Chapter 15
From Grade School to Grad School: An Integrated STEM Pipeline Model through Robotics

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ABSTRACT

The STEM pipeline is an often-used analogy for efforts to increase the number of people entering the critical areas of science, technology, engineering, and mathematics. The analogy references the attempt to get young students into the educational conduit and have them emerge from the other end as professionals with graduate and post-graduate degrees. Much like the trans-Alaskan pipeline that is 800 miles long and has 11 major pumping stations, the educational conduit needs to have its own entrance points and activities that keep the contents flowing. The authors present a model of a pipeline program based on the results of research work examining the impact of robotics competitions on students' self-perceptions for success in STEM. The model has a unique component of employing older students as informal role models along with formal adult mentors, providing a self-perpetuating cycle in the pipeline.

INTRODUCTION

I want to be on this robotics group because I think that girls should have a chance to do things that we wouldn't normally get to do. I also think that it would be really cool to do something like this without my brother, because I do almost everything with him. I also would like to do this because I think robots are pretty cool and I think that it would be fun to try it out. I have never done anything like this before, so I don't really know if I'm that good at it. — Isadora, 7th grade participant

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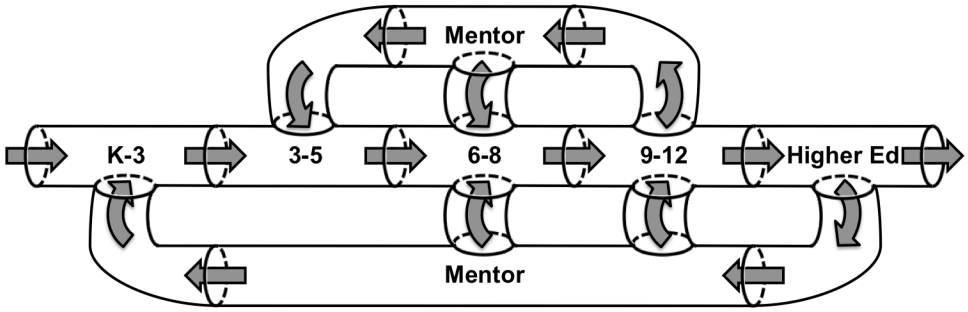
This essay was written to answer a call for participants from a middle school science teacher of a public school who was forming a team to compete in a robotics tournament. Isadora expressed exceptionally well the importance of hands-on engagement in creating a pipeline of students into STEM careers: "I have never done anything like this before, so I don't really know if I'm that good at it." Why do any of us choose to engage in the activities that we do? Particularly, how do we choose these activities at an early age when we begin to develop a self-image that leads to career choices? Our choices are based largely on our self-belief that we have an ability to be successful. We must have some idea or self-perception that we can succeed at the activities in which we engage. This is the essence of *self-efficacy*, a belief that we can successfully perform a behavior to achieve a desired outcome or goal (Bandura, 1977). Of course, we also must perceive that there is worth in attaining the goal. For children the sense of worth in a goal comes primarily from external influences, specifically recognition from parents, teachers, mentors, and peers. Self-efficacy and worthiness of goals are the two key components of *achievement-related choices*—choosing activities we feel we can attain and we find worth in attaining (for example, Eccles, 1994; Wigfield & Eccles, 2000).

How do we help Isadora believe that she has the ability and interest to be a successful person in a STEM career? From an achievement-related choices perspective, we create a series of STEM activities that engage her interest, develop her abilities and skills, provide opportunities for success, create a sense of future success, and support her interest through recognition. In this chapter, we describe how to develop this belief through a self-perpetuating robotics pipeline model that is a result of cooperation between K-12 and post-secondary educators. The effectiveness of such a robotics pipeline is supported by our own empirical studies of robotics activities and achievement-related choices.

The pipeline begins engagement of interest in the early grades (see Figure 1). Activities start to take on a deliberate educational focus at the "age of reason", the 6 to 8 year old range, where children begin to link their behaviors to their beliefs (Davis-Kean, Huesmann, Collins, Bates, & Lansford, 2008). The first hallmark of the pipeline is the recruitment of participation from one major point to the next. This creates a perpetuation of the pipeline. It also provides an important opportunity for children to envision future success. Children tend to watch people five to six years older than themselves and model their behavior (Jenkins, 2006). An example of this can be seen in the appeal of American Idol where 50% of the audience are 13 year olds watching 18 to 20 year olds (Hammack, 2010). This effect is an important component of the pipeline as younger children can observe the activities of role models just three to five years older than themselves.

Figure 1. Overview of the STEM pipeline



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