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.

KEYWORDS
Decision Making, Embodied Cognition, Metaphors, Mirror Neurons, Neuroscience, Robotics, STEM

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

Figure 1. Conceptual framework

- **NEUROSCIENCE**
  - study of the brain

- **COGNITIVE LINGUISTICS & PHILOSOPHY OF THE MIND**
  - COMPREHENSION OF METAPHORS
  - CONSTRUCTIVISM creating mental models from experiences & ideas

- **EDUCATIONAL THEORIES**
  - SOCIAL CONSTRUCTIONISM social relations & activities are critical

- **STEM TOPICS**
  - Verbal/semantic
  - Visual
  - Animation

- **STIMULI**
  - **EDUCATIONAL MODEL:** Creates analogies for STEM topics using the content of popular music videos
  - **OUTCOMES** with respect to STEM topics:
    - Comprehension
    - Retention
    - Attitude & Importance
    - Decision making and Judgement

- **MUSIC VIDEO CONTENT**
  - **STIMULI**
    - Verbal (lyrics)
    - Visual (images)
    - Sensorimotor (dance & other motion)
    - Auditory (music)
Understanding Non-Decision Making
www.igi-global.com/chapter/understanding-non-decision-making/11335?camid=4v1a

Mapping the Critical Links between Supply Chain Evaluation System and Supply Chain Integration Sustainability: An Empirical Study
www.igi-global.com/article/mapping-critical-links-between-supply/53024?camid=4v1a