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Technology and a Course for Those Thinking About Teaching: A Response to Henriques

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"Preparing Tomorrow's Science Teachers to Use Technology: An Example From the Field" by Laura Henriques (2002) makes a valuable contribution to the field of science education by providing examples that operationalize guidelines published in this journal on appropriate uses of technology in science teacher education ("Guidelines"; Flick & Bell, 2000).

The significance of this report lies in the presentation of examples within the context of a single course, Introduction to Teaching Science. The structure of a course, with stated purposes and an identified student population, allows readers to more easily evaluate technological applications. An example of technology use may seem appropriate in an isolated context as written in the Guidelines, but when applied in the context of a course, its value is more easily assessed. For instance, in the science education Guidelines, Flick and Bell (2000) proposed that the use of ArcView is appropriate, because the cited examples take effective advantage of the technological innovations to teach important science concepts. However, when used in the context of an introductory course, such as the one Henriques reported, learning ArcView consumes a significant amount of time in the course and, therefore, its use may not look as appropriate.

The context Henriques described is a three-unit course designed to introduce "students to the profession of teaching in the state of California with particular attention to science teaching." The course operates in two venues. Students complete 45 hours (4 hours/week) as a classroom aide for two or more secondary or middle level teachers. The second venue is the university, where students attend three hours of "lecture" as described in the syllabus. The class touches on most of the elements of teaching, in general, and teaching in California schools, in particular. Students typically have a bachelor's degree in science and are interested in teaching high school science. The enrollment is limited to 30.

This review will examine selected applications Henriques has proposed in the context of the course, Introduction to Teaching Science. Examples of technology applications will be compared to course material and relevant national and state standards, as well as the Guidelines.

Within this context, Henriques examined her own biases toward the uses of computer technologies. In discussing her view that educational technologies do not offer obvious fixes for educational problems, she made an apt comparison between computer technologies and TV and videotape recorders. Video technologies are tools that provoked and continue to provoke the imagination of educators for ways to support learning. The basic technoloies have been around for decades, but Henriques pointed out that they were not a quick fix for educators. We may be only beginning to see the effective use of video as a learning tool as it is integrated with computer and networking technologies. When thinking about these same issues, Perkins (1985) posed a set of questions to test the efficacy of any innovation that purports to improve teaching and learning:

- Is the opportunity really there in terms of improved learning?
- Do learners recognize the opportunity?
- Are learners sufficiently motivated to take the opportunity?

The argument of some published work, especially with popular topics such as computer technologies, depends on the reader joining the writer in the assumption that the innovation is effective and that it is just a matter of explaining how to use it. Upon closer examination, however, determining whether there was really a new learning opportunity or a familiar approach dressed up in new materials is difficult. If a new learning opportunity existed, did the learner recognize its potential? This is an important point for any learning tool. Recognizing the value of a technological innovation for improving learning implies that learners are sufficiently aware of their own processes of learning to make the connection between their learning goals and the learning opportunity. The ability to recognize one's learning strategies and to engage those strategies is a metacognitive skill at which most students are not proficient (Wigfield, Eccles, & Pintrich, 1996). Hence the researcher or educator who purports to evaluate the potential value of an innovation for learning must consider how context and instruction support learner engagement with the innovation. According to the Guidelines, these are important factors when evaluating whether a computer application is appropriate.

GUIDELINE 1: TECHNOLOGY IN THE CONTEXT OF SCIENCE

The first group of examples presented by Henriques was the use of technology in the context of science. This is to be contrasted with using technology as its own context and, therefore, for its own sake. It is interesting to read Henriques's initial examples from "low budget" technology (i.e., overhead projector, VCR, and chalkboard). Clearly these are important and ubiquitous technologies that require thoughtful application. These examples also set up a contrast with presentation software. Henriques pointed out that "photographs, graphs, and images can be incorporated into the lecture in ways that cannot be done with chalkboards and overheads."

In addition to contrasting older and newer technologies, the examples should also contrast use in the context of science versus an application of technology for its own sake. Would Henriques argue, for example, that prospective student teachers gain more understanding of the value of VCR or overhead applications within a science context? If so, why? One position might be that a subject-matter framework creates images of lesson delivery in science for new teachers that include technological components. These could be overhead projectors or computer projection. However, this by itself does not argue for the presentation of technology in subject matter context. Technology could be presented out of context, with students making the connection to science instruction.

The argument can be extended from a cognitive perspective of a student who is thinking about studying science teaching. The three questions from Perkins to structure the analysis will be used. A context-free or generic presentation of technology places demands on student thinking and experience that is not required when technology is used in a science context. Most students who are thinking about teaching as a career have not had sufficient experience in classrooms or with curricula to associate a context-free technology experience with meaningful applications. Without such associations, the value of the technology to learning science is not likely to be recognized. Given that a demonstrated technology does, in fact, have potential instructional value, then the science context helps the prospective science teacher recognize the potential. When the presentation example has been carefully chosen, such as Henriques' soap and surface tension example, then the student is aided in making a generalization about the potential value of technology to teaching.

GUIDELINE 2: ADDRESSING WORTHWHILE CONTENT WITH APPROPRIATE PEDAGOGY

The second group of examples deals with technology that supports the presentation of worthwhile science with appropriate pedagogy. There are two parts to this guideline, and both of them pose challenges to student teachers. What is worthwhile science and what is appropriate pedagogy? Student teachers need to become sensitive to instruction and begin building a set of standards by which to judge teaching. The guideline was written to foster the development of standards in teaching science. However, the instructional context, students who are *thinking about* studying teaching, suggests a twist. What role can technology play in helping new student teachers appreciate worthwhile science and appropriate pedagogy? Students must first establish criteria by which to evaluate these two concepts before they can assess the role of technology. Henriques posed questions intended to promote students' critical thinking at the beginning of the section. "Is there a better way to teach this?" "Does the inclusion of technology increase active student involvement?"

The reader is left with no indication of how this course promotes meaningful answers to the questions. Henriques' discussion of the examples elaborates on what the technology can accomplish but does not deal with how Guideline 2 actually operates in these instances. For example, what criteria do new student teachers use to evaluate CD-ROMs as instructional supplements for worthwhile science content? How does the use of CD-ROMs or spreadsheets or a VCR facilitate student understanding of appropriate pedagogy? It would be useful to consider what elements of pedagogy are highlighted by a given technological application. Consider Henriques' example of growing virtual plants as presented on a CD. Does this help student teachers evaluate the potential for enhanced class discussion, as emphasized in the *National Science Education Standards*? Does it promote student teacher understanding of the significance of classroom discourse in supporting data interpretation? Future articles might relate how the principles in the Guidelines explicitly operate in a particular course context.

GUIDELINE 3: TAKING ADVANTAGE OF UNIQUE FEATURES OF TECHNOLOGY

The next section deals with applications that take advantage of unique features of technology. To understand which features technology offers to instruction that are distinct from what is typically possible in science instruction, student teachers must reflect on their knowledge of common classroom practice. Mobile probeware is easily recognizable as unique to student teachers. Data gathering outdoors in streams or forests is quite different from lab bench activities. Not so obviously distinct are the uses of video cameras on flexible stands for making classroom activities or demonstrations more meaningful and accessible. In their learning about this equipment, students need to examine the technology in detail to raise questions and critical comments about features they think should be there but are not.

GUIDELINE 4: MAKING SCIENTIFIC VIEWS MORE ACCESSIBLE

In Henriques' section dealing with the accessibility of scientific views, she used a different meaning than was presented in the Guidelines. Henriques equated the term *accessible* to *available* by stating that "scientific information is available to anyone with an Internet connection." She applied the same interpretation to accessibility of teaching resources, research in education, and sharing ideas with other professionals. This is a reasonable principle as it applies to appropriate uses of technology. However, within the Guidelines, this principle was subsumed under the previous guideline on utilizing unique features of technology. Access to a rapidly expanding environment of information is a unique feature of the Internet and other resources for today's computers.This feature of access is a powerful educational tool unparalleled by earlier technologies.

The access referred to in Guideline 4 relates to the use of technology for making concepts and principles of science more *conceptually* accessible than would be the case without the technological tools. The point was expressed in the following way, “Many scientifically accepted ideas are difficult for students to understand due to their complexity, abstract nature, and/or contrariness to common sense and experience.” Guideline 4 referred to the large body of literature on misconceptions and also related broad research findings to the challenge of making counterintuitive ideas understandable to K-12 students. So the meaning of accessible is more aligned with “understanding it,” whereas Henriques emphasized “finding it.” The two ideas are not incompatible. In fact, the far reach of the Internet allows students to gather background information on a single topic from several sources. This kind of locating-access can lead to better conceptual-access. It appears that students who are able to approach an idea by utilizing different representations are better able to develop an understanding of the idea (Dunbar, 2001).

Prospective student teachers in science may find that the technological capabilities for “finding it” can support “understand it” when applied to selected topics in science education. Henriques stated, “We want our teachers to leave the program knowing about and utilizing the research base to inform their practice.” To achieve this goal her students construct summaries from research made available on the web. These summaries are shared using presentation software. The assignment tends to focus more on the technicalities of Power Point presentation construction than on the content of the research summary itself (see the assignment, Science Education Topic Presentation). To develop the concept of modern technologies supporting access to understanding, the assignment could be modified to require small groups of students to develop a summary of a key issue in science education.

One example that relates closely with the concept of “science as inquiry,” a central principle of the *National Science Education Standards*, would be teaching critical thinking. Searching the ERIC-Digest database as suggested by Henriques brings up “Thinking in Outdoor Inquiry” (Knapp, 1992) with background on views of knowledge and discussion of thinking skills. Searching the National Association of Researchers in Science Teaching Research Matters to the Science Teacher (http://www.educ.sfu.ca/narstsite/research/research.htm) database will locate “Definition and Assessment of Higher Order Cognitive Skills” by Audrey Champagne (1990). These two documents provide background from different perspectives on higher order thinking. Research Matters presents the character of higher order thinking in terms of interpreting a puzzling phenomena of motion. Further it raises a question central to cognitive psychology and ultimately to science education: Are higher-order skills task or discipline specific or do they work on problems generally? Knapp presented the view that critical thinking skills may be general but should be taught in the context of specific content. Some additional searching on the web will bring up other information about the teaching of critical thinking. The Institute for Teaching and Learning at San Jose State University has developed an Interactive Tutorial for Critical Thinking (http://www.sjsu.edu/depts/itl/graphics/main.html) that provides more in-depth background on instructional approaches and content. Examining a concept from multiple perspectives is an important strategy for learning in depth. With instructional scaffolding, the technological capability of access in terms of "finding it" can be directed toward gaining access to concepts in terms of "understanding it."

GUIDELINE 5: THE RELATIONSHIP BETWEEN TECHNOLOGY AND SCIENCE

When interpreting the guideline about the relationship between technology and science, Henriques chose to extend the meaning to include "and science teaching." In a sense, one could argue that the entire set of five guidelines was aimed at relating technology to science teaching. Henriques asked students to critically evaluate applications of technologies to classroom instruction, for example CD-ROMs. This activity could be seen as a means to apply the previous four guidelines in an in-depth example. Students could ask, "Does this CD provide a true science context? If so, does it address worthwhile science and afford appropriate pedagogy? Does this application take advantage of the unique features of CD-ROMs, for example their speed, search capabilities, and potential for integrated sound, video or animation, and print? And finally, does this application make scientific views more accessible?"

The intent of Guideline 5 was to highlight the longstanding and significant relationship between science and technology. This guideline is the most discipline-specific of the set. The idea is to extrapolate the use of educational technologies toward a better understanding of how technologies and science interact. The CD-ROM example described in the previous paragraph could be used as an analogy to the way science and technology interact. Once students have examined what the CD-ROM does or does not do for teaching science, they could be asked to consider how this technology might influence a scientific (rather than a science education) context. If the CD allows students to search a large database of information, how has such a technological application influenced scientific work? What if the database were a thousand times larger and faster? What might become possible that was not possible before? What kinds of information could be made available to science that would have a significant impact on scientific progress?

THE COURSE CONTEXT

A final aspect of reviewing Henriques' application of the Guidelines is to examine the course context within which these examples were presented. As stated earlier, presenting applications within the context of a course is a strength of this paper. So it remains to examine how the course itself helps promote appropriate uses for technology in science teaching. When examining this aspect of the course, one must remain aware that the course serves several important purposes beyond relating technology to science teaching. Henriques stated in the course overview, "(The course) covers in an introductory fashion: the structure, organization, and culture of schools; curriculum, instruction, assessment, and classroom management primarily in secondary school settings; the history and current status of the subject area; becoming a reflective practitioner." This is a tall order for any course, but its broad purposes are intended to help students decide if they want to continue in teaching. Such a course should stimulate broad discussion of what it means to be a science teacher in an urban setting.

To deepen understanding of how the Guidelines were operationalized in this course, readers would benefit from knowing how assignments and assessment criteria were aligned with instructional activities with technology. For example, what criteria were used to structure microteaching activities and associated lesson planning (worth 15% of the course grade)? What criteria were used to structure and evaluate the 45 hours of field work (worth 30% of the course grade)? The explicit alignment among course objectives, implementation of instruction, and assessment procedures provide the best evidence of the opportunity to learn in the course. The ultimate value of this course in promoting a contemporary vision of science teaching and the appropriate uses of technology will be embedded in this evidence.

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