

The Curmudgeon Counterexample

Seeking Sustainable STEM Transformation

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Abstract—When it comes to evidence-based practices (EBPs) such as interactive engagement, collaborative problem solving, and project-based learning, the proof is in the name. These pedagogies are called "evidence-based" because there is little conflicting evidence about their efficacy. Yet, discipline-based education research still tends to focus on students' outcomes from EBPs, rather than on how to successfully sustain the use of those EBPs. Because of students' transient engagement with STEM higher education (i.e., a four- to five-year window), STEM education reformers should not rely on them as the primary change agents for sustained transformation of the culture in STEM fields, especially when instructors can spend decades in the STEM higher education context and touch the lives of thousands of students. That is, rather than asking about students' outcomes from EBPs, the truly transformative questions are a) given all of the evidence that EBPs are effective, why are so many instructors still unwilling to abandon straight didactic lecture, and b) why are EBP-supportive instructors still referred to as the "choir," rather than the norm? This work-in-progress begins with the hypothesis that instructors' own mental processes around teaching and learning may be the most important and least explored aspects of the slow progress in transforming the culture in STEM fields. Through the development of a brief (less than 15 question) survey, this work seeks to answer three important questions related to why instructors choose to implement EBPs (or not) in their teaching: 1. What psychological attributes correlate with sustained implementation of EBPs? 2. Are there "counterexample" instructors who successfully implement EBPs when their psychological attributes predict that they would not? 3. What factors contribute to counterexample instructors' success in implementing EBPs? By drawing out themes from the answers to these questions, this work proposes to operationalize instructors' experiences into actionable methods of helping reluctant instructors with higher psychological tolls for implementing EBPs overcome those tolls.

Keywords—*faculty survey, STEM culture, evidence-based practices, sustainable change*

I. BACKGROUND AND MOTIVATION

In my own graduate and postdoctoral research, I have focused on students. How does interactive engagement affect engineering students' learning outcomes? What aspects of an engineering course are most important in motivating engineering students to persist? Do female students and students from historically underrepresented groups (HUGs) benefit more than white male students from collaborative problem solving in introductory science courses? While these

are all important questions to ask, they neglect a vital component of the overall picture—the instructor.

When it comes to evidence-based practices (EBPs) such as interactive engagement, collaborative problem solving, and project-based learning, the proof is in the name. These pedagogies are called "evidence-based" because there is little conflicting evidence about their efficacy. We know that EBPs benefit students. We know that EBPs narrow the science achievement gap between white men and women/HUGs/etc. We know that context matters very little; that is, EBPs work at small, large, rural, urban, public, private, US, and international institutions. Yet, discipline-based education research continues to focus on students—on their experiences in single courses that are taught for a single semester by instructors with little institutional incentive to continue using EBPs in their teaching practice.

With this proposed project, I want to refocus to the instructor. Given all of the evidence that EBPs are effective, why are so many instructors still unwilling to abandon straight didactic lecture? Why are EBP-supportive instructors still referred to as the "choir," rather than the norm? My colleagues and I note that when instructors set out to incorporate EBPs into their courses, they face a slew of barriers; these include time sinks, financial costs, political taxes, and psychological tolls [1]. Although many instructors willingly discuss the time and resources necessary to overhaul a course or even "the way things have always been done in the department" as reasons why they have not adopted EBPs, few instructors bring up their own mental process around teaching and learning as a contributing factor. Thus, the least studied of these common barriers are the psychological tolls.

With psychological tolls in mind, I seek to answer three important questions related to why instructors choose to implement EBPs (or not) in their teaching:

- What psychological attributes correlate with sustained implementation of EBPs?
- Are there "counterexample" instructors who successfully implement EBPs when their psychological attributes predict that they would not?
- What factors contribute to counterexample instructors' success in implementing EBPs?

II. PROPOSED METHOD

Because this project is a work in progress, I will describe the proposed method by the research question to be answered. The three research questions build from the results of each previous question and culminate in generating actionable possibilities for sustainable change to STEM culture.

A. *What psychological attributes correlate with sustained implementation of EBPs?*

During the first phase of the proposed project, researchers will create a survey that includes measures of a) fixed versus growth mindset, b) authoritarianism, c) internal versus external locus of control, and d) self-reported teaching behaviors. To obtain a large, diverse sample of instructors, participant solicitation should focus on large, public institutions in the Midwest where instructors are less likely to be from liberal, economically-privileged backgrounds. This proposed project could be linked with an upcoming effort within the Association of American Universities (AAU) to investigate how grant-funded education reform efforts are supported and sustained across institutions. In particular, a focus on some of the larger AAU member institutions such as the University of Illinois at Urbana-Champaign, the University of Missouri, and the University of Michigan would likely result in a sufficient sample population. Survey responses must be identity-linked to facilitate the ability to follow up with specific participants (See Section II.C.). Once survey data collection is complete, researchers will look for correlations between instructors' teaching behaviors and the three psychological measures. Any correlations will provide the baseline in seeking counterexamples.

B. *Are there "counterexample" instructors who successfully implement EBPs when their psychological attributes predict that they would not?*

Researchers will look for counterexamples within each of the psychological measures individually and using all combinations of the three. For example, if a growth mindset correlates positively with EBP teaching behaviors, does authoritarianism mitigate or enhance that correlation? Most notably, any instructors who are predicted not to implement EBPs on all three psychological measures, but self-report some amount of EBP teaching behaviors regardless will be earmarked so that researchers can contact them—the "counterexample" instructors—to gather more information about their success.

C. *What factors contribute to counterexample instructors' success in implementing EBPs?*

Once survey data analysis is complete, researchers will interview counterexample instructors about their teaching behaviors, beliefs about teaching, and how they experienced their journey to their present teaching practice. Themes drawn from these more robust qualitative data could then be operationalized into actionable methods of helping reluctant instructors with higher psychological tolls for implementing EBPs overcome those tolls. For example, if casual water cooler conversations commonly played a key role in counterexample instructors' adoption of EBPs, then STEM education reformers could develop resources that would provide specific talking

points to instructors who might find themselves involved in such conversations. Through exploration of the lived experience of counterexample instructors, all variety of change agents could have a toolbox of demonstrated transformative interventions rather than placing all hope in numerical student outcomes as the impetus for cultural change in STEM fields.

III. RESOURCES FOR FACULTY SURVEY DESIGN

Decades of research on mindset, authoritarianism, and locus of control have generated a plethora of measures for use in a variety of different contexts. I make recommendations for the design of the faculty survey discussed in Section II.A. based on the context of an instructor teaching undergraduate students.

A. *Fixed Versus Growth Mindset*

Questions that cue mindset generally use respondents' perceptions of "intelligence" or "talent" to understand their particular location on the "fixed-versus-growth" continuum. A 16-question survey can be found on Carol Dweck's mindset website [2], and these questions are further distilled into just three questions in the PERTS Growth Mindset Assessment [3]. These three questions ask respondents to indicate their level of agreement with the following statements:

- *You can learn new things, but you can't really change your basic intelligence.*
- *Your intelligence is something about you that you can't change very much.*
- *You have a certain amount of intelligence and you really can't do much to change it.*

Although there are other mindset measures available, for the faculty survey, I recommend using some variation of either Dweck's "Test Your Mindset" measure or the PERTS questions because of their simplicity and popularity (i.e., having many past responses from many different populations to compare to). However, rather than a 6-point Likert scale, I recommend using a 4-point Likert scale or even a True/False format to simplify the response for already overextended faculty for whom the difference between a 5-minute and a 15-minute survey may be significant.

B. *Authoritarianism*

A well-known measure of authoritarianism, particularly in relation to social and political beliefs, is the Right-Wing Authoritarianism (RWA) Scale developed by Bob Altemeyer [4]. However, many of the questions included in this scale are strongly worded and may evoke defensiveness or unproductive negativity in relation to the rest of the faculty survey. For example, "There is absolutely nothing wrong with nudist camps" or "Women should have to promise to obey their husbands when they get married" may be straying too far from the intended purpose of the faculty survey in relationship to authoritarianism.

To reduce the possibility of defensiveness and make the survey relatable to a larger audience of respondents, using beliefs about childrearing and children may prove more fruitful. I recommend using the following question made up of four items developed by Karen Stenner [5]:

Although there are a number of qualities that people feel that children should have, every person thinks that some are more important than others. Please indicate which one you think is more important for a child to have:

- *Independence OR Respect for Elders*
- *Curiosity OR Good Manners*
- *Obedience OR Self-Reliance*
- *Being Considerate OR Well-Behaved*

C. Internal Versus External Locus of Control

The seminal work on the concept of locus of control was undertaken by Julian Rotter in 1966 [6]. He developed a 23-item measure of whether an individual has an internal (within one's own control) or external (outside of one's own control) locus of control which has been generalized to and modified for a variety of contexts. One such modification is the Teacher Locus of Control Scale [7]. Although the measure was originally designed for elementary school teachers, some of the questions in the Teacher Locus of Control Scale are directly applicable to instructors at the college level. For example:

- *When the grades of your students improve, it is more likely:*
 - *Because you found ways to motivate the students, or*
 - *Because the students were trying harder to do well.*
- *When a student gets a better grade on their report card than they usually get, it is:*
 - *Because the student was putting more effort into his schoolwork, or*
 - *Because you found a better way of teaching that student.*
- *If you couldn't keep your class quiet, it would probably be:*
 - *Because the students came to school more rowdy than usual, or*
 - *Because you were so frustrated that you weren't able to settle them down.*

If some of these types of questions were modified for the higher education context and validated for use with faculty, they could reveal a more instruction-targeted view into faculty beliefs about their locus of control than some of the more general measures of the construct.

D. Self-Reported Teaching Behaviors

Any survey can fall prey to the perils of confirmation bias, and a survey about teaching behaviors, particularly when asking about didactic lecture or inclusivity, is no different. To mitigate confirmation bias based on the connotation of terms like "traditional lecture" or "active learning," I recommend using positively-worded questions such as those included in the AAU Faculty Survey as a part of their Undergraduate STEM Education Initiative [8]. Each of the following questions asks instructors to indicate how descriptive the statement is of their teaching practice:

- *I guide students through major course topics as they listen and take notes.*
- *I frequently ask students to respond to questions during class.*
- *I structure class so that students regularly talk to one another about course concepts.*
- *I require students to work together in small groups.*

These questions illustrate progressively more active teaching behaviors (lecturing, asking questions, facilitating discussion, small group work) without making any of the behaviors sound particularly undesirable or more correct than any other.

Any variation on these types of questions would likely yield useful information about respondents' teaching behaviors. For ease of response, a slider to indicate the percentage of class time spent on a particular activity might replace the 4-point Likert scale of "descriptiveness" used in the AAU Faculty Survey.

IV. FUTURE WORK

Finalizing the questions to be included and piloting the resulting faculty survey are the first steps toward a better understanding of the psychological tolls that instructors face in relation to STEM education reform and how said tolls can be overcome. Any researchers interested in using this proposal as a jumping-off point are encouraged to do so, preferably using the FIE community as a collaboration hub.

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