Sponsoring Committee: Professor Stephen I. Sumner, Advisor
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[An Abstract of]

ORDERED EFFECTS OF TECHNOLOGY EDUCATION UNITS ON HIGHER-ORDER CRITICAL THINKING SKILLS OF MIDDLE SCHOOL STUDENTS

Kern D. Mojica

Submitted in partial fulfillment of the requirements for the degree of
Doctor of Professional Studies in Computing in the
Seidenberg School of Computer Science and Information Systems
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In this quasi-experimental quantitative study, 105 eighth grade students at a suburban middle school in New York State participated in a seven month-long project involving the ordered effects of the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skills as measured by the Cornell Critical Thinking Test, Level X. The 105 students were separated into six groups. Each group worked on the three problem-solving technology education units in a strategic order. This study extends the research of Lewis (1999) and Hansen (1995) in technology education curriculum reform and ventures into an unexplored area of ordered technology education curriculum implementation.

It was concluded that the ordered effects of the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skills as measured by the Cornell Critical Thinking Test, Level X did not have a statistically significant effect on students' higher-order critical thinking skills, nor did the effects vary by gender, age, or the learner's academic category (this is the category a student is placed in, based on the level of their mathematics and science courses).

Although quantitative findings did not show statistically significant effects of the ordered technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge, the results of this study provide signs that a controlled process of strategic, ordered implementation of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge has a positive effect on students' higher-order critical thinking skills. There are also indications that females benefited more from the use of the three technology education units than males.

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DEDICATION

I dedicate my dissertation work to my family, especially to my mother, Jennifer Maureen Benjamin. Everything I have done, I did to make your hard work and sacrifice all worthwhile. I love you! To the Gagliardi and Newman/Onorato families for their unconditional love and support, thank you for opening your hearts and your home.

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CHAPTER I

RESEARCH OBJECTIVE

The aptitude to examine, problem-solve, reason, and think critically has been the foundation for the success and progress of the human race. These abilities have helped our society move into an age of technology that was a mere fantasy to our ancestors. The competitive academic world, in which we live, continues to challenge educators to move their focus towards developing more progressive teaching and learning approaches. Sternberg and Baron (1985) established that "whether our focus is on classical education, new math, or basics, the ultimate goal of education has been to teach children to think critically and independently" (p. 40).

Background of the Problem

Literature has shown that the academic roots of critical thinking dates back to the time of Aristotle, Plato, and Socrates. These well-known thinkers encouraged their students to question the "givens," to contemplate the common understandings that are seldom examined for contemporary relevance and truth. In addition to critical thinking skills, higher-order critical thinking skills are a different and vital topic in modern education. Higher-order critical thinking skills involve a combination of information and thoughts. This type of thought process occurs when there is an interconnection of stored memory and new information,

which can reorganize and extend a person's intellectual understanding to find a possible answer to a puzzling circumstance. The United States Department of Education and other governmental agencies have recognized American students' deficiencies in higher-order critical thinking, and the need to educate students to develop these skills (Piro and Iorio, 1990). In President Barack Obama's (2009) first major speech on education, he stated the following:

> I'm calling on our nation's governors and state education chiefs to develop standards and assessments that don't simply measure whether students can fill in a bubble on a test, but whether they possess 21st century skills like problem-solving and critical thinking and entrepreneurship and creativity. (¶ 8)

Educators are interested in teaching higher-order critical thinking skills to their students. It has become a staple in the educational system in the United States of America and the world. Academic departments, at all levels of education, expect that their instructors and professors will develop into informed educators in the strategies of teaching higher-order critical thinking skills. To become well-versed, educators need to identify areas in their courses as the proper place to emphasize and teach higher-order critical thinking, and at the same time develop assessments that test students' critical thinking skills (Schafersman, 1991). The New York State Education Department's Technology Education syllabus (Eric, 2009) discussed that technology education content should be focused on critical thinking and creative problem-solving skills using a design process, but does not specify a process by which educators can accomplish this.

In addition to the need for young students to expand their critical thinking and problem-solving skills, there is a need for research to improve curriculum development in order to enhance these student skills. Relatively little is known about how to organize curriculum in technology education so that students' critical thinking skills mature. It is, therefore, difficult to establish and integrate a standardized, ordered curriculum into technology education.

The current technology education curriculum focuses on the effect of individual technology education units, as opposed to cumulative effects of all the units within the course, as the foundation of content which aims to engage students' problem-solving and critical thinking skills. Present technology education units such as Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge have each been introduced into school systems in an attempt to foster students' problem-solving skills (Gibbon, 200; Ohler, 2005; Olson, 2000; Palumbo and Palumbo, 1993). These three units are designed to engage students in an abstract learning experience in which science, mathematics, and engineering are explored and applied in a hands-on, cooperative setting (Gokhale, 1995). The ordering in which they are explored has not been examined.

The Lego® Mindstorms™ NXT Robotics System is a robotics kit with specially designed software intended to permit students to create individualized computer programs that solve a problem or challenge designed by their instructor. The Digital Storytelling with Microsoft Windows Movie Maker unit allows

students to use their creativity to express themselves through pictures and videos joined together in the form of storyboarding, voice recordings, and the incorporation of music. The Marble Maze Challenge unit employs students' designs into a structure consisting of a cardboard maze through which a marble must travel through without falling off the maze. Students are given limited supplies to build a structure that must meet particular standards for credit on the technology unit.

These technology education units are implanted throughout technology classrooms nationwide, but there are no standardizations for when educators implement each unit or methods of assessing gains in specific thinking skills. Identifying alternative curriculum planning processes could have a considerable influence on the future of technology education. If teachers are able to make use of curriculum development parallel to the goals they choose to implement, then the similarity between the goals and practice of technology education will be more aligned for success within their classroom. With educators focusing on decisions about content and the presentation of said content, this may result in a recognizable difference in student accomplishments in technology education (Zuga, 1989).

<u>Purpose of the Study</u>

In technology education, current curriculum suggestions focus on technology as the foundation of content. Technology educators also focus on

classification of technological concepts, which reflect an academic curriculum design. Technology education curriculum involves the problem-solving approach which introduces learners through processes that are essential for problem-solving. According to Myrmel (2003), these thought processes include: identifying the problem, gathering information about the problem, generating potential solutions to the problem, and developing and testing the optimal solution to the problem. Students need these tools and skills to become more creative and to be prepared for the world in which they live. It is imperative students leave school capable of reasoning, and understanding the importance of disciplined thinking. The concepts of a subject such as technology education are identified for the purpose of generating constructs which cuts across traditional skills and processes (Myrmel, 2003).

Teachers need to take the responsibility for initiating an evaluation and possible revision of what is taught with respect to the curriculum. This is important because successful practice in the classroom has been linked to curriculum and pedagogical development, which essentially dictates the everyday decision about what to teach and how to teach. In looking at curriculum evaluation, possible modifications include the examination of the framework within the technology education curriculum, where principals, school-board members, parents and educators are all key informants (Lewis, 1999). Educators would not be able to recognize the impact of such a change in the curriculum without a close-up examination of technology education programs, where data

collection would be required to validate changes. It is evident through multiple New York State assessments that educators already employ a technical design for the purpose of creating curriculum documents for local and state education departments. Departments that require those designs often utilize quite different curriculum processes for their own purpose of assessing and ranking school districts (Lewis, 1999).

Lewis (1999) and Hansen (1995) identified a structure for research in technology education. This structure specifically identified critical thinking and problem-solving skills as an area for future research in curriculum development practices. As state standards in education emphasize the importance of problem-solving abilities and critical thinking skills, educators are challenged to provide insight into best practices for creating and developing critical thinking skills.

This is particularly significant for a subject matter like technology education which is currently in a state of evolution, and thinking skills, which are often left as an abstract idea rather than as a sequenced set of skills. Learning about best ordering of units in a diversified curriculum design and process would result in a more informed technology educator, capable of making more accurate curriculum decisions about which technology education unit should be taught next based on more specific learning objects. Therefore, each instructor has a responsibility to his/her students to incorporate new methods and strategies and remain up to date with current studies regarding new areas of curriculum, particularly due to the fact that technology changes and evolves rapidly. If

students are not educated to thinking critically, they will be limited when it is their time to enter the workplace (Alexander, 2004).

Research has shown that technology educators rarely address an important part of their vocation (Hanson, 1995); designing and reorganizing material while reevaluating appropriate curricula and calculated implementation of such curriculum. Teachers need to continue to identify both curriculum planning practices and the means of teaching curriculum planning. This will improve teachers' abilities to implement the goals of technology education (Hanson, 1995).

Research on critical thinking skills, particularly in technology education, is not a new concept. Previous studies (Bae, 2006; Childress, 1994; Daniel, 2003; Gibbon, 2007; Gokhale, 1995; Hanson, 1995; Horvath, 2006; Jurdak, 2000; Lewis 1999; Molefe, 2004; Myrmel, 2003; Park, 2004; Palumbo & Palumbo, 1993; Ricca, Lulis, & Bade, 2006; Thode, 1997) in technology education have looked at factors associated with critical thinking and problem-solving skills. However, none of these studies addressed an implementation of standardized, strategically ordered, technology education units.

The purpose of this study, therefore, was to determine the ordered effect, if any, of using three problem-solving technology education units, specifically Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge, on the higher-order critical thinking skills of eighth-grade technology students. Furthermore, this study extends the contributions of a uniform eighth-grade technology education

curriculum with the use of problem-solving units to enhance critical thinking skills in eighth-grade students.

The current research suggests that there is a great need to increase the development of higher-order critical thinking skills. This study addressed a gap in the literature regarding curriculum planning in technology education and a standardized curriculum for the means of escalating higher-order critical thinking skills. Prior research made little distinction between curriculum design to enhance higher-order critical thinking skills and the order in which problem-solving units are implemented in the technology education curriculum. This study examines whether, and to what extent, changing the order in which three different technology education units are introduced, impacts students' learning of higher-order critical thinking skills.

Research Questions

The overarching research question which drove this study was:

What is the ordered effect of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skills of eighth grade technology students as measured by the Cornell Critical Thinking Test, Level X?

There are seven subquestions which provide more in-depth focus:

1. What is the ordered effect of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skill of *induction* as measured by the Cornell Critical Thinking Test, Level X?
2. What is the ordered effect of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skill of *observation* as measured by the Cornell Critical Thinking Test, Level X?
3. What is the ordered effect of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skill of *deduction* as measured by the Cornell Critical Thinking Test, Level X?
4. What is the ordered effect of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with Microsoft Windows Movie Maker, and the Marble Maze Challenge on the higher-order critical thinking skill of *assumption identification* as measured by the Cornell Critical Thinking Test, Level X?
5. Do the ordered effects of using the technology education units of Lego® Mindstorms™ NXT Robotics System, Digital Storytelling with