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Collaborative Engagement and Help-Seeking Behaviors in Engineering Asynchronous Online Discussions*

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With current online learning platform technology, we are now able to observe undergraduate student learning in many spaces outside of the formal classroom, including through the use of technologies like asynchronous online discussion forums (AODs). The help-seeking and knowledge building behaviors of students in these virtual learning spaces, and engineering students in particular, merit further investigation to elucidate the ways that discussion forums may support or hinder knowledge-building and collaborative processes that are important for engineering students' learning outcomes. This study employed qualitative content analysis of a large amount of discussion forum data from seven semesters of the same blended university-level engineering course to investigate the ways that students used the forum to engage with their peers and course material. Our findings indicate various collaborative engagement patterns existed to promote group knowledge acquisition (e.g., asking technical questions, providing technical answers, and challenging or validating those answers). We posit that these engagement patterns made the forum an effective computer-supported collaborative learning (CSCL) space for the community of users as a whole. We find further support for the role of social presence, or a sense of group cohesion, learners may feel when interacting on the forum, and the ways in which it may shape knowledge construction in blended learning environments. We provide a series of practical implications to engineering educators and AOD designers for optimizing the ways in which learning happens for engineering students on educational discussion forums.

Keywords: engineering; asynchronous online discussion forum; computer supported collaborative learning; content analysis; collaboration; group learning

1. Introduction

Educational researchers have extensively studied how students learn outside of the formal classroom, often focusing on the use of computer-mediated learning technologies, such as asynchronous online discussion forums (AODs) [1–3]. AODs play an important and expanding role in supporting a variety of learning activities that may enhance student outcomes, and have the further benefit of allowing researchers to more rigorously track and study students' out-of-class interactions [2, 4–6]. In fact, the link between AODs and academic outcomes is being made increasingly clear, with recent evidence showing that these pedagogical tools increase critical thinking skills; flexible, independent, and collaborative learning; and knowledge construction [6–9].

In engineering courses, there is a strong need to identify and adopt innovative pedagogical approaches and technological tools, like AODs, that address the unique challenges these students face [10–12] and to improve the historically high rates of underperformance and dropout, particularly in the United States [13–15]. In fact, the President's Council of Advisors on Science and Technology (PCAST) encouraged colleges and universities to urgently address problems with STEM

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student retention and underperformance so as to produce an additional one million STEM graduates by 2022 [16]. Further, preparing future engineers to solve problems collaboratively has been a crucial demand from industry and the engineering programs' accrediting body [17–19]. With this in mind, our large public Midwestern university designed and implemented the *Freeform* environment, an educational setting used in core engineering courses (often "bottleneck courses") to improve student outcomes. Using active learning structures, blended learning models, and collaborative learning opportunities (ABC) to support our engineering students, the *Freeform* environment has reduced the rate at which students fail or withdraw from courses [20].

As part of the Freeform ABC paradigm, students in the Dynamics class that we have studied over multiple years are encouraged to participate on a course-specific AOD. The purpose of this study is to identify the behaviors exhibited by engineering students using our AOD and investigate the ways in which those behaviors may shape their learning process. Though there are many advantages of AOD use, there are still unanswered questions with respect to the ways in which students engage on these forums in the context of engineering courses and the elements of a productive online discussion environment that facilitate conceptual and procedural learning. The results of this study enable us to make practical contributions to engineering educators and AOD designers, in that we suggest a number of ways AODs can be designed and employed in undergraduate engineering environments to promote group learning and optimize knowledge acquisition.

AODs provide an accessible and flexible environment in which to study learning behaviors because they create new possibilities for academic help-seeking practices not available in a solely face-to-face classroom format. In such classrooms, a number of social, affective, and motivational factors may prevent learners from actively seeking help with their academic problems. We have known for decades that students may be embarrassed or anxious about disclosing their need for help and see it as a threat to their self-esteem, which may hamper their tendencies to ask for help when needed [21–23]. Student academic performance may be negatively impacted if students do not receive the help that they need, so designing a space where students can effectively seek help has positive implications for student learning.

It has long been established that the supportive and student-centric features of online discussions help to make a space that improves learners' help-seeking tendencies and learning practices [24–27]. Students, in particular those with less social confidence, sense of belonging, or desire to engage with others, may feel less threatened to participate, as they have more time to structure their thoughts and communicate their questions [28, 29]. Further, students can take on different learning approaches, either through their active participation or passive review of their peers' discussion, which may increase student tendencies to seek help on AODs [30]. Because AODs are known to improve student help-seeking behaviors, the *Freeform* AOD is a rich environment in which to investigate student engagement patterns to determine which methods of engagement are most beneficial for engineering student learning.

1.1 Research Questions

Based upon prior literature and our experiences with Freeform, we pose the following RQs:

RQ1. What patterns of help-seeking and help-providing can be observed on online course discussion forums?

RQ2. What emotional and attitudinal behaviors and forms of social interaction are present on the discussion forums?

RQ3. How might the aforementioned patterns of help-seeking and help-providing promote or hinder learning and knowledge construction for both individual users as well as for the community of AOD users as a whole?

1.2 Theoretical Framework – Computer-Supported Collaborative Learning

Computer-supported collaborative learning (CSCL) was used as the main framework describing course design and delivery in this study. A CSCL environment typically offers tools and provides a virtual space for sharing information, ideas, and expertise in the pursuit of group learning [11, 31]. CSCL as a tool has a number of educational benefits. First, a CSCL environment promotes the use of specific pedagogical techniques, like critical thinking, that stimulate deep and meaningful learning [32]. Second, CSCL environments enable geographically dispersed participants to coordinate and collaborate across time and space, removing the barriers associated with scheduling and colocation that many learners face [33]. Last, when instructors intervene and engage in explicit actions to stimulate activities and dialogues, CSCL can efficiently promote group knowledge construction and team development [34].

Further, CSCL environments have a social element of community that may stimulate learning. When students work in groups to complete a task or achieve a common goal, they learn to be effective communicators [11]. CSCL operates under the premise that learners function as a team; this means, for example, that learners must trust one another [33]. When members are reluctant or unmotivated to participate in a CSCL space, the efficiency of CSCL declines [32].

Specific CSCL strategies have been found to enhance the quality of asynchronous online discussions [35]. Social interdependence, or the extent to which students believe their success is impacted by other students' actions (as discussed above); summarizing, or a student's ability to create statements that outline main ideas and organize information clearly; and synchronicity, or the timely ability to clarify ambiguity and reach a group understanding, are among the strategies that may help to structure discussions in ways that optimize learning and collaborative outcomes [35].

The technological and social aspects of CSCL, and the specific CSCL discussion strategies, are used to facilitate and understand positive learning outcomes at individual and community levels [11, 33, 34]. The construction of meaning (and ultimately, learning) can be understood and measured through the degree to which there are frequent and timely, clear, and high-trust (or socially interdependent) communication patterns that create the required foundation for community-oriented learning on our AOD. Thus, we see CSCL as the appropriate theoretical framework selection, as the larger aim of our study is to examine whether the level of communication supported by the *Freeform* online discussion forum and the patterns of behavior observed in this space are sufficient to promote the collaboration that facilitates knowledge acquisition at the individual or community level.

2. Relevant Literature

2.1 Asynchronous Online Discussion (AOD)

An AOD forum is a virtual environment and web application that facilitates dialogue and social interaction outside of the formal classroom and is increasingly used in educational institutions to supplement face-to-face learning [30, 36, 37]. Unbound by temporal or geographical barriers, AODs enable both student-to-student and instructor-to-student discussions and debates [38, 39]. Users have the freedom and flexibility to decide when and where they will participate in AODs without being present at the same time. Further, the asynchronous nature of AODs enables users to have more time to structure their thoughts, and they can communicate simultaneously in multiple conversations [29]. The discussion forums create a digital, textual record of conversations, allowing participants to refer back to previous discussions and maximize their reflection of the content [40]. These records also allow for a detailed analysis of the posts (or individual discussion comments, as differentiated from a 'thread', which is a series of posts, or post segments, coded portions of a post) and of students' collaborations.

Student participation on AODs facilitates collaborative learning and group knowledge construction. Rather than static knowledge, AOD participants learn a creative cognitive process [41]. The participants practice generating new ideas, negotiating them with other learners, exploring comments and criticisms, and reshaping their understandings during peer discussion. Students exchange hypotheses and negotiate their meanings in the pursuit of shared understandings [41–43]. In essence, AODs expand opportunities for dialogue, feedback, reflection, self-assessment, and deep knowledge construction and internalization. These collaborative practices can enhance the learner's understanding of the course material and their academic performance [6, 28, 44, 45]. Considerable research shows that these elements of AODs improve students' critical thinking and analytical skills, decision-making abilities, written communication skills, and may also advance their abilities to organize and analyze information [6, 8, 9].

It is important to note that this understanding of AODs and their educational benefits implies the need for active participation and continuous contributions from student learners, and it overlooks how learning may happen for those who participate only passively in AOD. *Lurkers* are defined as those who do not actively contribute to the conversations happening, but rather read through the comments and potentially learn from the AOD [28, 46–49]. In order for lurking to yield positive educational benefits, however, the AOD content must have some degree of quality and quantity of contributions from the active participants [28, 50, 51]. Dennen (2008) argues that most learners are likely lurkers at some point, and it may be important to examine this passive participation when investigating how learning can happen on AODs.

Further, the literature suggests that the effectiveness of online discussion forums is also influenced by a number of external factors: incentives to participate, the perceived value of AODs as a learning tool, the past experiences of students using these tools, and the quality of the discussions [6, 51]. In order for AODs to effectively contribute to learning, participants need timely feedback, the ability to navigate the online environment, and a sense of content relevancy based on facts rather than personal opinions [6, 46, 52]. In short, the quality of an AOD environment is subject to the same kinds of considerations required for any other technology-enabled learning tool or face-to-face learning interaction.

2.2 Social Presence and Community

Social presence is an integral component of an online learning environment, as AOD forums are an inherently social and interactive place. Garrison, Anderson, and Archer (2001) describe social presence as the affective communication, open expression, and sense of group cohesion that learners experience as they interact with one another. When AOD participants sense a high degree of social presence established on their forum, cognitive development and effective collaboration are more easily sustained [53, 54]. According to Jelfs and Whitelock (2000), a sense of physical presence is mimicked when participants become aware of their peers' existence and contributions to the virtual space. AOD users may experience a sense of team within these collegial environments, and this social experience creates a sense of affiliation and solidarity. As students are more able to embrace the perspectives of their peers, they may deepen their own cognitive and learning opportunities [40].

2.3 Research Purpose

In this study, we seek to identify and understand the effective strategies for stimulating meaningful peer-to-peer learning interactions in an AOD. Further, we intend to understand the social environment of our AOD and the ways in which emotional and interactional components may contribute to the sense of community needed for an effective CSCL space. Finally, we aim to gain a deeper understanding of the ways in which productive individual and group knowledge construction may occur for both active and passive engineering learners.

3. Methods

3.1 Sites and Participants

The findings of the present study come from a larger longitudinal mixed methods study with 796 participants (see Table 1) enrolled in an undergraduate engineering mechanics (dynamics) course at a large research-focused Midwestern university. Our interdisciplinary team of researchers across mechanical engineering, engineering education, and anthropology examined 4,210 posts on a course AOD over seven semesters from the spring semester of 2015 through the spring semester of 2018. We exclude the data gathered from the students who enrolled in the course but opted out of participation in the larger research study. The subsequent analysis investigated comments only of those students who both consented to our IRB approved study and participated by posting on the course discussion forum.

3.2 Freeform Setting

In 2008, faculty at the university in which this study took place developed and introduced the *Freeform* approach to learning in mechanical engineering classrooms. Core, middle-year engineering courses have historically high rates of student underperformance and dropout [55–59]). Motivated by these challenges, the *Freeform* educational approach incorporates research-based practices in active, blended, and collaborative (ABC) instruction to improve student learning and retention during these critical middle two years of study.

A variety of resources were provided to students in the *Freeform* classroom during a 16-week semester. The *Freeform* system moves away from passive face-to-face lecturing models and towards an interactive, multi-dimensional, student-centered approach. Since the implementation of ABC pedagogies into classrooms at this university and at various partner institutions, academic outcomes and reported experiences have greatly improved for student adopters. Students learning in the *Freeform* classroom may benefit from a shared sense of community and feel their specific learning preferences are supported with the breadth of course resources [60, 61].

Among the diverse teaching and learning resources, the course website is the centerpiece of the blended component of the *Freeform* environment. The website contains many immediate resources for dynamics students: an interactive

Table 1. Number of Participants and Number of Posts

Semester	AOD	IRB + AOD	Number of Posts
Spring 2015	235	189	1822
Fall 2015	38	17	142
Spring 2016	200	190	973
Fall 2016	47	36	116
Spring 2017	71	69	322
Fall 2017	20	17	47
Spring 2018	161	153	788
Total	**772**	**671**	**4210**

```
-----------------------------------NEXT POST-----------------------------------
Post: 2069
Comment: 769
Commenter: 40@        .edu
Date: 2015-02-09 18:13:50

w_ab = 2.78 K rad/s  a_ab= -84.36 rad/s*2 Sound right?

-------------------------------------------------------------------------------------
```

Fig. 1. An example of the content and details of a student post on the Dynamics online discussion forum.

AOD forum where students can review and discuss their homework assignments, but also separate pages housing hundreds of problem solution videos, course examination examples, and videos that show physical demonstrations of core dynamics concepts. Providing a convenient and collaborative place for students to discuss homework assignments, the AOD forum we study allows students to communicate asynchronously about a host of classroom topics. Students are assigned six homework problems per week, and the AOD hosts a thread for each homework problem. Course instructors explicitly champion the AOD (via announcements and encouragement during in-person class meetings) as a place for students to seek and provide help to their peers as they progress through the course material.

3.3 Data Collection

3.3.1 Procedures

The AOD that we study is hosted on a Wordpress platform, with access provided to the students enrolled in the course and their instructors, whom varied each semester. Students could choose their username when they write their posts on the forum and make their identity anonymous, if preferred. The majority of the forum was organized by homework problem to encourage all of the posts in a given thread to be related to a specific dynamics problem. The instructor posted an initial thread-starter for each homework problem (consisting of an image related to the problem and an invitation to discuss), but rarely contributed to the discussion thereafter, so as not to stifle communication amongst students who were encouraged to collaborate to reach answers and understandings on their own. Instructors monitored the course forum and intervened if a discussion was derailed or hindered, which happened very rarely.

The online discussion forum was made accessible to students from the beginning to the end of the course. After writing five posts, students received a small amount of extra credit as a reward for their participation on the AOD. This incentives approach was selected after doing many tests over a period of semesters to determine an appropriate incentives formula.

3.3.2 Data Source

The primary data source for this work is the XML file from the online course discussion forum, downloaded from Wordpress at the end of each semester. We used Python code to extract data associated with each comment in the XML file and created a chronological CSV text file (example shown for post #2069 in Spring 2015 in Fig. 1). The CSV files from the discussion forums were uploaded into the QSR NVivo 12 data management program, and a comprehensive process of data coding and theme identification was undertaken. Two qualitative coders from sociology and engineering management reviewed transcripts from each of the 7 semesters in the dataset.

3.4 Data Analysis: Qualitative Coding

Qualitative data were processed using content analysis to extract and categorize patterns of relevant information. Our coders established a coding scheme for help-seeking (HS) and help-providing (HP) behavior that builds off the HS/HP model proposed by Cross et al. (2017) [62]. Cross et al. identified five parent codes (Help-Seeking, Help-Providing, Resolution, Clarification, and Social Interaction), each with a series of nuanced sub-codes. While this framework provided initial direction for the content analysis, over a series of four iterations as the analysis progressed and results emerged, we subtracted, modified, and collapsed parent and sub-codes through a reflexive and iterative process [62]. For example, Cross et al.'s study identified the sub-code "Direct Question", but did not differentiate between types of direct questions, whereas we distinguish between questions related to course content and those that are not [62]. This qualitative coding allowed us to adapt the framework for the unique content identified on the *Free-form* forum. The collaborative procedure ensured the categorization of codes were supported by excerpts from the participants' posts. Our final codebook included 5 parent codes and 21 sub-codes (See Appendix A), and the frequency of each code identified in our data set was calculated by dividing the total number of sentences with a given code by the total number of coded sentences (excluding the Engagement and Resolution codes, which we discuss below).

The unit of analysis was at the sentence level or at the partial sentence of each comment (termed here as post segment), rather than at the post itself, which could contain numerous sentences. Our scheme was developed with the intent to increase accuracy in our representation of the behaviors expressed. However, the manner in which researchers can acknowledge contextual information is an additional benefit to the qualitative methodology employed. When dissecting comments at the sentence or partial sentence level, researchers took into account the context of the preceding or subsequent coded sentences (threads) to better understand the behaviors exhibited. For example, it became clear when to label a 'Challenge or Validation' sentence when we situated it in the presence of a previous 'Sharing Technical Knowledge' post that it disputed. By taking larger threads of conversation into account when segregating comments into their corresponding codes, we benefited from a more nuanced and holistic understanding of the interactions and communications present on the forum.

We developed the coding scheme with mutual exclusivity, to ensure the defining criteria of each code gave it a unique meaning that differentiated it from another code. The only exception to this exclusivity was the Engagement and Resolution codes, which were applied to every help-seeking post to indicate whether it received any form of resolution. We calculated the frequency of each Engagement and Resolution code by dividing the given code by the total number of help-seeking codes. We conducted numerous consistency checks to ensure accurate and reliable coding among the researchers. We addressed any inconsistencies in coding by making the appropriate modifications to the codebook and recoding the inconsistency to its appropriate category. In this research study, we did not do any direct detection or analysis of lurkers because of our focus on active user engagement; however, our analysis will allow us to understand how the *Freeform* AOD may benefit the entire user community.

4. Results

Content analysis enabled us to identify a series of patterns students used to engage with the course AOD. Most notably, the students' engagement predominately fell under either the 'help-seeking' or 'help-providing' classifications. This means that students primarily interacted on the discussion forum either to solicit information about course topics and logistics or dynamics content, or to share information about such points. However, we did also observe a series of much less frequent methods of engagement, for example emotional or attitudinal expressions, or social interactions among forum participants, namely through their exchanges of social niceties. We outline these results in Table 2 and go into detail about them and their significance below.

Extrapolating further from the coding scheme developed by Cross et al. in 2017, we were further interested in understanding the degree to which help-seeking interactions between forum participants received some form of resolution (Table 3) [62]. We broke this parent theme down into a series of sub-codes to identify the degree to which questions asked on the forum received a direct answer confirmed as resolving the question, a degree of

Table 2. A comparison of coding frequencies by category. Frequencies represent the proportion of all post segments placed in each category. These codes are mutually exclusive

Category	Sub-code	Coding frequency
Help-Seeking	Asking Technical Questions	0.237
	Asking Implicit Questions	0.035
	Asking for Clarification	0.044
	Asking Non-Technical Questions	0.015
	Asking for Answer Verification	0.024
Help-Providing	Sharing Technical Knowledge	0.324
	Sharing Non-Technical Knowledge	0.010
	Challenging or Validating	0.205
	Exchanging Resources	0.044
Emotional and Attitudinal	Positive Emotion	0.000
	Negative Emotion	0.003
	Neutral/Ambiguous Emotion	0.006
Social Interaction	Positive Social Interaction	0.030
	Negative Social Interaction	0.000
	Unrelated/Neutral Social Interaction	0.023

Table 3. Codes applied to Help-Seeking category sub-codes to determine their outcome

Engagement and Resolution	
Help Received	0.057
Help Received Non-Technical	0.001
Help Not Received	0.148
Help Not Received Non-Technical	0.016
Help Attempted	0.753
Help Attempted Non-Technical	0.026

engagement with no clear marker of resolution, or an obvious lack of resolution marked by the absence of any engagement to the help-seeking question posted.

4.1 Forms of Engagement: Help-Seeking

We identified and categorized a significant portion of student behavior on the forum as Help-Seeking. Each of these help-seeking behaviors is described as follows.

4.1.1 Asking Technical Questions (ATQ)

Students commonly engaged with the dynamics discussion forum to solicit information from other students by asking explicit questions about a technical concept or procedure. We categorized these as 'Asking Technical Questions' (ATQ) and identified their presence (as with most help-seeking codes) by the inclusion of sentences whose meanings are clear solicitations for help, like "Is it. . .", "How do. . .", "I am wondering if. . .", "I don't know how. . ..", or other types of help-seeking syntax regardless of grammatical rules. For example, the below quotes are comments from student help-seekers who engaged in ATQ behavior.

> "Is it ok to assume the velocity of P is only in the j direction?"
>
> "I am wondering if it is ok to assume the velocity of P is only in the j direction?"
>
> "How do you find the moment of inertia of the plate Or do you not need it"
>
> "I don't know how you find the moment of inertia of the plate Or you don't need it?"

ATQ is unique from other HS codes in that it must be an explicit question presented to the other users and clearly related to course content and dynamics information (to be distinguished from 'Asking Non-Technical Questions', as defined below). The large number of ATQ codes (23.7% of all of the post segments) was unsurprising because the forum was explicitly constructed to help students collaborate to solve their dynamics homework problems. The majority of HS engagement falls into the ATQ category.

4.1.2 Asking for Clarification (AC)

Students also sought clarifications about others' help-seeking or help-providing posts. We identified the 'Asking for Clarification' code (AC, which appeared in 4.4% post of segments) when students attempted to elicit specificity or elaboration on another user's comment. The students engaged in this behavior to probe for clarity, prompting a further response from the original poster or someone else who may have understood the point of confusion.

> "I figured, so you're saying we would use the relative accelerations for the forces acting on P? If so, that makes sense."

We identified a frequent pattern of AC posting where a student would ask a technical question (ATQ) or respond to shared technical knowledge (STK), and they would then make a request for further clarification (AC). The thread continued when the point of confusion was made clear (by either the original poster or by someone new) and the discussions and collaborative process continued. In this sense, AC posts may have contributed to student participation and engagement, as users who could provide clarification to a peer took advantage of the opportunity to participate by doing so.

4.1.3 Asking Implicit Questions (AIQ)

Students asked implicit questions (3.5% of the time) when they probed into a specific topic and the need for additional information with statements. Asking Implicit Questions (AIQ) were usually inquiries about the technical course content, as students stated an uncertainty about a specific dynamics concept or procedure without asking a direct question relating to their confusion.

> "I got the problem solved out to where I have the theta double dot and r double dot. I can't seem to grasp how to relate the v and v dot to the problem though."
>
> "I am having trouble determining the magnitude of the velocity to multiply the tangent vector by. . ."

Although few, we also observed the presence of AIQs made about non-technical content. We chose not to distinguish AIQs into technical and non-technical categories (as we did with other HS/HP behaviors) because the small number of non-technical AIQs did not meaningfully contribute to our analysis of student interactions.

4.1.4 Asking Non-Technical Questions (ANTQ)

Despite student HS engagement being mainly related to the course concepts and procedures, students also solicited help unrelated to the technical content of the course. We uncovered a series of logistical and administrative questions, or Asking Non-Technical Questions (ANTQ), illuminating the manner in which students also found the forum useful in ways outside of their dynamics knowledge development. For example, participants asked questions about exam dates or locations, the course forum set up, teaching assistant availability, or review session scheduling. Although students were clearly soliciting help in their ANTQs, these codes are not directly related to their knowledge construction and learning processes.

> "Is there going to be a TA in the help room tomorrow?"
>
> "Can anyone clarify when the review sessions are if any for the final?"

In fact, the course website provided a separate location for students and instructors to discuss information of this nature. The *Freeform* team developed the 'Exam Pages' section of the course website to house logistical discussions, so the frequency of ANTQs observed on the AOD (1.5%) are only a small portion of all of the inquiries made of this nature.

4.1.5 Asking for Answer Verification (AAV)

Lastly, we identified students 'Asking for Answer Verification', or probing for confirmation from other forum users that a numerical answer or equation of the homework problem (or a step in the homework problem) was correct. Qualitative coders easily detected AAV – it always included a mathematical result (or results) and overtly requested peers to affirm or reject its validity.

> "I found A = 0, B = 3/275 in my xp equation can anyone confirm this?"
>
> "Did you guys get Aa = –9i + 1j and Ab = –5i –3j ?"

Often, AAV posts included the phrase 'did anyone else get' preceded by a series of answers, prompting other students to review and compare their answer and reply either with an affirmation or rejection. Notably, we identified the overwhelming majority of AAV posts in the Spring 2015 semester. The Spring 2016 and 2018 semesters contained only a few of these posts, and none were identified in the Spring 2017 semester or any of the Fall semesters. Although AAV posts were highly present in Spring 2015, they made up 2.4% of all of the post segments due to their declining frequency in the subsequent semesters. Instructor directions about forum use may have differed in Spring 2015 in comparison to other semesters, and this could be the reason for the presence of AAV posts largely contained to this semester.

Further, AAV posts appeared to have facilitated additional engagement from other forum participants. For example, when a student sought answer verification, often there were many responses from peers. We speculate this additional engagement may have been related to the low cognitive load required to simply agree or disagree with a previous user, and it may have been perceived to be an easy way to receive the extra credit points for participation.

4.2 Forms of Engagement: Engagement and Resolution

We were also interested in the degree to which help-seeking participants received some form of resolution to their questions. All of the Engagement and Resolution codes were applied to the help-seeking post itself, as a way of documenting the subsequent resolution result for that question. Below we describe each of these potential engagement and resolution outcomes in detail.

4.2.1 Help Received and Help Received Non-Technical (HR or HRNT)

We identified and applied the 'Help Received' code to indicate complete resolution of a given help-seeking post. For a help-seeking post to receive an HR code, we required not only a direct response to the question with relevant information, but also an explicit textual indication from the help-seeker that help was in fact received (for example, by saying "Got it, thanks"). We subcategorized the HR code into 'Help Received' (HR), and 'Help Received Non-Technical' (HRNT), differentiated by the nature of the original help-seeking post; resolved questions about course concepts and procedures earned an HR code, while those relating to administrative, logistical or other non-technical aspects were assigned HRNT codes. In the example below, the original help-seeking post received an HR code.

> Help-Seeker: "For part A, is Vb perpendicular to BD or does it run along AB?"
>
> Help-Provider: "For either figure, VB should be perpendicular to BD because it is directly attached to a pin joint which means it has to rotate about that point."
>
> Help-Seeker: "Thank you!"

In requiring responses of acknowledgement for HR codes, the researchers omit their own projections of resolution, instead coding for a sense of resolution perceived by the help-seeker. 'Help Received' does not necessarily indicate that the help-provision post was factually accurate, only that it maintained relevance to the question and prompted a response of acknowledgement from the original poster. Of all of the help-seeking posts identified on our forum, HR or HRNT proved the least likely resolution outcome (5.7% and 0.1% of all of the help-seeking post segments, respectively). However, if we had relaxed the confirmation requirement for inclusion in the 'Help Received' code, and used our researcher judgment to define help-seeking posts as receiving resolution, the vast majority of help-seeking posts would fall into the 'Help Received' category. We opted not to make these assumptions to increase the accuracy of the codes.

4.2.2 Help Not Received (HNR or HNRNT)

We identified a non-trivial number of help-seeking posts that went unanswered (16.4% of help-seeking post segments), receiving no engagement or relevant responses from peers. We categorized these ignored or overlooked questions as 'Help Not Received' to indicate the obvious lack of resolution for the help-seeking student. Similarly to the HR/HRNT codes, we classified occurrences of no resolution as either 'Help Not Received' (HNR) or 'Help Not Received Non Technical' (HNRNT) to categorize them correspondingly with the nature of the original help-seeking question. As exemplified by Fig. 2, we identified an 'ATQ' as the last comment for the given homework thread. No students returned to engage with the question, and it received the HNR categorization.

Not surprisingly, we identified an overrepresented number of unresolved questions towards the end of each homework thread (which were organized chronologically). In other words, help-seeking posts made towards the end of the conversation (and closer to the homework submission deadline) were more likely to go unanswered. The HNR post below is a technical question asked at the very end of the homework's discussion thread and received no engagement or response.

4.2.3 Help Attempted (HA)

The majority of help-seeking (77.9% of help-seeking post segments) identified on the discussion forum received engagement from peers, but no clear resolution was observed. In other words, relevant help-provisions were made in response to most of the questions asked on the forum, but the original posters often did not reply to their help-providing peer (or peers) acknowledging that those responses answered their questions. We categorized these occurrences as 'Help Attempted' (HA), or 'Help Attempted Non-Technical' (HANT) to acknowledge the presence of one or more relevant help-providing responses, without assuming the help-seeker either read the response or responses, or that it did in fact clear up their uncertainty (although that may have been the case).

> Help-Seeker: "Are BCE and CD connected by a pin or is it one rigid body?"
>
> Help-Provider: "I believe it's one rigid body"
>
> Help-Seeker: (no response)

As exemplified above, the technical question received an appropriate response that answered the question. However, their conversation ended there, as the help-seeker never returned to acknowledge that response and confirm it resolved their question. Perhaps the help-seeker never saw this response, or perhaps they felt it did not resolve their inquiry.

4.3 Forms of Engagement: Help-Providing

Consistent with the preponderance of help-seeking posts, we categorized a vast majority of discussion posts as help-providing responses to those inquiries. In fact, help-providing posts consisted of the largest number of posts and the most common form of engagement.

4.3.1 Sharing Technical Knowledge (STK)

Sharing Technical Knowledge (STK) was the most common form of HP behavior identified on our AOD, representing 32.4% of all of the post segments. 'STK' posts are responses to previous help-seeking posts where information about course topics or dynamics procedures was provided in response to another student's post.

> "I think you only need to set it up for B with respect to O since we know that B is constrained to move vertically in the global system. So for global, vB = vBJ. Then for local, vB = vO + wBOE x rB/O + vB/Orel. vB/Orel should be 0 because B is a fixed distance away from O. Equate the two vB equations and use the relationship between the local and global coordinate system to make sure all your terms are either in relation to the global system or the local system."
>
> "I think you are supposed to assume the axes coincide, so theta = 0. It would probably just be easier to make note of that at the beginning."
>
> "I believe the value of "b" refers to the length from O to B."

STK posts elaborate on or clarify the specific technical details raised in a previous HS post and are differentiated from other HP posts in that they share information only about the technical or analytical aspects of dynamics material. In this

Help-Seeker: "How did you find the rate of change in speed of P?"

NEXT POST

Fig. 2. An example of a post segment receiving the HNR code, given the context of the subsequent post.

way, STK is the appropriate counterpart to 'Asking Technical Questions' that focus only on dynamics concepts and procedures. Similarly to ATQ, because the forum was erected as a space for students to discuss homework assignments, the research team expected a majority of HP behavior identified on the forum to include these technical and analytical aspects.

4.3.2 Sharing Non-Technical Knowledge (SNTK)

However, in congruence with the emergence of ANTQs, where participants posed questions to their peers about administrative or non-technical aspects of the course, we identified a series of corresponding help-provision posts that we labeled 'Sharing Non-Technical Knowledge'. SNTK posts were responses to previous help-seeking posts that requested information from other users about scheduling details, due dates, or exam material, for example.

> "If you look in the exams section, you'll find the formal Exam 1 Equation sheet."
>
> "Correct. This homework is due tomorrow."

As the AOD was not designed to be a space for inquiries like these (and in fact there was a separate location on the course website to discuss such topics), SNTK were much less prevalent (1.0% of all of the post segments) than those related to course content.

4.3.3 Challenging or Validating (CV)

Another way in which students provided help was to challenge or validate other forum users' work, responses, or opinions. We labeled these endorsements or feedback for and rejection of other's responses as 'Challenging or Validating' (CV). When students 'CV', they engaged with a specific idea or statement from another user and shared additional information to support or contradict the point in question. 'CV' engagement is a way of sharing information, similar to the 'STK' code. However, we utilized the 'CV' code to account for a more nuanced method of help-provision that went above simply sharing information and to account for the contextualization and negotiation occurring. For this reason, we lumped the act of challenging or validating others' work together, instead of creating a separate code for each behavior. Students usually challenged or validated other's help-providing posts; however, we also identified the presence of CV codes as reactions to claims asserted in a previous help-seeking post (particularly AAV posts). For example, the conversations below exemplify the CV process occurring within a variety of help-seeking and help-providing contexts.

> Help-Seeker: "Just to ensure I understand this problem, the satellite is moving from left to right (with increasing theta). So theta=0 is before what I pictured?"
>
> Help-Provider: "That was my understanding." (validation)
>
> ---
>
> Help-Provider: "I believe the ball cannot stop. I derived an exponential decay function for the ball's speed as a function of distance. This will approach zero asymptotically, but will never actually reach the value of zero. This makes sense, as the normal force used for kinetic friction is dependent upon v. Therefore friction will decay with speed, so in an imaginary world the ball will never truly stop."
>
> Help-Provider: "Good that's what I got too" (validation)
>
> ---
>
> Help-Provider: "I derived the exponential function too. Trying to take the ln(0) does not turn out well. I think you can plug in a relatively small value for final velocity (v) in order to get a pretty good approximation of the relation to distance (s) though."
>
> Help-Provider: "I think conceptually you're correct, but if you integrate your velocity equation, you will get a distance traveled and it's not infinity. I think this is because theres [sic] a point where the particle is going really slow and keeps getting slower so theoretically it will never reach a certain distance (this is the physical representation of a limit)." (challenge)
>
> ---
>
> Help-Seeker: -6pi e_r -3pi^2 e_theta for v?
>
> Help-Provider 1: "I have the same result, but my e_theta term is (-3pi^2)/2." (validation)
>
> Help-Provider 2: "Me too." (validation)

As demonstrated above, the CV code often provided justifications and explanations for the dispute or support made; however, simple agreements like "me too" were also categorized in this code. After STK, CV codes were the most common form of help-provision for forum participants (appearing in 20.5% of all of the post segments), and can be understood as a method of negotiation, debate, and shared knowledge construction as students engage with other ideas in new or supportive ways.

4.3.4 Exchanging Resources (ER)

Additionally, we observed forum participants sharing resources with their peers as a form of help-provision. We identified and categorized the 'Exchanging Resources' (ER) code when students made recommendations to review content on other websites, the course lecturebook (our proprietary course textbook/workbook) or other *Freeform* resources. We also included input from the instructor as a form of ER.

> "For instance, the coefficient of static friction for rubber is 1.16 *[link inserted]*."

> "This problem is kinda like Lecture problem 4.A.8, however, the shape of the connector is not the same."

Often, students would include ER codes in a post with other HP components. For example, a student would share technical knowledge (STK) related to the point of confusion and subsequently direct their peer to a page in the lecturebook or video solution problem with a similar procedural or conceptual aspect. Although ER codes made up a non-trivial portion of all HP posts (and 4.4% of all post segments), their frequency proved incomparable to the omnipresent STK and CV posts.

4.4 Forms of Engagement: Emotional & Attitudinal

Outside of student engagement targeted around the course content and students' problem-solving procedures, our observations of the forum data indicated that users at times expressed emotional or attitudinal statements. This category of forum participation was broken down into subcategories to recognize their positive ('Positive Emotion', or PE), ambiguous or neutral ('Ambiguous/Neutral', or AE), or negative connotations ('Negative Emotion', or NE). For example, we identified students expressing emotions and attitudes about the topic or problem with a positive tonality or sharing their thoughts in negative ways.

However, these 'Emotional and Attitudinal' posts presented a particular challenge for the research team when codifying this method of forum engagement. When attempting to understand the emotions of student users through their participation on our forum, it was tempting to infer meaning or impart our own researcher interpretations onto the post at hand. Rather than speculating or inferring about the motivations or context behind these posts, we agreed to categorize only overtly negative and positive expressions when there was clear and explicit meaning. For example, we identified an overtly positive sentiment (PE) in the first quote below, and an explicitly negative tone (NE) in the second one:

> PE: "I love it when I get the answer right on the first try!"
>
> NE: "This problem sucks."

All other 'Emotional and Attitudinal' posts that simply expressed confusion or had no overt emotional overtone were categorized as Ambiguous/Neutral (AE). Because we used this method (originally suggested in the Stump et al. in 2013 study on coding emotions in forum data) to understand the emotional and attitudinal expressions of our forum users, the vast majority of these posts fell in the AE category. Although we may have lost some degree of information by coding this way, we feel we strengthened the reliability of our data by reducing the speculation of meaning and interpretation of the users' tones.

Of further interest, we identified only a tiny fraction (0.9%) of all of the forum post segments as containing emotional or attitudinal components. Similarly to the Social Interaction code described below, there was an obvious and definitive under-representation of this code throughout the forum. In short, the course forum was not an environment where participants exhibited emotional behaviors in meaningful ways.

4.5 Forms of Engagement: Social Interactions

Student behavior on the forum was also categorized to recognize the occurrence of their social interactions. Similarly to the 'Emotional and Attitudinal' category, social interactions were less frequent (5.3%) and therefore not considered a major pattern of total AOD engagement. Like the emotional codes, social interactions were analyzed and distributed into their corresponding distinctions based on their positive (Positive Social Interaction/PSI), unrelated or neutral (Unrelated/Neutral Social Interaction/USI), or negative nature (Negative Social Interaction/NSI). The most common interactions identified on the forum were social niceties: expressions of gratitude from help-seekers, or gestures of goodwill from help-providers.

> PSI: "I really hope this helps! Have a great day!"
>
> PSI: "You are a life saver"

Although we created a code to capture the expression of negative social interactions (NSI), there were no examples of this identified in our forum data. Similarly to the Emotional and Attitudinal data, we omitted categorizing social interactions based on researcher projections and interpretations, although we felt there were fewer ambiguities when understanding this behavior. While we did uncover the presence of social interaction codes unrelated to course discussion, (for example "*If I punch myself and it hurts, am I strong or weak?*"), most SI codes did in fact correspond to the general forum discussions.

5. Discussion

5.1 User Engagement Patterns

In the preceding sections, we have described the variations in engagement observed on the *Freeform* course discussion forum and how they are distinguished along help-seeking and knowledge building or social and affective lines. Specifically, we have described the patterns of engagement identified on the course discussion forum. As outlined, the forum

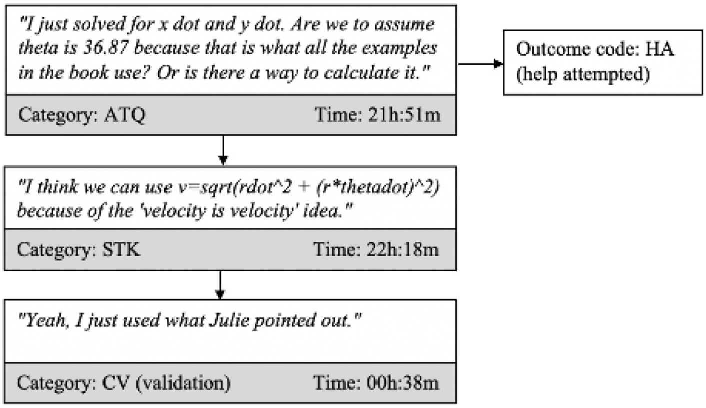

Fig. 3. An example of common collaborative interaction pattern, with time indicating clock time in 24h format.

is clearly a space in which participants comfortably sought and provided help to their peers, and we have delineated a series of ways in which they engaged in these HS/HP behaviors. Notably, we repeatedly observed a specific interaction pattern involving a technical question about a dynamics concept or procedure, followed by a help-provision post with information about that question, which would be subsequently challenged or validated. Overwhelmingly, the original poster would not return to acknowledge the help-provision posts, and the thread would end with the original HS post receiving the 'Help Attempted' categorization. We contextualize this pattern as a form of collaboration and discuss its implications in the subsequent section. This process is outlined in Fig. 3.

Overall, posts and comments received more engagement from peers if they were directly related to the course content and technical nature of the homework assignment (Asking Technical Questions, Asking for Answer Verification, Sharing Technical Knowledge, and Challenging or Validating). Although codes like Asking for Clarification or Exchanging Resources are related to course concepts and procedures, we do not make any claims about how they may have stimulated engagement, due to their overall lower presence on the forum. Each code's frequency was described previously in Table 2.

Although it is clear that most HS posts received engagement from peers with no obvious resolution (and therefore were categorized as 'Help Attempted'), no clear patterns of resolution within HS categories can be made. We could draw no conclusions about whether specific kinds of HS posts (Asking Implicit Questions versus Asking Technical Questions, for example) were more likely to receive resolution.

Further, we observed very few variations in patterns of engagement across semesters. The only exception to this consistency was the 'Asking for Answer Verification' code, which was overwhelmingly contained to the Spring 2015 semester. Across all of the semesters, the other codes were similarly represented, with ATQ as the primary help-seeking behavior and STK and CV as the primary help-provision behaviors. 'Help Attempted' proved the most likely resolution outcome across all semesters. Throughout the seven semesters of study, Emotional and Attitudinal and Social Interaction codes were uncommon engagement patterns.

Next, we discuss the larger significance of these results by contextualizing them with each other and by situating our understanding in the literature. Our discussion focuses on how these communication and engagement patterns may or may not facilitate a sense of community or affect individual and group learning outcomes. We posit that the degree of collaborative behavior on the AOD supported an effective CSCL space that positively shaped cognitive development and group learning processes in engineering classrooms.

5.2 Collaboration

Our qualitative results and context-driven assessment of communication patterns on the AOD show a deep and meaningful degree of collaboration, and suggest that the exposure to a variety of timely ideas may stimulate an effective exchange of information and creativity [11, 63, 64]. Student forum participants engaged sincerely and with purpose in each aspect of the collaborative process. They asked insightful and relevant questions about mechanics topics, explored misunderstandings and identified aspects of the material where additional knowledge was needed. These questions prompted other users to examine their interpretations of the material and share information related to those knowledge gaps. When students shared and presented their ideas on a given discussion point, they were often exposed to others' comments and criticisms and became involved in a socially interdependent negotiation process where new perspectives were shared and knowledge was constructed. It is clear that these processes of negotiation and collaboration are instrumental in students' knowledge building and cognitive skills development [45, 65–68], and in our case, they provided the scaffolding to the next level of mechanics knowledge.

We discovered a highly interactive and socially interdependent community throughout the period of study. The vast majority (77.9%) of help-seeking post segments received acknowledgement and responses from peers ('Help Attempted'), whereas a much smaller number (16.4%) of communications were ignored ('Help Not Received'). As a reminder, all help-seeking posts received an Engagement and Resolution code to document the outcome, so these totals, combined with the Help Received code, add up to 100%. When evaluating these patterns of interaction and their frequencies together, the ways in which students co-construct knowledge through their virtual interactions becomes clearer. Highly collaborative interactions, supported by frequent and consistent communication that incorporates purposeful engagement of the course material, are essential elements in creating effective CSCL practices [6, 28, 44]. Help-seekers themselves substantiated this notion when they acknowledged experiencing a sense of resolution (Help Received, 5.8% of help-seeking post segments) and indicated they developed new insights and understandings.

These collaborative learning practices got richer over time. In Spring 2015, we identified a non-trivial number of 'Asking for Answer Verification (AAV)' posts. Although AAV may have spurred further engagement from peers because it required only a simple confirmation or rejection of the original poster's answer (or because instructor directions about the appropriate forum use differed), we view this behavior as shallow and with limited relation to meaningful constructions of knowledge. The other major help-seeking/help-providing patterns require deep thought, metacognition, critical thinking, effective communication, and meaningful engagement with the dynamics concepts and procedures associated with their homework assignments. When students ask or respond to AAV posts, an opportunity to observe others demonstrate these processes is interrupted, and no insights into their problem-solving process can be gleaned. Therefore, we posit that as the prevalence of AAV diminished throughout the period of study, replaced instead by ATQ posts (as shown below, in Table 4) that stimulate meaningful debates and deeper knowledge construction, the richness of the collaboration and educational benefit also increased.

Table 4. Asking for Answer Verification (AAV) and Asking Technical Questions (ATQ) occurrences by semester

Semester	AAV	ATQ
Spring 2015	60	110
Fall 2015	0	55
Spring 2016	11	283
Fall 2016	0	60
Spring 2017	0	116
Fall 2017	0	26
Spring 2018	1	243
Total	**72**	**993**

5.3 Affective and Social Behaviors in the Online Environment

Our results suggest that the affective and social behaviors exhibited by forum participants were so infrequent that they likely did not play a role in creating social cohesion or a sense of community. In fact, affective and social expressions were so scarce (6.2% of all units of analysis) that their contributions to overall discussions are largely inconsequential and did not make up a meaningful pattern. Rather, our characterizations of the forum engagement appear to be more transactional. That is, students participate in the course discussion forum to seek and provide help and not to express emotions or interact with one another. Further, they largely overlook affective and social behaviors as even a secondary purpose of participation, meaning that they are often comfortable excluding social niceties or expressions of their emotional wellbeing, even if it might further their help-seeking or help-providing outcomes. This is not necessarily surprising to the research team, as the AOD design and implementation is formatted in a fairly transactional manner, with the primary purpose being to facilitate discussions related to homework problems (and to a lesser extent, the exams).

5.4 Affective and Social Behaviors in the In-Person Environment

It has been noted that a strong sense of social presence is a prerequisite for further learning on AODs [54]. Without the affective and open communication styles necessary for creating a warm and collegial environment on the forum [69], the productive and effective collaboration we see is in fact unique. However, when we take into account the larger sociocultural ecosystem of the department, and the cooperation and sense of community deeply embedded into the Mechanical Engineering culture at our particular institution [70], the patterns of group learning and collaboration are less unusual. We posit that the strong sense of community present in these in-person interactions has a similar effect on group learning in blended learning environments that strong social presence has in fully online courses. In this sense, our findings here align with the broader discussions that suggest that a sense of community plays an integral role in facilitating group learning.

5.5 Understanding Engineering Learning

AODs provide a space outside of the face-to-face classroom for learners to interact and communicate, and they can therefore be a valuable educational resource in addition to classroom materials and traditional lectures. The highly collaborative, interactive, and socially interdependent *Freeform* discussion forum, coupled with the strong sense of community that learners experience during their in-person interactions, supports and advances the group knowledge construction and co-learning experiences of our AOD users. However, in assessing how learning may have happened at the individual level, a different picture emerges. We did not investigate individual student outcomes and their relationship to forum participation in this study, although we did in a separate, mixed-methods study of the AOD data [71]. We cannot confirm that specific help-seekers on the forum received timely and appropriate answers to their homework question. Student help-providers were not always accurate in the information they shared, and help-seekers often did not indicate a full sense of resolution occurred ('Help Received'). Therefore, our analysis is limited in its ability to assume occurrences of individual learning that facilitated better academic outcomes for any given participant.

However, when understood holistically as a CSCL tool that promoted a rich quantity and quality of collaborative learning behaviors (including summative, timely, and socially interdependent behaviors), we contend that the *Freeform* AOD sparked a series of deep learning practices that benefited the *Freeform* community of users. Further, these collaborations and exhibitions of deep learning likely also benefited lurkers, who participated only passively, in that it provided ample opportunities to observe the critical thinking and problem-solving processes of their peers. Below, we conclude our analysis with a series of practical design recommendations informed by this discussion.

6. Limitation and Future Work

This study has several limitations that should be noted. Our qualitative content analysis only examined students who created posts on the AOD and but did not include students who only read posts (*lurkers*). Although students can certainly learn by lurking, we could not examine how these students influenced the help-seeking and help-providing behaviors of other students in our AOD forums.

Another limitation is that this study did not examine the instructor's role in facilitating student discussions in the AOD. Thus, our findings need to be interpreted in the context where an instructor did not facilitate student communication. In an AOD, instructor participation can be influential. When an instructor participates in the communications by posting questions, comments, or other responses, the quality and quantity and the patterns of student communication can be considerably changed, depending on whether the instructor's facilitation was successful or not.

Further studies might explore student-level behavior by connecting their AOD data to their work products in class and examine potential connections. Other student-level explorations might investigate how students interact with their peers on an AOD in the Freeform classroom with diverse student populations. Underrepresented minorities are known to experience considerable challenges because of social, cultural, linguistic, or other factors of STEM classrooms in the United States [72–74]. A recent study shows that factors like race, language, or class size may impact the student interaction patterns in an AOD [75, 76]. In short, future research might focus on comprehensive aspects of individual students from different cultural, social, linguistic, and ethnic backgrounds.

7. Conclusion

This study shows the affordance of asynchronous online discussion (AOD) forums in a blended learning environment of engineering education. The findings reveal that student academic help-seeking and help-providing behaviors have specific patterns in asynchronous online discussions. Particularly, the presence of help-provision related to technical engineering knowledge is promising in that the AOD enables undergraduate engineering students to seek help about content knowledge outside of classrooms. The finding of this study (e.g., the high frequency of help-provision) shows that undergraduate students in this setting will help their peers better understand challenging content knowledge. In short, university instructors who use AODs in blended classroom environments need to understand the affordance of AODs and how to integrate them with their face-to-face classroom environments for their course.

There is a need to understand how instructors can better use AODs to foster student participation and engagement in collaborative problem-solving activities of engineering learning. CSCL spaces like

AOD forums can extend limited traditional interactions in a face-to-face classroom to unlimited access to online interactions. Thus, an instructor should show that student help-seeking behaviors occur in specific patterns in AODs, such as the three steps of help-exchanging: asking a technical question, providing an answer, and challenging or validating the answer. Instructors can consider the process of this student interaction as a practice model in classroom activities to encourage students to replicate it on an AOD in undergraduate engineering courses. In contrast to an instructor's actual presence, where they play an active role in creating and facilitating discussion on the forum itself, instructors can still play a meaningful role by facilitating group discussion in this way. In short, it is important for instructors to understand the value of student collaboration for engineering learning on AOD forums and integrate it into their teaching in a face-to-face classroom with a strong sense of community.

Finally, expanding the capacity for both students and instructors to participate in asynchronous online discussions would be beneficial. This study has provided a characterization of the circumstances under which effective (and less effective) asynchronous discussion occurred and advances our understanding of how to further develop online pedagogy, particularly for undergraduate engineering students. In order to design, mediate, and promote asynchronous discussion, it is essential to understand how student help-seeking and help-providing interact to support collaborative knowledge formation. Indeed, from these findings, a set of online communicative strategies were developed into a guide for fostering online discussions that contribute to improved online pedagogies and best practices in a blended engineering learning environment.

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Appendix 1.

Codebook of help-seeking and help-providing behaviors in *Freeform* asynchronous online forums

Help-Seeking	Asking Technical Questions	ATQ	Asking directly for technical help, either in a general or targeted way. Can provide context (which is a way of sharing information), or not.
	Asking for Answer Verification	AAV	Seeking confirmation or rejection to a numerical answer or equation.
	Asking Implicit Questions	AIQ	Asking an indirect question by presenting a difficulty in the problem-solving process without explicitly requesting an answer. An example of this is "I tried solving for x but I couldn't really get a legitimate answer."
	Asking Non-Technical Questions	ANTQ	Asking for information on something not related to technical course topics, theories, or calculations. Tend to be logistic or administrative in nature.
	Asking for Clarification	AC	Asking a follow up question to a previously answered question or shared knowledge to elicit specific information.

Help-Providing	Sharing Technical Knowledge	STK	User sharing their knowledge on technical course content. Can be a reply to a help-seeking post, or the elaboration of a previously given help-providing post. Includes clarifications and explanations of how a specific conclusion was drawn.
	Sharing Non-Technical Knowledge	SNTK	User sharing their knowledge on non-technical topics. Can be a reply to a non-technical help-seeking post or the elaboration of a previously given help-providing post. Tend to be logistical or administrative in nature.
	Exchanging Resources	ER	Providing resources as part of an answer. Linking to websites, references, books, course materials, or input from Professor.
	Challenge or Validation Given	CV	Challenging or providing feedback/validation (agreement) on a user's work/response/opinion can be given even when validation is not sought ("Yes, that is correct").
Engagement & Resolution	Help Received	HR	An explicit textual indication that help as received ("Got it, thanks!"); When a response to a help-seeking post with relevant information (STK) is provided, and the help-seeker acknowledges this information is helpful. (Code HR to ATQ)
	Help Received Non-Technical	HRNT	An explicit indication that help was received from a non-technical course topic. ("Thank you"); (Code HR non-technical to ANTQ)
	Help Not Received	HNR	A help-seeking question with no relevant response or engagement from others. (Code HNR to ATQ post)
	Help Not Received Non-Technical	HNRNT	A non-technical help-seeking question with no relevant response or engagement from others. (Code HNR non-technical to ANTQ)
	Help Attempted	HA	A direct, technical question that received a response message or other technical form of engagement (links to external resources, for example). This engagement may or may not resolve the question. Resolution of the question is unclear because original poster did not acknowledge the help response.
	Help Attempted Non-Technical	HANT	A non-technical question that received a response message or other form of engagement. This engagement may or may not resolve the question. Resolution of the question is unclear because original poster did not acknowledge the help response.
Social Interaction	Unrelated/ Neutral	USI	Unrelated or neutral social interaction, random statement or question that is not related to a topic, ("Is anyone going to this event?").
	Negative	NSI	Abusive, overly critical or inappropriate language and attitude towards another user
	Positive	PSI	Supportive, encouraging, or generally amiable language and attitude towards another user
Emotional & Attitudinal	Ambiguous/ Neutral	AE	Expressing unclear or undecided emotions (confusion) and/or perceptions of the AOD, course, content, etc.
	Negative	NE	Expressing overtly negative emotions and/or perceptions (frustrations) of the AOD, course, content, etc.
	Positive	PE	Expressing positive emotions and/ or perceptions of the AOD, course, content, etc.

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