Reviving Dewey's "Reflective Thinking" Framework for the Design of Problems in Virtual Learning Environment-based Assessments of Content and Inquiry

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Abstract: This poster presentation revives Dewey's "reflective thinking" framework to inform the design of problems for virtual environment-based assessments of content and inquiry. After describing "reflective thinking" and illuminating a conceptualization of what is a problem, we show how we are using the "reflective thinking" framework to inform the design of problems in our SAVE Science virtual environment assessment modules.

Virtual Learning Environments (VLEs)

Since digital media are increasingly becoming a part of students' lives in and out of school, VLEs and supporting technologies can be woven into the fabric of their everyday school science experiences to prompt reflective thinking. It has been shown that contemporary education using virtual methods of inquiry can play a significant role in substituting for physical experimentation in K-12, because they obviate the need for expensive equipment and minimize the impact of deficient training for teachers on how to implement inquiry (Ketelhut and Nelson, in press; Nelson & Ketelhut, 2007). Furthermore, it has also been shown that virtual environments have the advantage of giving students time to 'reflect' on their course of action (Schank & Cleary, 1995). But, what are the design heuristics necessary for prompting reflective thinking? In this paper, we propose a framework for designing problem-based VLEs to promote reflection based on Dewey's Reflective Thinking Framework (1910). We discuss how this framework was used to design modular assessments in an NSF-funded project, called Situated Assessment in Virtual Environment for Science Content and Inquiry (SAVE Science).

Reflective Thinking

"Reflective thinking," according to Dewey (1910), is "[a]ctive, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends" (p. 6). Reflective thinking is part of the critical thinking process of analyzing and making judgments about what has occurred or what problem has been posed. Reflective thinking ranges from simple acceptance of a judgment to deep inquiry into posed problems.

Dewey developed and articulated the four steps required for reflective thinking, or problem solving. The four steps are: 1) identify or define the problem; 2) suggest solution; 3) collect evidence; and 4) conclude. Although the steps are enumerated, reflective thinking (problem solving) does not necessarily occur in that order or in a linear fashion. One does not have to complete the first step in order to proceed to the second. The formal steps involved in reflective thinking are less important than a sequence that results in the solution to the specific problem. Furthermore, during reflective thinking the problem solver goes back and forth through general stages before settling on a solution.

Reflective Thinking Problem Design

Problems that arise from experiences can be arrayed on a continuum with simple problems (easy task) to complex problems (hard task) as extremities. Simple problems are those that typically appear in classroom science and mathematics and can be solved easily. The simplest of all problems would be solved progressing through each of Dewey's four reflective thinking stages only once before a conclusion is made. However, problems in life are never this easy. Complex problems can be difficult social problems, like hunger and poverty, and are hard to solve. As problems become increasingly more complex, the problem solving pathway through the reflective thinking stages can occur multiple times before a conclusion is drawn.

According to Dewey (1910), experiences are imbued with rich sources of problems. He believed that a problem causes a "state of perplexity, hesitation, [or] doubt" (p. 9) creates a tension mental unrest (disequilibrium) and suspense. This imbalance was a precondition for inquiry and reflective thinking. Indeed, the perception of a disturbance "would lead to an act of search or investigation directed toward bringing to light further facts which serve to corroborate or to nullify the suggested belief" (p. 9). Dewey assumed that this tension was often vague and not clearly focused. In fact, his first state of reflective thinking was a search performed within the environment for information that would clarify the problem.

What are the characteristics of a good problem that creates this mental unrest? Drawing on Dewey's notion of genuine problems (1910), Polanyi (1957) suggests that good problems should: 1) hint that there is a

known but hidden solution; 2) result in the amount of effort matching the reward of finding that solution; and 3) have clues that hint at or are part of the solution. Dewey (1910) further recommended that the problem should be based in a story, and should have interest for the solver. Foreshadowing Csikszentmihalyi's concept of flow years later (1990), Polanyi (1957) cautions that the "logical gap" (the difference between what is known and what is needed to be known to solve the problem) is a major factor to be considered in designing the problem.

Applying Reflecting Thinking Problem Design to SAVE Science

The SAVE Science project is designing and implementing a series of virtual environment-based assessment adventures (or quests) used for assessing both science content and inquiry in middle grades. To do this, we are creating assessment quests for students to solve using knowledge they have gained in their middle school science classroom. We are using the above framework to guide our design of our assessment quests. "Sheep trouble" is the first quest that we designed to assess student understanding of concepts of adaptation and structure/function. First, to create a problem with a knowable but hidden solution, we have students greeted by a medieval farmer who asks them to help him find a scientific solution for why his new sheep are dying. His brother and many of the townsfolk think that there is no findable solution, but he is convinced that there is and that the student-scientist can help him find it. Second, we are supporting student effort as they progress through the problem by foregrounding relevant elements and events in the virtual environment. We are doing this by highlighting computer agents and other interactive items. Third, students are provided clues to the solution through posters, computer agents, and the design of the actual world. For example, a poster shows that the new sheep come from a very different locale (flat, snowy island) from the current farm (hilly, rocky, and dry). By exploring, students also discover that to find the best grass to eat, the sheep need to climb the hill. Finally, the problem is firmly based in a narrative that includes helping the farmer save his sheep from the town executioner who is under orders to destroy them unless proof that they are not 'bad magic' is found.

SAVE Science Pilot

A pilot was conducted in May 2009 in a mid-Atlantic school. Twenty students participated in the sheep trouble module. While this was primarily a usability implementation, we were also evaluating our problem design framework. Using students' own words (see table 1), we discovered that our problem narrative was interesting. All students felt that the solution was discoverable as witnessed by their engagement with the project. Students used the provided clues to solve the problem and when questioned, pointed to those clues in their rationale. Finally, students indicated that our 'logical gap' might have been too small as many students asked for more complexity or difficulty in future modules.

Table 1. Example student comments on the four aspects of our design framework (n=20).

Solution availability	Effort-benefit ratio	Clues to problem	Narrative interest
it was fun with the evidence that you had to find on the two kinds of sheep	It was really fun because you got to go around and explore why the new sheep were sick	I liked how you could interact with the different people	its really fun
the game was very intriguing. It was a brain puzzle but still lots of fun	it was sort of a challenge.	Give a second hint about what the problem is	its real enough looking that I can really get into it.
I think this a great way for students to test their skills	I think the barriers of the game was too small.	I need more stuff to interact with	But the story will get old and it would probably be better if there were different challenges
You get to figure out what's wrong	It was fairly easy	(need) more clues or hints	It seemed like a real-life question
the most interesting part was trying to find out what was wrong with sheep.	Make a bit harder and longer		It was fun and realistic. It didn't feel like we were just taking a test on a blank screen.

References

Csikszentmihalyi, M. (1990). *Flow: The psychology of optical experience*. New York: Harper Perennial.

Dewey, J. (1910). *How we think.* Boston: Heath.

Ketelhut, D.J., and Nelson, B. (in press). Designing for real-world scientific inquiry in virtual environments. *Educational Research*.

Nelson, B., and Ketelhut, D. J. (2007). Scientific inquiry in multi-user virtual environments. *Educational Psychology Review 19*(3), p. 265-283.

Polanyi, M. (1957). Problem solving. *British Journal for the Philosophy of Science, 8*(30), 89-103.

Schank, R. and Cleary, C. (1995). *Engines for education.* Hove, UK: Lawrence Erlbaum Associates.