Engineering Design: A Facilitator for Science, Technology, Engineering, and Mathematics [STEM] Education

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I. Introduction

The significance of Science, Technology, Engineering, and Mathematics (STEM) education has increased from K-12 education to the national level. National science, mathematics, and technology education professional associations in the United States are united in their support for integrating STEM areas. The emergence of a variety of efforts to integrate STEM disciplines is quite noble for students, teaching experts, and the education environment. In other words, the importance and value of STEM education results from the needs of the learners, society, and government.

With rapid educational transitions, educational communities have endeavored to search for their unique strategies to establish the rationale for their disciplines. STEM education should also establish its rationale to have credibility and recognition from the public. To obtain a robust place in general education, STEM education should possess its methodology and pedagogy. Although many scholars in the field of STEM education have searched for its rationale to implement in general education, an exemplary method or strategy to implement STEM education has not been studied yet.

The Standards for Technological Literacy (International Technology Education Association [ITEA], 2000) publication addresses the centrality of design to implement technology education. Design has been considered the major problem-solving process of technological development. In
other words, technology education has been heavily involved in the problem solving process than other disciplines and technology educators have emphasized technological design activities as one major technology activity or methodology of technology education. Historically, these design activities have been one of the major methodologies or strategies in technology/engineering education. The Accreditation Board for Engineering and Technology (ABET) mentions that engineering design is “the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs” (2007, p. 21).

Recently, science education has become interested in design pedagogy and methodology. Science educators believe in the importance of design and technological literacy in the implementation of authentic science education. Benchmarks for Science Literacy describes the significance of design and the undeniable relationship between science and technology (American Association for the Advancement of Science [AAAS], 1993). Even though inquiry is the signature pedagogy of science education, science educators are beginning to employ design pedagogy in their science classes. Design is a form of problem solving in which thinking, tool manipulation, and materials are reflected in the construction of an artifact (Roth, 2001).

These recent trends of technology education and science education have led them both to employ a variety of design components such as engineering/technological design, design process, and design loop in their teaching implementations. For these reasons, pedagogical or methodological approaches that employ the design components in their teaching are most appropriate for the implementation of STEM education. This study employs the definition of STEM education as an integrative curriculum model that seeks to make connections among STEM disciplines through the use of open-ended and real world problems (Drake & Burns, 2004; Sanders, 2006; VT Technology Education, 2006). The definition focuses on the integrative characteristic of STEM education. It is possible that technological content and/or technological process based on hands-on activities play a significant role in integrating and connecting STEM areas. The purpose of this study is to investigate “What are key common topics identified and discussed in relevant literature associated with the integrative efforts among STEM disciplines?” This study introduces several characterized trends and cases of integrating STEM disciplines through reviewing relevant literature. To achieve the purpose of this study, the following specific research questions are established.

1) What is the key methodology and pedagogy presented in literature associated with the integrative efforts among STEM disciplines?
2) What are the significant benefits of using the design method for STEM education?

II. Research Procedure

This investigation was performed in two phases. One was the establishment of a research background for the main study and included a process of collecting relevant literature regarding the integration among STEM disciplines. This phase was conducted by two screening procedures.

The first step was to search for relevant literature from 1999 to 2008 through the Education Resources Information Center (ERIC) database as of 15 August 2009. The authors used various combinations of the following searching words through the library database of Virginia Polytechnic Institute and State University and Utah State University respectively: “integration”, “interdisciplinary”, “multidisciplinary”, “science”, “technology”, “engineering”, “mathematics”, “integrative efforts”, “STEM education”, “technological design”, “engineering design”, “scientific inquiry”, “integrated curriculum”,