Chapter 12
A Strategic Perspective on Using Symbolic Transformation in STEM Education:
Robotics and Automation

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ABSTRACT

This paper describes and implements an innovative model for teaching Science, Technology, Engineering and Mathematics (STEM) that enhances the decision making process of students considering a major or a career in STEM fields. The model can also be used as a decision making tool for educators interested in stressing the importance of STEM for career enhancement and for society as a whole. The model creates analogies and metaphors for various STEM topics using the contents of popular music videos. Theories of neuroscience, the interdisciplinary study of the nervous system, are used to describe and validate our decision making model. Concepts such as, embodied cognition, mirror neurons and the connection between emotion and cognition, are used to explain how the brain processes the information and multi-modal stimuli generated by our model. The model was implemented using the topic of automated decision processes in robotics and automation with a group of university and high school students and teachers. The impact of the model was evaluated using the National Science Foundation (NSF) frameworks for evaluating informal science projects. The results indicate that the model using symbolic transformation to teach STEM can have a significant impact on students' attitude towards STEM and the decision making process about their careers.

INTRODUCTION

In this paper, we propose an innovative educational model to enhance STEM learning. STEM is the acronym that refers to the disciplines of science, technology, engineering and mathematics. The model creates analogies for various STEM topics using the content of popular music videos including the lyrics of popular songs, still images, dance, other movements of humans and inanimate objects, facial expressions and the general motion pictures. Because the music can instill an emotional aspect to a presentation, our model is particularly innovative in its application to STEM topics that are not normally associated with emotions. The model can enhance the role of the imagination in the learning process and engage students with diverse academic and cultural backgrounds. We implement our model for the study of robotics and automation and measure its effectiveness using frameworks proposed for the evaluation of informal STEM projects. Most of the analogies presented in this paper as examples of our model are based upon robotics and automation topics, many with themes of fashion and dance.

As depicted in Figure 1, theories from the fields of education, psychology, philosophy, linguistics are cited to support our model. The theory of metaphor plays a central role in the theory of cognitive linguists. For example, George Lakoff (1989,1999) believed that all or nearly all thought is essentially metaphorical. Various writings dealing with the theory of art and communication theory study the cognitive significance of visual metaphors in works of art and other visual media.

In addition, we cite theories from the field of neuroscience and its allied disciplines, philosophy and psychology, to support our model. Researchers in these fields have studied embodied cognition and the embodied mind. They have argued that all aspects of cognition, including decision making, are shaped by aspects of the body. These physical aspects include the motor system and the perceptual system that are built into the brain and effect the body's interaction with the environment (Rosch, Thompson & Varela, 1991). In social and cognitive psychology, research on embodied cognition encompasses issues such as social interaction and decision-making (Borghi & Cimatti, 2010). This research supports the embodied cognition view that the motor system influences cognition, just as the mind influences bodily actions. Furthermore, Edelman (2004) and Damasio (1999) have outlined the connection between the body, individual structures in the brain and aspects of the mind such as consciousness, emotion, self-awareness and will.

Consequently, the study of neuroscience provides the basis for understanding how cognitive information is created by superimposing stimuli from various modes, semantic, visual, sensorimotor, and auditory. Lyrics from songs can be used to represent various aspects of robotic and manufacturing processes. Visual metaphors are also developed by aligning images from music videos with various aspects of robotic processes and automated systems. Motion from the music videos, like dance, can represent either real or animated motions of robotic or manufacturing processes. Some of the more technical aspects of robotics, such as coded commands and numerical/geometric models, are also represented by various forms of dance and visual metaphors.

Building on the concept of embodied cognition, neuroscience tells us that effective decision making is not possible without the motivation and meaning provided by emotional input. For example, Antonio Damasio had a patient who underwent neurosurgery for a tumor and lost the part of his brain connecting the frontal lobes, that control reason, with the emotions. Rather than this making the patient more rational, he became paralyzed by every decision in life. In other words, feelings provide an essential component of human decisions (Jarrett, 2014; Seth, 2014).

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