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Students utilization of Discord Messaging Platform in an Introduction to MATLAB Course

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Introduction

Engineering courses are increasingly utilizing technology tools to enhance and support learning of engineering content. Some of these tools include virtual labs [1], [2], concept or clicker questions [3], [4], and online and interactive textbooks. Yet, we know adding technology to a classroom does not always improve learning [5]. The COVID-19 pandemic and the move to emergency online instruction only increased the use of such tools as other avenues to connect with students and enhance online instruction. An overview of several tools used for online collaboration and interaction with discussion on classroom integration is described by Konstantinou and Epps [6]. One tool described is Discord, a text, voice, and video messaging platform focused on building community that has risen in popularity during the pandemic, especially with young people [7].

Discord was initially released in 2015 to the gaming community to increase access to virtual communication with friends across the world. It is a free service available across all devices, PCs, Macs, and mobile devices, and provides a user-focused interface such that each server is privately managed and modified by the server creator [8]. It has since grown to include online communities of all types, including academic study groups, both formal and informal, with moderate adoption from students as a classroom tool depending on internet access and previous familiarity with the platform [6], [9]–[11]. In addition, previous research on learning in online communities has shown to be useful in student learning and engagement [12].

Our research team is interested in creating opportunities for students to become more active in their learning by creating new and different problems or projects [13], using different learning activities in class [14], or creating spaces like a Discord server to learn from each other. Little is known about how Discord can aid students in learning as it was first introduced and gained popularity relatively recently. We are interested in how students utilized the platform and engaged with each other, specifically how they used the platform to make sense of the material. Therefore, we ask:

1) How did students utilize the Discord platform throughout the course?
2) How did students utilize the Discord platform to make sense of content and understand the course material?

Background

In this study we aim to examine the channel messages to create a larger picture of how students used the Discord server followed by a more specific examination of instances where students were attempting to understand or make sense of the concepts of the course. We are focusing on these instances as forming a deeper understanding of concepts as research in science, technology, engineering, and math has shown a more difficult process for students than learning procedural knowledge [15]. Studies of engineering students have shown that even graduating seniors have difficulty answering conceptual questions in mechanics, circuits, and thermal sciences [16], so much so, that groups of faculty have worked to create banks of questions to use in class to help build students' conceptual knowledge, sometimes delivered through online interfaces or clicker questions [3]. Prior research has also shown that conversations between students, such as during homework sessions, aid in making sense of concepts or sense-making [17], [18]. *Sense-making*, derived from science education, is "the process of building an explanation to resolve a perceived gap or conflict in knowledge" (p.187)[19] and is "seen as the primary mechanism for promoting deep understanding of complex concepts and robust reasoning" (p.284)[17]. In the case of this study, we will examine messages between students for instances of sense-making. More specifically, we are looking for instances of making sense of an engineering problem in the form of complex equations and linear algebra and how students develop a program and write a program to solve the problem.

Methods

Engineering Computations is a freshman and sophomore level course required in most engineering degrees at a large public institution in the northeast. The course covers introduction to programming using MATLAB and solving systems of equations using linear algebra with most students in this course having little to no previous programming or linear algebra experience. The COVID-19 pandemic resulted in the Spring 2021 semester being offered completely online with eight sections taught across three instructors with a total of 444 students enrolled. The first author (E. Hammond) was an instructor of two sections with 120 students enrolled in their sections. Assignments included weekly homework with 13 total (8 on MATLAB, 5 on linear algebra), a midterm exam on the MATLAB portion of the course, a final exam on the linear algebra portion of the class, and an extensive final project requiring MATLAB knowledge and linear algebra concepts.

The project was assigned to groups of up to two students divided into six parts with each part being designated a letter A through F. During the Spring 2021 semester, the topic involved modeling the deflection of a tuning fork over time using an analytical and numerical solution. Parts A through D required students to write four different MATLAB functions: Part A involved straightforward mathematical calculations that were comparable to freshman level knowledge;

Part B contained five complex mathematical calculations that described the analytical solution; Part C contained a complex linear system of equations describing the corresponding numerical solution. The equations for part B and C contained notation that is not typically introduced to students until junior or senior level; however, the overall goal of these parts was focused on how to write a program based on the equation notation, not on equation derivation. Given the extensive use of equations in parts A through C, MATLAB Grader was used to provide feedback to students and inform them if their MATLAB functions produced the correct output. Part D involved creating a plot based animation to illustrate the analytical and numerical results over time. Part E required a script file that provided a text-based user interface and used the functions in A through D to calculate the final results showing the deflection of a fork over time given a specific set of parameters. Lastly, part F required students to write a final written report describing their program and showing their results.

To aid students, office hours were held by all instructors and six TAs in the same virtual room between 9AM and 6PM Monday through Friday. Additionally, a Discord server was set up by the first author (E. Hammond) and separate channels were made for general discussion, homework discussion, exam discussion, and project discussion. At the prompting of the students and in order to account for discussion relating to each separate part of the project, five corresponding Discord channels were created for the programming parts of the project, likewise assigned letters A through E. A final channel was created for chat based office hours hosted by the first author (E. Hammond) for a total of 10 channels.

The first author (E. Hammond) explicitly invited all of their 120 students to the server and implicitly invited all other students to the server via the chat based office hours invite. To join the server, students were required to create a free account and a self-developed username. Joining was not required and no restrictions were put in place for username generation.

Data Analysis

Following the semester, all channels were downloaded and each unique user was assigned an anonymous name with the exception of the first author. In analyzing the data, we took a mixed-methods approach. For each channel and each student, unique messages were tabulated to identify how often the server was used and how many students took advantage of the resource. Additionally, the number of messages posted per day per student per channel were counted and displayed by date to determine the frequency of messages throughout the semester. Throughout the semester 246 students joined the server with a total of 5366 messages posted across all channels.

To better understand how students used Discord to make sense of course concepts, we used thematic analysis [20] and techniques from discourse analysis [21] and grounded theory [22] to produce an array of codes to categorize individual messages. Considering the large number of messages shared throughout the entire discord server, as well as the diverse array of topics covered across the channels, we decided it would be best to focus our research on only one portion of the entire server, the final programming project. We chose this focus as it was restricted to a specific number of channels and revolved around one significant course assignment that engages the students in complex concepts and tasks.

Developing the codes involved an iterative approach premised on the idea of open coding, a practice of writing notes and themes to categorize data [22]. During open coding, it became clear that our codes could not be broken into one category, due to the fact that the data we were analyzing was conversational. Thus, each message contained both a type of speech (problem, statement, answer, etc.), and a topic (MATLAB code, MATLAB Grader, interpretation, etc.). In accounting for this structure, we tabulated our codes into two lists, each following one of two subcategories; comments and topics. Initial codes from each category were developed by the second author (J. Mitchell), a student who participated in the course and the use of Discord, after analyzing a portion of the Discord chat logs line-by-line, noting the comments and topics of each sentence. These were then reevaluated using focused coding by applying the established codes to the data [22] to produce a final set of initial codes in each subcategory.

To establish the reliability of the coding scheme, the first and second author (E. Hammond, J. Mitchell) separately evaluated 100 lines from the Part B channel and compared their analysis. Given disagreement, the first and second authors (E. Hammond, J. Mitchell) clarified and refined the initial codes; collapsing, expanding and removing codes when necessary. After coming to a consensus, both authors evaluated 100 new lines of code from the part A channel using the refined code definitions. This process was repeated one more time before a final set of codes was developed within each subcategory. Once the final codes were developed, the second author (J. Mitchell) coded the Discord channels corresponding to the programming project so that each unique message corresponded to a code. Following coding, the number of messages corresponding to each code by channel were counted and instances of students making sense of the content were reported.

For codes relating to the types of speech, initial coding resulted in nine different comment codes, including statement, question, answer, assistance, attachment, agreement, suggestion, problem, and solution. Following revision, these codes were simplified to statement, problem which combined the previous question and problem codes, explanation which combined answer and suggestion codes, apparent resolution which was renamed for solution, attachment, and general assistance. This refinement focused on if students were posing a problem, if students were responding and assisting with the problem, and if students expressed a final resolution to the problem. The final codes for the different comment types with definitions and examples are shown in Table 3.

Table 3: The final codes relating to the types of speech used by students

Comments		
Code	Example(s)	Coded Example(s)
PROBLEM Students looking for assistance by either asking or stating an issue they are facing	Asking for help resolving a debugging error Stating that MATLAB is giving an error and they do not know how to resolve it	"What does your for loop look like? for ? = ? to ?" "can anyone help me with part A? it says my frequency and length are [1 8] instead of [8 1] im not sure how to fix it"
EXPLANATION Providing an answer or idea to others to assist their thought process	Providing an answer to a previously asked question Suggesting an idea to other students regarding a current issue they are experiencing	"No my W is populated w numbers all of the way thru" "Yeah just make sure you don't fill them in the loop you use to fill 3 to M-2."
APPARENT RESOLUTION Students sharing the resolution of an issue in the moment both by using an interjection or claiming they believe they found an answer after coming to a consensus on their thought process	Informing others that a previous problem has been resolved Thanking someone for their help in attempting to solve a problem Students sharing an interjection in relation to understanding and resolving the problem	"Ok. I think I found my problem. I forgot to put in the coefficients from equations 13 and 14 into my A. that would explain why determinant is 0" "Oooh I got it now, I was missing something on the left side of the equation. Thank you." "That was extremely helpful"
STATEMENT Any remark that doesn't directly fill another category	Conversing about the project in a manner not related to problem solving	"lol trust me you are not alone" "I'm still working on it."
ATTACHMENT Image attachment	Attaching a picture of an error a student received Using emotes	"This is what I got in the grader. [attachment link]."
GENERAL ASSISTANCE Helping others in a non-suggestive way	Informing others of current issues in MATLAB Grader Students sharing extra resources they found helpful with the class	"There's an error with matlab grader. It won't mark anything as correct unless you change the call function every single time"."

For the topic codes, ten initial codes were identified, including talking about programming and grader issues and helping with the corresponding issue, talking about a solution or sharing results, interpretation of the equations and data, clarifying a previous statement, providing further help, and expressing emotion. Revision simplified the ten codes into six codes: interpretation which was narrowed to specify to how students understood the equations provided in the project, development which combined part of interpretation and part of programming issues and corresponding help, debugging which combined part of programming issues, clarification, and solution, grader pertaining to MATLAB Grader issues and corresponding help, further help, and general discussion. The final codes for topical conversation are shown in Table 4.

Table 4: The final codes relating to the topics of conversation

Topic		
Code	Example(s)	Coded Example(s)
INTERPRETATION Students conversing about their comprehension of the provided equations	Asking for help to gain an understanding of what a specific formula will do Sharing ideas regarding what an equation means Clarifying an equation and how to use it	“Not quite following you. so, you're saying the equation 5 goes in for each w in equation 12?” “Oh, I thought they were both zero from equations 10 and 11.”
DEVELOPMENT Students discussing how to develop their program and using programming concepts	Asking others about steps relating to converting the provided equations into a program Students questioning whether or not variables within their program that were interpreted from the equations are correct Talking about which programming constructs should be used	"do you have to do a double loop for phik" "Z(K) what exactly is the value of k? is it supposed to be from 1E-10 to 100?"
DEBUGGING Students conversing about and clarifying statements made in regards to their MATLAB program once they already have a working program	Students asking for help resolving an error in MATLAB Sharing output values received after running their program Suggesting changes that should be made within their program	"whenever i evaluate a section of my code to see if it works correctly it displays the error Index exceeds the number of array elements ." "And i think.. Logically that's wat we r supposed to get" “Also, make sure you are multiplying omegak by the t value, not the t index.”
GRADER Students conversing about MATLAB Grader topics	Sharing that there is an issue with MATLAB Grader Helping other students use MATLAB Grader	“I think the grader is messed up. I put W = 2 in for part C and it marked me right.” “Make sure you're putting that 3/f into the inputs in the call command.”
FURTHER HELP Going beyond giving verbal help by suggesting outside material/resources	Sending links to clips from [instructor]’s YouTube videos Students suggesting going to office hours for help	“Updated video: [link to YouTube].” “Hmmm might have to wait for office hours to get this problem settled.”
GENERAL DISCUSSION Students having a general conversation about topics unrelated to any specific aspect of the project	Asking where assignments are located on [LMS] Sharing which instructor students have	"The whole project is posted in [LMS]." "I got [instructor]."

Data

We will present the data looking across all messages as a whole and narrow down to specific instances where students were making sense of course content. Table 1 displays the number of messages posted per channel. The homework channel contained the most messages since it was available throughout the entire semester and corresponded to assignments that students had throughout the whole semester. Minimal messages were counted on the office hours channel due to the fact that questions were typically posted and answered in the homework channel.

Table 1: The number of messages posted by channel

Channel	Exam-discussion	General	Office hours	Home work	Project General	Project Part A	Project Part B	Project Part C	Project Part D	Project Part E	Total
Number of posts	706	1162	173	2230	238	151	106	227	227	146	5366

The breakdown of the number of messages posted per day per channel is displayed in Figure 1. The office hours channel and homework channel show high utilization throughout the semester with a periodic trend seen corresponding to homework due dates. The general channel and exam channel also show significant utilization, specifically right before the midterm and final exam, with over 350 messages posted in a single day. For the project channels, the general channel shows student engagement at the beginning of the project when students were looking for a partner and at the end when the project was due and writing up the final report. Following the individual project channels, the chart demonstrates how students progressed their way through the project over time.

Table 2: Number of students who posted broken down by the number of posts

Category	Number of students	Percentage
Never posted	89	36%
Less or equal to 10 posts	71	29%
Between 10 and 30 posts, not including 10	39	16%
Between 30 and 100 posts, not including 30	29	12%
Between 100 and 150 posts, not including 100	14	6%
Between 150 and 250 posts, not including 250	3	1%
Greater than 250 posts	1	0.39%
Total	**256**	**100%**

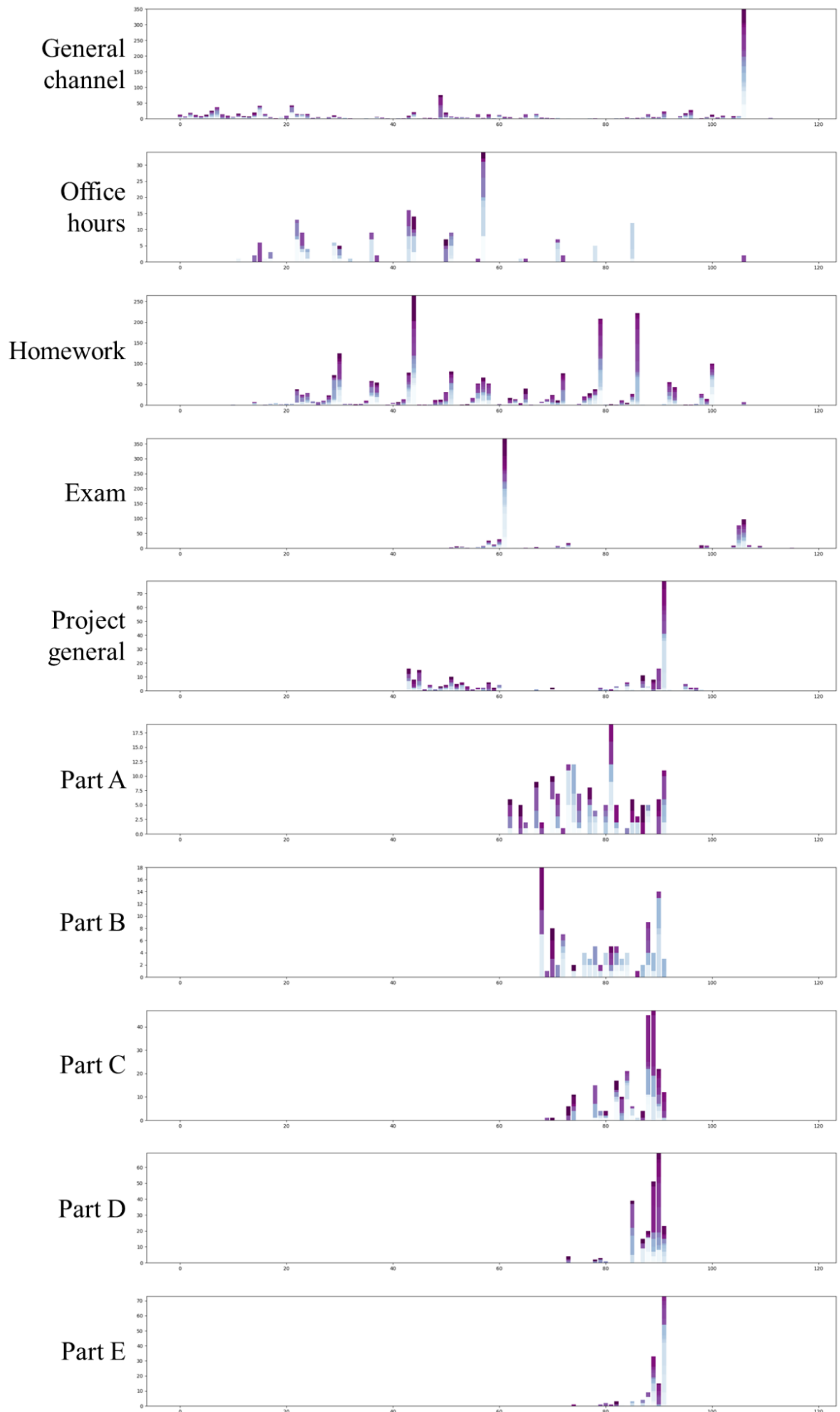

Figure 1: Frequency of messages posted per day broken up by channel

The number of messages posted was also broken down into how often each individual student posted with results displayed in Table 2. Out of the 256 students, a little more than a third of them joined but never posted any messages and another third of them posted less than ten times. Of the remaining students, most posted between 10 and 100 times, typically on the homework channel. Finally, 18 students posted extensively with more than 100 posts across most channels with one student posting 402 times across all channels.

Table 5: The percent of messages relating to the types of speech made by students

	Part A	Part B	Part C	Part D	Part E	Total
Problem	39%	39%	40%	42%	39%	39%
Explanation	35%	30%	35%	32%	38%	34%
Apparent resolution	12%	13%	8%	12%	9%	10%
Statement	6%	7%	9%	11%	11%	9%
Attachment	5%	6%	7%	6%	3%	6%
General assistance	3%	4%	1%	0%	0%	2%

Table 6: The percent of messages relating to the types of topics discussed by students

	Part A	Part B	Part C	Part D	Part E	Total
Interpretation	15%	16%	24%	1%	9%	15%
Development	26%	34%	34%	30%	54%	35%
Debugging	39%	32%	27%	52%	25%	33%
Grader	11%	12%	8%	1%	1%	7%
Further help	4%	6%	4%	5%	3%	4%
General discussion	4%	1%	3%	10%	8%	5%

In narrowing our analysis to the five channels corresponding to the five sections of the final project, we computed the percent of messages for each code using the two different coding schemes as with results shown in Tables 5 and 6. Across all channels, approximately 40% of the messages related to students expressing a problem or issue they wanted help resolving while 34% related to providing an explanation for a problem. In comparison, only 10% of messages related to achieving an apparent resolution. For individual channels, these percentages appeared fairly stable regardless of which channel was being analyzed. In terms of topics discussed, students spent most of the time discussing development of their code and debugging their code followed by interpretation of the equations. These percentages did change depending on the channel and relate to which each part required. Parts A, B, and C primarily required translating equations into a program with Part C showing the highest percent relating to equation interpretation. Part D required students to write a function that created an animated plot with the lowest interpretation percent, but the highest percent discussion related to debugging. Part E involved students writing a series of loops for user input validation, traditionally difficult content for students, where most of the messages related to development of code.

For instances of sense making, only one instance was reported resulting from a long discussion across 78 messages between four students two to three days before the project deadline spanning a total of nine hours, 11PM to 1PM followed by 8AM to 3PM the following day. Below are seven lines near the conclusion of their discussion on the Part C channel.

Ciel	Interpretation	"equation 5 gives the W value for the initial time t=0, how do you solve for the second answer W2? bc t will no longer be 0"
Iman	Development	"First 2 columns are both known. Plug in equation 5 for both"
Ciel	Interpretation	"so u solve eq 5 for w1 and w2, which are supposed to be the same via [instructor]'s part C video, but don't they have different x_m values? Sorry im j having trouble wrapping my head around this for some reason."
Shaw	Interpretation	"they don't for the first two columns. the idea is that the first column is at t1=0 and the second is at the first deltaT, which is negligibly small (basically 0)."
Ciel	Development	"so even tho equation 5 is for the initial time, it can be used for that second time interval immediately after bc deltaT is so small?"
Shaw	Interpretation	"yes. this is given to us in the form of equation 11, which basically is telling you there is no difference between w1 and w2."
Ciel	Interpretation	"WOW that makes so much more sense now, thanks."

These three students are discussing creating matrix W, a matrix that contains the deflection of the tuning fork over time, using the complex system of equations provided in Part C. This conversation is specifically pertaining to comprehending how to form this matrix using a vector of time points and equation 5. Equation 5 assigns the first 2 columns of matrix W as initial conditions and then students are required to repeatedly fill the rest of the matrix using the system of equations that represents all remaining timepoints. Ciel seems to be confused as to how the first two columns, representing the first and second deflections, are the same as they believe their deflection vectors differ, yet, equation 5 is used for both of them. This means if both columns were to have a different deflection vector their values could not be the same. This is when Shaw explains that the change in time between the two deflections only changes by a negligibly small amount; therefore, the fact that any time has passed is ignored and both columns are assumed to be the same. This idea is further specified in equation 11 which states that column 1 and 2 are the same and that is what Shaw references at the end. This conversation illustrates the process of a student rectifying the difference between what happens in reality, how that is represented in equations, and how that translates into writing a program.

In addition to the one sense-making instance, bids for sense-making were found where a student posed a good question that was not followed-up on. For example, the following message by a student demonstrates that they have some understanding of the problem, the same problem as the students above, but are missing a fundamental piece to finish writing and designing their program.

> "Anyone have any tips on how to understand the summation for W. I understand how to pull different values from each array/matrix, but I'm not sure whether I should be using an entire row/column or just pick one number to use for each iteration of the summation."

They indicate that they understand how to use MATLAB to access values in vectors and matrices, but are missing the key understanding of how to translate the equation into their program. Unfortunately, no one responded to their problem and continued the conversation.

Discussion

This study determined that Discord was a useful platform for students in this engineering computations course. We found that approximately 57% of students enrolled in the course across all sections joined the server with approximately two-thirds of them posting at least one message on a channel. Konstantinou and Epps also found similar rates with additional reporting that most students posted during the evening and night hours, times that do not follow the typical 9AM to 6PM schedule of professors and TAs [6]. For those remaining students with no posting or even minimal posting history, messages are never removed from a server, meaning students who choose to lurk on the server may still benefit from reading the student dialog. Additionally, we showed that usage increased in the few days before the deadline of each homework, showing further utilization as a general tool for students. Lastly, students used it to develop camaraderie prior to an exam with over 350 posts seen the day before each exam and in the ability to find a partner for the programming project.

The nature of the data in this study is text based conversation which limits the dialog as seen in the comment codes. Only 10% of messages were coded as apparent resolution in comparison to the amount of messages coded as problem and explanation. Very few problems, once answered, were indicated to be resolved via follow-up text. This may be because of the anonymous nature of the Discord conversations and lack of needing to acknowledge help from physically present conversational partners. This may also explain the result that minimal instances of sense making were found in the data. The majority of previous studies of sense-making, especially those in science classrooms, were of students working in groups in recitation sessions or classrooms engaged in assignments and tasks [17]–[19].

Even though few sense-making conversations were identified, topical codes indicated that students still spent two thirds of their conversation code development and debugging with an additional 15% of the time in interpretation. We viewed these codes as relating to programming in three phases: understanding the problem (interpretation), designing the code (development), and debugging the code (debugging). These results showed that students spent less time in understanding the problem which is known to be a challenging phase for novice programmers [23]. Instead of taking time to understand the problem, students almost immediately begin writing their program. Similarly, in studies of students working on fluid mechanics and controls homework problems students spent the majority of their time focused on getting the task done and not much time having conversations to make sense of concepts [24], [25].

Beyond the data displayed in this study, we believe there are other potential benefits of using Discord as a tool for students. Generally, TAs and professors are only privy to the topics and challenges discussed during their individual office hours. With the use of Discord, the professor and TAs can be more aware of what students are discussing and struggling with as noted and observed by the first author (E. Hammond). Additionally, Discord may offer an additional course resource for students who may face struggles in utilizing traditional resources such as non-traditional, LGBTQ, or disabled students [26].

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