WIP: ChatVis: Enhancing Academic Team Collaboration through WhatsApp Chat Analytics

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***Abstract*— This work in progress research paper describes the development and utilization of ChatVis, a novel tool designed to enhance collaboration and teamwork, key learning outcomes emphasized in engineering and computing curricula by industry employers and accrediting bodies such as the Accreditation Board for Engineering and Technology (ABET).**

Instructors implement project-based learning to help students develop these skills, often using communication platforms like WhatsApp, Slack, and Discord.

Despite the availability of tools supporting teamwork and collaborative learning, a truly non-invasive method for collecting and evaluating interaction and team dynamics remains elusive.

ChatVis addresses this gap by enabling instructors to assess team dynamics and individual contributions effectively without disrupting student workflow.

Deployed in a C Programming course at a university in Mexico, ChatVis involved 33 students in a mini project, significantly improving student interaction, communication, and engagement.

Instructors were able to visualize and provide targeted feedback on student engagement and team dynamics, thereby enhancing the quality of student work. Future work will extend this preliminary study with a comprehensive analysis aimed at determining the statistical significance and broader impacts of ChatVis.

Keywords— Software Engineering Education; Team Dynamics Quantification; WhatsApp Communication Analysis.

I. Introduction

Teaching team collaboration is vital for preparing students for engineering and computing careers. Each student team develops its own dynamic, and instructors must decide when to intervene or let teams resolve issues independently.

Maintaining spontaneous communication is essential, making chat services like WhatsApp valuable for collaborative projects. However, while convenient for students, these apps often lack real-time monitoring capabilities for instructors. This presents a challenge: instructors need to understand and evaluate interactions without disrupting organic conversations, especially when grading participation and identifying workload distribution among team members.

Social network analysis can help by converting text and metadata into a network, allowing instructors to identify communication patterns and active or silent participants. This paper introduces 'ChatVis,' a tool designed to enhance the assessment of collaborative learning by leveraging social media interactions to refine teaching strategies in engineering and computer science.

'ChatVis' enables instructors to export, visualize, and analyze data from social media platforms like WhatsApp used in collaborative learning. The research question is:

How can instructors effectively measure and analyze individual contributions and team dynamics in collaborative learning environments using non-invasive tools?

To explore this, we studied eight teams, each with three to five members, completing a programming task. Initial observations guided improvements for future activities, and subsequent tasks showed slight teamwork enhancements according to ChatVis analytics. Initial data suggest a reduction in procrastination, indicating that 'ChatVis' may help educators better understand and foster collaborative behavior. This study presents an innovative approach to assess and improve collaborative learning through social network analysis, impacting the design of effective pedagogical strategies and enhancing learning quality in these disciplines.

II. Literature Review

Collaborative and team-based learning are rooted in the constructivist theory of learning, wherein learners construct knowledge by working with peers to solve problems, accomplish tasks, or perform other learning activities [1]. Research has shown that these learning approaches yield myriad benefits for learners. For instance, collaborative learning can enhance critical thinking and teamwork, improve academic performance, and facilitate active engagement and

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participation [2,3]. Furthermore, collaboration and teamwork are critical skills emphasized by industry employers and accrediting bodies such as ABET [2]. These skills are closely associated with instructional approaches like project-based learning (PbL), where students work in groups to address real-world problems, thereby developing problem-solving, project management, teamwork, critical thinking, and communication skills [1,4]. A growing number of researchers [1,2,3,5,11] continue to investigate various aspects of collaborative learning within engineering and computing education. However, we could not find any studies relating a non-invasive approach to evaluating interaction and team dynamics among students in a collaborative learning setting.

Reid and Wilson [6] presented results using software (SW) version control systems to manage student tasks. They used the CVS tool and reported that "this is both a simpler and a more flexible way to manage student assignments." Their approach is compared to the fact that "students in most programming courses use a homegrown electronic submission program to submit their work, and email to coordinate with partners when doing team projects."

In a study conducted in 2006, Glassy [7] had students use Subversion, an open-source version control system, to manage their programming assignments. This experience demonstrated that version control is a valuable tool for gaining insight into how students develop code.

Sarma, A., Maccherone, L., Wagstrom, P., & Herbsleb, J. [8] introduced Tesseract, an interactive environment that visualizes relationships between technical artifacts, developers, errors, and communications in SW development. This tool integrates technical and social information to offer a more comprehensive understanding of the SW development process, as evidenced by its evaluation highlighting its viability and usability for the open-source community. Jones [9] revisited the use of the Subversion tool and showed how to use this version control system as an aid in determining the accomplishments of everyone in a group programming project. Towards the second decade of the 21st century, the use of digital social networks became popular. Effective structuring of SW development teams is essential to ensure smooth collaboration and the production of high-quality SW. Social network analysis (SNA) emerged as a popular approach to examining how people organize and collaborate in SW development teams. Recent research has proposed SNA metrics that can predict SW quality and describe team dynamics. However, the question arises whether SNA metrics truly reflect socio-technical relationships. Meneely and Williams [10] address this question by investigating whether developer networks match the perceptions of the developers themselves. Their findings indicate a statistical correlation between connections in the developer network and the collaborators identified by the developers, suggesting that SNA metrics effectively capture socio-technical relationships in open-source SW development projects. Additionally, Alkhathlan and Al-Daraiseh [11] conducted an analytical study on the use of social networks for collaborative learning in higher education. Their research examines the impact of social networks on collaborative learning, improvement of the learning process, and academic engagement of students. Through a comprehensive review of current literature, they propose a framework for educational social networks aimed at supporting collaborative learning and improving learning outcomes for higher education students.

In summary, the reviewed literature emphasizes the importance of understanding socio-technical relationships in SW development, as well as the potential of emerging technologies and pedagogical strategies to enhance collaboration and team learning in diverse educational and professional contexts.

The study presented here shows a novel approach to understanding student collaboration dynamics in team projects via WhatsApp. interesting correlations were found between message content and project performance across different fields of study

III. Methodology

To address the research on the utility impact of WhatsApp usage in the SW development process in educational settings, we employed a mixed-method approach combining quantitative and qualitative methods. This work in progress paper focuses on the initial quantitative method results. The research was conducted within two sections of a software engineering (SWE) course at a university in Mexico, each composed of teams created by the instructor. Each section comprised four teams, with three, to five members per team. To simulate real-world SWE projects, teams were randomly assigned by the instructor to prevent students from forming groups with peers they already knew. Each team was tasked with developing a SW program following the programming best practices taught during the course. The program had to be coded in the C programming language and executed in a text-only format, without graphical user interfaces. Communication among team members was restricted to newly created WhatsApp groups specific to each team. All communication, including task organization and work distribution, had to be conducted exclusively via WhatsApp messages, adhering strictly to the rule that code could only be shared as plain text within the body of the message and not as attachments or images. Teams were given two assignments to complete, each with a specific deadline for completion. The first assignment was given to the teams, and they had four days to complete it. WhatsApp chat logs were exported after the assignment period ended to capture all interactions and communications within each team. The second assignment was given after the first assignment period and an intervention action, and they had another four days to complete it.

For quantitative analysis, we defined our metrics as follows:

- Number of messages sent
- Number of messages.
- Participation rate of each member.

Qualitative analysis of the chat logs aimed to identify communication patterns, individual team member roles, and challenges encountered during the SW development process.

Specifically, we looked for patterns indicating effective collaboration, leadership emergence, and any obstacles hindering team progress.

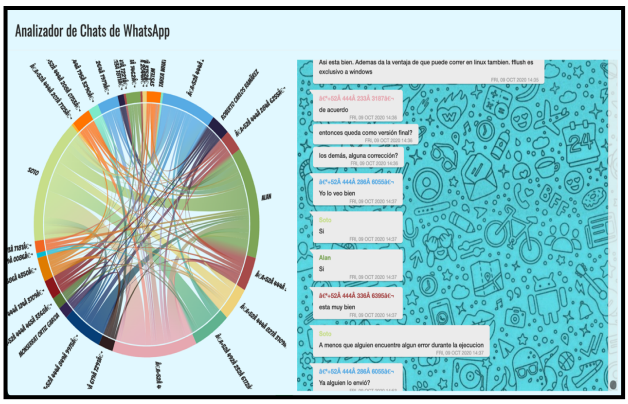

Fig 1. Visualizing Chat Interactions and Conversations in WhatsApp Groups.

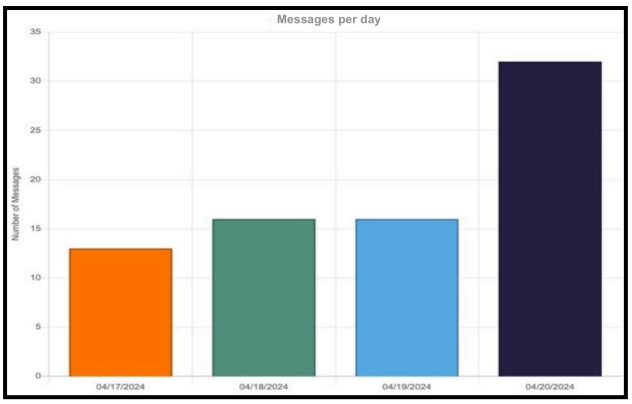

Fig 2. Patterns of Daily Messaging

The intervention was conducted using ChatVis to provide teams with feedback on their communication patterns in their first assignment, with the goal of fostering more effective collaboration. Ethical guidelines were strictly followed throughout the study, with informed consent obtained from all participants, and their confidentiality rigorously maintained.

IV. ChatVis: The Tool

ChatVis is a SW tool designed to enhance collaborative learning by providing analytics based on social media communication data, specifically from WhatsApp. By leveraging these analytics, educators can gain a deeper understanding of team dynamics and communication patterns.

The system was designed, and its development was directed by the first author of this paper and was developed by his SWE students in 2020. ChtVis offers several key features that make it an asset for educators:

Direct Data Integration: ChatVis utilizes data exported from WhatsApp chat logs, eliminating the need for preprocessing. This simplifies the data retrieval process, making it easier to access and analyze communication data.

Dynamic Visualizations: The tool generates dynamic visualizations, including an arc or chord diagram (Fig. 1) and a bar chart, (Fig. 2) to illustrate the evolution of communication over time. The arc diagram offers a comprehensive view of communication patterns within the team. The arcs between segments illustrate the flow and frequency of messages exchanged between members, with the thickness of these arcs representing the intensity of interactions. Fig. 1 showcases the completion of ChatVis's. execution.

Insightful Analytics: ChatVis provides valuable analytical insights, such as participation metrics and key patterns in team communication. Educators can identify the most active and engaged members, as well as central figures that facilitate information flow. Additionally, the tool helps uncover members who may be isolated from the main group, enabling educators to guide teams toward more effective collaboration. In all diagrams, each color corresponds to a different member of the team. This key enables users to identify individual team members and their interactions within the visualization.

V. Analysis of Team Communication Patterns

To understand the dynamics of collaboration within each of the eight teams participating in the study, we conducted a detailed analysis of their internal communication patterns using ChatVis. The messaging data from each team provides insights into their intra-team interaction levels, communication strategies, and the overall effectiveness of their collaboration.. Through the combination of arc diagrams, chat extracts, and bar charts, we gained a nuanced understanding of how each team navigated their tasks and met their goals. Let's begin by analyzing the first team.

A. Analysis of one of the Teams

The visualizations provided offer a look into the communication patterns of one of the teams (Team: D) (see Fig. 3). The arc diagram shows the interactions among team members: *Iván uaslp, Aura uaslp, Sebas uaslp,* and *The Beards!!.* The thickness of the arcs indicates the volume of messages exchanged, with thicker arcs representing a higher communication frequency between members. The team members have varying levels of communication, with *Sebas uaslp* and *The Beards!!* showing a significant exchange, as indicated by the thicker arcs. The complete chat (not showed) provides context to the interactions, showing real conversations among the team members. The chat reveals how team members collaborated to solve problems, coordinate tasks, and share updates. The members actively discuss technical issues, share suggestions, and work together to resolve problems. Towards the end, there's a closing message indicating the task's completion and expressing gratitude among the team members.

The bar chart (Fig. 2) displays the number of messages sent each day withing team D, illustrating a clear progression in the team's communication over three days.

A noticeable increase in messaging activity occurs on April 20th compared to the previous days, indicating heightened collaboration as the task deadline approached. The pattern reflects typical team behavior, where communication intensifies closer to deadlines. The first team demonstrated strong collaborative behavior, particularly as the task deadline neared.

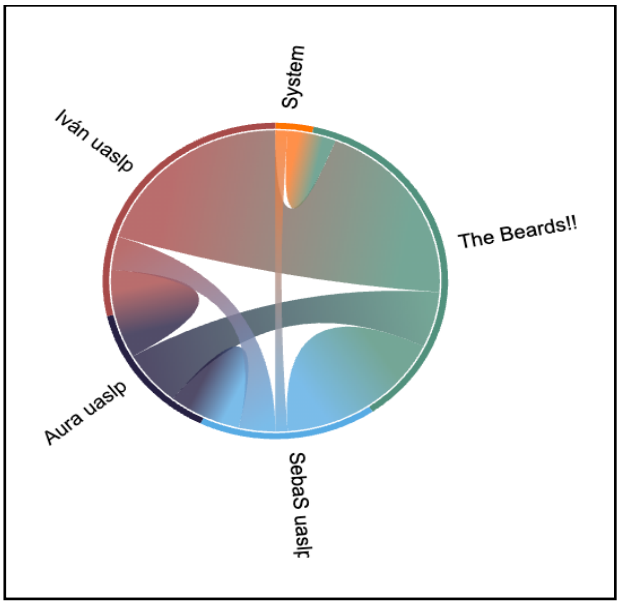

Fig 3. Team Interaction.

B. *Field study*

Following the study explained in Section III, data was collected from eight teams, and their summary is presented in Figs. 4 and 5. Fig 4 illustrates the daily communication patterns across eight teams from April 16th to April 20th, 2024. Each team is represented by a different color, and the y-axis indicates the number of messages exchanged per day. Overall, the chart reflects the common trend of increased communication activity leading up to deadlines, highlighting a substantial increase in collaboration on April 20th compared to the previous days. Fig. 5 provides a normalized view of daily communication patterns across different teams from those days. By presenting the data in percentage terms, it allows for a more balanced comparison of messaging activity across teams of varying sizes. The visualization reveals significant shifts in communication dynamics, with the highest activity observed on April 20th as the teams approached the project deadline. Notably, Team *H* and Team *G* showed the most substantial engagement, suggesting their increased focus on collaboration during this critical period.

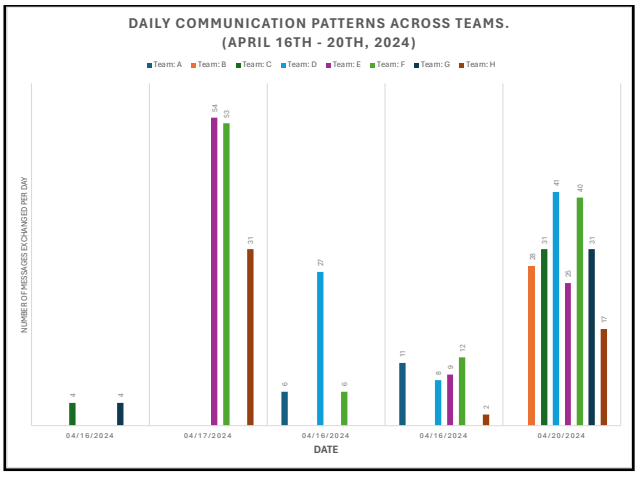

Fig 4. Daily Communication Patterns Across Teams.

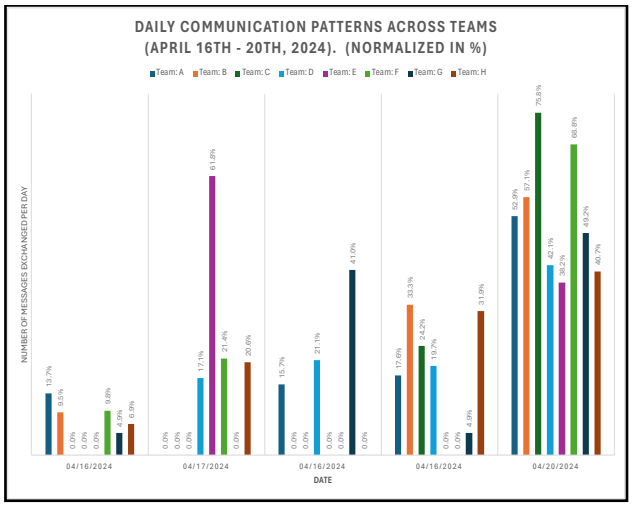

Fig 5. Daily Communication Patterns Across Teams. (Normalized) Round 1

After showing the students the results of their work in the first round, they were assigned a new task, keeping the same teams, members, and time period for submission. The results of this new round, now normalized, are shown in Fig. 6.

IV. RESULTS

The analysis of the communication patterns across teams utilizing the 'ChatVis' tool has yielded insightful results, demonstrating its efficacy in enhancing collaborative learning. The daily communication data, visualized in the accompanying chart, highlights notable trends and variations between the two rounds of the study.

In Round 1, communication activity started at a modest 5.61% on Day 1, saw an increase to 15.11% on Day 2, followed by a slight decline to 9.53% on Day 3. It then rose to 16.46% on Day 4, culminating in a substantial peak of 53.11% on Day 5. This pattern suggests a high degree of procrastination, with a majority of the communication occurring close to the deadline. Following this observation, the results from Round 1 were shared with the students, highlighting the procrastination trend and encouraging more consistent engagement.

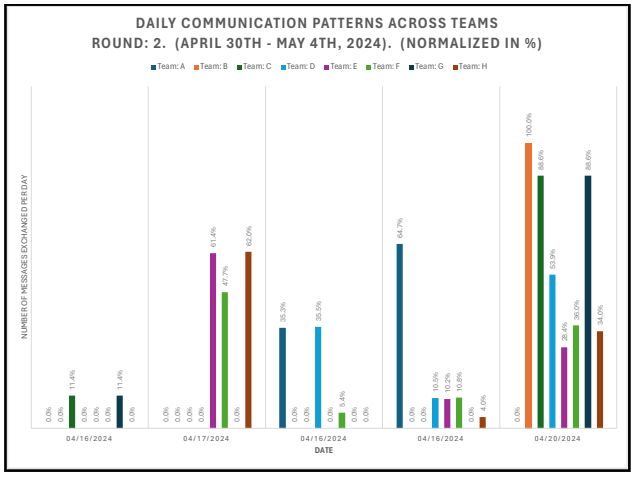

Fig 6. Daily Communication Patterns Across Teams. (Normalized) Round 2

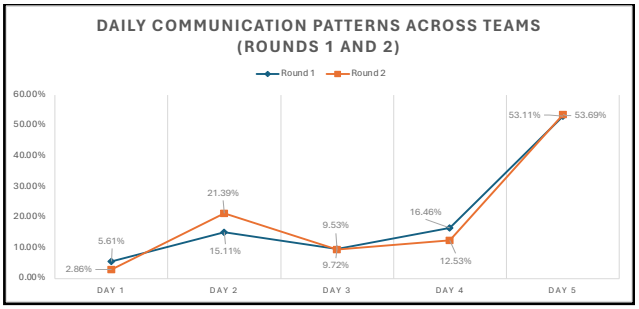

Fig 7. Daily Communication Patterns. (Normalized) Rounds comparison.

In Round 2, initial communication started slightly lower at 2.86% on Day 1, then saw an important increment to 21.39% on Day 2. Day 3 and Day 4 showed relatively stable communication levels at 9.72% and 12.53% respectively, with a significant increase to 53.69% on Day 5.

Despite the intervention, Round 2 data indicates that while there was a small reduction in procrastination, the overall communication pattern still showed a peak towards the end of the assignment period. This suggests that although students were more aware of the need for consistent engagement, the difference was not substantial enough to completely eliminate the tendency to delay significant collaboration until the final day. The slight discrepancies in communication percentages between the two rounds reflect the tool's ability to capture and visualize subtle shifts in team dynamics and individual engagement levels. This data underscores the potential of 'ChatVis' to provide educators with valuable insights into the temporal patterns of team interactions, facilitating targeted interventions to enhance collaborative learning outcomes.

VI. Summary anfd future work

This study explored the impact of using WhatsApp as a communication platform in collaborative learning within a SWE course. The integration of 'ChatVis' provided a novel approach to visualizing and analyzing team interactions, offering valuable insights into student engagement and collaboration patterns.

The initial analysis of Round 1 demonstrated a high degree of procrastination among students, with the majority of communication occurring close to the assignment deadline. This pattern was identified through the visualization capabilities of 'ChatVis', which highlighted the need for improved time management among team members. After presenting the results of Round 1 to the students, a new task was assigned, maintaining the same teams, members, and deadlines. The subsequent round showed a small reduction in procrastination, although significant communication still clustered towards the end of the task period. This indicated a moderate improvement in collaborative behavior, suggesting that increased awareness and feedback can enhance team dynamics, though further strategies may be needed to foster sustained, balanced engagement. Overall, 'ChatVis' proved effective in capturing and visualizing communication patterns, providing educators with detailed insights into team interactions. This facilitated targeted feedback and interventions, aimed at improving collaborative practices and student outcomes in engineering education. It is important to consider that the number of messages does not necessarily reflect the amount of work done or its complexity. Therefore, a new version of the system (Semantic ChatVis) is already being developed to analyze the content of the messages. Initial results of this version will be presented in upcoming reports. The Future research will focus on extending the use of 'ChatVis' to various institutions within the United States to validate its versatility and effectiveness in different cultural and educational environments. Additionally, there will be an emphasis on evaluating the long-term impact of 'ChatVis' on the development of collaborative skills and overall academic success. Furthermore, integrating advanced data analysis techniques, will enhance the tool's capability in providing deeper insights into team dynamics and individual contributions. The study suggests that further exploration could involve incorporating additional social network analysis metrics. Metrics such as robustness could offer insights into team cohesion and the significance of individual members. Moreover, in assignments where students assume predefined roles, the tool might assist in evaluating adherence to those roles. Additionally, cluster identification could provide valuable insights into communication patterns and subgroup dynamics within teams. These enhancements could enrich the tool's analytical capabilities and offer educators deeper insights into team dynamics and collaborative processes. By continuing to refine and expand the use of 'ChatVis', educators can better understand and enhance the collaborative learning experience, ultimately leading to improved educational outcomes and more effective teamwork skills among students.

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