# Model-Eliciting Activities for Promoting Diversity & Inclusion

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## Abstract

This research-in-progress focuses on examining how diversity and inclusion (D&I) can be integrated into one or more assignments in a required first-year engineering course. The method of integration will be through model-eliciting activities (MEAs). MEAs are realistic problems that require student teams to develop a mathematical model as a procedure or process as a solution. The MEA facilitates high-order thinking through collaborative discussions, creative problem-solving and development of conceptual understandings in real-world contexts. In this paper, we begin to explore how first-year engineering students can better empathize with those that are different and appreciate the benefits of diversity and inclusion through a new type of MEA that necessitate the consideration of D&I within their solutions (D&I-MEAs). We will first survey students about their initial thoughts on a particular D&I issue related to their forthcoming D&I-MEA intervention. During the intervention, students will be asked to assist a hypothetical technology company in solving a D&I related problem that includes D&I. Our overarching hypothesis is that by reaching students early in their college education, they can become aware of such issues and help improve the campus social climate. To assess the effectiveness of the D&I-MEAs and identify areas for improvement, pre- and post-surveys will be administered.

Keywords: MEA, model-eliciting activity, diversity, inclusion, social climate

## Introduction

The American Society of Engineering Education (ASEE) has awarded Auburn University the 2019 Bronze Award and Exemplar for its efforts in promoting the ASEE Diversity and Inclusion (D&I) Initiative, which is aimed at increasing the diversity and inclusiveness of the engineering student body and faculty. Auburn's 2020 D&I efforts will be focused on: (1) inclusive class assignments, (2) social climate, (3) childcare for students, and (4) support for non-native English speakers. In regard to our focus on *inclusive class assignments*, this research-in-progress examines how diversity and inclusion might be integrated into one or more assignments in an early STEM course. The type of engineering course we are considering for this D&I intervention is a required first-year engineering course. The first-year of college is advantageous for D&I awareness and appreciation for improving the *social climate* on campus. Not only is there a disparity in the number of underserved and underrepresented students that choose to begin a STEM major [1, 2], there is also a disparity in the reasons why they choose to leave the STEM major [3, 4]. In both cases, the perceived social climate plays a significant role in recruitment and retention [3, 4]. That is, the difficulty of STEM courses can increase while a sense of belonging or acceptance can decrease, which can affect students academic performance as well as their persistence in their STEM program [5]. However, highly-performing students have also been reported to leave STEM due to social climate [5].

Prior efforts to address D&I in STEM include the use of MEAs has been promoted as a tool limited to use by researchers and practitioners to investigate upper K-12 and first-year college students' learning, thinking, and assessment [6,7]. A means to diagnose and identify highly-gifted and creative students [7,8]. Encourage students to solve real-world problems with mathematical models [7].

What is unique about our method of integrating D&I awareness and appreciation into the collegiate climate is its seamless integration into STEM curriculum. That is, instead of focusing solely on educating the faculty, as usual, we focus on educating the students. To eliminate the sense of giving extra work to the students, D&I is strategically integrated into their class assignments. And to eliminate the burden of coming up with new problems for different courses, we are designing novel model-eliciting activities (MEAs), which can be used as a variety of courses or disciplines. That is, MEAs are open problems that require student teams to develop procedures or processes to solve the problem [9]. Each team's procedure may be different because MEAs allow students to use multiple representations. As defined by Lesh and Doerr (2003), the ability of the student to represent concepts through five different categories of representation and the ability of the student to translate between and within representational forms emphasizes understanding of concepts. The Lesh Translation Model (Figure 1) represents student understanding of conceptual mathematical knowledge [6]. It consists of five nodes, each node is one category of representation: (1) Representation through Realistic, Real-World, or Experienced Contexts, (2) Symbolic Representation, (3) Language Representation, (4) Pictorial Representation, and (5) Representation with Manipulatives (concrete, hands-on models).

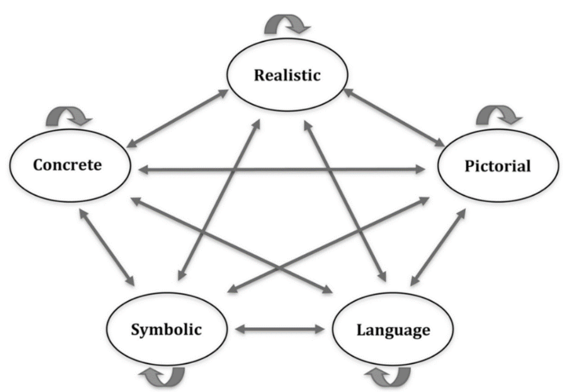


**Figure 1:** The Lesh Translation Model.

Another benefit of using MEAs for D&I is that MEAs facilitate high-order thinking through collaborative discussions, creative problem-solving, and developing conceptual understandings in real-world contexts [9]. Such a challenge requires students to focus on D&I issues in an engineering context, which is likely to be at a level and internalization that students have yet to experience. Often, issues of D&I are presented in a way that is not personalized, significant, or in a way that challenges the student to solve a problem in an area that they are passionate about.

This work in progress investigates how first-year engineering students can better empathize with those that are different then they are, or by appreciating the benefits of diversity and inclusion, through MEAs that necessitate the consideration of D&I within their solutions. These new types of diversity and inclusion model-eliciting activities will be referred to as D&I-MEAs. It appears that this effort is the first of its kind that uses MEAs to bring about socio-cultural change or awareness. In the methods section, we will describe our first D&I-MEA and its corresponding pre- and post-surveys that will be used for assessment. Since we have just obtained IRB approval, data will be collected, analyzed, and published at a later date. In this paper, we present our experimental procedure for the purposes of feedback from the engineering-education and psychology communities.

## Theoretical Framework

The role of modeling is fundamental in engineering. Modeling, at its core, is mathematical. The models and modeling perspective (MMP)[6], a theoretical construct, posits that modeling is an iterative, designed based process that is essential to the STEM disciplines. Researchers who work within the theoretical framework of models and modeling take a broad view of modeling. A model is a system that explains, describes, or represents another system and has elements, operations, and relations that allow for logical relationships to emerge. Many times, a model is not sufficient to completely describe the system it represents, but, if it is useful, it closely approximates the system without being unnecessarily complex [10]. Well-developed modeling activities involve problematic situations that "are defined to be goal-directed activities in which adaptations need to be made in existing ways of thinking about givens, goals, and possible procedural steps", p. 319 [11]. The MMP offers Modeling-Eliciting Activities as one potential research and instructional tool to address this critical issue of modeling in STEM disciplines.

## Methodology

Since this is the first time that MEAs are being proposed to enact sociocultural awareness or change, we begin by developing a method to test its feasibility. We do this by first creating an initial D&I-MEA and corresponding survey for assessment. By definition, an MEA is a realistic, client-driven problem that is inherently interdisciplinary and requires student teams to develop a mathematical model of a client procedure/product for a given problem [9]. MEAs facilitate learning by developing students' conceptual understandings and sense-making of data in real-world contexts. MEAs are model-eliciting in that they require students to mathematize (e.g., quantify) information in context to develop a mathematical model as a procedure/product [9]. MEAs are thought-revealing in that they provide student teams an opportunity to self-reflect and provide teachers a window into students' thinking during solution development. Six principles guide the development of MEAs [9]: 1. Model construction – a math model of a procedure/product, 2. Realistic context – an authentic STEM-related problem, 3. Self-assessment – an opportunity for student teams to self-assess the usefulness of the model, 4. Model documentation – a procedure/product description, 5. Model shareability and reusability – shareability and reusability for similar purposes, 6. A useful learning prototype – a globally generalizable or modifiable procedure/prototype.

To create an MEA that integrates issues concerning diversity or inclusion, i.e. a D&I-MEA, we propose adding a seventh criterion: 7. D&I – the problem or solution relies on an issue that is unique to an underrepresented group. To assess the feasibility of a D&I-MEA for enacting social-cultural awareness or change, we propose to compare the differences between pre- and post-surveys given to a significant number of students. The pre- and post-surveys will have nearly the same questions requiring both quantitative and qualitative responses. Results of the survey should reveal the portion of students that were pre-aware, newly-aware, unperturbed, and by how much. A t-test will be used to determine if the survey results due to the D&I-MEA are statistically significant. An example of D&I-MEA and survey is given below.

## Diversity & Inclusion Model-Eliciting Activity

Using the seven principles, the following diversity and inclusion model-eliciting activity (D&I-MEA) demonstrates how such an activity might be used to bring awareness of the disparity and need for a greater number of women in STEM (science, technology, engineering, and mathematics).

> **D&I-MEA**
> Dear Colleague, a team of technology leaders is launching an organization called *FEES*, which stands for the *Foundation of Equality and Equity in STEM*. The goal of the organization is to study significant issues concerning the lack of equality and equity in STEM and how such issues affect the rate of human advancement and global prosperity. For our initial study, we would like to develop a model that can be used to predict the societal-scale impact of increasing the number of women in STEM to that of men. We would like to commission your team to create such a model. For situational awareness, your team should begin by identifying who was: the first computer programmer; the first to contemplate artificial intelligence; the first to determine the structure of DNA; the first to figure out how to measure the distance between stars; and the gender that created agriculture, which is responsible for launching civilization. In developing your model, your modeling parameters should likely consider the relationship between GDP (gross domestic product) and the number of STEM professionals; the percentage of women in STEM; the number of additional women that would need to enter into the STEM profession to match that of men; and the increase in GDP if such matching were to occur. Please document your modeling procedure and describe your modeling assumptions.

As required, this client-driven D&I-MEA is realistic, it poses a problem that is inherently interdisciplinary, and it elicits the development of a reusable mathematical model. The D&I-MEA incorporates the six conventional principles plus our new seventh D&I principle. To assess the effectiveness of the D&I-MEA, we plan to compare student surveys taken before seeing the D&I-MEA and after completing the D&I-MEA. A measure of its effectiveness is the statistical significance between the pre- and post-surveys based on a t-test. The main difference between the pre and post surveys is that the post-survey includes added demographic data. Besides untraceable student identifiers, student surveys will be otherwise anonymous. Tentative survey questions follow, where questions 1-6 will appear on both surveys, while questions a-e only appear on the post-survey. To assess students' personal knowledge, the students are to take the surveys individually (not as a team) and without the aid of the Internet or notes. Tentative pre- and post-survey questions include: 1. New innovations have a tendency to create new jobs: Strongly agree ... Not at all, 2. What percent of STEM professionals are women? 10, 20, 30, 40, 50%, 3. Estimate the increase in innovations/year if women in STEM increased to that of men?

25, 50, 100, 150, 200%, 4. If the number of women in STEM were increased to that of men, jobs would increase? Strongly agree ... Not at all, 5. Name five STEM contributions that women have made that impact your life? 6. Is it important to attract more women into STEM? Strongly agree ... Not at all, 6. What is your gender? 7. Which ethnicity do you identify with? 8. Do you have any female relatives that are in STEM? Yes, No. , 9. Do you have any male relatives that are in STEM? Yes, No, 10. Which females in STEM do you most admire and why?

## Summary

This work-in-progress describes the development of a first D&I-MEA to promote awareness of diversity and inclusion through problem solving. Compared to traditional MEAs, D&I-MEAs have the potential to ease learning STEM and educate students about the importance of D&I. Diversity and inclusive teaching is essential for preparing civically engaged students who recognize the contributions of all people and understand the importance of embracing differences. This project proposes a solution that will help students actively practice diversity and inclusion.

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