A MAJOR E-LEARNING PROJECT TO RENOVATE SCIENCE LEANING ENVIRONMENT IN TAIWAN

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ABSTRACT
This article summarizes a major e-Learning project recently funded by the National Science Council of Taiwan and envisions some of the future research directions in this area. This project intends to initiate the 'Center for excellence in e-Learning Sciences (CeeLS): i^4 future learning environment' at the National Taiwan Normal University. In collaboration with multiple leading institutes and universities involved in the areas of science education, computer science and computer engineering from around the world, NTNU proposes to develop an innovative science learning environment which **integrates** various modern technologies such as image processing, speech processing, automatic video processing, speech recognition, mobile technologies, machine translation, natural language processing, data mining and machine learning. Our aim is to create an **intelligent** classroom embedded with **individualized and interactive** learning materials and assessment tools. To realize the aforementioned goals, the CeeLS endeavors to bring together a group of experts in the area of science education, cognitive science, computer science, and computer engineering. We will propose three closely interrelated research directions conducted by three major projects: (1) Project Classroom 2.0, to establish this envisioned future classroom; (2) Project Mobile 2.0, to enhance the interactions among teacher, students, and student peers, and (3) Project Testing 2.0, to pioneer new technologies on assessment and to assist the CeeLS to carry out program evaluations for the project. Four major changes (in both cognitive and affective domains including students' domain knowledge, higher-order thinking ability and attitudes and motivation in the subject matters) will be investigated and evaluated under the innovative learning environment. The investigations will include: (1) Teachers' Teaching Approaches (TTA), (2) Students' Learning Strategies (SLS), (3) Student-Teacher Interactions (STI), and (4) Student Science Learning Outcomes (SLO).

BACKGROUND

Science teaching is conducted primarily in three types of learning environments: classroom, laboratory; and outdoors (Orion *et al.*, 1997). The importance of Science Classroom Learning Environment (SCLE) has been recognized by many researchers and teachers during the past two decades. The teaching standard proposed by the recent science education standards in the USA also describes that:

> As part of challenging students to take responsibility for their learning, teachers involve students in the design and management of the learning environment. (National Research Council, 1996)
> The specific criteria for a science learning environment will depend on many factors such as the needs of the students and the characteristics of the science program. (National Research Council, 1996)

Educational research has usually compared or contrasted two different types of instructional methods or learning environments: one being traditional, and the other referred to as the new, modern, or reform (Chang, 2001, 2002, 2003; Chang, Hsiao, & Barufaldi, 2006; Chang & Mao, 1999). The modern SCLE is mainly categorized as the constructivist learning environment. It adopts the constructive pedagogy and is 'constructive oriented,' 'interdisciplinary oriented', or 'student centered'. Students in the constructive setting are encouraged to be actively engaged throughout the learning process with a high degree of self-regulation. Teachers in this environment adopt internal control over the learning process of the classroom. On the other hand, the traditional SCLE is frequently labeled as the objectivism/expository learning environment, which emphasizes the objective pedagogy and is ‘reproduction oriented’, ‘subject matter oriented’, or ‘teacher centered’. Students in this setting learn in a reproductive/surface approach where memorization of facts is stressed. Teachers in this setting adopt external control over the learning process of the classroom. The stereotypical, traditional image is so prevalent among many science teachers and educators that many people consider teacher-centered learning (or reproductive learning) and student-centered learning (or constructive learning) as two contrasting poles of one dimension (Wierstra *et al.*, 2003). Nevertheless, some previously conducted studies revealed that constructive learning and reproductive learning were not always negatively correlated and sometimes resulted in a positive correlation (Slaats *et al.*, 1999; Vermetten *et al.*, 1999).

Kinchin (2004) pointed out that the tension created between objectivism (the objective teacher-centered pedagogy) and constructivism (the constructive and student-centered pedagogy) represents a real classroom issue that influences teaching and learning. The recent TIMSS (Third International Mathematics and Science Study) 2003 International Science Report (Martin *et al.*, 2004) specifically documented that internationally, the three most predominant activities accounting for 57 percent of class time were teacher lecture (24%), teacher-guided student practice (19%), and students working on problems on their own (14%) in science classes around the world. Therefore, it appears that the current science classroom learning environment is often a mixture of divergent pedagogies and diverse student orientations or preferences (Chang & Tsai, 2005; Chang, Hsiao, & Barufaldi, 2006).

The modern science learning environment is also filled with new technologies such as computers and the Internet. After reviewing meta-analyses and other studies of media's influence on learning, Clark (1983) concluded that there are no learning benefits to be gained from employing any specific medium to deliver instruction (Clark, 1983). He went on to argue that most media comparison research, which compared computer-assisted instruction with conventional instruction or other media, suffered from inherently flawed methodologies. He also made the claim that media is only the vehicle that delivers instruction but that it does not influence student achievement or learning (Clark, 1994). Hokanson and Hooper (2000) claimed that the expanded use of computers in education continues despite research having failed to accrue definite benefits in learners’ performance. They also argued that, ‘traditional achievement has not changed through the use of computers to apply or deliver the same instructional methods.’ (Hokanson & Hooper, 2000).

The mixed research results and perspectives on computer or Internet aided learning/learning environments perhaps stems from some unknown factors that might revolve around *the capabilities and designs of new technologies* and *students’ characteristics and their preferences of (online) learning environment* in the science classes. For example, Linn (2003) reviewed the past, present, and future of technology in science education and concluded that two overall trends in technological advance have been present over the past 25 years. First, designers have tailored general tools to specific disciplines by offering learners features specific to the topics or tasks to be learned. Second, new technologies usually support user customization, enabling individuals to personalize their modeling tools, Internet portals, or discussion boards (Linn, 2003). However, both the tailoring of applications and the customization of tools require a trade-off between supporting specialized learning activities and allowing tool generalizations.

In addition to the aforementioned debates/issues, the science learning environment (classroom, lab, and outdoor) seems to have remained relatively unchanged for the past few decades. De Corte (2000) writes: “Recent research on learning and instruction has substantially advanced our understanding of the processes of knowledge and skill acquisition. However, school practices have not been innovated and improved in ways that reflect this progress in the development of a theory of learning from instruction”. School practices in a realistic sense are majorly centered on school learning environment. It is generally recognized among practitioners that our school science learning environment has neither been innovated nor reformed to reflect the new knowledge of learning and teaching. Moreover, modern technologies, beyond just the use of computers and internet, in the school have not been fully integrated/incorporated in the current science learning environment (Chang & Wang, 2009). Therefore, this research project sets out to establish a Center for excellence in e-Learning Sciences (CeeLS) with the aim of realizing the common goal of modernizing school practices. We endeavor to renovate the science leaning environment through an integration of three major research directions:

(1) Classroom 2.0: creating an intelligent classroom environment with smart technologies (ex., automatic video processing and speech recognition) embedded into the process of teaching and learning. The technologies in this type of innovative classroom should be intelligent, interactive, individualized and integrated as the follows: (A) intelligent: the classroom technology should be highly context-aware and adaptively support tasks that originally require excessive human interventions; (b) interactive: the classroom technology should facilitate interactions between classroom instructor and the students; (c) individualized: the classroom technology should react differently in accordance to individual user; and (d) integrated: the classroom technologies should be integrated as one i4 system instead of many separate systems.

(2) Mobile 2.0: enhancing the interactions among teacher, students, and student peers through a common communication platform for ubiquitous interactions among different handheld devices. This study will involve research in autonomic computing of handheld devices, and the resulting lecturing environment will be self-configurable, self-healing, self-optimized, and self-protected. Research in adaptive rate control techniques for data transmission in the i^4 future learning environments, and agile transposing techniques for audio, video, and documents will also be conducted in the project. This study will also involve research into network security techniques that can automatically detect malicious attacks and adapt themselves to secure data transmissions in the i^4 future learning environments.

(3)Testing 2.0: pioneering new technologies (Wang, Chang & Li, 2008) such as machine learning, natural language processing, machine translation and user modeling to improve assessment tools in terms of content, formats, scoring and analysis methods. In particular, Testing 2.0 will investigate two lines of research. The first line of research aims to develop interactive and intelligent tools for supporting tasks of item authoring, response grading, grade reporting, and item banking in educational testing. Thorough behavioral and educational tasks, analysis will be conducted as the foundation for technological innovation. Another line of research will investigate machine translation technologies for localizing international tests into traditional Chinese items. Related assistive technologies, including text mining and retrieval for intelligent item access, duplication detection, item categorization, and item augmentation and expansion, will also be explored. Testing 2.0 will adopt the current Web standards and technologies, such as Web 2.0, XML, and AJAX, throughout the design and development of online assessment tools. Testing 2.0 will develop a state-of-the-art item banking system to achieve the research objectives.

An innovative modern learning environment, from our point of view, should incorporate all the aforementioned new technologies into its settings. Accordingly the following questions need to be addressed: 1) How will these new technologies be properly incorporated into science learning environment? 2) How will the newly developed learning environment change/affect the practice of school learning and teaching in terms of teachers' teaching approaches, student learning strategies, student-teacher interactions, and student science learning outcomes?

These research questions not only trigger our research interest in this area but also merit further in-depth investigations. Our research team will try to address the aforementioned issues via establishing the new center and conducting a three-year study/project.

PROJECT FRAMEWORK

The project framework is delineated in four major stages, DOIT (Development, cOllaborations, Implementations, and Test it), followed by Oh! (Outreach) as illustrated in Figure 1. The following three research teams will be involved in the project efforts throughout the 3-year period: (1) Classroom 2.0; (2) Mobile 2.0; and (3) Testing 2.0. Under the same umbrella of research framework, the aforementioned teams will not only work closely together on the same research agenda but also conduct their own research schemes.

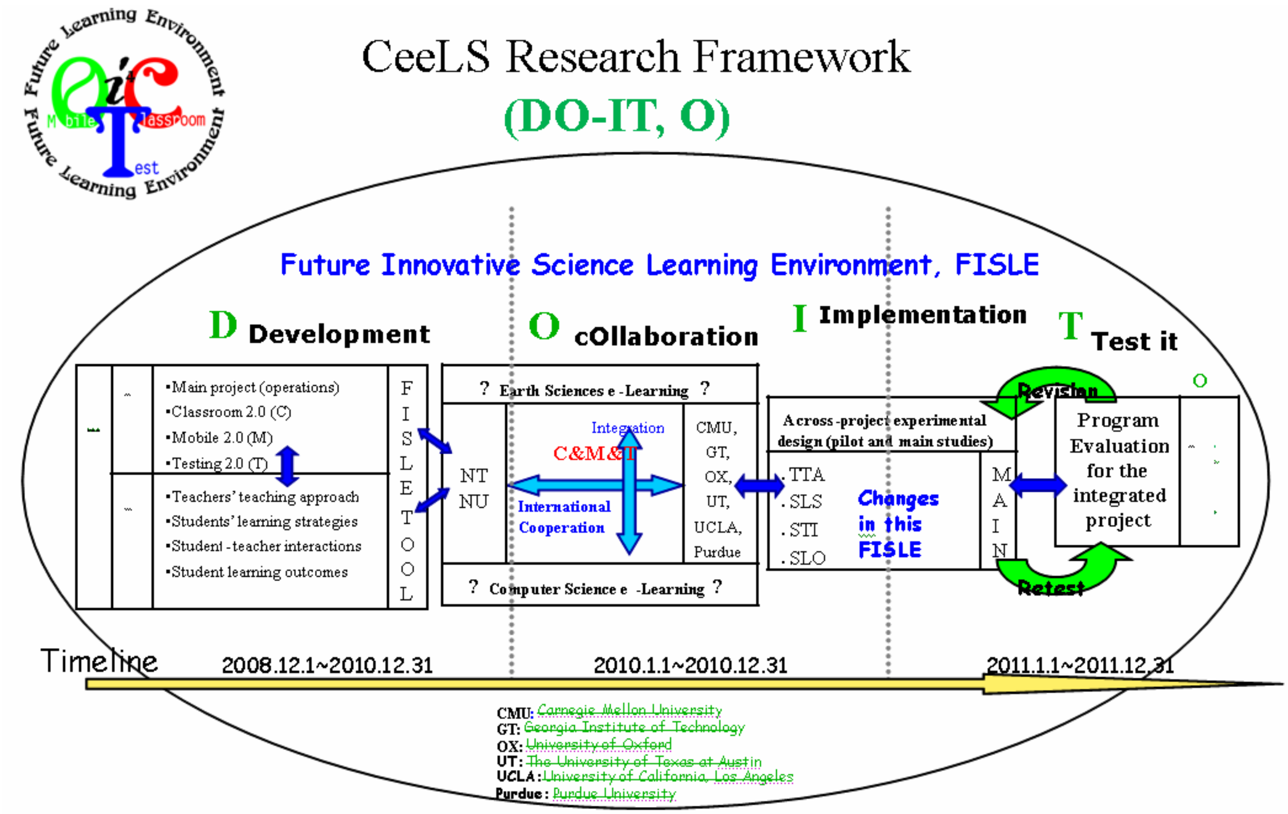
1. **D (Development stage):** The major goal of this stage will be the development of a future innovative science learning environment with various new embedded technologies. Innovative educational research tools such as machine-assisted processing of videos will be included in the future vision of the CeeLS. Several classes of students enrolled in earth sciences/computer science courses will be first test pilots of the new science learning environment; this will provide a base for further revisions, derived from the suggestions and comments of those participating students and professors. The final

version of the learning environment will be improved based on several subsequent pilot studies and is expected to be completed before the end of year 2009.

2. **O (cOllaborations stage):** This stage represents the major collaboration between NTNU and other prestigious institutes around the world in designing new materials and exchanging ideas. The proposed CeeLS has received letters of collaboration from leading universities such as Carnegie Mellon University, Georgia Institute of Technology, the University of Oxford, The University of Texas at Austin, Purdue University and University of California at Los Angeles. It is noteworthy that the collaborations among these institutes will not only be limited to the 'O' stage but rather extending to the outer circle (the big black circle encompassing the entire DO-IT, O! framework), ensuring the on-going collaborations throughout the project periods and collaborated efforts between NTNU and other institutes.
3. **I (Implementations stage):** The objectives of this stage will be the development of assessment tools (starting from the first year) to tap TTA, SLS, STI, and SLO as explained below. The science courses will also be piloted and field tested during this period. Four major changes (components) will be investigated through the development and administering of respective instruments to answer our research questions:
   A. TTA: Teachers' Teaching Approaches
   B. SLS: Students' Learning Strategies
   C. STI: Student-Teacher Interactions
   D. SLO: Student Learning Outcomes

4. **T (Test it stage):** This is the main program evaluation stage which incorporates an experimental design involving different groups. The results of the main evaluation studies will not only serve as a framework for the future design of an innovative learning environment for the university course but it will also enable teachers to customize their own instruction styles into their future classes or courses. The innovative science learning environment is also envisioned to be applied to the senior high schools. It is noted that the 'implementations and test it' stages, as illustrated in Figure 1, are actually cyclical stages that allow for re-entry into those stages for revision and re-evaluation purposes (as well as to further improve and corroborate the feasibility of the DO-IT framework). Therefore, the results of the study will not only serve as a viable alternative for teaching university students but could also be the base for development of a future science learning environment for both university and senior high school classes.

5. **O (Outreach programs):** The results of the project efforts will have new development and instructional implications regarding the use of new technologies and the implementation of future science learning environments within university courses and senior high schools worldwide.



The anticipated results of this project

1. Publishing high-quality papers in internationally prestigious journals, indexed in SSCI (Social Science Citation Index), with high impact factors and high citations.
2. Forming an excellent research center in good collaboration with several leading research institutes.
3. Exerting positive influences on the international academic society at large.
4. Hosting international conferences of e-Learning in Taiwan.
5. The practical and effective development of new science learning environment should not only be limited to being published in high-impact journals, but also enable us to receive patents in Taiwan and Mainland (where patents are gaining in economic value compared to that of other countries).
6. Serving as a framework for the future design of innovative science learning environments.
7. Outreaching and applying to courses such as those proposed in senior high schools, general education and teacher's education.

CONCLUSION

The 'Center for excellence in e-Learning Sciences (CeeLS): i^4 future learning environment' at the National Taiwan Normal University proposes to develop an innovative science learning environment which **integrates** various modern technologies within an **intelligent** classroom embedded with **individualized and interactive** learning materials and assessment tools. Three major projects, Classroom 2.0, Mobile 2.0, and Testing 2.0, to pioneer new technologies on assessment with four major changes will be investigated and evaluated under the innovative learning environment. We endeavor not only to renovate the science leaning environment but classroom learning as we know it. We are confident that the research framework and model proposed by this study will be applicable in university courses, senior high schools as well as in teacher's education courses worldwide.

REFERENCES

Chang, C. Y. (2001) A problem-solving based computer-assisted tutorial for the earth sciences. *Journal of Computer Assisted Learning,* 17, 263-274.

Chang, C. Y. (2002). The impact of different forms of multimedia CAI on students' science achievement. *Innovations in Education & Teaching International, 39*(4), 280-288.

Chang, C. Y. (2003). Teaching earth sciences: Should we implement teacher-directed or student-controlled CAI in the secondary classroom? *International Journal of Science Education, 25*(4), 427-438.

Chang, C. Y., Hsiao, C. H., & Barufaldi, J. P. (2006). Preferred-actual learning environment 'spaces' and earth science outcomes in Taiwan. *Science Education*, *90(3)*, 420-433.

Chang, C. Y., & Mao, S. L. (1999) Comparison of Taiwan science students' outcomes with inquiry-group versus traditional instruction. *The Journal of Educational Research,* 92*,* 340-346.

Chang, C. Y., & Tsai, C.-C. (2005). The interplay between different forms of CAI and students' preferences of learning environment in the secondary science class. *Science Education, 89,* 707-724.

Chang, C. Y., & Wang, H.-C. (2009). Issues of inquiry learning in digital learning environments. *British Journal of Educational Technology*. *40*, 169-173.

Clark, R. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*, 445-459.

Clark, R. (1994). Media will never influence learning. *Educational Technology Research and Development, 42*, 21-29.

De Corte, E. (2000). Marrying theory building and the improvement of school practice: A permanent challenge for instructional psychology. *Learning and Instruction, 10*, 249-266.

Hokanson, B., & Hooper, S. (2000). Computes as cognitive media: Examining the potential of computers in education. *Computers in Human Behavior, 16*, 537-552.

Kinchin, I. M. (2004). Investigating students' beliefs about their preferred role as learners. *Educational Research, 46 (3)*, 301-312.

Linn, M. C. (2003). Technology and science education: Starting points, research programs, and trends. *International Journal of Science Education, 25*(6), 727-758.

Martin, M. O., Mullis, I. V. S., Gonzalez, E. J., & Chrostowski, S. J. (2004). *TIMSS 2003 international science report*. Boston, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Orion, N., Hofstein, A., Tamir, P., & Giddings, G. J. (1997). Development and validation of an instrument for assessing the learning environment of outdoor science activities. *Science Education, 81*(2), 161-171.

van Driel, J. H., Bulte, A. M. W., & Verloop, N. (2005). The conceptions of chemistry teachers about teaching and learning in the context of a curriculum innovation. *International Journal of Science Education, 27*(3), 303-322.

Wang, H.-C., Chang, C. -Y., & Li, T. -Y. (2008). Assessing creative problem-solving with automated text grading. *Computers & Education, 51,* 1450–1466.

Wierstra, R. F. A., KANSELAAR, G., VAN DER LINDEN, J. L., LODEWIJKS, H. G. L. C., & VERMUNT, J. A. D. (2003). The impact of the university context on European students' learning approaches and learning environment preferences. *Higher Education, 45*, 503-523.