Leveraging Communication Analysis to Identify Key Challenges in an Innovation Course in computer science

Múcio J. Alves de Andrade[1]**, Cristiano C. de Araújo**[1]**, Geber L. Ramalho**[1]

[1]Universidade Federal de Pernambuco (UFPE)

{mjaa, cca2, glr}@cin.ufpe.br

Abstract. *This paper presents a case study investigating students' main challenges in an undergraduate innovation course. The course follows a learning journey to discover opportunities, and design and implement innovative digital solutions. The results indicate that one of the main challenges students face is ineffective collaboration in multidisciplinary teams. While these challenges are complex for teachers to identify, they are evident in student communications on social tools. This research used data from interviews and communications analysis on social networks such as Whatsapp and Telegram to understand these challenges better.*

1. INTRODUCTION

Education for innovation plays a crucial role in fostering innovative behaviors among individuals, organizations, and economies [Maritz et al. 2014, Mota and Scott 2014]. As a result, the cultivation of talented individuals capable of driving innovation, particularly within higher education, becomes imperative [OECD. 2016]. Notably, students who participate in innovation-oriented undergraduate courses exhibit enhanced leadership skills, increased motivation to pursue their professional careers, and recognize the value of such knowledge in their professional development [Brinton et al. 2013]. Recently, Chandra et al. [Chandra et al. 2020, Maritz et al. 2014] conducted a comprehensive review encompassing 32 journal papers in order to examine and discuss this subject. Chandra's study shows that these initiatives aim to assess whether students have acquired a deeper understanding of innovation principles or have gained increased confidence in applying the learned techniques [Charosky et al. 2018, Xu et al. 2018, Yu and Alex 2014]. However, the study also reveals a lack of consensus regarding the most effective approach to teaching innovation or the optimal pedagogical methods to be employed (Chandra et al., 2020). Notwithstanding the absence of consensus, it has been observed that most endeavors in teaching innovation exhibit certain shared characteristics [Chandra et al. 2020, Carvalho et al. 2022, Jokiniemi et al. 2020]. Firstly, these initiatives commence with the identification of real-world needs [Bohl et al. 2018, Wang et al. 2018, Jokiniemi et al. 2020]. Secondly, they require students to propose and deliver tangible solutions that address the identified needs, often employing methodologies akin to design thinking [Bohl et al. 2018, Wang et al. 2018, Jokiniemi et al. 2020]. Lastly, these initiatives typically involve the formation of multidisciplinary teams, thereby encouraging collaboration and drawing upon diverse expertise [Jokiniemi et al. 2020].

Consequently, it becomes imperative for these multidisciplinary teams to effectively leverage their respective skills and expertise in pursuit of a shared objective, fostering a collaborative environment where discussions, idea generation, and solution propos-

als can thrive [Zhao et al. 2020, Sandland et al. 2020]. In practice, numerous challenges impede the effective functioning of such teams.

Conflicts may arise among team members, stemming from differing perspectives, interests, or approaches, which can impede the smooth progress of collaborative efforts. Furthermore, team dynamics may be affected by an imbalance in workload distribution, resulting in certain individuals being overwhelmed with tasks while others may not actively contribute to the team's activities. Typically, students come from different courses, classes and periods, leading them to choose social media tools such as WhatsApp, Telegram, Teams, Slack, among others to facilitate communication and teamwork.

However, the initiatives discussed earlier have not thoroughly addressed the underlying causes of the challenges encountered in undergraduate innovation courses. Consequently, this paper aims to bridge this gap by presenting a case study that seeks to identify and prioritize the primary difficulties faced by students with diverse backgrounds when collaborating within multidisciplinary teams in the context of an undergraduate innovation course offered by a computer science department. This particular undergraduate course follows a structured learning journey wherein students are tasked with discovering opportunities, engaging in the design process, and implementing innovative digital solutions. To achieve the research objectives, the case study employs a combination of problem interviews adapted from the Lean startup approach and an analysis of communication patterns within two teams, utilizing platforms such as Whatsapp and Telegram. By utilizing these research methodologies, a comprehensive understanding of the main challenges faced by students in this specific educational context can be obtained.

The rest of the paper is organized as follows. Section 2 describes the innovation course. In section 3 it is explained how the case study was performed. The results and findings are presented in section 4. Results and findings are discussed in section 5. Finally, some conclusions and future work are presented in section 6.

2. Undergradute Innovation Course

Over the past 15 years, our computing institute has offered a practical undergraduate innovation course. The primary objective of this course is to enable students to develop innovative software products or services that address real-life problems. While the majority of students enrolled in the course come from computer science and computer engineering backgrounds, it is important to note that students and teachers come from various departments, including computer science and engineering, biomedical engineering, chemistry, administration, psychology, and design. This course takes students on a learning journey, comprising **nine quests** that provide guidance, resources, and materials for developing innovative solutions. Furthermore, students have the freedom to choose their communication tools such as WhatsApp, Telegram, Slack, etc.

Students are exposed to customer interview techniques to gain valuable insights and feedback, as well as the blue ocean innovation strategy for exploring untapped market spaces. These learning experiences empower students to think creatively and develop customer-centric solutions that address real-world challenges. By equipping students with the necessary knowledge and tools, the course fosters their ability to navigate the innovation process effectively. The **nine quests** are described bellow:

In **Quest 01**, it is necessary to conduct an "in loco" visit to understand the context

of people and activities in a given space, such as a public square, a company, etc. These activities will help identify relevant subjects and audiences. In **Quest 02**, opportunities for innovation within the chosen context should be identified. In **Quest 03**, a problem to be addressed must be selected and defined in how the proposed solution would help people meet their needs. In **Quest 04**, it is necessary to identify essential values and unique elements to develop an innovative solution based on concrete evidence and empirical knowledge. In **Quest 05**, a Minimum Viable Product (MVP) must be developed to deliver the idea or solution with the identified essential aspects to the user or consumer. In **Quest 06**, a business model must be defined to ensure the enterprise's sustainability. In **Quest 07**, a proof of concept must be created to evaluate the developed solution concretely. In **Quest 08**, a panoramic view of the process carried out must be carried out, estimating deadlines and the entire production process with validation of the solution with eager users, observing the results for validation of the solution leaving it functional for demo day. Finally, in **Quest 09**, it is necessary to plan how to present the solution to demonstrate its impact on the general public, entrepreneurs and investors in the local ecosystem.

While this course has achieved considerable success in terms of producing innovative project results, it is important to acknowledge that there are certain challenges that impact student outcomes. One notable issue is the occurrence of dropouts and unsatisfactory evaluations during the final assessment. It appears that teams encounter difficulties in effectively engaging all members to successfully complete each quest. As a result, it is evident that students face obstacles throughout their innovation journey, and the specific factors contributing to these difficulties remain unidentified.

Recognizing the importance of enhancing the innovation course and similar programs with a comparable structure, it becomes crucial to gain a comprehensive understanding of the challenges faced by students. Surprisingly, there is a lack of research conducted on this specific topic within the context of such courses. Consequently, due to the absence of clear indications from the existing literature regarding the primary issues encountered by students in innovation learning courses, we have undertaken an exploratory case study.

3. Case Study

The primary objective of this case study is to investigate and gain insights into the challenges faced by students in the innovation course. Specifically, it aims to comprehensively explore and understand the problems encountered, delve into the underlying causes of these issues, and ultimately identify the key problem areas that students prioritize. The central research question that guides this study is: "What are the priority problems that affect students' learning in the innovation course?"

To achieve this objective, the following steps are taken in conducting the case study: 1. interviewing a professor / researcher of the discipline, 2. defining initial problem hypotheses, 3. defining of unit of analysis, 4. conducting interviews with students, 5. collecting communication data from tools like Telegram and Whatsapp, 5. analyzing data sources.

3.1. Problem Hypotheses

The initial problem hypotheses were formulated based on interviews conducted with a course founder teacher. To ensure the objectivity and minimize potential biases, these

Table 1. Problem assumptions

Hypothesis	Description
HP01	The student has difficulties with the team, for example, overload/idleness of members, conflicting environment, misalignment about decisions, inexperience in charging/delegating tasks.
HP02	Students are unsure about what they need to deliver in the quests and are unsure about what and how it was done.
HP03	Students are discouraged during the course, either with the project theme, with the solution that is not innovative, or the solution does not look like a product.
HP04	Students have difficulties in validating and connecting with customers and users.

hypotheses were shared with another researcher for further scrutiny. The aim was to establish a collaborative approach in identifying the key problem areas. Table 1 presents the initial problem hypotheses derived from the interviews with the specialists.

3.2. Analysis Unit

The analysis unit for this case study consisted of students from two classes held in different institutions: Class 1 at a Federal University and Class 2 at a Federal Institute (both in Brazil), separated by a distance of approximately 2,200 km. Class 1 had experienced teachers and students from diverse majors such as Computer Engineering, Computer Science, Information Systems, Psychology, Administration, Design, Chemical Engineering, and Production Engineering. In contrast, Class 2 had teachers who were teaching the course for the first time and hab no prior experience, with students majoring in Computer Science, Electrical Engineering, Finance, Business, and Mathematics. This diverse representation allows for a comprehensive examination of the challenges and experiences faced by students in the innovation course across different educational contexts.

3.3. Student's Interviews

An adaptation of the *problem interview* proposed in Running Lean [Maurya 2012] was used for the interviews. The objective of the interview process in this case study is to validate the problem hypotheses and gain insights into how the interviewees approach these problems. The interviewees are given the opportunity to introduce new problems as additional hypotheses during the interview. The identified problems are categorized into three levels of pain: "Must-have", "Nice-to-have" and "Don't need". A must-have problem is confirmed when the hypothesis is validated and the interviewee considers finding a solution essential. A nice-to-have problem is confirmed when the hypothesis is validated, and a solution would be useful but not crucial. A don't need problem arises when the hypothesis is not confirmed or when the interviewee deems a solution unnecessary.

The interview process consists of three stages: in the first stage, collecting demographic data, such data referring to the name of the course, period, and the student's experience in innovation projects and/or hackathons. In the second stage, the student reports their initial hypotheses and identifies new ones and, finally, in the third stage, the student is asked to classify the hypotheses by pain level and classify them based on per-

ceived importance. This structured interview approach allows for the validation and prioritization of problem hypotheses while gaining insights into interviewees' perspectives and approaches to solving those problems.

2nd Stage: Validation of problem hypotheses

1. Have you or your team ever faced the problem presented?
2. If so, how did you deal with it?
3. Can you share other problems that you or your team have faced?

3nd Stage: Classification

1. Considering the Must-have, Nice to have and Don't need criteria as levels of pain, what would be the level of pain of these problems for you?
2. How would you rank or prioritize the problems?

3.4. Data Collection and Analysis

Data collection for this case study was carried out after the end of the course, and involved interviews and analysis of the team's communication carried out through messaging platforms such as Whatsapp and Telegram. For the interviews, this study involved the participation of 19 students from both Class 1 and Class 2 (Table 2), who willingly agreed to take part in the research .

Team communication data was collected from the teams' primary communication sources, exclusively from Class 1 through WhatsApp (Team 1) and Telegram (Team 2). This comprehensive dataset included messages, along with information such as dates, times, participating members, and various types of attachments like audio files, images, videos, and links. The data collection occurred voluntarily at the end of the course, provided by the team members. In the case of Team 2, subteams were formed based on project demands, resulting in the creation of separate Telegram groups for each subteam: frontend, requirements, backend, research, and development. The analysis of the collected data involved both quantitative and qualitative approaches. Quantitatively, we examined the frequency of messages sent by each student, while qualitatively, we analyzed the content semantics and the relationship dynamics among the participants, utilizing the available data.

After conducting the interviews, the next step involved qualitative data analysis, which entailed categorizing and summarizing the collected data. For relevance and prioritization purposes, the following criteria were established: a problem would be classified as *Must-Have* if it was mentioned as such by more than 50% of the students and ranked as their top priority. Problems categorized as *Nice-to-Have* and *Don't Need* were disregarded as they were deemed non-essential by the students. Additionally, an analysis of the quantity and frequency of communication messages on WhatsApp and Telegram was performed, examining both group and individual student participation. The qualitative analysis encompassed content analysis, with a focus on conflicts, questions, and the type of media shared. Importantly, the entire analysis was conducted anonymously, ensuring the privacy and confidentiality of the students' identities.

4. Results

4.1. Problems identification and prioritization

From the comprehensive interviews conducted with the participants, a total of 17 problems were identified and validated. These problems were then categorized into five dis-

Table 2. Student courses and classes

Course	Quantitative	Class
Computer Science	3	1
Computer Engineering	2	1
Production Engineering	1	1
Design	1	1
Psychology	1	1
Chemical Engineering	1	1
Information Systems	6	1
Business	1	1
Electrical Engineering	2	2
Computer Science	1	2

tinct categories, namely *Collaboration*, *Insecurity*, *Feedback*, *Motivation*, and *Validation*. The breakdown of these categories in their corresponding problems can be found in Table 3. Furthermore, Table 4 presents the classification and prioritization of the identified problems as determined by the students.

Notably, two problems, namely P01 and P16, were classified as "must-have" problems. P01, is related to team members' workload imbalances and idleness. It aligns with the collaboration problem category and validates the initial hypothesis (HP01). The prioritization of P01 underscores the challenges faced by students in effectively coordinating, communicating, and cooperating with their team members. Another notable problem that emerged was P16, which pertains to motivation. Some students expressed concerns that the developed projects may lack innovation or fail to meet desired standards of product quality. While motivation is undeniably vital in the context of an innovation course, the participants prioritized P01 as their primary concern.

4.2. Collaboration problems identified through Whatsapp and Telegram

The analysis of team communication on Whatsapp and Telegram revealed instances where team members expressed frustration and dissatisfaction when trying to collaborate. One team leader in particular highlighted the lack of cooperation among members, resulting in delayed progress and concerns about the project's overall quality. The excerpt exemplifies the challenges faced within the team, with certain members not actively participating or fulfilling their assigned tasks. This deficiency in collaboration hindered the team's effectiveness and raised concerns about the final deliverables.

"Guys, we are the most significant subgroup and the one with the least results. I have created the board in Trello, and so far, it has not been modified, and today was the agreed day to deliver part of the result; that is, most of the priorities should already be being completed. This is shameful. Next week, if we continue like this, we will review this strategy and possibly will no longer have each one's autonomy to choose tasks. It is disappointing, even if someone says, "oh, but I have a test this week" There are already done tasks, and you just need 15 minutes to organize them."
Student 6, Project Manager, sub-team Development.

Table 3. Categorized issues

Problems	Category	Description
P01	Collaboration	The student has difficulties with the team with overload/idleness of members, conflictive environment, misalignment about decisions, inexperience in charging/delegating tasks.
P02	Collaboration	The student had difficulty with the time to develop, validate and present the solution.
P03	Collaboration	The student feels difficulty with the formation and availability of the team.
P04	Collaboration	The student has difficulties related to the meeting, decision making, and engagement of members.
P05	Collaboration	The Student has difficulty with the organization of time and activities.
P06	Collaboration	Students have conflicts between the team and fail to make it clear to teachers.
P07	Insecurity	The student is unsure of what to deliver in Quests and is unsure about what and how it was done.
P08	Insecurity	The student is not clear how the course works (evaluation criteria) and what the process is.
P09	Insecurity	The student is not prepared for what he will face in the course.
P10	Insecurity	The student feels that course is loose, mainly related to the presence in class and assessment among members.
P11	Insecurity	The student feels that the technique and definition of persona is superficial and does not reach the real situation of the problem.
P12	Feedback	The student feels a lack of support or a closer / constant help from the teacher.
P13	Feedback	The student feels that discussions in follow-up classes could be shorter and more productive.
P14	Feedback	Student finds it difficult to extract accurate feedback from teachers and which to follow in case of conflicts between them.
P15	Feedback	The student feels that the course has inconsistent or contradictory feedback.
P16	Motivation	The student is unmotivated either with the project theme, with the solution that is not innovative, or has no product finish.
P17	Validation	The student has difficulty validating and connecting with clients and users.

Table 4. Classification and Prioritization of Problems

Problem	Must Have	Nice-to-Have	Prioritization
P01	11	7	1
P16	11	6	2

In addition to the qualitative findings, quantitative data extracted from the communication further supplemented the analysis. For instance, following the initial complaint, there was a noticeable increase in communication during weeks 2 and 3, which subsequently declined in weeks 4, 5, and 6 (Figure 1(b)). This indicates that despite the complaint, the collaboration issues persisted over time. Moreover, individual behaviors that exhibited a lack of collaboration were also observed. For instance, student 13 from the Development subteam in team 2 initiated a conversation to seek clarification on certain tasks. Student 6, who held the role of project manager, responded shortly after, and student 13 remained unresponsive for a period of eight days, as depicted in Figure 1(a). Additionally, it was observed that the Requirements sub-team experienced a gradual increase in the number of members over time, reaching a total of 15 students (dashed line in Figure 1(c)). However, the majority of communication within this sub-team was limited to only six students. Notably, there were distinct peaks in student participation, occurring between October 3rd and October 20th, November 6th and November 23rd, and November 28th and December 10th, with a total of 49 days without any communication observed (Figure 1(c)).
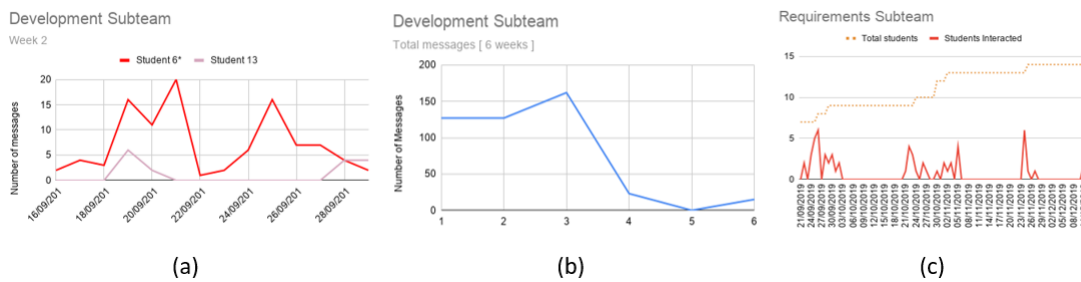

(a) (b) (c)

Figure 1. Communication student 13 and Student 6 (Project Manager)

The analysis of team 1's communication also revealed an imbalanced distribution of individual student participation. Figure 2 illustrates that only five team members actively engaged in sending messages. The percentage of total messages indicates that while the first student's contribution was unusually high, the number of messages from other students was considerably lower, with none of them reaching even half of the messages sent by students 3, 2, 9, and 4 (Figure 2(a)). Regarding team 2, an analysis of its communication patterns revealed an irregular and non-uniform distribution of interactions among its members.

Furthermore, in team 2, the sub-teams consisting of Requirements (Figure 2(b)), Development (Figure 2(c)), and Backend (Figure 2(d)) comprised 14, 10, and 8 students, respectively. However, the communication within these sub-teams was predominantly limited to only four students. These quantitative findings provide support for the identified problem P01 as a *Must-Have* and highlight its high priority, as they demonstrate a significant discrepancy in the level of engagement and participation among team members. Collectively, these quantitative data underscore the persistent challenges and deficiencies in collaboration within the teams, emphasizing the need for effective strategies to enhance team communication and engagement.
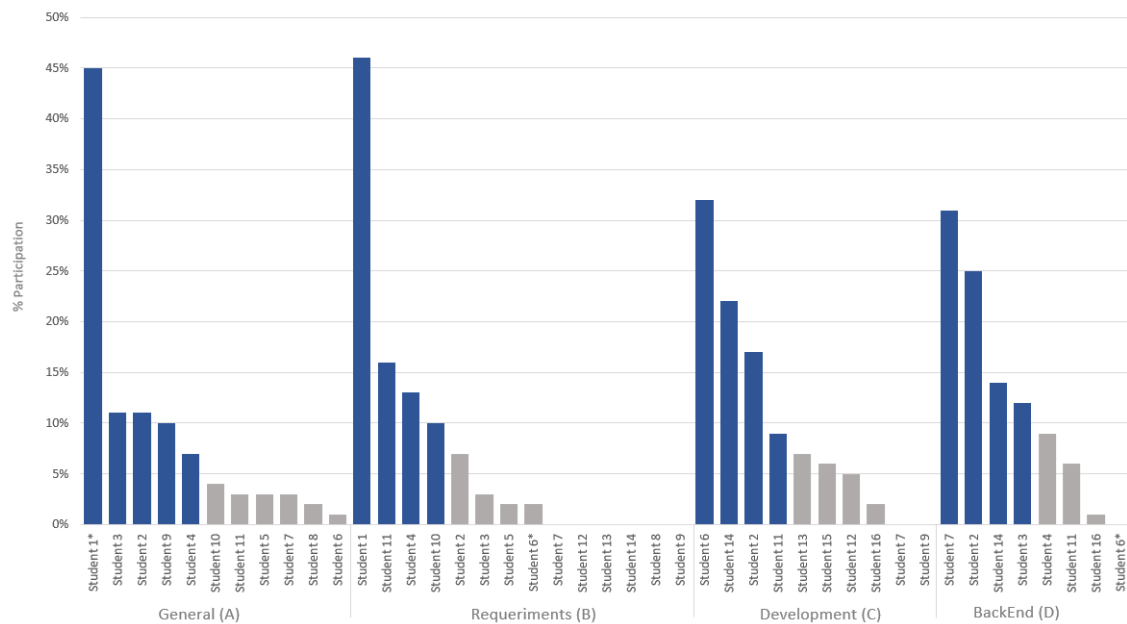
Figure 2. Participation in student's communication

5. Discussion

Although the course presents positive aspects, the results of the interviews indicate that students face several challenges when learning innovation in practice. Many of these challenges share common characteristics and were therefore categorized into five groups, similar to the works of [Swartz et al. 2020, Chowdhury et al. 2020, Pastel et al. 2015]. The main contribution from this work when compared to the listed ones is the identification of students' central challenge: ineffective collaboration in their teams, Problem (P01). Despite the main challenge, other issues were categorized.

Another issue refers to *feedback*: the results show that students feel that a better alignment of feedback from the professor and a more significant amount of feedback could help them more. The categories listed in this work show us other demands that are required of the student, who often needs to prepare, thus generating insecurity about what to do or how to apply a specific technique, *insecurity* category. *Motivation*, in turn, may be linked to the student's skills: many of them may play the role of project designer without having the necessary knowledge or seeking this knowledge, which may result in a project with little visual appeal. About the *validation* category, in many cases, there is difficulty in maintaining contact with the potential client, which may be related to a lack of experience in contacting them or difficulty in travelling for on-site visitation.

The *collaboration* category was the most pointed out by students. This may be due to several factors: students are challenged to work in large teams, which involves listing and distributing tasks, maintaining communication among members and making important decisions. This requires maturity and management skills on the part of the students. The overload and idleness of students has been cited by[Wolfe et al. 2016]. [Pastel et al. 2015] work found problems related to task management. Finally, similar to

our findings, misalignment in essential decisions and conflicting environments were also found in [Chowdhury et al. 2020] work.

In the second phase of our studies, we analyzed student communication data to understand if it would be possible to identify collaboration problems using social networking tools. In addition, we explored other factors related to teams, such as dynamics among members, topics covered in the communication and who communicate the most. These analyses corroborated the main problem found. The data showed that some students communicate frequently while others go several days without establishing communication. These findings are aligned with the results presented by [Swartz et al. 2020, Pastel et al. 2015] in their studies on education for innovation. Students who sent more messages were most involved and collaborated with teamwork, being overloaded by performing more activities than others. This situation may occur due to a need for coordination, one of the elements of collaboration. According to [Fuks et al. 2011], the triad communication-coordination-cooperation must be present for collaboration to occur more effectively in a team. Thus, possible failures in some aspects of collaboration generate problems for team members and impact their performance.

This study has some restrictions and threats to its validity. The main one is the small amount of data collected. Regarding the interviews, it would be desirable to increase the sample of admitted students and include other classes of the discipline to strengthen the results obtained. In addition, we needed help in obtaining a more extensive set of social media communication data from the teams. Therefore, expanding the sample and carrying out more research on the subject is necessary. One way to increase evidence would be to apply the methodology to other teams to identify more patterns and confirm existing ones. In addition, it established that associating greater participation in communication with greater engagement are hypotheses that need to be investigated in more depth.

6. Conclusion and Future Work

This case study's main contribution was identifying and prioritizing students' main problems when enrolled in a practical innovation learning course and working in multidisciplinary teams. The results confirm that students face problems in the course, and it was also possible to identify the difficulty of collaboration between team members as a priority problem. The analysis of team communications using tools such as Whatsapp and Telegram corroborated the priority problem. Although this is a case study performed with students of a specific course on innovation, since the literature on education for innovation has not yet deepened the discussion on the main problems faced by students, we consider that our work can contribute to the field. In the future, this analysis points to the possibility of supporting students by quickly identifying collaboration problems in their communications through social communication tools using artificial intelligence.

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