The Effect of a Required Core Mechanics Course on Student Mindset

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Work in Progress: The Effect of a Required Core Mechanics Course on Student Mindset

Abstract

In this study, we will be examining how a required engineering course, Mechanical Engineering 220 – Fundamentals of Mechanics (ME 220), at the United States Air Force Academy influences student mindset. ME 220 is the first of many STEM courses that all students, both engineering and non-engineering majors, are required to take at USAFA. For this study, students were given a mindset questionnaire the first week of class and at the end of the course. It was hoped that students' experiences in the course would help them develop a stronger growth mindset. Unfortunately, the students' average mindset rating actually decreased from the pre-class to the post-class questionnaire. What still needs to be investigated, however, is whether this result is due to students' fatigue at the end of the semester or due to some other reason.

Introduction

Psychologist Carol Dweck developed the concept of a "fixed" and a "growth" mindset [1]. According to Dweck, a mindset is a self-perception or "self-theory" that people hold about themselves. Based on Dweck's research, a person's mindset can have a profound effect on learning achievement as well as other dimensions of life. According to Dweck, "In a fixed mindset, people believe their basic qualities, like their intelligence or talent, are simply fixed traits. They spend their time documenting their intelligence or talent instead of developing them. They also believe that talent alone creates success—without effort." [2] In contrast, "In a growth mindset, people believe that their most basic abilities can be developed through dedication and hard work—brains and talent are just the starting point. This view creates a love of learning and a resilience that is essential for great accomplishment." [2]

There have been a limited number of studies that examine mindset in the context of engineering education [3-6]. In Ref. [3] Frary first determined the mindset of students in a Thermodynamics class and then tried to determine whether the students' mindsets could be shifted away from a fixed mindset and toward a growth mindset. He gave a mindset survey at the start and at the end of the semester, and there were several interventions employed, including watching a TED talk by Dwerk and then watching a Kahn Academy video followed by a class discussion. There were several reading assignments throughout the course, and each class was started with a mindset quote. He states that anecdotally students learned about having a growth mindset, but numerical data did not support the assertion that learning about a growth mindset enables students to shift from a fixed mindset to a growth mindset. A similar result was found in Ref. [4], which focused on interventions to elicit a growth mindset or a belonging mindset. The researchers found that interventions were not effective in increasing a growth mindset in students, but their scores on growth mindset were already high prior to the interventions. An excellent literature review of mindset interventions for engineering students can be found in Ref. [7]. This paper summarizes the literature exploring the effectiveness of different interventions in developing a growth

mindset in engineering students, what measures have been used in assessing the effectiveness of these interventions, and who has benefited from these interventions, in terms of gender and year of study. They used engineering, education, and psychology databases. Their analysis of results shows a wide variation in effectiveness of different interventions among the fifteen studies examined in detail.

Outside of an engineering context, there has been a tremendous amount of work on mindset. An excellent summary of the literature and two meta-analyses can be found in Ref. [8]. In their first meta-analysis (k = 273, N = 365,915), they examined the strength of the relationship between mindset and academic achievement. In the second meta-analysis (k = 43, N = 57,155), they examined the effectiveness of mindset interventions on academic achievement. Overall, the first meta-analysis demonstrated only a very weak relationship between mindsets and academic achievement. Similarly, the second meta-analysis demonstrated only a very small overall effect of mindset interventions on academic achievement.

In this study, we will be examining how a required engineering course, Mechanical Engineering 220 – Fundamentals of Mechanics (ME 220), at the United States Air Force Academy influences student mindset. ME 220 is the first of many STEM courses that all students, both engineering and non-engineering majors, are required to take at USAFA. These required courses are called "core" courses. This core course focuses on statics and mechanics of materials, and it is the first engineering-focused core course students are required to take. In this course, there is anecdotal evidence that some students explain their difficulty in the course by saying that they have "fuzzy" majors, that is, non-technical majors, or that they are "not good at math and science." Students with technical majors are often called "techies" and, anecdotally, are much less likely to complain about the class. The purpose of this study is to determine if this course helps students with a fixed mindset develop a growth mindset or if it reinforces students' existing mindset. To accomplish this, students were given a mindset questionnaire both pre-class and post-class. The questionnaire used was developed at USAFA[9-10]. The purpose of these questionnaires is to help us understand what effects the course currently has on mindset.

In this paper, we will present the pre-class and post-class questionnaire results for the course. We anticipate presenting the results from the Spring semester at a future conference.

Instrument and data collection

The mindset questionnaire used was developed at USAFA. The questionnaire consisted of 31, 8-point Likert Scale items ranging from 1 (strongly disagree) to 8 (strongly agree); a higher total score indicated a growth mindset. The instrument contained 8 questions from Dweck's book [1], 18 questions developed from previous research studies and theoretical perspectives, and 5 questions that focused specifically on ME 220. Some questions were reverse scored, concept factors were scrambled, and other recommended psychometric strategies were followed.

Previous analysis of 26 questions (excluding the ME 220 questions) indicated six factors [9]. These factors were determined using a Principal Component Analysis (PCA) with a Promax rotation with Kaiser Normalization. These are shown in Table 1.

Table 1 – Factor analysis results of the original instrument (excluding course specific questions)

Factor	Sample question
Intelligence	No matter how much intelligence you have, you can always change it quite a bit.
Ability	You can learn new things, but you can't really change how much ability you have in areas such as sports, music, art, and leadership.
Feedback	I appreciate when others (parents, coaches, teachers) give me feedback about my performance.
Learning focused	I feel successful when I improve in school even if other students are getting higher scores than me.
Change	No matter what kind of person you are, you can always change substantially.
Personal Qualities	You can always change basic things about the kind of person you are.

In addition to the mindset questions, we asked demographic questions such as gender, race, major, and whether students classified themselves as a "Techie" or a "Fuzzy." The pre-class questionnaire was administered the first week of class. All the students and instructors were emailed a link to the questionnaire. Each instructor encouraged their students to complete the questionnaire, and some put the link on their course Teams page or Blackboard page. The post-class questionnaire was administered the last week of the semester using a similar process. The data was downloaded from SurveyMonkey and analyzed in Excel. After adjusting for reverse scoring, the overall average was computed for each student.

Results

To evaluate the current effect the course has on mindset, that is with no intervention, the pre-class questionnaire (N = 299) results were compared to the post-class questionnaires (N = 318). We were also able to have paired responses for 174 students. In Figure 1 is shown the results from comparing the pre-class questionnaire to the post-class questionnaire for all 31 questions by grouping the scores into 10-point bins. The average score in the pre-class questionnaire was 74.8%, and the average score in the post-class questionnaire was 71.9%, meaning there was a 2.8% reduction in the score. There was a statistically significant difference in the two averages ($p = 0.0011$). A higher score indicates a growth mindset, so a reduction in the average means that there was more of a fixed mindset at the end of the course than at the beginning.

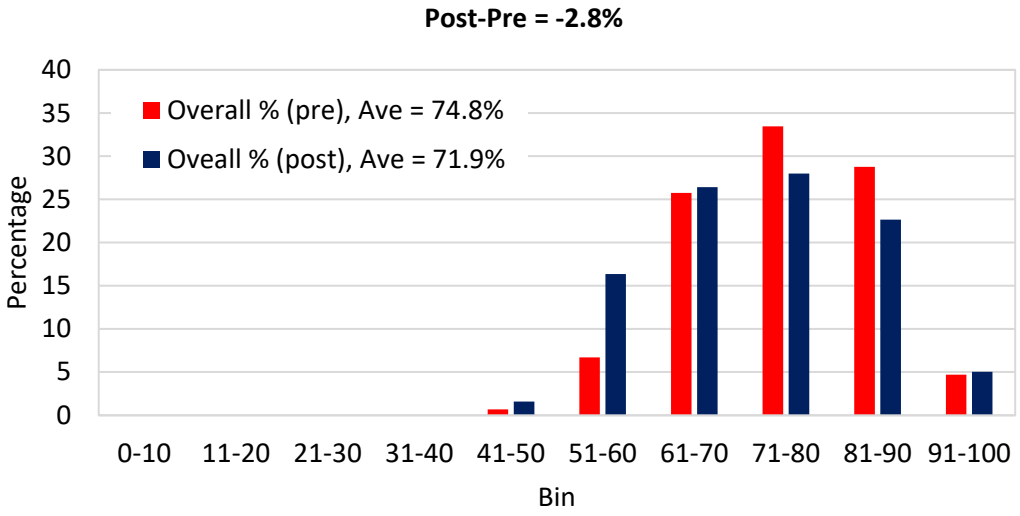

Figure 1 – Comparison of pre-class and post-class average scores on the mindset survey for all the students.

In addition to looking at all the students, we also examined the data based on gender (Figure 2) and race (Figure 3). As seen in Figure 2 the average score decreased by 2.6% and 2.9% for the women and men, respectively. The average score decreased by 1.0% and 3.4% for the non-white and white students, respectively.

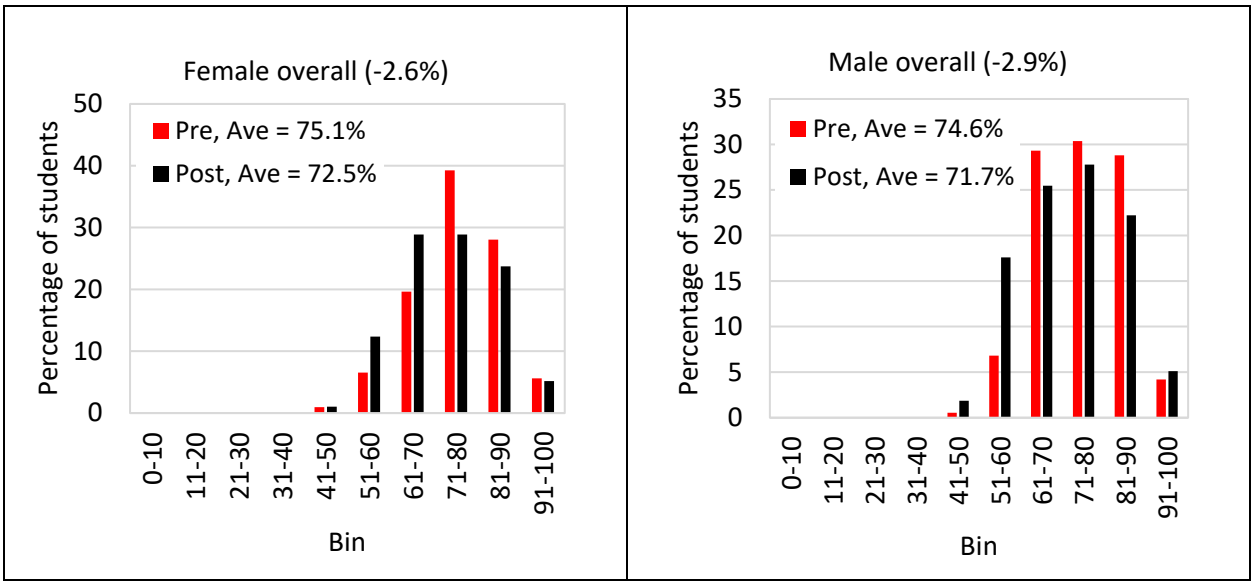

Figure 2 – Comparison of pre-class and post-class average scores of the mindset survey based on gender.

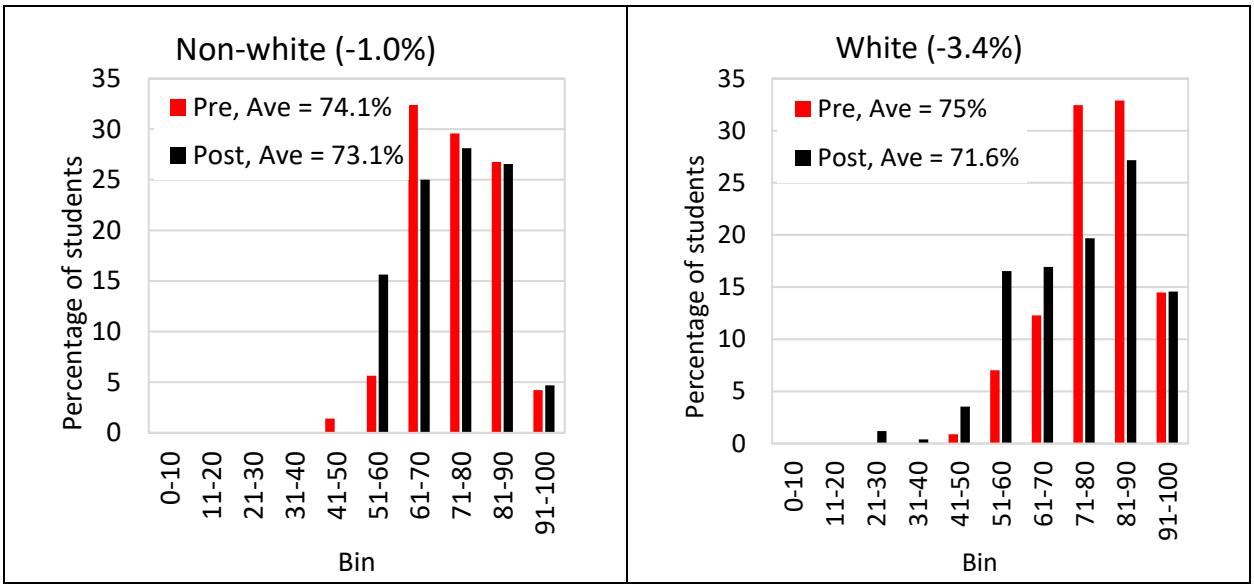

Figure 3 – Comparison of pre-class and post-class average scores of the mindset survey based on race (non-white vs. white).

We also compared the pre- and post- results based on the factors shown in Table 1. These results are shown in Figure 4. Recall that a higher score is intended to represent a grown mindset. The statements focused on learning had the lowest pre- and post-class averages. These were statements such as, "It is more important for me to perform well compared to others than to push my boundaries and potentially perform poorly" and "I prefer to engage in activities that I can do perfectly or with few mistakes." We are continuing to analyze this data to better understand these categories and the student responses.

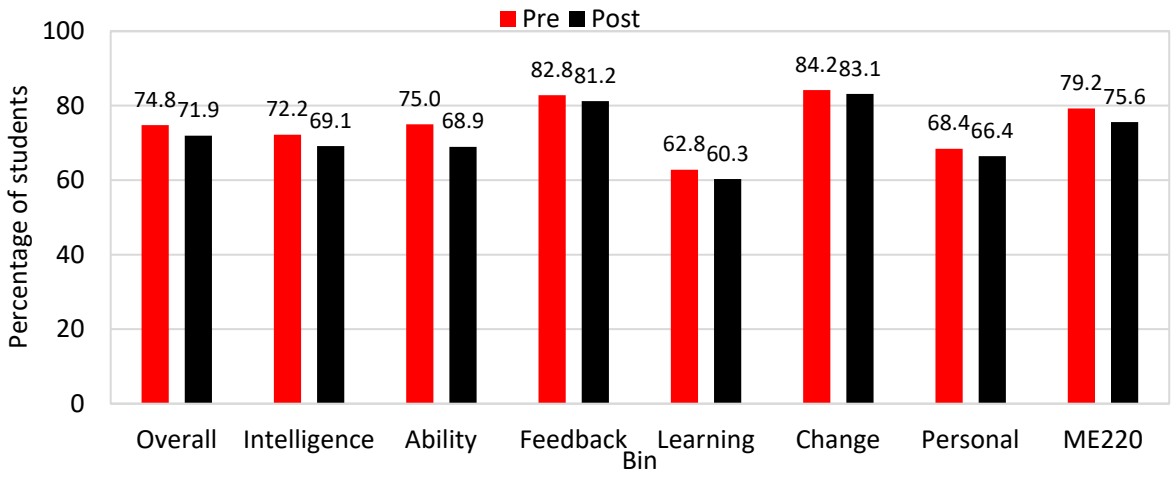

Figure 4 – Comparison of pre-class and post-class average scores for each factor identified using a factor analysis.

The change average score for each category is shown in Figure 5. From this figure, it is clear that the average score for each category decreased, with the questions focused on ability having the largest drop of 6.1%. This category has statements such as, “Your math ability is something very basic about you that you can’t change very much” and “You can learn new things, but you can’t really change how much ability you have in areas such as sports, music, art, and leadership.”

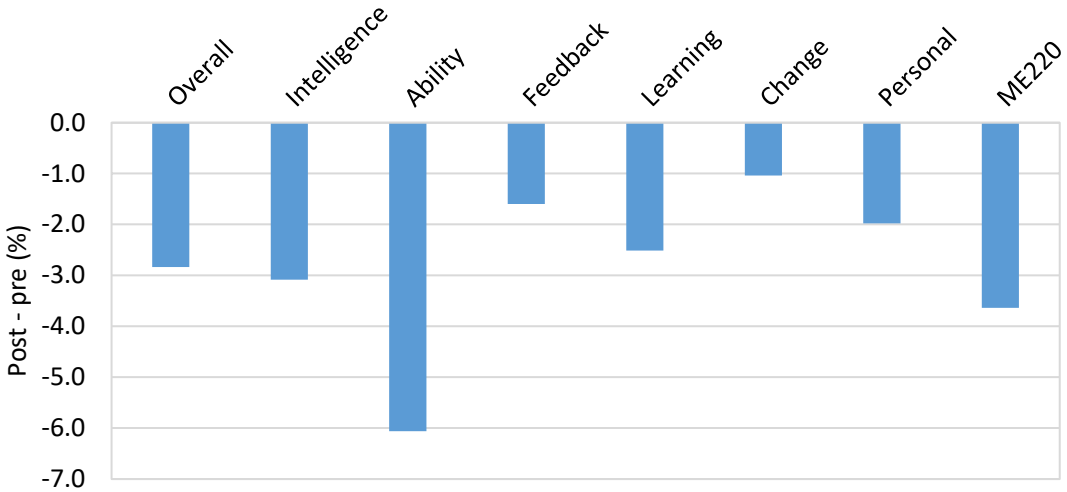

Figure 5 – The difference between the post-class score and the pre-class score for each category.

Finally, we looked at the change in average score for each question. In Figure 6 is shown these results with the questions ordered based on the pre-class score. Question 7 had the highest score, with the students’ average answer indicating a strong agreement and therefore a strong growth mindset. This question was, “Given the appropriate amount of time and practice, people can substantially improve at any task.”

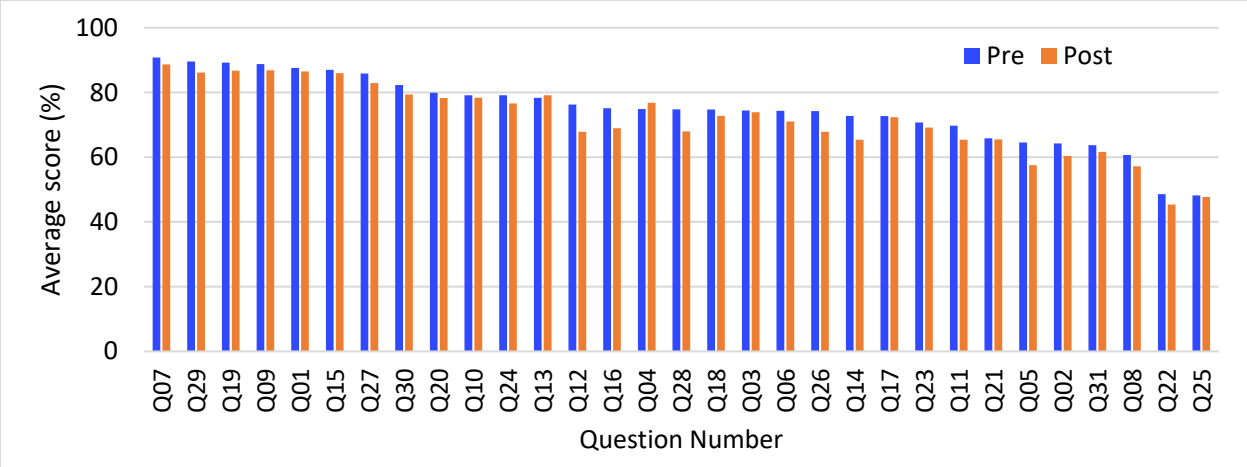

Figure 6 – Comparison of pre-class and post-class average scores for each statement sorted by the pre-class scores.

The two questions with the lowest average scores were questions 22 and 25. These questions were, “Truly smart people don’t need to try as hard” and “I prefer to engage in activities that I can do perfectly or with few mistakes.” In Figure 7 is shown the difference between the post-class average score and the pre-class average score sorted by difference. Only two questions had a higher average score in the post-class questionnaire, with the biggest gain being found on question 4, which was, “You can always change basic things about the kind of person you are.” The question with the biggest loss was question 12, “Your writing ability is something very basic about you that you can't change that much.” We are continuing to analyze these data.

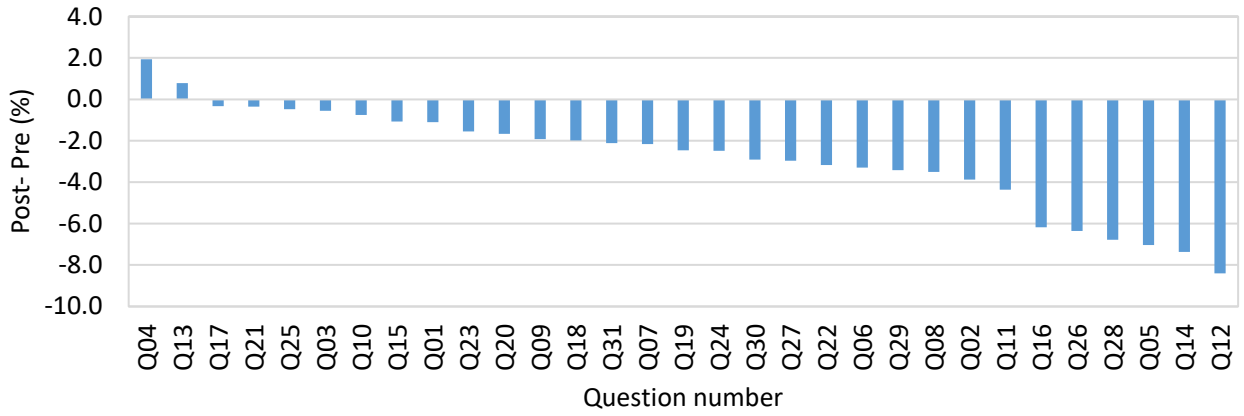

Figure 7 – The difference between the pre-class and post-class average scores for each statement.

Conclusions and future work

In this work-in-progress paper we gave a mindset survey to students in a required mechanical engineering course at the start of the semester and at the end of the semester, but without any intervention. The hope was to determine how the current course, with no modifications, affects students’ mindsets. Our results indicate a more fixed mindset at the conclusion of the course than at the start of the course. What still needs to be investigated, however, is whether this result is due to students’ fatigue at the end of the semester or due to some other reason. Until this is clearly understood, deciding on an intervention, if one is necessary, is premature.

To better understand the current result, we plan to give the questionnaire multiple times during the Spring semester. We also plan to give the faculty members teaching the course a questionnaire designed for them. This will allow us to determine if the mindset of faculty members affects the mindsets of their students as shown in previous research [11-12]. Based on these results we will decide what, if any, intervention to implement in the course.

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