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BOARD # 324: Anybody can program. . . I just don't like it

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Anybody Can Program…I just Don't Like It (RIEF)

Introduction

Programming and "computational thinking" are critical aspects of engineering training, and many engineering students learn essential programming skills in their first year engineering courses. However, these skills are cognitively difficult, frustrating, and are sometimes not clearly linked to students' perceptions of engineering[1], [2]. Self-efficacy and expectancy-value theories have been linked student persistence, achievement, and future plans[3]. Among engineering students, computing skills are a strong influencer of confidence and self-efficacy [4]. Prior research with students learning to program in required first-year university courses demonstrated that baseline motivation for learning – specifically, their self-efficacy and utility value – varied significantly. One recent study demonstrates that students in computationally-focused majors have higher self-efficacy [5]. A multi-year explanatory mixed-methods project set out to determine whether the baseline motivation of engineering students learning to program in their first semester varied based on students' intended major or concentration.

Participants were students from two universities: a large midwestern state university (StateU) and a small private university (PrivateU) in their first semester as an undergraduate engineering major. Recruitment occurred after 4 – 7 weeks learning MATLAB in the course and before the final course project. Survey questions specifically targeted students' self-efficacy and utility value related to programming in general and MATLAB in particular, and were adapted from an established instrument used for similar purposes with students learning C++ [6]. Preliminary results were presented at prior conferences and are summarized here. Analysis of variance showed that the original hypothesis was not supported, and that there is no difference in the mean utility value or self-efficacy related to programming and MATLAB based on students' intended major at the alpha = 0.05 significance level. Two-way ANOVA tests also failed to show a statistically significant relationship between intended major and motivation when accounting for the expected confounding variables of gender, experience with programming tools, race, and first-generation status [7], [8].

Methodology

A selection of students were invited to participate in an hour-long interview 3- 5 months after taking the survey. Interviews were conducted in each of the three years of the study with a subset of student participants at both schools. Students were asked about their experience learning to use MATLAB, with specific questions relating their learning to the large final project. Initial questions asked about students' choice of major or specialization within engineering, relating that to their interest, experiences, and motivation for learning programming. The interview protocol asked students multiple questions related to motivation such as whether they enjoyed learning to use MATLAB (interest), whether they thought it was useful (utility value), and whether they believed they could develop proficiency (self-efficacy). Follow up questions were often asked to get clarity and to make sure that responses were in the interviewee's own words. If students were considering their perceived skills or interest in using programming when choosing their major, their responses to the interview questions should document that.

All transcripts were cleaned to remove any identifying information, and each participant's name was replaced by a pseudonym randomly chosen from a list of the most common first names for boys and girls in North America. All interview participants self-identified as either man or woman. Gender is known to affect students' motivation for learning to program, and gendered names were tied to participants with that gender. Coding and analysis were done using DeDoose. Ultimately, sixty topics were identified, and each interview was analyzed to note each time one of these topics was discussed. Thus, each topic is a "code" and the identifying the presence of these topics involved "coding" the interview. There were a total of 15 parent (general level) codes and 45 child (more specific level) codes, which fell into three big categories:

- Experience with engineering before the course (in particular how they related to their intended major and learning MATLAB).
- Experience learning to use MATLAB in the course, including relationships with team members and application of skills in the final project.
- Motivation to learn MATLAB and programming, in particular as related to interest, self-efficacy, and utility value.

The results presented in this paper focus on the relationship between students' motivation and mindset as demonstrated by the prevalence of different codes as correlated with the interviewees' survey responses.

During analysis of the interview transcripts, researchers noted a recurring theme of growth vs. fixed mindset in student responses. This was typically in the part of the interview aimed at understanding participant beliefs. Example questions that a were asked in this part of the interview include the following:

- Is it important to know how to use MATLAB?
- Do you think you are capable of being skilled at using MATLAB?
- Are you a "coder" or a "programmer? Would you want to be?
- Do you think you are capable of learning to be adept at using computational tools in general?
- Now that we've talked about engineering and computational modeling, have you gained any insight about these ideas?

Statements about growth mindset demonstrated that students believed their abilities (specifically with respect to MATLAB) could be improved with effort and practice, whereas fixed mindset was indicated by comments demonstrating a student believed their abilities could not be changed. While instances of growth or fixed mindset were first recorded as a memo, it was documented frequently enough to merit further investigation. A label "Growth Mindset" was added to the code tree, with child codes for both "growth mindset" and "fixed mindset". Interviews were revisited in order to apply these codes in lieu of memos and future coding analyses included these codes. Every time a student's comment demonstrated their belief in or described an action based on growth mindset, the code +*Growth Mindset* was applied to the excerpt. Each time a student demonstrated belief in or described an action based on application of a fixed mindset, the code -*Fixed Mindset* was used for the excerpt. Each count of the code is for a separate instance, using a rule that at least 20 lines of transcript had to be present between separate instances. Multiple counts for growth mindset would therefore indicate that the interviewee mentioned it in distinctly different parts of the interview.

Results

The counts for each of the motivation-related codes are presented for each of these nine students in Table 1. Of 14 interviews conducted in the first two years of the study, 9 interviewees discussed either growth or fixed mindset despite not being explicitly asked about it by the interviewer. These students are group A. The pseudonyms and code count for each of these are in the first 10 columns of Table 1. The sum of the counts for the remaining 5 interviewees (Group B) are given in the left-most column. Four of the students in group A intended to major in either electrical or computer systems engineering – fields known for requiring a lot of programming; none of the students in Group B intended to do so. Group B students declared positive self-efficacy and utility value much more frequently than they did negative self-efficacy or utility value.

Table 1: Counts for each code category for the nine interviewees who mentioned either growth mindset or fixed mindset (identified by each of their pseudonyms). The total number of counts for the 5 students who did not discuss growth or fixed mindset.

	Group A										***B***
	Beth	David	Isabel	James	Mario	Rebecca	Rosa	Shane	Victor	***Sum***	*Sum of counts of other 5 interviewees (Sarah, John, Joseph, Nicholas, Richard)*
Intended Major	**CSE**	**BME**	**EE**	**AERO**	**EE**	**ME**	**CHE**	**CSE**	**EE**		
Average Utility Value	1.75	5.25	3	5.75	5.5	6	2.75	4.75	2.75		
Average Self-Efficacy	1.77	5.08	2	4.31	2.83	4.23	3.38	5.38	4.62		
Average Skill	1.33	5.67	2.33	3.67	4	4.67	4	5.33	4.67		
Growth Mindset											
Fixed Mindset	0	0	0	2	1	0	0	0	2	**5**	0
Growth Mindset	3	2	0	2	0	1	1	1	4	**14**	0
Experience learning MATLAB											
Negative – Did not enjoy	0	0	0	3	0	0	1	0	7	**11**	1
Positive – Did enjoy	1	2	2	0	4	1	5	0	0	**15**	6
Interest in Computing											
Negative interest in computing	0	0	0	1	0	0	0	0	0	**1**	2
Positive interest in computing	3	0	0	0	0	1	0	1	0	**5**	5
Self efficacy for MATLAB											
Negative	6	0	0	5	0	3	0	0	0	**14**	1
Positive	1	3	0	4	0	2	0	2	0	**12**	14

This data supports the following statements:

- When growth & fixed mindset is discussed by the students, statements that demonstrate a growth mindset are more numerous than those that demonstrate a fixed mindset.
- Group A shows greater ambivalence as a whole for learning MATLAB as demonstrated by the number of counts for both positive and negative statements with regards to Experience, Self-efficacy, and Utility Value. Group B, in contrast, overwhelmingly enjoyed learning to use MATLAB, demonstrated positive self-efficacy, and said learning MATLAB was useful for either future courses or their eventual career.

Discussion

The data presented could help explain some of the findings of the survey. The survey did not show any difference in mean motivation scores between different groupings of intended major. There was also no correlation between self-efficacy and utility value among students. The nine students in Group A have mixed levels of self-efficacy and utility value, whereas Group B students have overwhelmingly high self-efficacy and utility value related to programming. While not conclusive, it is possible that having a growth mindset could explain some apparent ambivalence or incongruence in individual students' reporting of their motivation and experiences.

Students who want to study computer systems or electrical engineering might be more willing to persist through difficulties learning to use programming tools even if they did not feel particularly good at it so long as they have a growth mindset. While growth mindset has been promoted in education settings, it is not regularly included as a confounding or explanatory factor. However, having a growth mindset can make other things like enjoyment or ease less important. In one interview, James said: "That (MATLAB skill) is something that has developed through learning it and working towards that goal. I believe that - you know if I actually sat down and did it, I probably wouldn't enjoy it - but if I sat down and I took time to learn MATLAB, I'd say I would be able to do that."

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