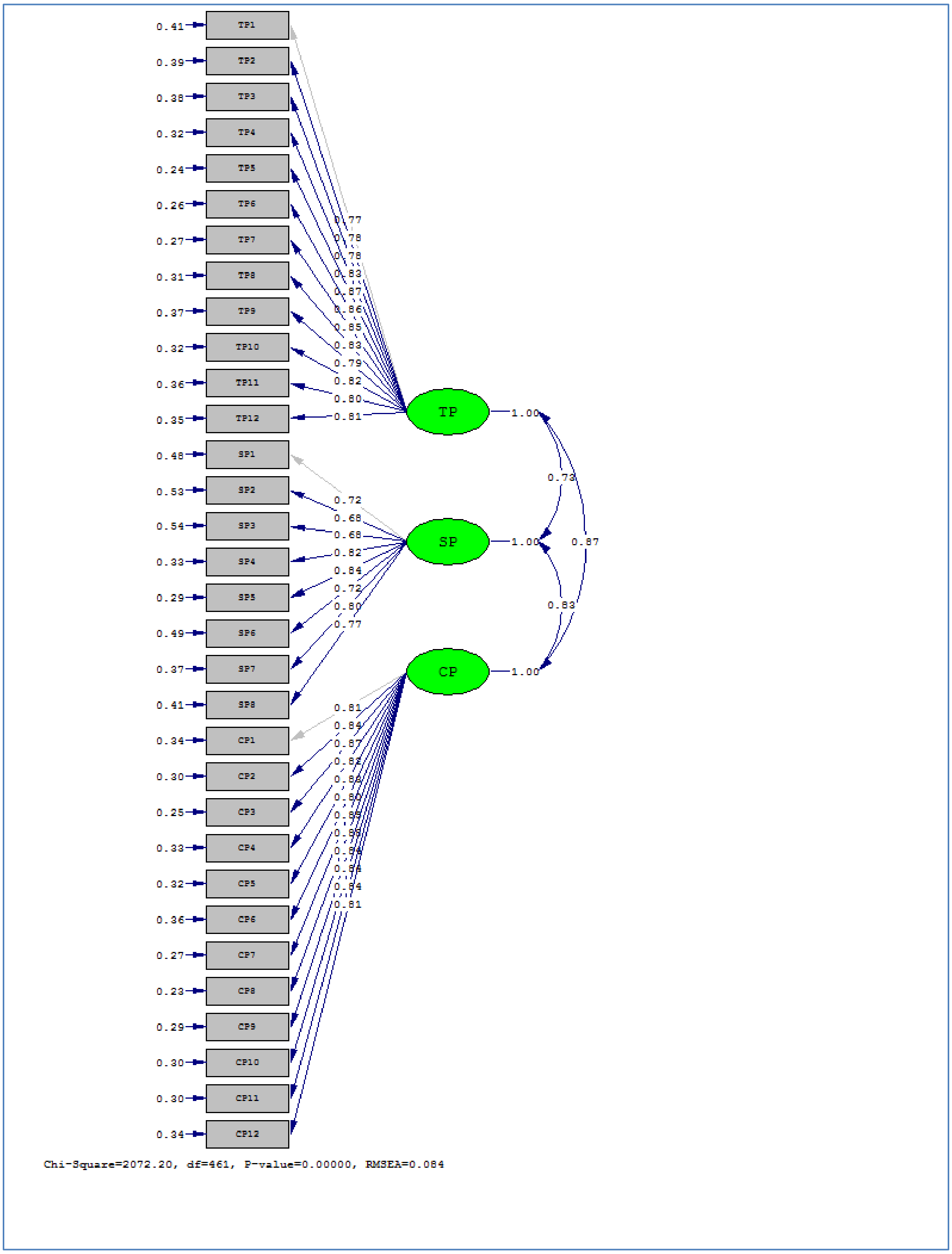

Figure 3. *Factor structure and completely standardized factor loadings*

CONCLUSION

The purpose of this study was to test the reliability and validity of the Community of Inquiry (CoI) instrument in Korean in an online learning setting. It was verified that the internal consistency reliabilities of the CoI instrument in Korean were excellent as a result of item analysis on the items belonged to each presence separately. Moreover, this study proved the validity of the CoI instrument in Korean with three-factor structures with social presence, teaching presence, and cognitive presence which were supported by the literature.

As a result of descriptive statistics analysis, the data in this study were confirmed to be appropriate to conduct exploratory factor analysis (EFA). The data was normally distributed, and the 498 sample size was large enough for EFA as it was larger than the suggested sample size of 300 (Comrey & Lee, 1992). Based on the results of exploratory factor analysis (EFA), this study successfully achieved the simple solution with three-factor structures, the same three factors as originally proposed by the CoI framework (Garrison, Anderson & Archer, 2001; 2010) and instrument (Arbaugh et al., 2008; Swan, et al., 2008) by deleting two items which cross-loaded on multiple factors. The three-factor structures was previously tested and verified for the English language version (Arbaugh, 2007; Arbaugh et al., 2008; Swan et al., 2008). For instance, Arbaugh and colleagues (2008) conducted a principal components analysis (PCA) on the 34 items of the Community of Inquiry (CoI) instrument with 287 graduate students in Education and Business. Their study found that 13 items of teaching presence, 9 items of social presence, and 12 items of cognitive presence were significantly loading on factor 1, factor 2, and factor 3 respectively. The internal consistency reliabilities of each presence were excellent with the Cronbach's Alpha of teaching, social, and cognitive presence at .95, .94, and .91 respectively (Arbaugh et al., 2008). However, for this study of the Korean language version, the final three-factor structure is composed of 32 items versus the original 34 of the English language version. Finally, the Korean language version of the CoI instrument had final three-factor structure composed of 32 items with 12 items for teaching presence, 12 items for cognitive presence, and 8 items for social presence. As a result of item analysis in this study, the reliabilities of all three presences were high (Cronbach's α: teaching presence = .954, social presence = .913, and cognitive presence = .956).

Two possible reasons can explain the discrepancy. One can be a translation problem. To investigate this problem, back-translation method can be adapted. Back-translation method is to re-translate from foreign language to original language after translated to foreign language. By comparing between original version and back-translated version, the researcher may determine whether the translation caused the problem or not. Another can be cultural or environmental difference between the US and Korea. For instance, the major type of delivery methods for online education is Video on Demand (VOD) in Cyber University in Korea, whereas reading, discussions, and reflections are main activities in online education in the US. For this reason, when Korean participants read the items for social presence, they might feel lower social presence or higher teaching or cognitive presence because participating in online discussion or interacting with other peers are not major components of online courses in the Cyber University. Therefore, further research is necessary to determine the main cause of the cross-loading problems of the CoI instrument in Korean.

The effect of cognitive presence, social presence, and teaching presence from the CoI framework on online student's meaningful learning experience has been verified by the previous literature in the United States. Thus, this study contributes to expanding the research area of the CoI framework to various learning environments including different languages and cultures.

REFERENCES

Akyol, Z., & Garrison, D. R. (2008). The development of a community of inquiry over time in an online course: Understanding the progression and integration of social, cognitive and teaching Presence. *Journal of Asynchronous Learning Networks*, *12*(3-4), 3−22.

Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001). Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks, 5*(2), 1-17.

Arbaugh, J. B. (2007). An empirical verification of the community of inquiry framework. *Journal of Asynchronous Learning Networks, 11*(1), 73-85.

Arbaugh, J. B., Cleveland-Innes, M., Diaz, S. R., Garrison, D. R., Ice, P., Richardson, J.C., & Swan, K. P. (2008). Developing a community of inquiry instrument: Testing a measure of the community of inquiry framework using a multi-institutional sample. *The Internet and Higher Education, 11*(3-4), 133-136.

Blunch, N. J. (2008). *Introduction to structural equation modelling Using SPSS and AMOS*. Thousand Oaks, CA: Sage Publications.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Newbury Park, CA: Sage Publications.

Burgess, M.L., Slate, J.R., Rojas-LeBouef, A., & LaPrairie, K. (2010). Teaching and learning in second life: Using the community of inquiry (CoI) model to support online instruction with graduate students in instructional technology. *Internet and Higher Education, 13*(1-2) 84-88.

Cattell, R. B. (1966). The meaning and strategic use of factor analysis. In R. B. Cattell (Ed.), *Handbook of multivariate experimental psychology* (pp. 174-243). Chicago: Rand McNally.

Communications Workers of America (2009). Nationwide study of real-time internet connection speeds shows US still lags behind other advanced nations, posts small gains last two years. Retrieved from http://www.cwa-union.org/news/nationwide-study-of-real-time-internet-connection-speeds-shows-u-s-still-lags-behind-other-advanced-nations-posts-small-gains-last-two-years.html

Comrey, A. L. & Lee, H. B. (1992). A first course in factor analysis (2nd edition). Hillsdale, NJ: Erlbaum.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking and computer conferencing: A model and tool to assess cognitive presence. *American Journal of Distance Education, 15*(1), 7−23.

Garrison, D.R., Anderson, T., & Archer, W. (2010). The first decade of the community of inquiry framework: A retrospective. *Internet and Higher Education, 13*(1-2), 5-9.

Garrison, D. R., & Arbaugh, J. B. (2007). Researching the community of inquiry framework: Review, issues, and future directions. *Internet and Higher Education, 10*(3), 157−172.

Hatcher, L. (1994). *A step-by-step approach to using the SAS system for factor analysis and structural equation modeling*. Cary, NC: SAS Institute, Inc.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1-55.

Jézégou, A. (2010). Community of inquiry in e-learning: A critical analysis of the Garrison and Anderson model. Journal of Distance Education, 24(3). Retrieved from http://www.jofde.ca/index.php/jde/article/view/707/1141

Ke, F. (2010). Examining online teaching, cognitive, and social presence for adult students, *Computers & Education, 55*(2), 808-820.

Lee, B., Yoon, J., & Lee, I. (2009). Learners' acceptance of e-learning in South Korea: Theories and results, *Computers & Education, 53*(4), 1320–1329.

Lim, C. (2007). The current status and future prospects of corporate e-learning in Korea. The International Review of Research in Open and Distance Learning, 8(1).

Misko, J., Choi, J., Hong, S. Y., & Lee, I. S. (2005). *E-learning in Australia and Korea: Learning from practice.* Korea Research Institute for Vocational Education & Training and National Centre for Vocational Education Research.

Morris, T.A. (2011). Exploring community college student perceptions of online learning. International Journal of Instructional Technology & Distance Learning, 8(6).

Netemeyer, R. G., Bearden, W. O., & Sharma, S.(2003). *Scaling Procedures: Issues and Applications*. London: Sage Publications.

Rovai, A. P. (2002). Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks. *The Internet and Higher Education, 5*(4), 319−332.

Schreiber, J. A., Stage, F. K., King, J., Nora, A., & Barlow, E. A. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research, 99*, 323-337.

Shea, P.J. (2006). A study of students' sense of community in online learning environments. *Journal of Asynchronous Learning Network, 10*(1), 35-44.

Shea, P., & Bidjerano, T. (2009). Community of inquiry as a theoretical framework to foster —"Epistemic engagement" and — "Cognitive presence" in online education. *Computers & Education, 52*(3), 543−553.

Swan, K., Richardson, J., Ice, P., Garrison, D. R., Cleveland-Innes, M., & Arbaugh, J. B. (2008). Validating a measurement tool of presence in online communities of inquiry. *E-Mentor, 2*(24), 1-12.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications.* Washington, D.C.: American Psychological Association.

York, C.S. & Richardson, J.C. (2012). Interpersonal interaction in online learning: Experienced online instructors' perceptions of influencing factors. *Journal of Asynchronous Learning Networks, 16*(4), 81-96.

KAERA Research Forum, *1(2)*, 36-42

RESEARCH ARTICLE

Future Learning Technology: Where Are We Heading?

Hyo-Jeong So, Heung-Chang Lee, and Soon-Mo Kwon
Pohang University of Science & Technology (POSTECH), Korea

In this paper, we discuss the trend of emerging technologies in education to provide both the current landscape and the future trend of learning technologies. In particular, we examine the potential values of learning analytics and 3D printing as promising technological applications in future learning. This paper also discusses a couple of issues that we need to consider shaping the future of learning with emerging technologies. On the whole, the main goal of this paper is to provoke our thinking about the fundamental role of technologies toward designing future learning environments.

Keywords: Learning Technology, Learning Analytics, 3D Printing

From the history of education, we have learnt that the classroom of the present is a genealogical object that reflects its historical predecessors (Schratzenstaller, 2010). The structure of future learning is likely to have considerable influences from the structures of its predecessors, coupled with societal needs to transform education. When we accept the historical legacy view of education, it is equally important to outlook what has been discussed as promising future trends that are likely to impact the landscape of future learning. It is clear that the rapid development and diffusion of emerging technologies have transformed our larger society, human behaviors in everyday life, and communication patterns. Education is not the exception in this transformative change. Indeed, the promise of emerging technologies has shaped much of the public discourse about future learning. While this is not to say that education should be driven by technological changes, the coupling of pedagogy and technology is more critical than ever due to the needs to support teaching and learning practices in the lifelong learning era.

To outlook the future trend of technologies that are likely to have a large impact in educational scenes, we trace the technology trend prediction in recent three years from two major sources, the Gartner report and the Horizon report. First, the *Gartner* report is a major source of information that predicts key trends of information technology (IT) in business sectors. Figure 1 presents the IT market trend by Gartner in 2012 – 2014. Second, the *Horizon report* published annually by the New Media Consortium (NMC) is specific to education sectors, and identifies the trend of emerging technologies likely to impact teaching and learning along three adoption horizons: near-term horizon (one year or less), mid-term horizon (two to three years), and far-term horizon (four to five years). Figure 2 shows the prediction of key trends in education technologies taken from the recent three years' Horizon reports (2011-2013).

Overall, the most notable trend in IT by Gartner is that technology becomes increasingly intelligent, customizable, and integrated. The emergence of *the Internet of Things* (IoT) represents this trend in which “the Internet extends into the real world embracing everyday objects. Physical items are no longer disconnected from the virtual world, but can be controlled remotely and can act as physical access points to Internet services” (Mattern & Floerkemeier, 2010, p.242). That is, moving away from a single application or service, the Internet of Things can seamlessly integrate physical and virtual spaces/objects based on the customization of individual needs and contexts.

Looking into the future IT trends in educational settings, the Horizon reports published in recent three years show the pattern similar to the Gartner trend report. Mobile technology and clouding computing, which have been predicted as the most impactful technology in business sectors, are already seen and used in many educational settings. What is notable in the 2013 Horizon report is that interactive media/technology such as game-based learning and augmented reality did not appear in the adoption horizon. Instead, learning analytics and open content regained its importance. Another notable trend is that for the first time, 3D printing and virtual remote technologies appear in the far-term horizon. This prediction is not surprising when considered the fast development and diffusion of 3D printing and remote control technologies in recent years.

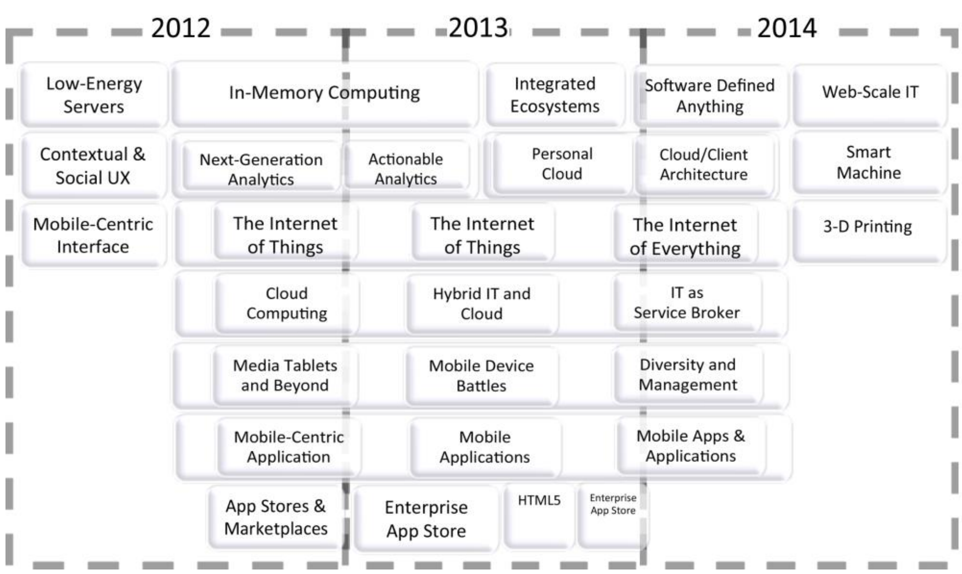

Figure 1. *Information Technology Trends by Gartner*

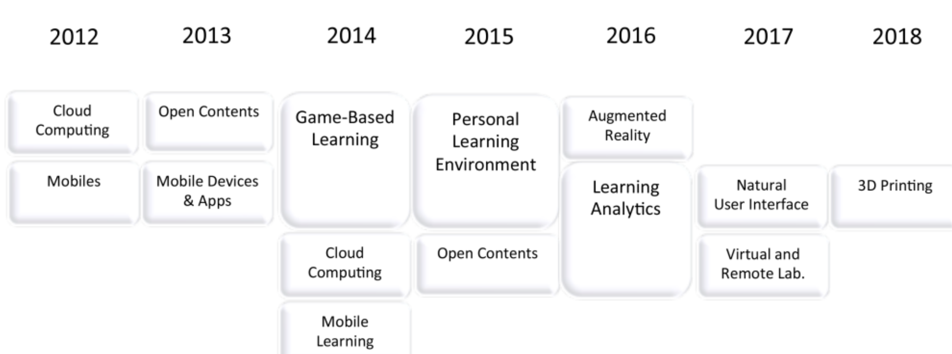

Figure 2. *Technology Outlook in K-12 Education by Horizon Report*

EMERGING TECHNOLOGIES IN EDUCATION

The previous section provides an overview of the future trend of technology in general. What type of technology is likely to be integrated in education depends on the tight coupling of technological and pedagogical affordances. A full discussion of future learning technology is beyond the scope of this paper. Thus, we particularly focus on two examples of emerging technologies that have been predicted to have significant impacts on future learning: *Learning analytics* and *3D printing*. The focus on learning analytics and 3D printing is associated with the pedagogical affordance of each technology as well as the likelihood of the increasing access and affordability of such technologies to be adopted in learning contexts. In this section, we first present the technical mechanisms of each technology, followed by its potential application in education and a set of challenging issues to consider.

Learning Analytics

For the past decade, learning analytics has emerged as a promising area of application with the proliferation of online learning services and platforms that produce vast amount of data. Ferguson (2012) contends "The rise of big data in education mirrors the increase in take-up of online learning" (p.306). *Learning analytics* are defined as "the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and advice on learning" (Siemens, 2010). Technically, learning analytics is based on techniques in *big data*, which refer to "datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyze" (Manyika et al., 2011, p.1). In the business sector, big data has been widely utilized to identify potential customers, and to provide personalized advertisement, information, and services.

Values underlying learning analytics are to analyze data about learners and their contexts in order to better understand and personalize their learning experiences. Learning analytics can take various forms depending on main purposes. Here, we categorize learning analytics mainly into three types: a) assessment and evaluation, b) recommendation and visualization, and c) social learning analytics, and then provide relevant examples to illustrate each type of learning analytics.

First, learning analytics for assessment and evaluation focuses on analyzing scores on student learning activities and performance in order to provide personalized feedback. For instance, Mathspace (https://mathspace.co/) is an online platform to help students observe and understand math problems at their own pace. Using analytics techniques, this program provides guided feedback from the analysis of students' scores in math problems and generates reports for teachers.

Second, learning analytics can be used to provide learners with personalized recommendation and visualization by analyzing a comprehensive set of learner behavior and assessment data (Duval, 2011). eAdivisor (https://eadvisor.asu.edu/) system used in Arizona State University is a good example of learning analytics for recommendation purposes. When students take an online course, this system provides personalized learning content and manages learning progress by monitoring and analyzing data about individual learners' performance and test scores. When students receive poor scores in core subjects or do not register for courses, this system recommends new majors or specific courses for students to take. Kickboard (http://www.kickboardforteachers.com/) is an example of learning analytics for visualization, which utilizes real-time data management systems to provide teachers with daily visual tracking of their students' behaviors, attitudes and performance in dashboards.

Lastly, social learning analytics is tapping on rich learning opportunities in online social media spaces, based on the analysis of data concerning online communication and learning activities (Lockyer & Dawson, 2011). Shum and Ferguson (2012) argue that social learning analytics is to move away from summative data-centeredness dominant in the exiting learning analytics practices. As an example, SocialLearn (http://sociallearn.open.ac.uk/public) developed by the Open University UK is a social media space for anyone who wants to connect, share and learn. This service offers processed data and output such as a mood graph of students, by visualizing results from a most recent self-report questionnaire about learners' disposition with recommendation techniques (Ferguson & Shum, 2012).

While learning analytics has received increasing attention for its application in education, potential problems exist. First, the use of personal data inevitably leads to significant security and privacy implications, especially when personal information is saved in data storage systems where anyone can access online. Currently, there are no established guidelines about data ownership and ethical use of data in learning analytics. Second, in the case of social learning analytics, data from social network services tend to be enormously huge, which makes data mining technically challenging for recommendation and evaluation meaningful to learners. Last but not least, there is a critical need to develop meaningful indicators or metrics that are easy for learners to understand and utilize. Still, several learning analytics techniques and platforms are using administration-focused data, producing little useful information from learners' perspectives (U.S. Department of Education, 2012). Thus far, learning analytics practices have been dominantly applied to students and instructors in higher education contexts. The nature of data and needs in K-12 contexts would be qualitatively different from those in higher education, implying a need for specific learning analytics techniques and applications relevant to K-12 learners.

3D Printing

The ecology of software development has changed significantly with the open-source movement, aiming to move away from a closed development cycle to collaborative community-based development practices. The similar paradigm shift is also observed in the field of manufacturing technologies. In 2012, the *Economis*t published a special report about manufacturing and innovation, and claimed that we are entering an era of the *third industrial revolution* as manufacturing increasingly goes digital, "moving away from mass manufacturing and toward much more individualized production" (Markillie, p.2). Tapping on the power of collaborative production and community expertise, Open-Source Hardware (OSHW) is defined as "a term for tangible artifacts – machines, devices, or other physical things – whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things" (Hansen & Howard, 2013, p.979). 3D printing is one of the hardware technologies leading such open-source hardware movement.

Mechanically, 3D printing works by fabricating a physical cubic object based on a three-dimensional digital model designed by computer-aided design (CAD) programs and 3D scanners. The basic principle of fabrication is that layers are printed from bottom like slices and accumulate multiple layers up to an object, enabling printers to produce any complex objects and models. Initially, the earlier version of 3D printer was enormously huge and expensive, thus making mass-commercialization nearly impossible. Furthermore, its use was limited to experts with high-level skills and knowledge about how to manipulate complex applications associated with 3D printing. With the advances of printing technologies, 3D printers have become much more affordable and smaller. For instance, in 2009, MakerBot, a 3D desktop printer producing company, released a 3D printer model under $2,500. Further, there has been an emergence of online free applications like Thingiverse, Autodesk, and PTC that offer digital design modules readily usable in 3D printers (Johnson et al., 2013). Users can download design files from these repository websites and customize printing properties using a simple software application.

While originated in the field of hardware manufacturing, recently 3D printing has been utilized in diverse fields such as architecture, business, medical fields, and industrial design and art (Dimitrov, Schreve, & Beer, 2006; Walter & Davies, 2010). Its relevance for teaching and learning has also received much attention. Here, we mainly discuss three pedagogical potentials of using 3D printing in educational contexts, namely: a) customizable teaching and learning materials, b) rapid prototyping for creative inquiry, and c) collaborative design thinking.

First, 3D printing can be utilized to create customizable teaching and learning materials, especially in subject areas where students tend to have difficulties in conceptual understanding. Teachers constantly face the challenge of meeting diverse needs of students with different abilities and interests. Printed educational materials and manipulatives commercially available in the market are extremely difficult to modify and customize to meet individual students' needs and interests. With the use of 3D printing, teachers can easily design and produce teaching and learning materials that are not readily available or difficult to create with existing resources. 3D printing technology can fabricate complex objects and structures that students tend to feel difficult visualizing such as proteins in chemistry, historical artifacts, and medical anatomy. For instance, 3D printing was used to create tangible representations of Kanji (Chinese characters in Japanese writing) characters (Kanev, Oido, Yoshioka, & Mirenkov, 2012). In this case, novice learners who tend to have difficulty understanding the complex fundamentals of Kanji construction learnt Kanji by assembling possible combinations and associating them with 3D physical models with the sense of touch and feel. Another example illustrates the use of 3D printing in medical education for rapid prototyping of complex teaching materials not readily available. Torres et al. (2011) discuss the feasibility of 3D printing for rapidly producing complex anatomical models such as vascular structures and skull elements, and using them for detailed visualization and procedural training.

Second, with the use of 3D printing, students can engage in rapid prototyping of creative ideas into tangible objects, experiencing the whole process in design from ideation to production. Gonzalez-Gomez et al. (2012) developed an open-source 3D printable robot platform for education called Miniskybot. In this platform, students can create a simple robot within three hours and under 57 Euros. Using this platform and 3D printer, students can turn their design ideas easily into tangible pieces and test technical functionalities of designed robots within a short time frame.

Lastly, leveraging the power of open-source hardware environments in 3D printing, students can engage in collaborative design thinking to initiate, plan, and produce certain design and objects as a group or community. The emergence of the digital Do-It-Yourself (DIY) and the Maker community culture has led to the diversification of product design and dissemination. Now, people can design, assemble, or repair objects without much help from experts and specialized tools, closing the line between producers and consumers. The digital DIY trend to some extent has been accelerated in accordance with the emergence of diverse platforms and services that help people to easily share, communicate, create, and mix design ideas. Likewise, students around the world can collaborate to design objects of their common interest using design ideas available in online repositories such as Thingiverse (http://www.thingiverse.com/)

and mobile 3D model creation services such as Autodesk 123D Catch (http://www.123dapp.com/catch), and turn them into tangible objects through a 3D printer.

While 3D printing holds several implications useful in teaching and learning, educators who intend to utilize 3D printing need to be aware of some challenges associated with this technology. With the advances of printing technologies, it would be possible to fabricate objects close to reality. Thus, it is important for educators to help students be fully aware of ethical, responsible, and safe usage of 3D printing not to print dangerous, hazardous, and immoral objects. Lack of useful educational applications utilizing the affordances of 3D printing is another issue that may slow down the widespread adoption of 3D printing in schools.

CONCLUSION

In this paper, we use the term “learning technology” to reflect the increasing criticality of human learning activities beyond the boundary of traditional schooling. With the rapid advances of communication technologies and social media, now learning can happen outside of formal learning contexts, crossing different physical locations and time scales. The field of learning technology has constantly experienced some tension between technology and pedagogy. When considering how the field of learning technology may progress to shape the design of future learning environments, it is important to understand, explore, and experiment potentials of various emerging technologies. This is not to say that our thinking about future learning should be technology-driven, with a hope that new technology will revolutionize teaching and learning. Rather, we agree with the perspective put forth by Kozma (2000), “If we choose to continue to ignore media considerations in our thinking, if we continue to treat them as mere delivery devices, both our thinking and our field will be impoverished” (p.14).

The main purpose of this paper, therefore, is to provoke our thinking about the fundamental role of technologies toward designing future learning environments. Despite the great enthusiasm toward the potential of emerging technologies, there is a great disparity between the rhetoric and the reality of learning technology practices (Selwyn, 2010). Designing a learning environment with technology inherently carries a plethora of complex practical issues. More research is necessary to examine potential applications and substantial practical issues introduced in this paper in order to close the gap between the rhetoric and the reality of learning technology in the future.

ACKNOWLEDGMENT

This research was supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the “IT Consilience Creative Program” (NIPA-2014-H0201-14-1001) supervised by the NIPA (National IT Industry Promotion Agency).

REFERENCES

Dimitrov, D., Schreve, K., & De Beer, N. (2006). Advances in three dimensional printing-state of the art and future perspectives. *Journal for New Generation Sciences, 4*(1), 21-49.

Duval, E. (2011, February). Attention please!: Learning analytics for visualization and recommendation. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge* (pp. 9-17). ACM.

Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning*, *4*(5), 304-317.

Ferguson, R., & Shum, S. B. (2012, April). *Social learning analytics: Five approaches. In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge* (pp. 23-33). ACM.

Gartner, Inc. (2010-2014). Gartner Identifies the Top 10 Strategic Technology Trends.

Gonzalez -Gomez, J., Valero-Gomez, A., Prieto-Moreno, A., & Abderrahim, M. (2012). A new open source 3D-printable mobile robotic platform for education. In *Advances in autonomous mini robots* (pp. 49-62). Berlin Heidelberg: Springer.

Hansen, A., & Howard, T. J. (2013). The current state of open source hardware: The deed for an open source development platform. In *ICoRD'13* (pp. 977-988). India: Springer.

Johnson, L., Adams Becker, S., Cummins, M., Estrada V., Freeman, A., & Ludgate, H. (2013). *NMC Horizon Report: K-12 Edition*. Austin, Texas: The New Media Consortium.

Kanev, K., Oido, I., Yoshioka, R., & Mirenkov, N. (2012). Employment of 3D printing for enhanced kanji learning. *In Proceedings of the 2012 Joint International Conference on Human-Centered Computer Environments* (pp. 165-170). ACM.

Kozma, R. (2000). Reflections on the state of educational technology research and development. *Educational Technology Research & Development*, *48*(1), 5-15.

Lockyer, L., & Dawson, S. (2011, February). Learning designs and learning analytics. In *Proceedings of the 1st international conference on learning analytics and knowledge* (pp. 153-156). ACM.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011). *Big data: The next frontier for innovation, competition, and productivity*. McKinsey Global Institute. Retrieved from http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation

Mattern, F., & Floerkemeier, C. (2010). From the Internet of Computers to the Internet of Things. In *From active data management to event-based systems and more* (pp. 242-259). Berlin Heidelberg: Springer.

Schratzenstaller, A. (2010). The classroom of the past. In K. Mäkitalo-Siegl, J. Zottmann, F. Kaplan, & F. Fischer (Eds.), *Classroom of the future: Orchestrating collaborative spaces* (pp. 15-39). Rotterdam, the Netherlands: Sense Publishers.

Selwyn, N. (2010). Looking beyond learning: Notes towards the critical study of educational technology. *Journal of Computer Assisted Learning*, *26*(1), 65-73.

Shum, S. B., & Ferguson, R. (2012). Social learning analytics. *Journal of Educational Technology & Society*,*15*(3), 3-26.

Siemens, G. (2010). What are learning analytics. *Retrieved on April*, 10, 2014 from http://www.elearnspace.org/blog/2010/08/25/what-are-learning-analytics/

Markillie , P. (2012, April). A third industrial revolution: Special report Manufacturing and innovation, *The Economist*. Retrieved from http://www.economist.com/node/21552901

Torres, K., Staśkiewicz, G., Śnieżyński, M., Drop, A., & Maciejewski, R. (2011). Application of rapid prototyping techniques for modelling of anatomical structures in medical training and education. *Folia Morphologica*, *70*(1), 1-4.

U.S. Department of Education, Office of Educational Technology (2012). *Enhancing teaching and learning through educational data mining and learning analytics: An issue brief*. Washington, D.C.: U.S. Department of Education, Office of Educational Technology.

Walters, P., & Davies, K. (2010). 3D printing for artists: research and creative practice. *Rapport: Journal of the Norwegian Print Association*, *1*, 12-15.