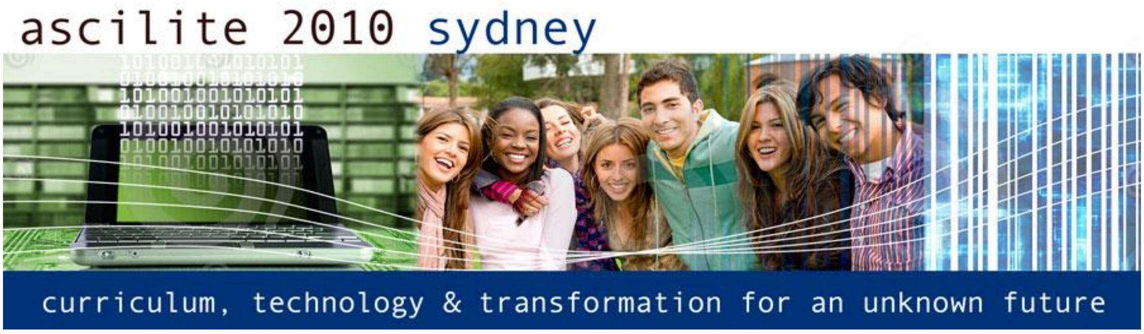

Designing an online problem representation engine with scaffoldings for effective teaching and learning (PRES-on)

Chwee Beng Lee, Keck Voon Ling & Si Thong Nguyen
Nanyang Technology University, Singapore

In this paper, we describe the web-based scaffolded dynamic simulation system (PRES-on) designed for pre-service teachers. PRES-on will act as a cognitive tool for learners to identify and articulate their thought processes in representing and solving problems using a set of building block icons (stocks, flows, converters, and connecters). It is a generic tool that is capable of supporting multidisciplinary learning which is highly important in today's context. PRES-on is designed to be used in an open learning environment that seeks to promote and cultivate divergent thinking and in situations where multiple perspectives are valued. The mathematical component of PRES-on will simulate the dynamic behaviour of the problem representation and capture complex patterns of such behaviours. In addition, as a web-based engine, learners can readily build and share their problem representation with their peers. Being one of the first initiatives to develop a web-based scaffolded dynamic simulation system for problem solving purpose, PRES-on will inform our understanding on how new technological development could enhance learning in environments that involve multidisciplinary problem solving. This project forms part of the continuing effort to bridge theory and practice as we aim to advance the pedagogical application of PRES-on through design experiment.

Key words: dynamic simulation, web-based, cognitive tool

Introduction

In recent years, Singapore's educational system has undergone many changes, from the notion of "thinking school, learning nation," to "teach less, learn more." The current system emphasizes the importance of nurturing young learners who can learn actively and independently, and providing opportunities for them to develop skills and knowledge that they will need as a citizen in the 21st century. In response to such changes, many local schools have started to incorporate inquiry-based learning, problem-based learning, and other forms of student-centred approaches and strategies. It is evident that problem-centred learning is one of the key approaches to engage learners and foster a higher level of cognition in education (Taconis, Ferguson-Hessler, & Brockkamp (2001). "Problem solving is among the most consistently complex and authentic forms of human cognitive activity (Jonassen, 2004, p.59)."

There is a growing interest in using problem solving strategies as a tool to improve students' conceptual understanding. Determining an appropriate problem space (Jonassen, 2003) is the most important process of solving an ill-structured problem because ill-structured problems have multiple representations of the problem. Ill-structured problems, encountered in everyday life and work, often possess conflicting goals, incomplete information, multiple solution methods, and multiple criteria for evaluating solutions, so there is uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized (Lee, Jonassen, Teo, 2009). During the problem solving process, experts usually propose fewer but more abstract solutions and spend more effort in developing arguments related to the solutions, whereas novices propose simpler solutions with few arguments. Constructing a mental model of problems is crucial to problem solving as such mental representation consists of the problem solver's procedural knowledge, structural knowledge, strategic knowledge (Jonassen, & Henning, 1999) and metacognitive knowledge. By integrating and structuring different types of knowledge, the problem solver is thus able to undergo a deeper understanding of the problem and later generate the most appropriate solution. Therefore, it is necessary to construct a problem representation (mental model) (Jonassen, 2004) of a problem space in order to evaluate the cause of the problem, develop solution paths, and provide justification for their problem solving decision.

We argue that if the key to problem solving is the way problem solver represents the problem space, problem solving activity must be supported by activities that seek to enable problem solvers to externalise their mental model in the most meaningful and engaging manner that will eventually lead them to the construction of a more sophisticated conceptual framework.

This paper describes our initial design of a web-based scaffolded dynamic simulation system (PRES-on) as a cognitive tool for learners to represent problems. For the widespread use of the PRES-on, we adopt the design experiment methodology to advance pre-service teachers' pedagogical applications of such engine for effective teaching and learning through the integration of PRES-on into the existing pre-service course. Specifically, our project aim to ultimately integrate PRES-on into pre-service teachers' curriculum and continuously improve on the design as well as the pedagogical approach.

PRES-on is a scaffolded dynamic simulation tool for learners to amplify their thinking by representing problems using a set of building block icons (stocks, flows, converters, and connecters). Such a tool will convey both covariational and mechanistic information (Jonassen, 2004), and it will be capable of supporting multidisciplinary learning. It is designed for an open learning environment, which is especially important in promoting divergent thinking and in situations where multiple perspectives are valued (Hannafin, Land, & Oliver, 1999). It promotes the discovery and manipulation of underlying beliefs because such a system has the affordances of putting the learners in a state of cognitive disequilibrium (Graesser, McNamara, & VanLehn, 2005), but at the same time scaffold their learning through different levels of question prompts to support users in reasoning (Graesser, Baggett, & Williams, 1996). The type of scaffolding provided in this study will be different levels of question prompts as questions are at the heart of virtually any complex task and such task could be in the form of questions.

Literature review

Problem representations

Expert problem solvers are able to flexibly coordinate qualitative and quantitative problem representations during problem solving (Ploetzner, Fehse, Kneser, & Spada, 1999). Studies have shown that when solving problems while novice problem solvers usually begin with manipulating equations, expert problem solvers typically seek to understand the mechanism that underlies the mathematical solution (Leonard, Dufresne, Mestre, 1996). Hence, it is necessary for learners to understand a problem from both the qualitative and quantitative perspectives in order to understand the underlying systems they are working in (Jonassen, Strobel, & Gottdenker, 2005). While quantitative analysis provides a rationale for thinking, qualitative analysis can help to support and provide justifications for qualitative analysis.

Our final design of PRES-on will include quantitative and quantitative components. PRES-on will allow users to form equations to represent the interconnections in their problem representations. Specifically, the mathematical component of PRES-on will simulate the dynamic behaviour of the problem representation over time, capturing the complex patterns of such behaviours. On the other hand, PRES-on will also allow problem solvers to represent their understanding qualitatively. They are able to input information such as the conditions under which relationships between variables can be applied, and the attributes of such variables (Ploetzner, Fehse, Kneser, & Spada, 1999). The scaffolding component is perhaps the most distinctive feature of PRES-on. Jonassen (2004) advocates the use of computer-based tools to scaffold the ability of learners to represent problems. In our proposed system, ultimately, there will be three possible levels of questions prompts embedded, providing timely scaffoldings while learners engage in the process of building or refining their problem representations. Procedural prompts are meant to direct students' attention to the procedures of building his/her problem representation while reflective prompts focuses on helping students to reflect upon their process of building problem representation, enabling students to engage in deeper level of thinking (Chen & Ge, 2006). Deep level, deep reasoning prompts such as "why do you think the output of your problem representation behaves in this manner?" enable the students to engage in explaining the causal mechanism (Graesser & McNamara, 2005; Graesser, Baggett, & Williams, 1996).

Web-based PRES-on

As a web-based tool, PRES-on allows problem solvers to store and share their problem representation more effectively and efficiently. The motivation behind PRES-on is to provide learners a powerful engine for problem solving. Currently the available commercial tools are not economical and invoke a steep learning curve (e.g. STELLA, PowerSim). Some are relatively economical (e.g. Model-It) but it is only suitable for elementary school children who are learning science. Most of these tools are non web-based (e.g. VenSim, NetLogo) or do not provide sufficient scaffold to guide learners in the process of building their problem representation. Although some tools such as Colab as an environment for synchronous collaborative inquiry does provide scaffolds, they are designed more for the learning of science (Bravo, van Joolingen, & de Jong, 2009). PRES-on as a generic engine for multidisciplinary learning will include common features of these tools and most importantly, it will include different levels of scaffold to guide learners.

Design of PRES-on

We began the design of PRES-on in the beginning of 2010 and we are currently moving into the second phase of the research project where we enhance the features of PRES-on. What we describe in this paper is the very initial design of PRES-on. PRES-on is built using a Scalable Vector Graphic (SVG) platform created by JavaScript as it works with other web technologies and provides seamless interactions with the webpage. Moreover, it is XML-based thus providing an easy way to store and retrieve data. This feature is important as PRES-on is meant for users to build their problem representation without the need to install any application and to save their files to the server which facilitates anytime, anywhere learning.

Our initial design of PRES-on allows users to create their own ID and password to access the system, build and run their problem representation and store it on the server (see figure 1 for the interface). We also provide step by step guidance on how to use PRES-on. Users can expect more interactions with the system with the improved version of PRES-on when the different levels of prompts are configured into the system. This will allow the system to play the role of an "intellectual partner", facilitating the user's problem solving process.

Figure 1: Interface login of PRES-on

Once the user logs into the system, they begin by creating a new working file. They can easily click and drag the "flow", "stock", "converter" and "connector" icons to build their problem representation (see figure 2). Like some system modelling tools such as STELLA, PRES-on allows users to build problem representation of any nature, be it on a social or natural phenomenon or even on a cognitive processes. Currently, PRES-on only allows user to build in mathematical functions to interrelate the variables. To scaffold users, the system is able to provide few basic procedural prompts such as: "have you checked the equation?", "do you know you can use converter to define/manipulate values?" Once they have completed building their problem representation, they can select the simulation output and run their graph (shown in figure 3).

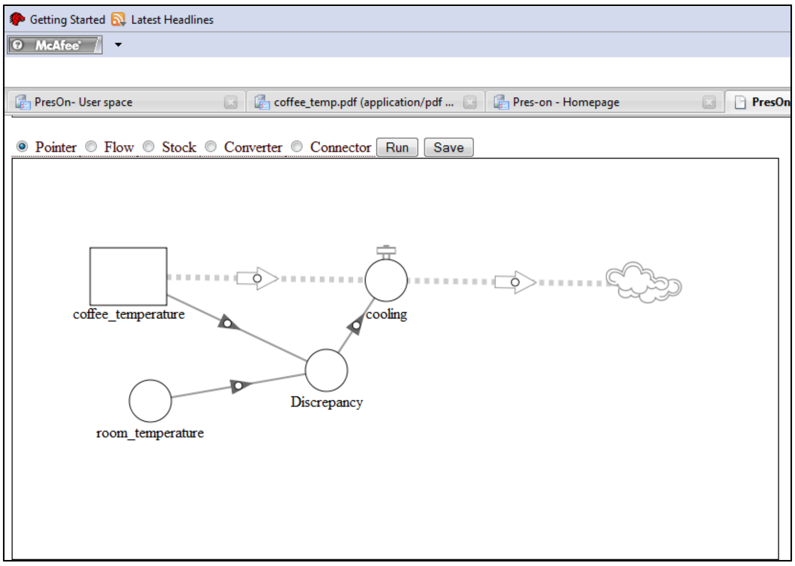

Figure 2: Building problem representation in PRES-on

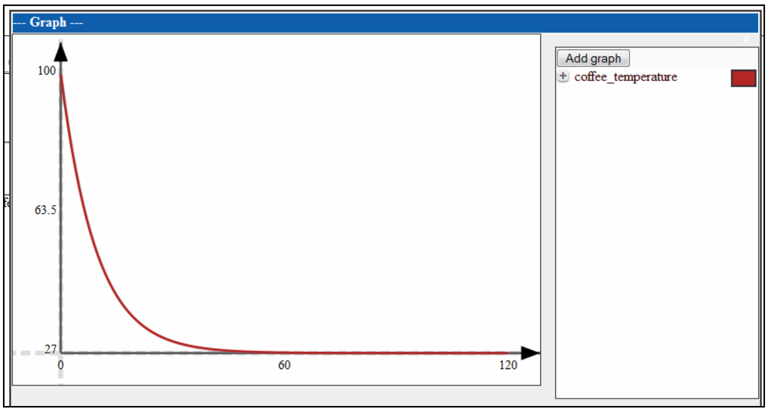

Figure 3: Running simulation graph in PRES-on

Conclusion

This paper describes the initial stage of our project. Ultimately, we will build in all the features stated in the literature review and integrate it into the pre-service teachers' curriculum where we seek to understand its pedagogical applications. Our current design only incorporates the quantitative component. We are in the process of embedding features that will allow users to build in qualitative representations and different levels of question prompts that will facilitate users' cognitive processes. Users will be able to key in their interpretations of the problem qualitatively. This is a necessary process as it helps users to engage in logical reasoning. The different levels of prompts will be incorporated and we anticipate that such prompts will appear intuitively when the system detects a need for it to appear, scaffolding users during their problem solving activity. Although the current PRES-on is in its infancy, we are confident that it will be able to be developed into a powerful problem representation, providing pre-service teachers an alternative to understanding content-based problems, classroom problems, and policy issues from a more systemic perspective. Moreover, unlike many other similar tools, as a web-based tool, it is capable of supporting anytime, anywhere learning.

References

Bravo, C., van Joolingen, W.R., & de Jong, T. (2009). Using Co-lab to build system dynamics models: Students' actions and on-line tutorial advice. *Computers & Education*.

Chen, C. H., & Ge. X. (2006). The design of a web-based cognitive modeling system to support ill-structured problem solving. *British Journal of Educational Technology*, 37 (2) 300-302.

Graesser, A.C., Baggett, W., & Williams, K. (1996). Question-driven explanatory reasoning. *Applied Cognitive Psychology*, 10, S17-S32.

Graesser, A, C. & McNamata, D. S. (2005). Scaffolding deep comprehension strategies through Point&Query, AutoTutor, and iStart. *Educational Psychologist, 40*(4), 225-234.

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* (pp. 115-140). Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, H.D., & Henning, P. (1999). Mental models: Knowledge in the head and knowledge in the world. *Educational Technology*, 39, 37-42.

Jonassen, D.H. (2003). Using cognitive tools to represent problems. *Journal of Research on Technology in Education*, 356-38.

Jonassen, D. H. (2004). *Learning to solve problems: an instructional design guide.* Preiffer.

Jonassen, D.H., Strobel, J., & Gottdenker, J. (2005). Model building for conceptual change. *Interactive Learning Environments, 13* (1-2), 15-37.

Lee, C.B., Jonassen, D. H., & Teo, T. (2009). The role of model building in problem solving and conceptual change. *Interactive Learning Environments.* ***DOI:*** *10.1080/10494820902850158*

Leonard, W. J., Dufresne, R. J., & Mestre, J. P. (1996). Using qualitative problem-solving strategies to highlight the role of conceptual knowledge in solving problems. *American Journal of Physics*, 64,1495-1503.

Ploetzner, R., Fehse, E., Kneser, C., & Spada, H. (1999). Learning to relate qualitative and quantitative problem representations in a model-based setting for collaborative problem solving. *The Journal of the Learning Sciences,* 8, 177-214.

Taconis, R., Ferguson-Hessler, M. G. M., & Broekkamp, H. (2001). Teaching science problem solving: An overview of experimental work. *Journal of Research in Science Teaching*, 38, 442-468.

Author contact details:
Chwee Beng Lee, chweebeng.lee@nie.edu.sg;
Keck Voon Ling, EKVLING@ntu.edu.sg;
Si Thong Nguyen**,** NGUY0052@ntu.edu.sg
Nanyang Technology University, Singapore

Please cite as: Lee, C. B., Ling, K. V., Nguyen, S. T. (2010). Designing an online problem representation engine with scaffoldings for effective teaching and learning (PRES-on). In C.H. Steel, M.J. Keppell, P. Gerbic & S. Housego (Eds.), *Curriculum, technology & transformation for an unknown future. Proceedings ascilite Sydney 2010* (pp.190-194).
http://ascilite.org.au/conferences/sydney10/procs/Chwee_Beng_Lee-concise.pdf