The standing offer of high pay, a high level of prestige, a high degree of autonomy, and great job security that accompanies STEM (science, technology, engineering, and math) careers is, surprisingly, not enough to draw the desired level of interest from today’s young people. As the innovators of the world, STEM professionals are essential to international economic success and to the future, and the current shortage merits significant concern. As a result, there has been a lot of research done about how to get more people interested in STEM, and how to encourage people to maintain their interest and go into a STEM career. Much of the focus of past research has been on STEM curriculums and programs in early education, encouraged by the notion that students need to be converted to STEM at an early age through exposure. However, there is increasingly more research on alternate ways to encourage STEM interest. These include cultural and psychological factors, the effects of project-based learning, and entirely different ways to approach the problem. This paper will discuss existing research within the field of STEM education, noting the ways in which the different studies support and contradict each other, and will also present several potential expansions that can help to more accurately describe the motivating factors that lead to STEM careers.

Early Exposure

Currently, the industry-standard strategy for encouraging people to pursue STEM careers is illustrated by the “pipeline metaphor.” The pipeline metaphor refers to a representation of a single path that students take to eventually become STEM professionals. The pipeline is wide at the beginning, encompassing a large group of students that could eventually enter the STEM workforce, and narrows toward the end as more students are lost to other careers. The consensus is that the best way to achieve the goal of more STEM professionals is to “patch the leaks,” by trying to stop people on the pathway to STEM careers from going a different direction, and “frontload,” or try to get as many people into the entrance of the pipeline as possible. The frontloading strategy, which is somewhat easier to achieve (and is therefore very common), encourages a concentration on early education, with the goal of getting as many students as possible interested in STEM at an early age. The logic goes that more students entering the “pipeline,” will mean more students eventually becoming STEM professionals. And this is a somewhat effective strategy. According to a study on the effect of high school STEM programs on STEM interest, conducted by University of Maryland’s April Bishop, “58.75% of the students in the STEM program aspired to STEM careers after high school compared to only 40.00% of students with similar academic achievement that were not in the STEM program. Students in the STEM program were 0.47 times more likely to aspire to STEM careers compared to their peers who did not participate in the STEM program” (Bishop, 2015).

In the same way that early exposure is thought to encourage STEM interest, primary and secondary school math ability and confidence also play a big role in a student’s decision to pursue STEM in college and as a career. According to a study conducted by Xueli Wang at the University of Wisconsin-Madison, “…intent to major in STEM is directly affected by 12th-grade math achievement, exposure to math and science courses, and math self-efficacy beliefs—all three subject to the influence of early achievement in and attitudes toward math” (Wang, 2013). Wang, too, concludes that early exposure is important to stimulating STEM interest, and adds to the discussion that math ability and confidence are also key. These ideas represent the baseline for STEM education research. Students who are exposed early, and are allowed to gain confidence in their math and science abilities, are able to identify with the STEM fields and are more likely to have the confidence to pursue their interests within STEM.

Positive Experiences

It seems an obvious conclusion that students who have the opportunity to become good at math and science will be more likely to maintain interest in math and science beyond high school. While this is helpful to know, and is a good place to start attacking the problem, a lot of alternative research has been done on other aspects of STEM motivation. A common theme in this research is the role of positive experiences and expectations. A study done at the University of Sargodha in Pakistan used a “structured questionnaire IRIS-Q…containing items regarding the influence of various factors for the choice of STEM subjects,” in order to address the question: what motivates students to pursue STEM degrees (Awan, Sarwar, Mehdi, Noureen, Anwar, 2017)? Among several factors that determine STEM interest, the study found that a student’s “school experience…experience as a student in the subject,” and “expectations of everyday life” play a significant role in their decision regarding whether or not to go into a STEM field (Awan, 2017). Another study, done at Rice University, addresses the importance of project-based learning, and concludes that: “engaging in at least one project‐based course during the first four semesters affected student perceptions of STEM skills, perceptions of the utility value of participating in STEM courses, and STEM career aspirations” (Beier, et al. 2018). Still another study, from Ball State University, examines the effect of podcasts on the interest level of middle school students in STEM, concluding that students who were exposed to STEM podcasts showed more interest in STEM compared to the control group, which was not exposed to STEM podcasts (Huelskamp, 2010). Grouped together, these three studies highlight the importance of positive experiences with STEM material, as well as positive examples of what STEM professionals do. Project-based learning, school experiences, and STEM podcasts all give students a picture of STEM careers. These careers require years of specialized training, and yet typically students get very few, if any, chances to see what a STEM career is really like. This means that students cling to the glimpses they do get of their potential future career – even if this is only through projects and podcasts. Positive expectations of everyday life can make all the difference in determining a student’s interest in STEM.

The Non-Traditional Half

In their study, Cannady, Greenwald, and Harris (2014) argue that the pipeline metaphor (the consensus way of thinking about motivating STEM interest) is inappropriate, and fails to describe the experience of about half of eventual STEM professionals. There is not a single path to STEM careers, but many different paths. This way of thinking about STEM education is a crucial step to understanding the true motivations behind students’ STEM interest. While this metaphor does, in the authors’ view, accurately illustrate some aspects of the pathway(s) to STEM careers (for example, the disparity between the number of high school students interested in STEM and the number of STEM professionals), its simplicity fails to describe integral qualities of the journey from middle and high school education to STEM careers. The authors contend that all metaphors must sacrifice some nuance for the sake of simplicity, but the fact that this is *the* metaphor misrepresents many of those that it looks to describe. Because of this, “…the pipeline metaphor has ill‐served policy makers who seek to improve the capacity and number of STEM professionals” (Cannady, Greenwald, & Harris, 2014).

The authors go on to note some specific problems that the pipeline metaphor presents: “First, it misleadingly suggests a universal and lock‐step trajectory toward STEM careers that fails to describe nearly half of all who end up in STEM careers; second, it obfuscates inquiry into a range of factors that decades of theory and research have established as critical to understanding the long and winding path toward a career,” noting further objections to the implications of this metaphor as the articles goes on (Cannady et al. , 2014). The article looks not to pick on the inherent inaccuracies of metaphors, but instead to productively find a better descriptor of STEM education experiences. The main questions that the authors address are: “(1)What proportion of scientists and engineers do not follow the traditional STEM pipeline to their career?, (2) Are those who do not follow the pipeline exceptions or are they a sizeable subset of the population that the metaphor fails to explain” (Cannady et al. , 2014)? These questions are important because if the pipeline metaphor fails to describe the experiences of a significant number of people, it misinforms policy-makers and leads to inefficient solutions to the shortage of STEM professionals. To find the answer to these questions, the authors use data from “The National Educational Longitudinal Study of the Eighth‐Grade Class of 1988 (NELS:88)… a data set that offers the most recent nationally representative sample of eighth graders,” and “…also includes postsecondary education and career outcomes data for these subjects” (Cannady et al. , 2014). Examining statistics on “eighth‐grade science or engineering career expectation (Tai et al., [2006](https://onlinelibrary-wiley-com.mutex.gmu.edu/doi/full/10.1002/sce.21108#sce21108-bib-0043)), earning credits in calculus while in high school (Adelman, [2006](https://onlinelibrary-wiley-com.mutex.gmu.edu/doi/full/10.1002/sce.21108#sce21108-bib-0001)), and intention to study a STEM field after high school while in 12th grade (Maltese & Tai, [2011](https://onlinelibrary-wiley-com.mutex.gmu.edu/doi/full/10.1002/sce.21108#sce21108-bib-0023)),” the authors found that a significant number (over fifty percent for some statistics) of students who went on to become STEM professionals did not fulfill all (or sometimes any) of the factors thought to accurately predict which students become STEM professionals (Cannady et al. , 2014). The authors, instead, suggest a new metaphor to represent the many pathways to STEM careers: the “pathway metaphor.”

What’s Missing

The current strategy of getting students interested in STEM early is an effective one. When young students are exposed to STEM, they gain familiarity and confidence that they may carry with them throughout their lives. But much more can be done to help those who miss the early bus. The pipeline metaphor all but ignores those who do not enter the pipeline as young students. These outliers are a huge, untapped resource that could be taken advantage of in order to encourage STEM interest.

The facilitating of positive experiences in STEM has been researched in specific ways, but the broader connection between these positive experiences has not been fully explored. Researchers know that things like listening to podcasts and project-based learning can encourage STEM interest, but there has been little to no research on what these experiences share. More research could be done to find what is at the core of these experiences, and the findings used to encourage “outlier students” to pursue STEM careers.

The stereotype of STEM students can be extremely counterproductive in terms of attracting more STEM interest. A big reason why it is important to expose young people to STEM is because it gives them the confidence to feel on the inside of the dividing wall that the STEM stereotype creates. But for those who do not fit the stereotype (which includes most people according to the Cannady study), the preconceptions about what it takes to make it in STEM act as a deterrent. Getting a STEM degree does require a lot of challenging work, but it does not require you to be a math prodigy. Most people would probably not be able to run a marathon at a moment’s notice. But, with the proper motivation and preparation, almost anyone could complete the twenty-six miles. STEM is no different. Although sometimes it may literally be rocket science, most people are capable of getting a degree in STEM. We need to find a way to fight the STEM stereotype so that more people can feel qualified to pursue STEM degrees and careers.

Similarly, math ability is an important predictor of STEM interest, but many students decide at an early age, due to poor test scores or poor teachers, that they just aren’t good at math. This is largely a myth, and although there are of course people who more easily grasp math concepts, most people are capable of understanding calculus. Math education has come a long way in recent years, as we now understand that students who may have difficulty with certain concepts in math are likely to find other concepts easier in relation to their peers; but more can be done to stop students from deciding they are simply incapable of understanding anything beyond the most basic math.

Furthermore, why should STEM even be treated, as it almost always is, as a group of indistinguishable fields? Science is different from technology is different from engineering is different from math. These fields, while they involve similar skillsets, are quite different from one another, especially when considering the motivations of those that pursue them. Separated from the rest of the world by the feared *mathematics*, STEM fields are thought to be basically the same. But in the same way that not all subjects that involve the English language (e.g. history, philosophy, and psychology) are the same, subjects that use the language of math can be extremely varied, and not just in trivial ways. Further research could be done on how to attract more students to each of these fields individually.

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