Problematizing the STEM Pipeline Metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce?

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Abstract

Researchers and policymakers often use the metaphor of an ever-narrowing pipeline to describe the trajectory to a science, technology, engineering or mathematics (STEM) degree or career. This study interrogates the appropriateness of the STEM pipeline as the dominant frame for understanding and making policies related to STEM career trajectories.

Our review of pertinent literature and independent analysis of data from the National Educational Longitudinal Study of 1988 finds that the trajectory implied by the pipeline metaphor fails to describe the experience for nearly half of those who go on to become scientists or engineers, masks meaningful differences in trajectories by sub-field, and informs policies which do little to diversify or increase the size of the STEM workforce.

We suggest a pathway metaphor to better illuminate the multiple trajectories toward STEM degrees and careers and present four composite trajectories as useful categories for the individual paths taken by STEM graduates and career entrants.

A Composite Approach

Nearly two thirds of college graduates never expressed an interest in STEM careers prior to entering college and three quarters did not take calculus. Approximately 1 in 5 students both expressed an interest in pursuing STEM in college and took HS Calculus.

Proportion of College Graduates per Composite

Critiques of the Pipeline Metaphor

Signal to Noise: Inconsistent, Unnecessary and Non-Linear Benchmarks
As a monolithic framework, there is inherent trade-off between the specificity of the benchmark criteria included in the pipeline trajectory and the proportion of STEM professionals it includes. This results in a pipeline trajectory that is either too general to distinguish those who become scientists or engineers from the rest of the population or too specific to explain the experiences of a great many STEM professionals.

Narrow and Fixed Outcome
Career fields in STEM are rapidly changing. Therefore, models derived from the path followed by current STEM professionals may not offer a useful template for future STEM professionals.

Assumed Uniformity of Experiences
With only a pipeline and a drain, the model suggests that all experiences along the pipeline are the same for all individuals. This leads to assumptions such as the view that all academically motivated students should be in STEM and that all those who do not take a particular course are not academically motivated enough for STEM.

Failure to Consider Career Choice in Context
The metaphor does not account for lived experiences outside of career and education. It can only sufficiently explain how a subset of the population advance through the process of becoming a scientist or engineer: those who are able to prioritize academic and career decisions over other life course events and decisions.

Questionable Policy Prescriptions
Research finds little evidence that simply mandating more students to pass through a particular gatekeeper at a prescribed time improves the likelihood that an individual will follow a STEM career trajectory.

Next Steps

The research presented here includes tentative findings suggested by our initial analyses. We will continue testing and refining these findings with additional passes through the data. Once we are satisfied with the validity of our findings, we will begin to systematically consider their implications for future researchers and policymakers.

Beyond our current study, we see several follow up investigations that would extend the work. First, a qualitative study of life history data could be used to identify further similarities within composites and differences between them. We are also interested in expanding this work to include STEM careers beyond science or engineering. Further, it would be interesting to examine cases of those who were on a pathway, as we have defined them, but who did not end up in a STEM career. Such a study would offer important insights into some of the impediments and detours along the pathway. Finally, we would like to revisit these analyses using the newer ELS:2002 data to learn what has changed in the generational change from gen X to millennials.

Research Design & Methods

We began by reviewing the literature both consistent with and critical of the STEM pipeline metaphor. This process yielded a recognition of the narrow utility of the pipeline metaphor and its reliance on a series of testable assumptions.

We then took a thorough review of relevant literature to identify important predictors of entering a career in STEM. From this review, we settled on three variables that were both widely reported and tractable using the NELS:88 database: early (8th grade) interest in STEM as a career, intent to major in a STEM field by 12th grade, and completion of Calculus in high school. There are eight possible combinations for these three variables. We then determined the percentages of scientists and engineers in the NELS:88 database who met the criteria for each of the eight possible combinations to a STEM career. We then found that key similarities between some of the combinations warranted collapsing them down to four pathway composites.

This process revealed that rather than a single pipeline sufficient to describe the trajectory of individuals to careers in STEM fields, there are, in fact, many different experiences. At the same time, those experiences may be usefully combined into four pathway composites.

Sankey Diagram: Composites through Degrees to Career

The majority of the Scientists and Engineers earned physical science degrees. The majority of those earning physical science degrees had both an early interest in pursuing either a STEM major or a science or engineering career. Many of those who earned degrees in the life sciences went on to work in medical professions. Most graduates with high school science degrees did not complete a high school calculus course.