The "Newest Media" and a Principled Approach for Integrating Technology into Instruction

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"New media in instruction?" *Déjà vu*, didn't we write that article over a decade ago? Wasn't it about HyperCard and JPEGs and Internet resources for teaching and learning? Isn't that "old media" yet? Some of the "New Media Centers" originally sponsored by Apple Computer are still here, but now they are populated with "iLife." The "new" in new media is ever changing. There will always be novel opportunities and technologies, but there will also be not-so-novel questions that we should continually ask about the integration of new media in education. As Clark and Mayer (2003) remind us, "what we have learned from all the media comparison research is that it's not the medium, but rather the instructional methods that cause learning (p. 21)." This is a reflection on the enduring question of the relationship between the "newest media" and instructional methods. We offer concrete suggestions from our experience and provide illustrations of how those suggestions are applied in Carnegie Mellon's Open Learning Initiative's use of new media.

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Even the older "new media" are still changing education. The advent of course management systems has meant a much broader community of faculty now using images, graphics, sound, video, and computer simulations as instructional materials. On top of that, newer technologies and their applications spring up constantly. What are the "new media" of 2004? Some candidates are: virtual worlds, gaming environments, blogs, wikis, intelligent agents, iPods, MP3 files and players, institutional repositories, etc. Technologies and adopters change, but the questions endure: Can these information technologies, in fact, add value to learning? Given the evolution of new media, how can educators determine what to use, when, and why? Hence, our guiding question is: How *should* educators assess the effectiveness of new media using performance-based measures, not relying only on the often-used survey of student satisfaction? This is, we believe, the question that has largely eluded a comprehensive answer throughout the recent history of "new media."

At Carnegie Mellon, the Eberly Center for Teaching Excellence and the Office of Technology for Education have forged a close relationship to consult with faculty colleagues on effective teaching approaches based in learning theory, including the integration of technology into course design and classroom pedagogy. One strategy we employ applies equally to any new approach in teaching, whether it employs "new media" or not. That strategy is to apply some of the best current knowledge from cognitive and learning sciences to assess proposed teaching innovation. We ask our colleagues to think in a systematic way about any new pedagogical strategy, including the use of media. Couched in terms of use of "new media", some of the fundamental questions we pose include:

1) What is the educational **need, problem, or gap** for which use of new media might potentially enhance learning?
2) Would the application of new media **assess students' prior knowledge** and either provide the instructor with relevant information about students' knowledge and skill level or provide help to students in acquiring the necessary prerequiste knowledge and skills if their prior knowledge is weak? (Clement 1982, Minstrell 2000)
3) Would the use of new media **enhance students' organization** of information given that organization determines retrieval and flexible use? (DiSessa 1982, Holyoak 1984)
4) Would the use of new media actively **engage students in purposeful practice** that promotes deeper learning so that students focus on underlying principles, theories, models, processes, etc. and not the superficial features of a problem/issue? (Craik and Lockhart 1972, NRC 1991, Ericsson 1990)
5) Would the application of new media provide **frequent, timely and constructive feedback** given that learning requires accurate information on one's misconceptions, misunderstandings, and weaknesses? (Black and William 1998, Thorndike 1931)
6) Would the application of new media help learners to develop the proficiency they need to **acquire the skills of selective monitoring**, **evaluating and adjusting their learning strategies** (some call these "metacognitive skills"), because these

skills enhance learning and, without them, students will not continue to learn once they leave college? (Matlin 1989, Nelson 1992)

7) Would the use of new media **adjust to students' individual differences** given that students are increasingly diverse in their educational backgrounds and preferred methods of learning ? (NRC 2000, Galotti 1999)

Each of these questions carries as its underlying presupposition a result from cognitive science. Collectively, we might call them "cognitive desiderata" for new teaching strategies. We have provided in associated endnotes reference to the research that justifies that presupposition for some of the questions. To give an example, Question 2) is based on the principle that prior knowledge as the basis for building new knowledge, can facilitate, interfere with, or distort the integration of incoming information. In other words, prior knowledge is the lens through which we view all new knowledge, so understanding [and then addressing] students' misperceptions when they enter a course will aid learning. This principle is justified by many researchers, including the work of J.J. Clement and J. Minstrell, which is referenced in the footnote on that question above.

However "technocool" or visually attractive or absorbing a piece or collection of new media is, unless its instructional application plausibly justifies an answer of "yes" to the questions above, *prima facie* it is unlikely to effect educational outcomes. In contrast, if a proposed use warrants an answer of "yes" to one or a number of the questions above, it stands a chance of making a difference. Of course, the ultimate test of whether any application of new media is instructionally significant is determined by empirical evaluation of its impact, an area that has too long been ignored in higher education in general.

Carnegie Mellon is currently undertaking a major project to develop web-based courses and course materials that make use of some kinds of new media and are based on what we know about learning from the cognitive and learning sciences. This project is known as the Open Learning Initiative (OLI) – http://www.cmu.edu/oli.[1] Faculty colleagues

[1] The OLI is funded by the William and Flora Hewlett Foundation

have brought to this project applications of new media that plausibly meet the "cognitive desiderata ."

Consider one piece of the OLI, the StatTutor developed by Dr. Marsha Lovett, a Cognitive Psychologist, in collaboration with the Statistics Department at Carnegie Mellon. This is a web-based tool for providing statistics students a scaffolded environment for learning how to represent, structure, and solve problems in introductory statistics. The creation of this instructional environment was a response to the concern of statistics educators that students often leave courses without the desired statistical reasoning skills and transfer ability, rendering their learning limited in use (Lovett, 2001). This establishes "need" per our first question. StatTutor also has particularly strong affirmative answers to questions 3), 4), 5) and 6). The StatTutor environment appears in Figure 1.

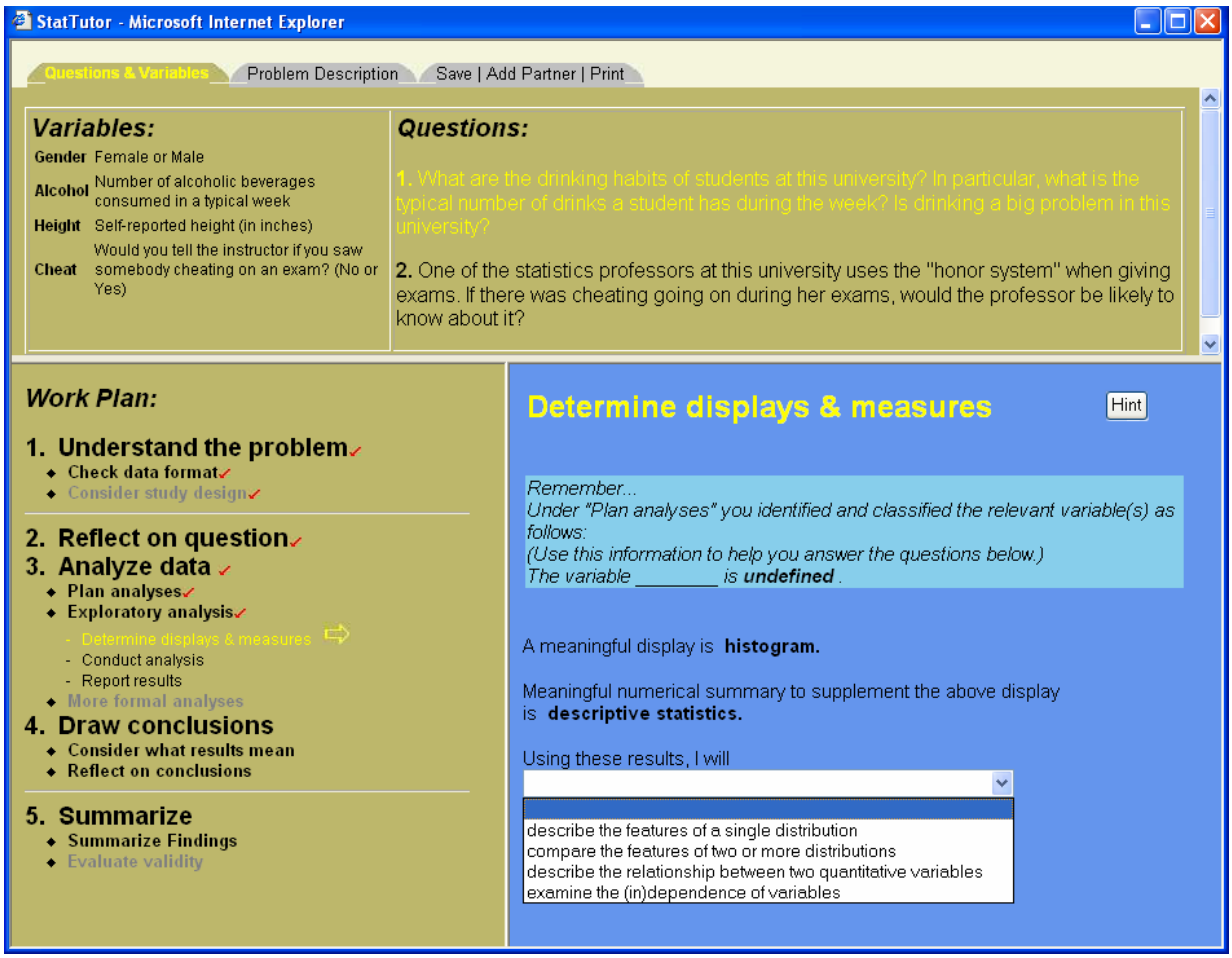

Figure 1.

In the left hand panel, the StatTutor provides the student with a "Work Plan," a consistent way for organizing their analysis of the problem. The students click on each step as they address the problem. This approach provides "purposeful practice" that focuses on the problem-solving process inherent in statistical reasoning (question 4). This "scaffolding" is removed as students move through the course so that they internalize this way of organizing an approach to problem-solving (question 3).

Students are challenged to respond to a large number of questions about the problems in the right hand panel as they step through the process. This interactive feature is tied to a version of a "cognitive tutor" (Anderson, et.al., 1995) which provides them with both feedback on incorrect answers and hints (note the Hint button) when they are stuck. Therefore StatTutor satisfies the criterion of providing "frequent, timely, and constructive feedback" (question 5). Taken together, the deeper learning of processes involved in statistical reasoning and the feedback provides students with metacognitive skills (a la question 6) that will be applicable in multiple contexts for multiple problems.

Another course under development for the Open Learning Initiative is in introductory chemistry. One fully developed tool for this course is Virtual Lab, the work of Dr. David Yaron, appears in Figure 2.

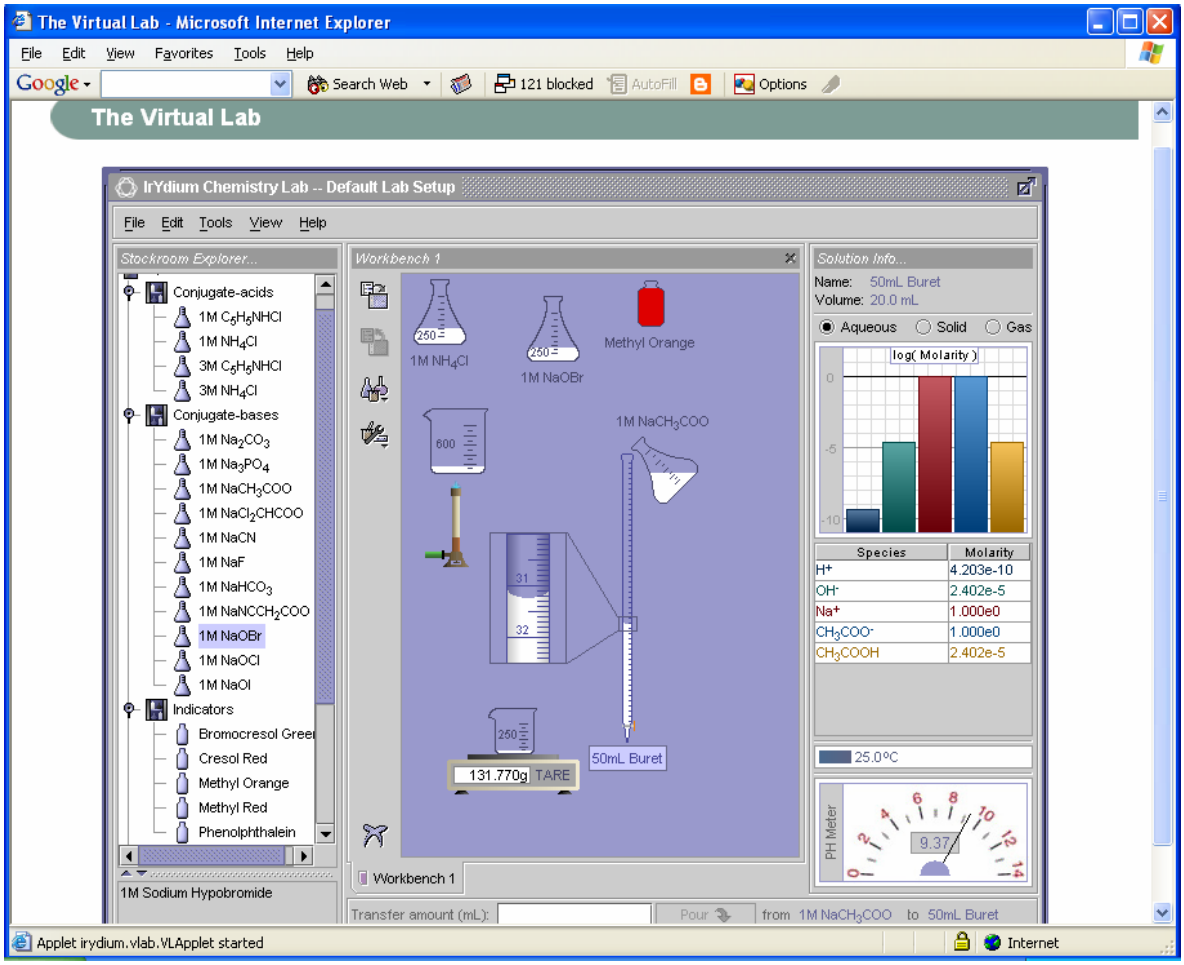

Figure 2.

Professor Yaron has created this powerful open-ended virtual lab environment (certainly something qualifying as “new media”) not as a replacement for wet labs (although it might serve that purpose for populations that don’t have any access to wet labs). Rather, his goal is to change the nature of how students think above solving problems in chemistry. To the first question of our desiderata, “What is the educational need, problem, or gap for which use of new media might potentially enhance learning?,” he answers: “Typically, students solve homework problems in chemistry by thumbing back through the chapter to find the appropriate equations into which they can “plug in” the numbers given in the problem, and this is a poor way to learn how chemists solve problems.” By using the Virtual Lab, he can change the nature of the problems presented to students. Rather than problems of the form: “An N molar solution of X and an M molar solution of Y are mixed together, what is the pH of the resulting buffer solution,”

the problems can be formulated as “Go to the virtual lab and create a buffer solution with a desired pH.” We believe this type of activity “promotes deeper learning,” thus yielding an affirmative answer to question 4 and, when the questions are structured properly, lets different students solve problems in different ways a la question 7. Virtual Lab activities were the primary mode of practice with course concepts and material for three out of the four instructional units (thermodynamics, equilibrium and acid-based chemistry) this past semester at Carnegie Mellon. The Virtual Lab activities engaged students in new modes of interaction, such as experimental design and comparison of different chemical models, and used realistic contexts, such as acid mine draining and design of a chemical solution that causes a protein to adopt a specific configuration. Student performance on end-of-unit exams containing traditional assessment items was equivalent to or better than past years that did not use the virtual lab. While feedback (other than success or failure) is not currently part of this experience, our questions point us toward the need for it and the Open Learning Initiative is adding mini cognitive tutors to the Virtual Lab so that students can get timely feedback.

We recognize that satisfying some or even all of the cognitive desiderata doesn’t guarantee that an application of new media will succeed. Obviously recent research in human-computer interaction provides vital information to those creating e-learning environments. The remaining piece, however, in the application of any new media is careful evaluation of actual impact. The Open Learning Initiative, following the long-standing practices of the Eberly Center at Carnegie Mellon and Learning Research and Development Center at the University of Pittsburgh (an evaluation partner in the OLI), engages in various kinds of evaluation of the impact of new media in its courses. Some techniques are based on a unique feature of digital learning environments: their capacity to record every choice a student takes in problem-solving. OLI courses and media tools are being instrumented to record student performance, both in learning environments like StatTutor and the Virtual Lab and in associated online assessments. The result is a test bed for experimenting with different kinds of educational uses of new media. This type of evaluation, while time-consuming and expensive, holds, we believe, great potential.

Other assessment methods used to evaluate OLI uses of new media are more traditional: pre-test, post-test comparisons, think aloud protocols, etc.

New media, in their many forms, do offer education the opportunity to deal both with intractable teaching and learning problems and the economic challenges facing post-secondary education. But the usefulness of each new wave must confront enduring questions. Some of those questions are captured in our "cognitive desiderata" listed above. Others are represented by long standing best practices in evaluation of instruction. Whatever our personal attraction to virtual labs or immersive digital worlds or multiplayer games, we must keep our eye on the goal – improving learning. The enduring questions provide us with a powerful framework within which to deploy new media in ways that will make a difference in education. That is the thread that should run through the constant change in media that digital technology will bring. The technology changes, but our goals and evaluative standards as educators endure.

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