STEM-Attraction through Model-Eliciting Activities

Q. M. Clark [1] and J. V. Clark [2]
[1] *Purdue University,* [2] *Auburn University, USA*

Abstract

This research-in-progress proposes factors that can help elementary students develop an affinity for STEM, in particular, consider future careers in STEM. We propose that this can be done by finding out what activities and careers students are already attracted to, why they are attracted to such activities and careers, and then integrate those attractors into a new type of model-eliciting activity. A traditional MEA is a realistic problem that requires student teams to develop a mathematical model (procedure) as a product. The process facilitates deep learning through discussions, creative problem-solving, development of conceptual understandings, and sense-making of data in real-world contexts. The major difference is that in a STEM-attraction MEA (SA-MEA), the student is both the client and contractor, where the student role-plays being a future STEM professional that envisions new technology to creatively solve a problem that the student identifies in the activity or career they are presently attracted to. To accommodate the vast variety of activities or careers that students are attracted to, we are developing open MEA problems, where students fill-in-the-blanks to customize the MEA to their unique activity. Although each SA-MEAs can be highly individualized. Our research question is: How can the use of integrated STEM modeling activities attract students to STEM careers? To assess our research questions, pre- and post- surveys are proposed.

Keywords: MEA, model-eliciting activity, STEM attraction, SA-MEA

I. Introduction

Studies show that by middle school many students have settled into a career direction that becomes more and more difficult to change as they age [1]. By the time students leave high school, 93% of them will not go on to major in STEM [2]. Over the last few decades, there have been numerous efforts from the National Science Foundation (NSF) and the Department of Education (DoED) to increase STEM attraction and STEM retention. The reason why is because a nation's prosperity and global stature rely primarily on its level of STEM-related activities and advancements. Although most students are fascinated by STEM, most students have not been shown how STEM can be a viable career option. Studies show that most students have settled into a particular non-STEM career path around the fourth grade [3]. Such early career-path settling influences which types of scholastic topics interest them, causing students to unwittingly think of math and science as unrelated or unnecessary. Therefore, it appears that it is imperative to introduce and attract students to STEM as a viable career option early in their education.
To engage students with STEM as a viable career option, we propose the use of modified model-eliciting activities (MEAs) that promote STEM attraction. Traditionally, an MEA is a realistic problem from a hypothetical or real client that requires a student team to develop a mathematical model as a procedure [4]. The MEA process facilitates deep learning through discussions, creative problem-solving, developing conceptual understandings, and sense-making of data in real-world contexts. Previously, 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 [4,5]; a means to diagnose and identify highly-gifted and creative students [4,6]; and to encourage students to solve real-world problems with mathematical models [4].

In this effort, we propose the development of a new type of MEA that is designed to make the field of STEM attractive for young students. Since different students are unlikely to be attracted to the same things and for the same reasons, we will use an open MEA that enables students to customize the MEA by filling in the blanks with their own choices. This will help ensure that the student will be working on an MEA that is based on an activity or career that they are already attracted to. The second modification of the MEA involves associating the student's attraction to STEM. This will be done by eliciting the student to use STEM to greatly improve the activity or career that they are attracted to. In Section II we discuss our tentative open SA-MEA, in Section III we discuss our tentative survey to test the effectiveness of the SA-MEA.

II. STEM Attraction Model-Eliciting Activity (SA-MEA)

We define an open model-eliciting activity as an MEA that allows users to edit parts of the MEA problem to their preference. In our open MEA presented below, users are invited to edit names and subject matter, but users cannot modify the problem's activity. Our STEM attraction MEA may be applied to a student's preferred career or activity. To simplify our description, we will use the 'career' in place of 'career or activity.' Our open MEAs will be focused on attracting students to STEM by having students use STEM to greatly improve a career choice that they are already attracted to. That is, instead of applying STEM to an arbitrary subject matter that may not interest or attract the student (as is commonly done), the student will be guided to strategically apply STEM to a career that they are actually interested in. In addition, the student will be using STEM to improve their preferred career by solving a problem that they have identified in that career. That is, a SA-MEA activity is deeply personal and immersive, where the student reveals their current career choice, then identifies a perceived problem in that career, then creates their own STEM-related solution to address that problem, and then imagines themselves as a future STEM-professional that finally solves that problem. Such activity is also meant to convey to the student the power of change one person can have through the creative use of STEM.

Our hypothesis is that if students can demonstrate for themselves how STEM can be used to make their preferred career choice more likable, then they will associate that increased likability to STEM. Qualities commonly associated with STEM professionals may also be integrated into the SA-MEA problem, such as an upper-class income level and lifestyle; treated with respect and admiration; a sense of helping others, making a societal impact, or creating a legacy; and greater opportunities for employment, upward mobility, or entrepreneurship.

Due to the interactive editing of SA-MEAs, they are amenable to being administered online as can be seen from an example SA-MEA provided below. Here, a student enters their name, grade level, career choice, and a perceived problem with the career. Thereafter, a SA-MEA is presented to the student that integrates their personal information as follows: Your name: *Jenae Johnson* (role player); Your grade level: 6 (future self), A career you might like: *police officer* (attractor); and the biggest problem in that career: *school shootings* (problem to solve). Based on student's data entry a personalized SA-MEA is generated, which might read: Dear Dr. *Jenae*

Johnson, this is Alice Stone and I work for a company that makes products for anyone that is a *police officer*. We've been in business since 2030. Your name was given to us by your college roommate. They told us that when you were a kid you wanted to become a *police officer* when you grew up, but you later decided that STEM was more interesting. So, after high school, you went on to college and majored in STEM. Now that you have a STEM degree, you now have the ability to create new technologies that most others can only dream about. Your college roommate said that you told them about a problem that needs to be solved for those that become a *police officer*, which was *school shootings*. Unfortunately, that problem still exists today. It is about time we solve that problem. We wonder if STEM can be used to solve the problem. So, we would like to pay you to use your creativity to create a new STEM idea to solve that problem. We will also pay you each time we sell your idea, which could be worth millions. Please describe your idea and mention what is saved by your solution. Also, present a mathematical model that determines what your solution saves over the next 20 years.

It can be seen that this open SA-MEA template elicits an activity that is general enough to accommodate a wide variety of different career choices and problem areas. The above SA-MEA has also been designed to adhere to the six traditional MEA principles [7], which are (1) elicits the construction of a mathematical model of a procedure/product; (2) is realistic in the context of an authentic STEM-related problem; (3) provides an opportunity for student teams to self-assess the usefulness of the model; (4) results in a documented description of the procedure/product; (5) requires that the model be shareable and reusable for similar purposes; and (6) requires that the procedure/prototype be globally generalizable or modifiable. We also plan to investigate the effectiveness of the converse SA-MEA. A converse SA-MEA will have the student choose the opposite; i.e., a career that they are highly unattracted to. The activity will be for the student to use STEM to somehow make an unattractive career attractive to them. For instance, using the example given above, if being a police office is highly unattractive due to the problem of being harmed, then a student would use STEM to increase the safety of police officers.

III. Survey

How can the use of integrated STEM modeling activities attract students to STEM careers? We create pre- and post-survey questions to assess the effectiveness of our SA-MEAs. Pre-survey questions will include 1. Does your initial career choice require a STEM degree (yes, no)? 2. How did you first learn about your initial career choice (tv, internet, family, friends, other)? 3. How likely are you to consider STEM as a career option (very likely, likely, unsure, unlikely, very unlikely)? Post-survey questions will include 1. Did this activity increase your interest in STEM (strongly agree, agree, no change, disagree, strongly disagree)? 2. Do you plan to consider STEM as a career option (strongly agree, agree, no change, disagree, strongly disagree)? 3. Did you find this activity interesting (strongly agree, agree, no change, disagree, strongly disagree)? Comparison Likert scale questions (very high = 5, high = 4, neutral = 3, low = 2, very low = 1) will include attributes (income level, sense of contribution, sense of helping others, creating a legacy, lifestyle, opportunities for employment, societal impact, and job satisfaction) to compare initial career choice and STEM career option. Lastly, Likert scale questions (very high = 5, high = 4, neutral = 3, low = 2, very low = 1) will inquire about the likelihood of student's substituting their initial career choice with a STEM career choice.

Summary

It is ironic that the STEM professions that enable young people to experience a higher quality of childhood than their parents' are the professions that students are least exposed to and least-likely to consider as a career. Our preliminary survey on career interests suggested that elementary students choose careers based on what they frequently encounter in popular media, which is highly biased towards music, sports, police, health care, law, acting, etc. The question is, how can more students be enticed to consider STEM as a viable career option as well? In this work-in-progress, we are exploring the use of an open model-eliciting activity (MEA) as a vehicle to actively expose students to STEM. We are doing this by developing a way for students to personalize an MEA by having them roleplay being themselves as a future STEM professional that solves a problem of their own liking. The effectiveness of this effort will be assessed by measuring the student's change in STEM interested due to this MEA intervention. Our preliminary STEM-attraction MEA and tentative survey questions are presented.

References

1. Auger, R. W., Blackhurst, A. E., & Wahl, K. H. (2005). The development of elementary-aged children's career aspirations and expectations. *Professional School Counseling*, 322-329.
2. Clark, Q.M., Mohler, J., Magana, A. (2015). *Learning style dynamics*. Paper presented at the American Society for Engineering Education Conference, Seattle, WA.
3. Mariani, M., Berger, C., Koerner, K., & Sandlin, C. (2016). Operation occupation: A college and career readiness intervention for elementary students. *Professional School Counseling*, *20*(1), 1096-2409.
4. Hamilton, E., Lesh, R., Lester, F., & Brilleslyper, M. (2008). Model-eliciting activities (MEAs) as a bridge between engineering education research and mathematics education research. *Advances in Engineering Education*, *1*(2).
5. Lesh, R., & Doerr, H. M. (2003). Foundations of a models and modeling perspective on mathematics teaching, learning, and problem solving, in *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning, and teaching*, pp. 3-33. NJ: Lawrence Erlbaum.
6. Chamberlin, S. A., & Moon, S. M. (2005). Model-eliciting activities as a tool to develop and identify creatively gifted mathematicians. *Journal of Secondary Gifted Education*, *17*(1), 37-47.
7. Diefes-Dux, H. A., Hjalmarson, M., Miller, T., and Lesh, R. (2008). Model-eliciting activities for engineering education, in *Models and Modeling in Engineering Education: Designing Experiences for All Students,* pp. 17-35.

Name of the paper's First Author

Quintana M. Clark is a Ph.D. candidate in the Department of Agricultural Sciences, Education, and Communication, in the College of Agriculture. She earned a *Graduate Certificate in Teaching and Learning Engineering* from the College of Engineering Education, a MS degree form Purdue's Polytechnic Institute, and earned her BS degree in *Management of Information Systems* from the University of San Francisco. Quincy's Research focuses on *STEM attraction* in K-12 through agriscience contexts, *STEM retention* in undergraduate levels through personalized learning tools, and *STEM diversity* in K-16 through modeling activities with sociocultural contexts.

Name of the paper's Second Author
Jason Clark is an assistant professor of Electrical and Computer Engineering at Auburn University. He has a PhD in Applied Science from the University of California at Berkeley and a BS in Physics from the California State University at Hayward. His research is in the area of micro/nano-scale electro-mechanical systems, which involves sensors, actuators, micro-robotics, computer-aided design and engineering, accurate and precise measurement, artificial intelligence, artificial muscle, energy harvesting, and electro-mechanical digital logic. He has several awarded patents, book chapters, over a dozen journal publications, and several dozen conferences publications.