Online Learning with Hands-on Activity Enhance Technological Creativity

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ABSTRACT
This article presents a learning framework that can enhance students' technological creativity in technology education classroom. This framework emphasizes learning online with hands-on experience, which provides students a full learning environment engaging in active, constructive, cooperative, authentic, and intentional learning technology as Jonassen, Howland, Moore, and Marra (2003) indicated. The online learning system first starts at presenting contextually meaningful technological problem situations that require students to learn the concepts of Mathematics, Science, and Technology (MST). Then, an online simulation was followed to help students utilizing those MST concepts to design virtual products. This can also provide student an opportunity to integrate the concepts they have learned. The online simulation, unlike conventional simulations that are used for acquisition of knowledge, requires students to fully employ the concepts learned in MST section to solve technological problem. Finally, after completing their simulation, students have to design and make real products in order to integrate concepts learned with practical problem. With the processes of learning MST concepts, online simulation, and working on hands-on product, students will be equipped with the domain-relevant skills that Amabile (1983) have urged when developing student's creativity.

Keywords: online learning, technological creativity, hands-on

INTRODUCTION
Technology education has long emphasized imparting cognitive competency such as creativity. By employing materials, tools, and machines, students in technology education classrooms have been engaging in the creative act to make product and learning to experience technology first-hand. This idea of making things is never divorced from schooling. In fact, hands-on activity has been used as the major means for developing technological creativity in technology education classroom. People with technological creativity invent or innovate new technological products using their domain knowledge and ability to use machines, tools and materials. For this reason, over the past two decades, the educational authorities all over the world have emphasized on the creative learning environment with creative contents in technology education classrooms.

Developing Technological Creativity in Technology Classroom
The word of "technological creativity" is used widely in recent years, but it takes little time to become an important issue in the field of creativity research. The major reason of this growing concern in technological creativity is because the rapid development of technology. More and more organization set the innovation laboratories for encouraging creative behaviors and supporting innovative projects in order to ensure their competition in business or industry (Lewis & Moultrie, 2005). However, not

many research studies have yet been written about technological creativity in our classrooms.

The nature of technology is one kind of performances about human creativity, and its evolution is involved with human invention and innovation, which is the performance of technological creativity (Lewis, 1999; Mokyr, 1990). Our technological society is always surrounded by products that are the material result of the creative process and embodies the very essence of technology. Todd (1991) indicated five different levels of technological decision-making abilities should be developed in technology education (see table 1). Among these abilities, technological creativity is the one that focused on knowing what and how with the ability of invention, which is often ignored by our schools teachers because our schools often emphasize teaching students know-what instead of know-how. Mayer (1999) urged that the value of technology education is to develop students' technological creativity in hands-on technological activity. Howard-Jones (2002) also indicated that technology teachers should take the responsibility of arousing and encouraging students' technological creativity in technology education. In other words, technology education should be taken as an important subject matter for developing students' technological creativity in educational settings. Furthermore, how to create the environment of creative process for students in making creative products should also be an important task for technology teachers.

Table 1 The classification of technological decision-making ability

Level	Knowledge Types	Ability
1.technological awareness	know what	cognition
2.technological literacy	know what	comprehension
3.technological ability	know what, how	application
4.technological creativity	know what, how	invention
5.technological criticism	know what, how, why	judgment

Resource: Todd, 1991, p. 24.

Technological creativity is related to personal performance in technological activity that is different from common creativity. Technological creativity focuses on not only bringing ideas up but also containing the whole process in technological system with operating the tools, handling the materials, and making the final products. In other words, technological creativity is the process of making product with originality and merit in specific field, and the creative process is related to the integration and application of cognition, attitude, and skill. Furthermore, Yeh (2004a) regard a creative product or outcome as being the result of the interaction of individuality and the environment. This individuality includes knowledge, experience, dispositions, skills, and strategies; whereas the environment includes the family, school, organization, and the social milieu. In this paper, the authors would consider technological creativity as the creative process of making good use of individuality and environment in order to generate the final product, and this creativity can be developed through online learning with hands-on activity.

Online Learning Enhances Technology Domain Concepts

Making of creative product is often viewed as an important approach in developing creativity. As Amabile (1983) stated, the making of creative product needs to include three basic components: (1) domain-relevant skills; (2) creativity-relevant skills; (3)

task motivation. This means the development of technological creativity must be founded on the establishment and application of domain skills, creative skills, and one's motivation. In this article, the authors would discuss how to use web to provide student with profound technological knowledge to equip his/her needs in domain skills when creating products. To enhance students' technological creativity in creating product, it is crucial to provide students with technology domain knowledge. There has been a considerable amount of work, position papers and professional pressure in recent years expressing the need for online learning in technology education. The potential of web as a tool for delivering education is promising at all levels of education. This is because online learning has the potential to provide students with a rich learning experience while they gain expertise in cutting-edge technology. In the past, learning technology was usually believed only feasible through hands-on experience. In fact, through web, using online activity becomes another opportunity to learn technology. From the aspect of learning, Jonassen, Howland, Moore, and Marra (2003) indicated that a real learning should ensure students engaging in active, constructive, cooperative, authentic, and intentional learning. The use of web has provided much information and design for supporting these five learning in a virtual environment. Tools in web environment often enable students to research, plan, design, and reflect on the creation of technological product, which indicates students can demonstrate their implementation of the interaction of these five interdependent attributes of meaningful learning through online learning. The study of technology is influenced by rapid changes in technology. When teaching technology, technology teacher often focuses various concepts and principles that are fundamental to the technological systems. Traditionally, school curriculum has been largely organized based on the concept that instruction should be separated into distinct subject. In recent, the concept of integrating school subject areas has gained significant attention as a plausible solution to develop a more relevant approach to teaching and learning. Especially, attention within the technology education field has been directed at integrating mathematics, science, and technology (LaPorte & Sanders, 1996). This integration can be easily made through web because in web environment students have an opportunity to think and reflect and develop ideas, and then to test their ideas. Furthermore, when involving in online learning, students can also conduct many activities such as evaluation, communication, modeling, generating ideas, research and investigation, and documenting. As a result, a true and meaningful learning can be easily conducted.

CREATING AN ONLINE LEARNING FRAMEWORK TO ENHANCE TECHNOLOGICAL CREATIVITY

To take the advantage of multimedia and interactivity of Web, the authors developed an online learning system, which contains three major sections: (1) MST (Mathematics/Science/Technology) concepts learning area, which provides student to learn the basic concepts of mathematics, science, and technology which related to the activity. (2) Online simulations area, which provides student to control the variable of MST concepts through online simulation for the purpose of integrating the concepts learned at previous section. (3) Online multimedia test area, which provides student an easy-to-use tool to assess his/her conceptual knowledge learned in MST and simulation.

After completing the learning on web, an hands-on project is required by very student. This hands-on project provides students an opportunity to integrate what they have

learned online to solve the technological problem and to use the materials, tools, and machines. In other words, using this learning framework, students need follow the step of MST concepts learning, online simulation, and online multimedia test, and finally to design and construct a hands-on project to complete the whole learning process. This learning framework is presented as the Figure 1 below. The online learning system is to help students developing the concepts to construct the knowledge domain to create a hands-on product. Also, some part of this online learning, like simulation, can provide student opportunities to integrate the concepts learned. This integration is also happened in the stage of making hands-on products when students using what they learned to design and make a technology product.

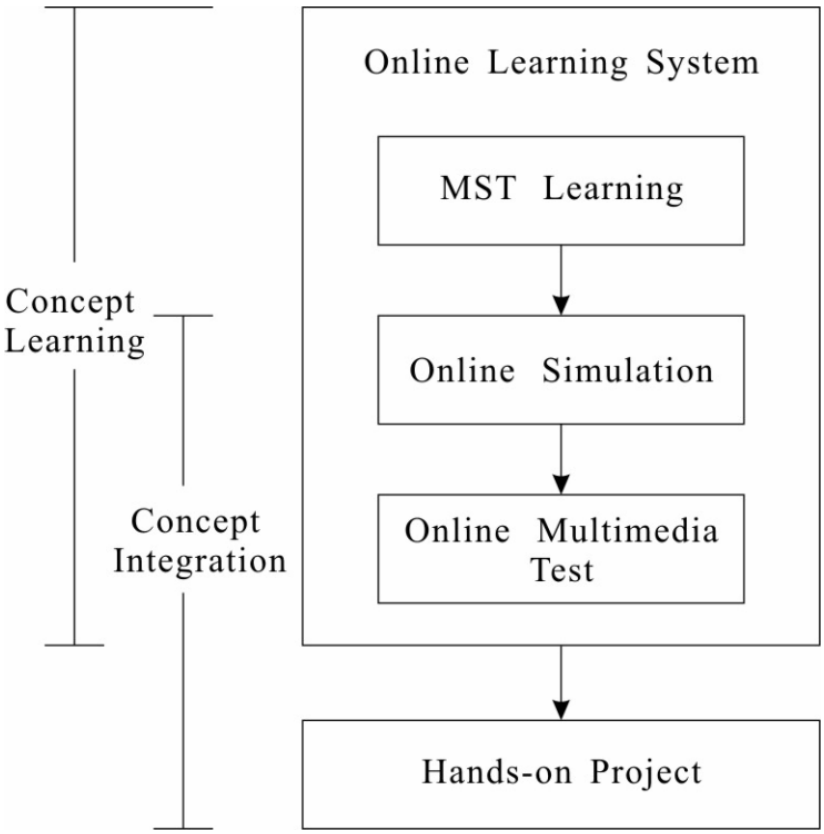
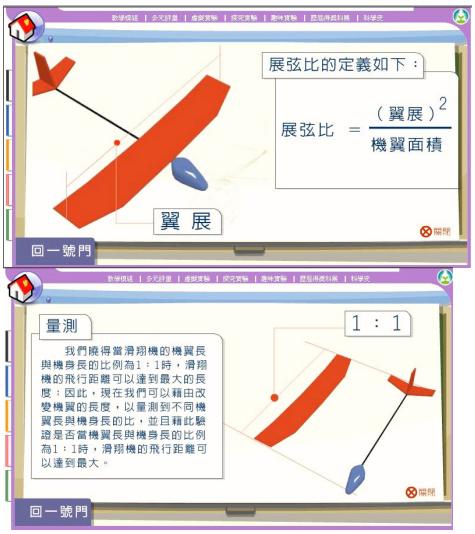


Figure 1 Framework of Learning Technology Online

MST concepts learning

The education of technology means that a closer working relationship among technology, science and mathematics to solving problems. The reason of this integrating is because science and mathematics are critical when explaining the process and meaning of technology. Many researches have been conducted related to MST curriculum. Wicklein and Schell (1995) focused on exploring the factors of influencing the integration of MST. Childress (1996) focused on exploring the effectiveness of developing students' ability in technological problem solving through the integration of MST. The research in the Boser, Daugherty, & Palmer (1996) also indicated that the MST interdisciplinary approach also change student's technology attitudes the most. Thus, the first section of this online learning system, MST concepts learning, is to help student understand all MST concepts related to the design and construction of a glider (Figure 2).

Mathematics Concepts



Students can learn the structure of a glider and knowledge of fly through the Mathematic, Science, and Technology concepts in this area

Science Concepts

Technology Concepts

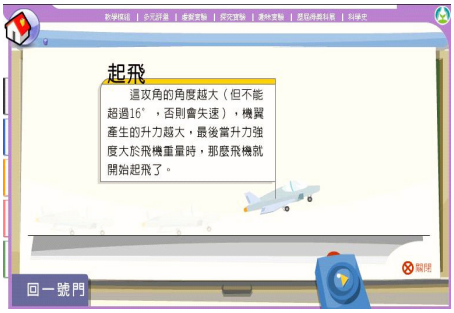


Figure 2 MST concepts learning

Online simulation

Simulation in educational settings is a widely employed technique to teach certain types of complex concepts. In certain situations, due to cost, feasibility, and/or safety, educators may not be able to provide students the opportunity to engage in hands-on activities. Computer simulation activities can be used as an alternative for reaching educational goals supported by research results (Michael, 2001). Gokhale (1996) also believes that the virtual experiences can provide the learner with an opportunity to learn by doing as opposed to straight lecture.

Though it is believed that most educators prefer real-life laboratory activities to simulations, simulation technology still can provide the learner with numerous advantages. For example, simulators can (Choi & Gennaro, 1987; Betz, 1996; Gokhale, 1996): (1) provide the students with the opportunity to engage in activities that may otherwise be unattainable; (2) enhance academic performance and learning achievement levels of students; (3) be equally as effective as real life hands-on laboratory experiences; (4) foster peer interaction; (5) provide students with immediate and reliable feedback. All of these can reflect the learning that Jonassen, Howland, Moore, and Marra (2003) indicated. In fact, there are many advantages of using online simulation to teach. For instance, simulations generally are far more tolerant of error and reducing learner anxiety. A significant benefit of using simulation

is that it often provides a smoother transition from simulation to real learning. This not only encourages the interest of study and strengthens learning experience effectively (Davies, 2002), but also to develop the ability like problem solving, analysis, and critical thinking (Yeh, 2004b).

As for the relationship between online simulation and technological creativity, some researchers speculate that computer simulation technology may have a positive effect on creativity (Betz, 1996; Gokhale, 1996; Kristensson & Norlander, 2003). Besides, in reviewing of developing learners' creativity in schools, some researchers had tried to use computer simulation in improving problem solving and creativity (Michael, 2001). In fact, online learning has the potential to provide students with a rich learning experience while they gain expertise in cutting-edge technology and develop technological creativity. On a practical level, online simulation allows students to engage in a variety of creative problem-solving activities and should be considered as an alternative to hands-on activities (Michael, 2001).

In the second part of the online system, an online simulation was created, using the MST concepts as variables, to assist students learning content through manipulating those input variables online (Figure 3). This simulation can help student review the concepts learned and create a virtual glider. Also, this simulation environment puts students in control since they can formulate their own designs and experiments. In fact, a student's perception is to be evanescent in nature, and a momentary impression usually fades quickly. As student reflects on these perceptions of technology, they form the conception of technology that student hold (Hine, 1997). Therefore, this online simulation manufactures an environment to provide students with virtual experience of learning to assist them to get the perceptions that are needed.

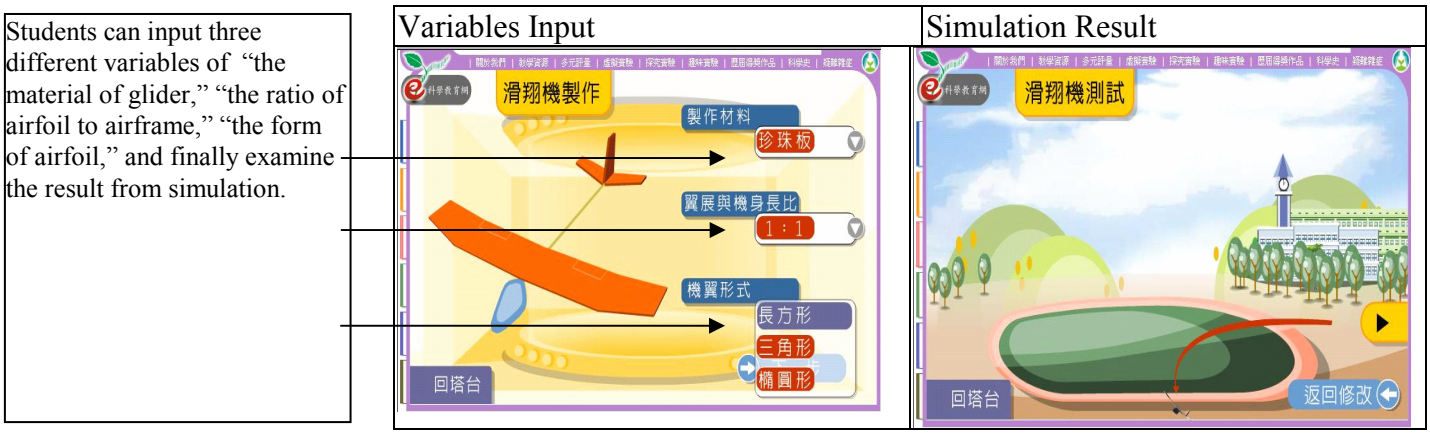


Figure 3 Online Simulation

Online Multimedia Test

Traditionally, assessment of technology has focused more on psychomotor skills than cognitive and affective domain. This is because that technology often characterized as more of an activity, the procedural knowledge, than a discrete body of content, the conceptual knowledge. Procedural knowledge is developed through the creation of a process and can be evaluated by the process or product that student completed. The conceptual knowledge, on the contrary, is often evaluated by a paper-and- pencil test, like literacy tests that have been done for years. However, using this paper-and-pencil test not only draw students out of the authentic educational setting, but also get those with poor reading or comprehension abilities into difficult of answering because of narrative form of test description.

With the rapid growth of online instruction, assisted testing system has become a new study field, offering the education researcher a new and, in some aspects, unique tool. The enabling technology changes the way of testing, and become a new trend of integrating technology in education. Also, there is a growing recognition that efforts need to go beyond computerizing multiple-choice tests to the development of assessments that capitalize on the computer's multimedia capabilities and facilitates learning in ways that paper can't measures (Bennett, 2005). For that matter, online test that integrates with multimedia and hyperlink will enrich and diversify the test format, and meanwhile improve the drawbacks of paper-based test. The abundant forms of media usually better transmit the meaning of the questions to test takers. Thus, the appropriate use of media elements and providing clear multimedia type test plays an effective role helping students understanding the subject course.

A multimedia test system is developed in this online learning system (Figure 4). The purpose of this multimedia test is to provide student an easy-to-use tool to assess his/her understanding in conceptual knowledge learned in MST section.

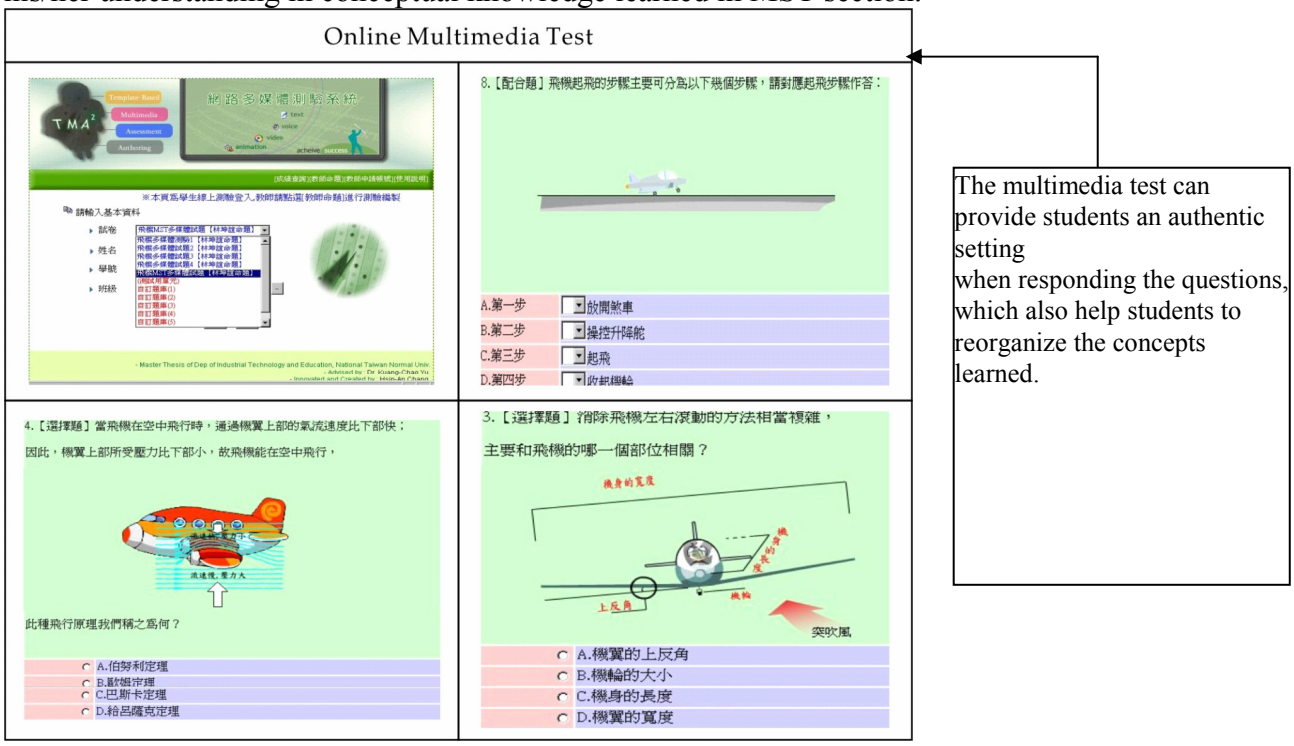


Fig. 4 Question types in Online Multimedia Testing System

The growth of multimedia technology has made various media elements integrated through the software with synchronization and collaboration functions. Active multimedia can provide sound-and-light effect and creative design. It also inspires learners' external motivation. On the basis of network infrastructure, using multimedia is now able to breakthrough traditional evaluation model in teaching and learning technology. Thus, using multimedia elements to conduct assessment can evaluate student's skills in cognitive, affective and psychomotor domain. That is to say, online multimedia test can provide not only multiple test formats, but also multiple viewpoints to evaluate students' learning achievement and their weakness.

Technology is in essence a manifestation of human creativity. Thus, an important means in which students can come to understand it would be by engaging in acts of technological creation. In order to prepare students for a technological society, technology learning must engage in methods that will nurture creative thinking. The

online learning developed indicated an appropriate process for students to learn technology and to apply creative thinking. By employ the MST learning, online simulation, and multimedia test, student would have the opportunity to learn the MST concepts and integrate the concepts to a final stage – the hands-on project.

USING HNADS-ON ACTIVITY TO INTEGRATE MST CONECPTS

The strength of hands-on is that students can develop their technological creativity through making technological products, that is, a "learning by doing" approach. In fact, not only does hands-on activity give students an experience of combining the theoretical and practical sides, it also serves as a simulation of the process of technological problem solving used in real world (Hong & Sheu, 1999). This is also what Sternberg (1986) has urged that teaching creativity effectively should comprise analytical, creative and practical aspects, and hands-on activity is the best approach to generate all.

Traditionally, face-to-face instruction combined with hands-on activities has been adopted in technology education to develop students' technological literacy and problem-solving skills. In this way, students can combine hands-on activities with minds-on activities. This is why Moshe & Yaron (1999) believed the role that hands-on activities in technology education can play in developing students' higher-order thinking skills.

People learn by doing. When they are finished with any learning experience, they usually like to try to do it in real by themselves. In other words, the way they learn anything is by practice, or called technical learning. Technical learning in laboratory has only been a cornerstone of technology education. For years, many scholars have realized the potential for technical learning, which includes using tools, materials, and machines, within general education. The need for technical learning will result to the final section of this learning process: hands-on experience.

A final hands-on project is required, in this learning framework, to provide students a opportunity to design and construct a glider under a proper working process with materials and tools. As mentioned above, when students understand the MST concepts and complete the simulation, a real hands-on experience with real tools and materials can provide student an opportunity to apply what they have learned. This is a significant step to let students think, reflect, and develop ideas, and finally to test their ideas in a practical context.

CONCLUSION

In conclusion, the learning of technology is not merely the study in cognition, but also the study of operation. This article presents a learning framework, which consists of online learning and hands-on activity. The online learning system provides three learning sections in the sequences of understand the MST concepts, an online simulation, an online multimedia test. Furthermore, this online learning system carefully selects and manages MST concepts to allow students constructing in relationship to what is already known and integrating the concepts learned. This learning framework is believed that can provide students with needed domain knowledge to create technological products.

In fact, most research on creativity has focused on the creative person and process, not the product. However, technology educators have chosen the creation of products or projects as a mean to teach technological concepts (Knoll, 1997). In fact, a product can be described as a physical object, article, patent, theoretical system, an equation,

or new technique (Brogden & Sprecher, 1964). Meanwhile, a creative product also represents one that possesses some degree of unusualness (originality) and usefulness (Moss, 1966). Therefore, the creative product can be viewed as a physical representation of a person's technological creativity (Besemer & O'Quin; 1993). This is also the spirit of the learning framework indicated in this paper.

REFERENCES

Amabile, T. M. (1983). *The Social Psychology of Creativity*. New York: Springer-Verlag.

Bennett, R. E. (2005). Inexorable and inevitable: The continuing story of technology and assessment. Retrieved June 25, 2005, from http://www.jtla.org

Besemer, S.P., & O'Quin, K. (1993). Assessing creative products: Progress and potentials. In S.G. Isaksen (Ed.), *Nurturing and developing creativity: The emergence of a discipline* (pp. 331-349). Norwood, New Jersey: Ablex Publishing Corp.

Betz, J.A. (1996). Computer games: Increase learning in an interactive multidisciplinary environment. *Journal of Technology Systems, 24* (2), 195-205.

Boser, R., Daugherty, M., & Palmer, J. (1996). *The effect of selected instructional approaches in technology education on students' attitude toward technology*. Reston, VA: Council on Technology Teacher Education.

Brogden, H., & Sprecher, T. (1964). Criteria of creativity, In Taylor, C.W., Creativity, progress and potential. New York: McGraw Hill.

Childress, V. W. (1996). Does integrating technology, science, and mathematics improve technological problem solving? A quasi-experiment. *Journal of Technology Education, 8* (1), 16-26.

Choi, B., & Gennaro, E. (1987). The effectiveness of using computer simulated experiments on junior high students' understanding of the volume displacement concept. *Journal of Research in Science Teaching, 24* (6), 539-552.

Davies, C. H. (2002). Student engagement with simulations: a case study. *Computers & Education, 39*(3), 271–282.

Gokhale, A.A. (1996). Effectiveness of computer simulation for enhancing higher order thinking. *Journal of Industrial Teacher Education, 33* (4), 36-46.

Hine, A. R. (1997). *Capturing and comparing students conceptions of technology*. Retrieved June 25, 2003, from http://www.lboro.ac.uk/idater/downloads97/hine97.pdf

Hong, J. C., & Sheu, S. W. (1999). The development of technological creativity through project work. Creativity and Innovation Management, 8(4), 269-280.

Howard-Jones, P. A. (2002). A dual-state model of creative cognition for supporting strategies that foster creativity in the classroom. International Journal of Technology and Design Education, 12, 215-226.

Jonassen, D. H., Howland, J., Moore, J., & Marra, R. M. (2003). Learning to solve problems with technology: A constructivist perspective. Upper Saddle River, NJ: Pearson Education.

Knoll, M. (1997). The project method: Its vocational education origin and international development. Journal of Industrial Teacher Education, 34(3), 59-80.

Kristensson, P., & Norlander, T. (2003). The creative product and the creative processes in virtual environments. *Creativity and Innovation Management, 12*(1), 32-40.

LaPorte, J. E., & Sanders, M. E. (1996). Integrating technology, science, and mathematics education. In G. E. (Ed.), *Foundations of technology education* (pp. 179-

219). Council on Technology Teacher Education 44th Yearbook. Peoria, IL: Glencoe/McGraw Hill.
Lewis, M., & Moultrie, J. (2005). The organizational innovation laboratory. *The Organizational Innovation Laboratory, 14*(1), 73-83.
Lewis, T. (1999). Research in Technology Education: Some areas of need. *Journal of Technology Education, 10*(2), 41-56.
Mayer, R. E. (1999). Fifty years of creativity research. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 449-460). Cambridge: Cambridge University Press.
Michael, K. Y. (2001). The effect of a computer simulation activity versus a hands-on activity on product creativity in technology education. *Journal of Technology Education, 13*(1), 31-43.
Mokyr, J. (1990). *The lever of riches: technological creativity and economic progress*. Oxford: Oxford University Press.
Moshe, B., & Yaron, D. (1999). Integrating the Cognitive Research Trust (CoRT) programme for creative thinking into a project-based technology curriculum. *Research in Science & Technological Education, 17*(2), 138-151.
Sternberg, R. J. (1986). *Intelligence applied*. New York: Havcourt Brace.
Todd, R. D. (1991). The natures and challenges of technological literacy. In Michael J. Dyrenfurth & Michael R. Kozak (Eds.), *Technological Literacy* (pp. 10-27). Blacklick, OH: Glencoe/McGraw Hill.
Wicklein, R. C., & Schell, J. W. (1995). Case studies of multidisciplinary approaches to integrating mathematics, science and technology education. *Journal of Technology Education, 6* (2), 59-76.
Yeh, Y. C. (2004a). The interactive influences of three ecological systems on R & D employee' technological creativity. *Creativity Research Journal, 16*(1), 11-25.
Yeh, Y. C. (2004b). Nurturing reflective teaching during critical-thinking instruction in a computer simulation program. *Computers and Education, 42*(2), 181–194.