2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34026

Work in Progress: Challenges and Mitigation Strategies in STEM Courses: Students' Perspectives

Dr. Saira Anwar, University of Florida

Saira Anwar is an Instructional Assistant Professor at the Department of Engineering Education, University of Florida. Dr. Anwar has over 12 years of teaching experience, primarily in computer science and software engineering. Her research focuses on studying the unique contribution of different instructional strategies to students' learning and motivation. Also, she is interested in designing interventions that help in understanding conceptually hard concepts in STEM courses. Dr. Anwar is the recipient of the 2020 outstanding researcher award by the School of Engineering Education, Purdue University. Also, she was the recipient of the "President of Pakistan Merit and Talent Scholarship" for her undergraduate studies.

Mr. Ahmed Ashraf Butt, Purdue University, West Lafayette

Ahmed Ashraf Butt is a doctoral student at the School of Engineering Education, Purdue University. He is currently working as a research assistant on the CourseMIRROR project funded by the Institute of Education Sciences (IES). He is interested in designing educational tools and exploring their impact on enhancing students' learning experiences. Before Purdue University, Ahmed has worked as a lecturer for two years at the University of Lahore, Pakistan. Additionally, he has been associated with the software industry in various capacities, from developer to consultant.

Dr. Muhsin Menekse, Purdue University, West Lafayette

Muhsin Menekse is an Assistant Professor at Purdue University with a joint appointment in the School of Engineering Education and the Department of Curriculum and Instruction. Dr. Menekse's primary research focus is on exploring K-16 students' engagement and learning of engineering and science concepts by creating innovative instructional resources and conducting interdisciplinary quasi-experimental research studies in and out of classroom environments. Dr. Menekse is the recipient of the 2014 William Elgin Wickenden Award by the American Society for Engineering Education. Dr. Menekse also received three Seed-for-Success Awards (in 2017, 2018, and 2019) from Purdue University's Excellence in Research Awards programs in recognition of obtaining three external grants of $1 million or more during each year. His research has been generously funded by grants from the Institute of Education Sciences (IES), Purdue Research Foundation (PRF), and National Science Foundation (NSF).

WIP: Challenges and Mitigation Strategies in STEM Courses – Students' Perspective

Background and Motivation

With various reforms to improve post-secondary STEM education, instructors focus on utilizing different strategies to enhance students' learning in diverse and dynamic ways. The research studies on these strategies emphasized improving post-secondary education by promoting transformative and innovative learning, e.g., [1], [2]. Prior studies introduced various instructional strategies to show the effectiveness of active learning, such as inquiry-based methods, project-based approached, flipped class models to enhance students learning, and incorporate active learning strategies, e.g. [3]–[5] Similarly, many studies describe the success stories of effective STEM integration in K-12 spaces for enhancing students' engagement, interest, and learning outcomes in STEM courses at the college level, e.g. [6], [7]. Despite these efforts, studies suggest low enrollment, graduation rate, and students' attrition in STEM courses at the post-secondary level [8], [9]. Considering the efforts to improve STEM education practices and still reported decline at the workforce level, it is essential to consider students' perspectives and experiences while studying STEM courses [10].

Although education studies have explored students' experiences and attitudes while studying STEM courses, e.g. [11], the primary focus of these studies was either on examining the relationship between students' characteristics and outcomes, e.g. [12], [13], or the role of instructional strategy on student outcomes, e.g. [11], [14]. It is noteworthy that limited studies took the detailed approach of understanding students' perspective of their learning needs, e.g. [15], expectations in the courses, e.g. [16] and academic challenges [17] that may hinder their progress in STEM courses, or future decision of a STEM career. Furthermore, most of these studies used a survey approach to understand students' perspectives and experiences and lacked direct interaction with students.

The purpose of this work in progress study is to understand detailed students' perspectives about their challenges in post-secondary STEM classrooms. More specifically, we focused on understanding which challenges or factors hindered students' progress in changing their perception about future STEM career options. Also, we focused on students' experience for the mitigation strategies they used for successful outcomes. More specifically, this exploratory qualitative study is guided by the following research questions:

RQ1: *What are students' perspectives on the challenges they experience while studying STEM courses?*

RQ2: *What actions students take to mitigate the challenges faced during the study of STEM courses, and how that impact their future decision of a STEM-related career?*

Methods

Context and Participants

We recruited 30 participants from two institutes located in the Midwest, USA. We collected the data using a purposive sampling strategy [18] to ensure the selection of diverse students who share a common focus on STEM discipline and courses. The data were collected during Summer 2019. In the participants, 43% of students were from various science disciplines, 17% were computer science or technology majors, and 40% were engineering majors. 33% of these students were male, while 67% were female. Students were at various stages of their degree STEM programs (10% freshmen, 6.67% sophomore, 23.33% junior, 36.67% senior, and 23.33% graduate students). Also, students belonged to diverse ethnicity with 16.67% participants were Asian American, 20% were Black or African American, 40% were white or European

American, 3.33% were Hispanic or Latin American, and 20% were of other uncategorized ethnicities.

Research Design

In this study, we collected data using a multimodal approach. Each student first answered the questionnaire questions. These questions were targeted to get students' individual opinions about challenges they experience in their STEM courses, strategies to stay focused in their courses, and steps students take to mitigate these challenges. Later, we divided these students into seven focus groups comprising five groups of four students and two groups of five students. In the focus groups, students collectively reflected on their learning challenges and strategies that worked for them. Also, students suggested the factors that influenced their decision on their future in a STEM career. The students' focus group discussion were video recorded. Further, the researchers wrote the reflection memos to identify the particular decisions and directions the conversations were moved. In this study, we used students' focus group data to analyze and triangulate the results of students' questionnaire responses and emphasize socially constructed views on challenges and mitigation strategies in STEM courses.

For students' questionnaire data, we applied the in-vivo descriptive codes to students' responses to preserve the participants' words' essence. Further, we used the inductive coding process [19] to understand students' perceptions and experiences of challenges and mitigation strategies. We then translated these codes into cross-cutting themes and categories. We used the inductive thematic analysis approach to identify themes from data. For the video recordings of the focus groups, the inductive codes identified in the questionnaire data were used to identify students' thoughts during focus groups to triangulate results better. The same descriptive codes were applied to the transcribed discussion. Further, researchers' reflections after the focus group helped in understanding the direction of the conversation.

Preliminary Results

We classified the results based on categories and themes in the preliminary qualitative thematic analysis of the questionnaire data. We found two prevalent categories of challenges students face while studying STEM courses. These categories are 1) personal factors and 2) course-related factors.

Almost three -fourth (73.33%) of the students reported various personal factors while describing their challenges in STEM courses. These students belonged from all ethnicities and were at various levels of their degree programs. Based on the in-vivo coding and classified themes, we divided these personal factors into five themes: study environment, interest in course, procrastination, out of major courses, and language barrier.

1) *Study environment (~40% students).* Students reported that their study setting plays a significant role in their experience of the course. However, students' study environment needs could vary. For example, a student reported, "*I find that my environment has a big effect on how long I can study in one sitting. To stay focused, I find a quiet place, find people studying the same topic, listen to music and drink coffee*". The other student informed that "*I get rid of all distractions while studying. During the semester, I delete all my social media apps. Also, I make sure to spend a lot of time in library.*"
2) *Interest in the course (~10% students).* Students attributed their lack of interest in the course as one of the challenges in STEM courses. For example, a student suggested, "*I lose interest in what I am studying very quickly. I also get distracted very easily. In the past, I had to study for very long periods of time to get good grades."*

3) *Procrastination (~13.33% students).* Students reported a factor delaying their tasks until the last minute as their challenge. For example, a student reported, *"I procrastinate. My challenge is overcommitting myself and not finding sufficient time to dedicate to study for a particular exam. More of an issue for midterms than final exams. Course material can be hard to learn in cram sessions and may need discussion with peers for me to fully grasp an idea, and this can be hard to do at the last minute."*
4) *Courses out of major (~6.67% students).* Students attributed irrelevancy of out-of-major classes to keep them engaged, possible challenge. For example, a student said, "*I find it challenging if courses are not from my field. It is difficult for me to keep up with the necessary background, like mathematics background in my statistics or programming classes.*"
5) *Language barrier (~6.67% students).* Another significant personal challenge was the student language barrier. For example, a student reported, "*As this was my first semester of college, and I am an international student, the hardest challenge so far was to switch to English language."*

All students reported various course-related factors while describing their challenges in STEM courses. We divided these course-related factors into six themes: course organization issues, lack of practice opportunities, professor's pace while explaining concepts, lack of resources, an overwhelming amount of material, and little explanation of conceptually hard concepts in STEM courses.

1) *Course organization (~16.67% students).* The students reported issues in course organization, i.e., misalignment between content and assessment. For example, a student reported, "*Test content is often not the same as class material. Maybe both were presented or thought about in a different context/way. No amount of studying can account for this".* Another student reported, "*Sometimes it is hard to follow course as is disorganized. Also sometimes it can be unsure expectations on what to expect on examination (i.e., material difficulty, etc.)".*
2) *Lack of practice opportunities (~20% students).* A commonly reported challenge amongst the participating students was the lack of appropriate practice opportunities. For example, one student wrote, "*Professors do not provide many examples. Theory is brushed on surface (not in detail)".* Another student informed, "*Some courses do not supply practice problems or examples of problems on exams which is not helpful. When courses give an abundance of practice, problems and explanations, it makes it easier to study".*
3) *Professor's pace (~16.67% students).* Students also informed the professor's fast pace, and hurry to go over the content can be challenging. For example, a student informed, "*Lectures are sometimes not helpful, professors talk very fast, there is lack of practice and lack of organization in the course."* Also, students informed that this fast pace sometimes hinders their process of taking notes. For example, a student wrote, "*The course lectures are very fast, and hard to keep up with. It is hard for me to transcribe his words. Therefore, when I study, it is hard for me to understand the notes".*
4) *Lack of resources (~13.33 % students).* Students reported a lack of study resources outside of classes. For example, a student informed, "*The course lecture is not enough resource to aid in doing homework or exams. In class, the professors normally just cover basic concepts, but additional resources are required for more complex and additional knowledge*". Also, students reported a lack of accessibility-based materials for students who are in need. For example, a student wrote, "*I find it hard to sometimes find accessible materials outside of the classroom. When studying, I look for videos or animation to help visually understand certain mechanisms, which I couldn't otherwise*".

5) Overwhelming amount of material (~13.33% students). Students found that some courses have an abundance of content information which is harder to keep up with. For example, a student informed, "*Professors expect us to know lots of material over the course of few months."* Another student wrote, "*Professors require us to read through dense paragraphs/pages of text without any example. Also, they ask us to memorize 100+ slide decks for closed-note quizzes".*

6) Little explanation of concepts (~20% students). Students suggested that they sometimes need more explanation of concepts, especially hard concepts. However, as professors focus on content coverage, they forego the additional details and examples needed for such concepts. For example, a student wrote, "*Sometimes a concept is more harder than others, if professor not explain that clearly, or describe concept too vaguely, it negatively impacts grades, and distract from studying."*

During the focus group discussions, most students indicated the need to revise the curriculum to have aligned content, assessment, and pedagogy, provide more practice opportunities, and use relevant technology tools that provide a personalized learning experience to students. Also, students reported the lack of accessibility-based materials to students (e.g., digital version of textual notes which could be read aloud by text to speech software, image files that could be zoomed for low vision students, etc.) have an impact on the students' learning, especially students who are in need and shy of communicating. Furthermore, students suggested modifications in the assessment methods of the courses. More specifically, the assessment methods requiring rote learning were found more challenging than practical aspects-based assessments.

For mitigation strategies, students indicated the use of online resources such as YouTube videos *(~40% students);* taking and organizing notes *(~76.67% students);* seeking help from a professor, peers, or teaching assistants *(~80% students);* looking for real-life application of concepts *(~13.33% students)*; dividing problems into smaller chunks *(~10% students).* Interestingly, organizing notes, students used various strategies such as color-coded notes, bubble charts, flashcards, or technology tools such as Quizlet. For example, a student described, *"for staying organized in the course, bubble charts are what I use. Usually, I write out the main idea and around it the small details. These visuals help me make connections."* The other student mentioned, *"I take handwritten notes with many different pen colors. I make a paper study guide with everything I need to know and then convert it into a Quizlet."*

In focus groups, students indicated the need for instructors' involvement in students' learning process. Students suggested that instructors' availability and interest in subject material make students' learning easier. Students accounted that professors' willingness to adjust their pace based on students' needs can help students. Moreover, if professors are involved in students' learning process, they will make efforts to be available for students and help students by connecting the concepts with real-world examples.

Significance

The study provides a unique perspective of diverse students, sharing a common trait of studying STEM courses and are at various stages of their STEM degree. The most common challenges included study environment, lack of practice opportunities, and less explanation of hard concepts. The most common mitigation strategies included using notes and seeking help from professors, peers, or online resources. Although this study's data were collected pre COVID-19 pandemic, these challenges and strategies suggest that instructors in post-COVID-19 a "new normal time" can include help opportunities and may use resources to provide a

personalized learning experience to students. This study highlights that students require a student-centered curriculum, course activities, and a learning environment aligned with course learning objectives.

Limitations and Future Directions

Some limitations of the study emerged from the sampling criteria of purposive sampling, limiting the generalizability, and could introduce the researcher bias. Also, the study has limitations of the qualitative study, which includes a small sample size for statistical inferences and non-verifiable results. To overcome some of the limitations, we used the multimodal approach. Future studies can be designed to overcome these limitations. This paper is part of a larger mixed-methods study to design an instrument on students' experiences in STEM courses. Hence, the immediate future directions include designing, validating, and disseminating the survey instrument. Future studies can be designed to understand the commonality and variations across students at the different stages of the degree program. The full mixed methods study could also shed more light on students' focus group discussion with quantitative data collected using the survey instrument. In this work in progress study, the main analysis method was a thematic analysis of questionnaire and triangulation using focus group discussion. However, future studies can use the phenomenology approach for richer descriptions of students' experiences.

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