Design Based Science – Selected Literature Review

November 16, 2013

John Heffernan
University of Massachusetts, Amherst

EDUC 738

Abstract

Although robotics has been identified as a promising way to increase STEM interest and also teach science concepts (Brophy, Portsmore, Klein, & Rogers, 2008), there is no research of student use of robotics in a sustained elementary program. The studies that do exist show promising results for short term robotics programs in middle and high school (Hynes, 2007; Sullivan, 2008). There are many studies that use design, engineering, or robotics as a way to teach science concepts. This literature review examines relevant papers on using design to teach science and engineering concepts. The goal of the review is to determine the most relevant theoretical frameworks and methodologies that can be used or modified in a longitudinal case study of elementary robotics students. A model for classifying the studies is presented. The studies uniformly use a constructivist, constructionist, and social constructivist approach. The studies vary in the age group studied, study methodologies, and the secondary goals of the instruction apart from the science focus. The studies report positive results but differ in their recommendations for instruction strategies. However, common themes are providing appropriate scaffolding to connect the design tasks to specific science concepts and processes.

Introduction

Although robotics has been identified as a promising way to increase STEM interest and also teach science concepts (Brophy et al., 2008), there is no research of student use of robotics in a sustained elementary program. The studies that do exist show promising results for short term robotics programs in middle and high school (Hynes, 2007; Sullivan, 2008). There are studies that use design, engineering, or robotics as a way to teach science concepts. This literature review examines relevant papers on using design to teach science and engineering concepts. The goal of the review is to determine the most relevant theoretical frameworks and methodologies that can be used or modified in a longitudinal case study of elementary robotics students. The research questions for this study are: 1) how do grade K to grade 6 elementary students' robotics engineering skills and processes change over time in terms of construction and programming techniques, (2) what changes in their techniques and processes can be seen over time that impact their ability to realize their design ideas? While these questions do not specifically look at the teaching of science concepts, a large body of design, engineering, and robotics research does look at science. What does that research tell us about the use of design to teach science? This literature review will be part of a larger dissertation review that includes a broader look at engineering and robotics education, not solely the use of engineering to teach science.

Methodology

I had already collected and read many papers on engineering and robotics education in preparation for my own research questions: 1) how do grade K to grade 6

elementary students' robotics engineering skills and processes change over time in terms of construction and programming techniques and 2) specifically, what changes in their techniques and processes can be seen over time that impact their ability to realize their design ideas? I further selected those having to do with the use of design, engineering, and robotics to teach science to match the topic for a graduate school class presentation. Note that for a dissertation or peer-reviewed paper, I would also use a search engine to ensure that no important papers were missed. I compared my list with a robotics literature review. I also cross-checked references for all papers noting any papers that were cited frequently or seemed relevant. Reading the robotics papers also led me to a series of papers that discuss the broader topic of research on the processes of design. Table 1 summarizes the papers.