

TECHNOLOGY ENGINEERING SCIENCE INSTRUCTION IN THE INFORMATION AGE: INTEGRATING INSTRUCTIONAL TECHNOLOGY IN K12 EDUCATION

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ABSTRACT

This paper is a summary of the use of Technology Engineering in K-12 education that integrates science and technology to positively impact students and teachers. The Technology-Enhanced Learning in Science Center (or "TELS") is a research consortium that uses dynamic and innovative technology-based solutions combined with science & mathematics curricula in an innovative way to empower teachers and enhance student learning. As a best practice, the TELS model can provide academicians with new teaching strategies that seamlessly integrate technology into the classroom to increase student retention and transfer of science and mathematics concepts.

Keywords: Instructional Methodology, Instructional Strategy, Professional Development, Science Education, Science Instruction, Technology Engineering, Technology-Enhanced Learning, Technology Integration, TELS, Web-Based Integrated Science Environment, WISE

INTRODUCTION

The Technology Engineering (Osler, 2006) is a teaching methodology that integrates and seamlessly infuses interactive technology, collaborative methods, and discovery learning with content and curriculum. Technology Engineering focuses on providing an empowering and effective teaching strategy that takes advantage of the many varied modes of instruction offered by "Information Age" technology. Technology Engineering is broadly defined as the combination of two distinct yet inter-related concepts collaboratively combined together as a whole. First, there is the term "Technology"; which is generally defined as, "the use of the tools and machines that help to solve problems". This is in turn followed by "Engineering" which is more commonly known as, "the application of technology to solve human problems". The two concepts are combined collaboratively to create the new methodology called: "Technology Engineering". Technology Engineering or TE is the root product of the two distinct "sets" of knowledge fused together and applied specifically to instruction (Osler, 2005). In order to gain a better grasp of Technology Engineering and its application to the learning environment as a teaching

methodology, an example is provided in the paragraphs that follow.

1. Technology Engineering - An Example

An exemplary example of the use of Technology Engineering as an instructional strategy is the Technology-Enhanced Learning in the Sciences or the "TELS Center". The TELS initiative was started as a research consortium to effectively promote the learning of the sciences in K-12 classrooms in which science learning was rapidly declining. TELS (the center for Technology-Enhanced Learning in Science) brings university researchers together with middle school and high school educators to improve instruction in science. Established by the National Science Foundation as a national Center for Learning and Teaching, TELS is headquartered at the University of California, Berkeley, and is directed by Professor Marcia C. Linn. TELS includes seven universities and an institute of technology (Arizona State University, Mills College, Christopher Newport University, North Carolina Central University, Pennsylvania State University, Technion - Israel Institute of Technology, University of California, Berkeley, and The University of Toronto), a nonprofit educational research and development organization (The Concord Consortium),

and seven school districts and additional school systems (Acton-Boxborough Regional Schools, Berkeley Unified School District, Boston Public Schools, Creighton School District, Cambridge Public Schools, Durham Public Schools, Gilbert Public Schools, Mt. Diablo Unified School District, Newport News Public Schools, Phoenix Union High School District, Portsmouth Public Schools). TELS also provides resources to the following affiliates at no cost: The Center for Curriculum Materials in Science (CCMS), The Center for Informal Learning and Schools (CILS), IDEAS Project, The MAC Project, The Making Thinking Visible Project, ROLE Project, The MODELS Project, The Technology Enhanced Active Learning (TEAL) Project at MIT, and VITEN of Norway.

The TELS instructional methodology integrates "Information Age" technological tools into the course curricula. Technology as an instructional tool is seamlessly embedded into the structure of the learning environment. In this manner, TE is not only a practice, but becomes an active and engaging philosophy used by teachers to create a dynamic and powerful learning environment centered around high learner locus of control. This in turn, allows the student to take advantage of their multiple learning styles while interacting with complex scientific concepts, models, and terminology through interactive technology. The instructor becomes an active "facilitator of learning" who promotes active learning and discovery, which in turn, makes knowledge more relevant and greatly affects the way in which learners retain content.

Interactivity and Collaboration are required. They are the inherent key components of Technology Engineering. The courses that are taught through TELS emphasize this through the use of online interactive networking programs (such as "Web-Based Learning" through an online tool called: WISE). These tools work in concert with interactive and dynamic teaching techniques (such as "Authentic Tasks", "Instructional Design Models", "Team-building Techniques", "Culturally Diverse Dynamic Teaching Methods", "Collaborative Projects", "Learner-Based Tools", "Product-Based Learning", "Hands-On Strategies", and Assignments that place a strong emphasis on "Discovery Learning"). This infusion of technology with

interactive and dynamic teaching methods creates an enriching experience for the learner and promotes innovation in the learning environment. This in turn yields a strong sense of ownership and community within the classroom that positively impacts both students and teachers. Students begin to learn and perform better and likewise, teachers can better deliver the science content and concepts that are mandated requirements from both national and state standards.

The TELS teaching method as an example of Technology Engineering provides the following technological advantages as elements to the learning environment:

1. A research consortium supported by the National Science Foundation to study how instructional technology can benefit teaching and learning in science.
2. Eight partnering institutions and their respective school districts across the U.S.
3. TELS partners conduct large-scale, collaborative, applied research to identify promising technology standards-based curricular materials and design principles.
4. The WISE: Web-Based Integrated Science Environment.
5. Merging technologies that are customizable for Technology-Enhanced Learning environments.
6. An environment that develops and tests science activities using innovative software and simulations that help students to explore key scientific concepts.
7. An interactive collaboration with active school partners to teach benchmark topics in Science Education.
8. Creation of engaging Technology-Enhanced instructional materials that actively involve students in the methods and techniques used in the process of scientific inquiry to engage them in learning more about key scientific concepts.
9. The design and implementation of professional development programs for teachers participating in the TELS program.

10. A cohesive research program in science classrooms that yields evidence for investigators, designers, and policy makers.
11. Faculty, Students, Researchers, and Developers throughout the academic year and over the summer have the opportunities to learn new technologies, to contribute to the design of the TELS environment, to design and develop curriculum/projects, and mentor and collaborate with teachers across the U.S.
12. Partnerships with: North Carolina Central University, The University of California at Berkeley, Norfolk State University, Arizona State University, Penn State University, Mills College, Technion/Israel Institute of Technology, The Concord Consortium, Durham Public Schools, Berkeley Unified School District, Maynard Public Schools, Cambridge Public Schools, and Mount Diablo Unified School District, and
13. The Concord Consortium Science Software: Pedagogica, Molecular Workbench, and Biologica.

Further features of TELS include:

1. Delivering science curricular units online.
2. Online note taking and online assessment tools to monitor students' progress and provide immediate feedback.
3. Providing an electronic forum for peer dialogue.
4. A learning environment guides students so the teacher can tutor individuals or small groups.
5. Customizing interactive content involves using student performance as evidence to refine science instruction.
6. WISE/TELS authoring makes content customization easy for teachers, who wish to implement interactive science software into their curricula.
7. Researchers and teachers use student responses and local opportunities to customize interactive content.
8. TELS Knowledge Integration includes: actively engaging students in the process of scientific inquiry, the incorporation of computer simulations of real-world phenomena into science based curricula, and the collection and analysis of scientifically derived data as a part of classroom instruction.
9. TELS Modules, and interactive software has the following elements: Virtual Chatting, Video Streaming, Real Time Interaction, Virtual Recording and Replay, E-mail, Teleconferencing, Message Boards, Graphic User Interfaces, WebPages, Virtual Development Tools; and Dynamic Interactive Learning Environments
10. The analysis of student outcomes which includes determining to what extent students involved in TELS learning develop a deeper, better integrated understanding of complex scientific topics via assessment, and
11. The TELS assessment methodology includes: Pre-test Assessment (determining knowledge of a scientific concept prior to module deployment), Post-test Assessment (determining the amount of knowledge retention at the end of module interaction), and Benchmark Assessment (conducted at the end of academic year to determine all TELS outcomes).

These additional eleven elements are exemplary examples of how the infusion and implementation of Technology Engineered programs such as the TELS initiative provide additional retention and transfer of scientific conceptual knowledge that enhances the learning environment.

The use of the aforementioned advantages and elements along with strong course design principles that encourage scientific examination, facilitate learning scientific concepts, and promote discovery in the learning process creates a new and innovative teaching paradigm in the sciences. This new paradigm is one that actively engages students in the learning process. Thus, the teacher can increase student interest in the sciences, while actively encouraging learning through available technology. As a result, Technology-Enhanced Learning in the Sciences seeks to enhance the disciplines of education and philosophy through a revolutionary collaborative between teachers, students, researchers, and content developers using current technology. This is the ultimate goal of Technology Engineering as a

philosophy.

2. Technology-Enhanced Learning in Science (TELS)

Over the past 25 years the coupling of science and technology has led to efforts to redefine the goals for science courses, produce scientific research that re-conceptualizes science instruction, and support studies that explore the impact of new technologies on student learning (Linn, 2003). The nature of teaching and learning is aided by educational technology and is vastly understood by many educational stakeholders that recognize the different levels of technology integration. Technology integration is a process in which teachers utilize computers and other technologies such as the internet, and software as tools to facilitate inquiry-based learning, collaboration, and problem solving (Eib and Mehlinger, 1998; Newman, et.al. 2005; Stevenson, 2005). Despite the positive impact of educational technology on student learning, its use in the classroom by teachers is still limited.

3. Web-Based Integrated Science Environment (WISE)

Technology creates a more learner-centered environment by allowing students to take on more responsibilities in their learning process (Nisan-Nelson, 2001). Because of this, technology-enhanced learning environments have emerged as the subject of study for many researchers with an interest in science education and technology. The Technology-Enhanced Learning in Science Program that has collaborated with many partners to develop a learning environment that would help students to make their thinking visible, encouraged student collaboration, promoted autonomous life long learning, and made science concepts more accessible (Linn, 2000a; Linn, Clark, and Slotta, 2002). The environment that facilitates this kind of learning is referred to as the Knowledge Integration Environment or KIE. The Knowledge Integration Environment is a byproduct of the "scaffolded" Knowledge Integration framework that sets students on a path of identifying what is known, linking it to new knowledge, and making connections to facilitate a deeper understanding based on the principles of scientific inquiry that afford them the opportunity to

connect science class information to personally relevant problems and prior knowledge (Williams and Linn, 2002).

Since inquiry-based learning is a key component of technology-enhanced learning environments, both teachers and students can become better critics of scientific concepts and materials as a result of engaging in inquiry projects (Linn, Clark, and Slotta, 2002). Prompts, discussions, recorded observations, and discourse between teachers and students all occur in technology learning environments which provide more challenging learning opportunities for students while providing supports that allow such challenging learning to be recognized (Songer, Lee, Kam, 2002). However, the challenge still remains which is to support teachers in harnessing these kinds of technological capabilities in the classroom.

4. TELS Teacher Professional Development

Professional development is defined as the process of improving staff skills and competencies needed to produce outstanding educational results for students (Kent, 2004). Over the past 20 years, standards have been developed for professional development to focus on knowing what students must be able to do, knowing which strategies lead to student success, and identifying focus areas to meet such goals (Hall, 2005).

The use of technology in the classroom has gained a significant amount of momentum. Changes in instruction, assessment, and the process of schooling have led to the need for various kinds of professional development. This is supported by researchers Wilson and Berne who state on page 173 of their article "Teacher learning and the acquisition of professional knowledge" in the Review of Educational Research state the following: "Mounting efforts to increase the professionalization of teaching constitutes yet another force. Professional teachers require professional development," (Wilson & Berne, 1999). This illustrates the increasing need for teacher professional development that is both timely and relevant. In today's diverse society, this is especially true when teachers are confronted with technology or science professional development and training.

According to Salpeter (2004), the absence of in-house, on-demand, and customized help often leads teachers to be reluctant to use technology in the classroom.

Despite the positive impact of professional development on teaching, there are several reasons why it often fails to achieve its objectives. The irrelevance of activities to classroom practices, one-shot workshops, and the inability to address teachers needs and concerns all set limitations on the effectiveness of professional development on classroom teaching (Mouza, 2003). Since successful use of computers largely depends on teacher pedagogy, then efforts must be devoted towards helping teachers understand: a) the purpose of educational technology and b) the important pedagogy that is needed for its implementation (Mouza and Bell, 2001; Eib and Cox, 2003).

Professional development is critical to the effective integration of technology into the classrooms and it must be based on teacher needs in order to ensure successful implementation into the classroom (Shuldman, 2004; Dawson and Rakes, 2003; Mouza, 2003). Yet, many teachers have not reached an adoption of such advances and their pedagogies do not reflect the integration of instructional technologies in their classrooms (Mitchem, et.al., 2003; Nisan-Nelson, 2001).

Conclusion

"Information Age" technologies enable teachers to deliver content in new and innovative ways. New pedagogical and andragogical methods are constantly being developed, deployed, and evaluated. Technology Engineering through the TELS initiative has the unlimited potential to take teaching the science to previously unforeseen heights. However, if we wish to truly reach and unlock the unlimited potential of our students we must delve further into interactive technologies that take advantage of "Information Age" students' familiarity with interactive technology. The future success with the TELS initiative largely depends on both the competency of the science teacher as well as support from the institutions' administration. The end results may initiate a new model in teaching that has far reaching implications

for education and may introduce a new generation of students to the sciences.

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