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Research Article

Improving Student Engagement in Online Chemical Engineering Classes: Using google tools to enhance collaboration and learning

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ABSTRACT
Online engineering education presents unique challenges in supporting student collaboration and engagement. This study looks at how Google Slides and Google Sheets can help improve collaboration and student engagement in online chemical engineering activities about process control and economic analysis. The study involved 11 students who worked together in real time using shared documents, with the instructor giving quick feedback during the activities. A questionnaire was used to collect students' opinions, and the results were analyzed using simple descriptive methods. The findings indicate that both Google Slides and Google Sheets were highly effective in fostering collaboration and enhancing the learning experience, with most students finding them user-friendly and helpful for understanding the material. This suggests that basic digital tools like Google Slides and Sheets can support better learning and teamwork in online engineering education. Future studies could explore broader applications of such tools across other technical disciplines.

Keywords: *Collaborative Learning Tools; Google Tools; Online Engineering Education; Online Learning; Student Engagement*

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1. Introduction

Effective collaboration and direct assessment are essential components of successful learning in engineering education, including chemical engineering (Qadir et al., 2020). These elements not only foster deeper understanding but also promote the development of critical problem-solving skills necessary for tackling real-world engineering challenges (Patel, 2024). Collaborative learning encourages students to work together, share diverse perspectives, and engage in active problem-solving, which is particularly important in the complex field of engineering (Emma et al., 2023; Mora et al., 2020). Additionally, direct assessment allows instructors to monitor student progress and provide timely feedback, ensuring that learning objectives are met throughout the course (Boshrabadi & Hosseini, 2020; Boud & Bearman, 2022).

In traditional learning environments, face-to-face interaction provides immediate opportunities for feedback and collaboration, but this becomes a significant challenge in online learning (Salta et al., 2022). The lack of physical presence can result in reduced student engagement, delayed feedback, and difficulties in fostering effective teamwork (Herriott & McNulty, 2022). In an online setting, the ability to foster both collaboration and real-time feedback becomes even more critical for maintaining student engagement and ensuring learning objectives are achieved (Bai et al., 2023). To address these challenges, the use of Google Tools offers significant potential for enhancing student interaction and engagement.

Google Tools, cloud-based applications that provide platforms for synchronous collaboration, document sharing, and real-time feedback, offer solutions that overcome some of the barriers faced in online education. These tools allow students to collaborate on complex tasks, enabling them to work together on shared documents, exchange ideas, and solve problems collaboratively, all in real time. Furthermore, Google Tools offer instructors the ability to provide immediate assessments and feedback, helping ensure that learning outcomes are met more effectively and promptly.

Google Tools have been widely utilized across various disciplines to support online learning by providing platforms for synchronous collaboration and real-time feedback (Akçıl et al., 2021). These tools are designed to facilitate interactive and collaborative learning, enabling students to engage with their peers and instructors in real time, regardless of location (Thuan & Nguyen, 2023; Sharov et al., 2024). With features that allow for document sharing, simultaneous editing, and immediate feedback, Google Tools create an environment that fosters active participation and continuous learning (Tin, 2024).

While Google Tools have been widely used in various educational fields, this study focuses on just two: Google Slides and Google Sheets. Google Slides has been applied in diverse areas beyond its traditional use for presentations, such as online graduate education (Sameshima & Orasi, 2022), medical education (Foohey et al., 2022), and construction engineering education (Rybkowski et al., 2021), where it has supported collaborative summaries, virtual environments, and online simulations. Similarly, Google Sheets has found applications in accounting education (Parra et al., 2021), water management education (Rosenberg, 2024), and medical education (Keadkraichaiwat et al., 2024), facilitating tasks like collaborative data analysis, reservoir modeling, and interactive assessments. Despite these successes in other fields, their application in chemical engineering education remains largely unexplored. This presents an opportunity to explore how Google Slides and Google Sheets can enhance collaboration and enable real-time assessment in chemical engineering.

This research aims to investigate how Google Tools can help students collaborate and receive direct feedback in online chemical engineering classes. Focusing on key topics such as process control and economic analysis, this study examines how these tools engage students, improve real-time collaboration, and provide effective feedback. Google Slides and Google Sheets have the potential to enhance the chemical engineering learning experience by enabling collaborative task completion and joint data analysis. This research addresses a gap in the literature by demonstrating how digital tools can enhance learning and collaboration in technical education, particularly in the relatively underexplored field of chemical engineering.

In addition to enhancing collaboration, Google Tools allow instructors to provide immediate feedback on student progress, making the learning experience more personalized and responsive. With features that track individual contributions and edits, instructors can quickly identify areas where students need more help and adjust their teaching strategies. This real-time feedback is especially beneficial in engineering fields, where students require continuous support to understand complex concepts and apply their knowledge effectively (Sipos & Kocsis, 2023).

While there are clear benefits to using these tools, challenges such as technical issues, poor connectivity, and difficulties with user registration and material uploads persist (Zdraveski et al., 2020). Nonetheless, the advantages of Google Tools in online learning—particularly for real-time collaboration and feedback—are significant. This study focuses on how Google Slides and Google Sheets can enhance collaboration and provide real-time assessments in chemical engineering education. The findings will offer

insights into integrating digital tools to improve student engagement and learning outcomes in engineering education.

2. Methods

This study uses a descriptive approach to examine how Google Tools—specifically Google Slides and Google Sheets—are utilized in the *Introduction to Chemical Engineering* course for first-year undergraduate students. The focus of the study is on two key topics: process control and economic analysis. These tools were employed to enhance collaboration, enable real-time assessment, and increase student engagement.

2.1 Participant and Course Setup

The study was conducted in an online *Introduction to Chemical Engineering* course, involving 11 students who were divided into small groups for collaborative activities. The course was delivered via the Zoom platform. Each class session lasted for two hours, with the first hour dedicated to theoretical instruction on the respective topics, followed by one hour of collaborative activity designed for practice and assessment. It was during this one-hour activity period that Google Slides and Google Sheets were used. In week 12, Google Slides was utilized for a task focused on process control, while in week 13, Google Sheets was employed for a cost calculation task related to economic analysis.

2.2 Use of Google Slides for Process Control (Week 12)

In week 12, students were provided with different pre-designed Google Slides links for a collaborative exercise, although the content and task were identical across groups. Each group was tasked with positioning sensors and controllers within a snippet of a Process and Instrumentation Diagram (P&ID). Students worked together in real time, dragging and placing images to complete the diagram while discussing design decisions within their groups. The instructor monitored their progress, provided feedback directly on the shared slides, and addressed questions during the activity. A screenshot of a sample slide from the activity is shown in Figure 1, illustrating the layout where students interacted with the diagram to complete the task.

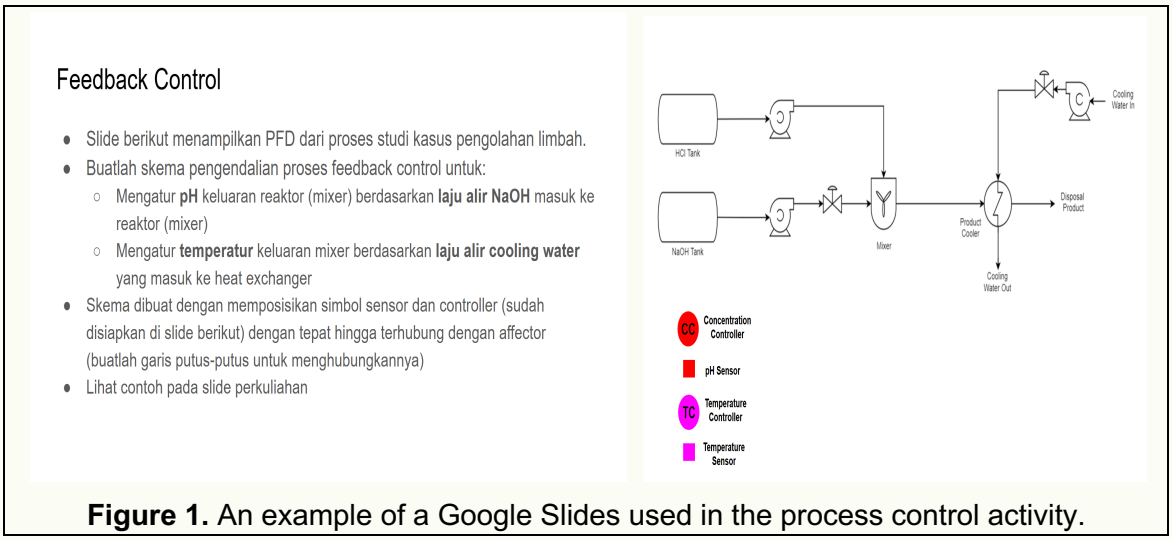
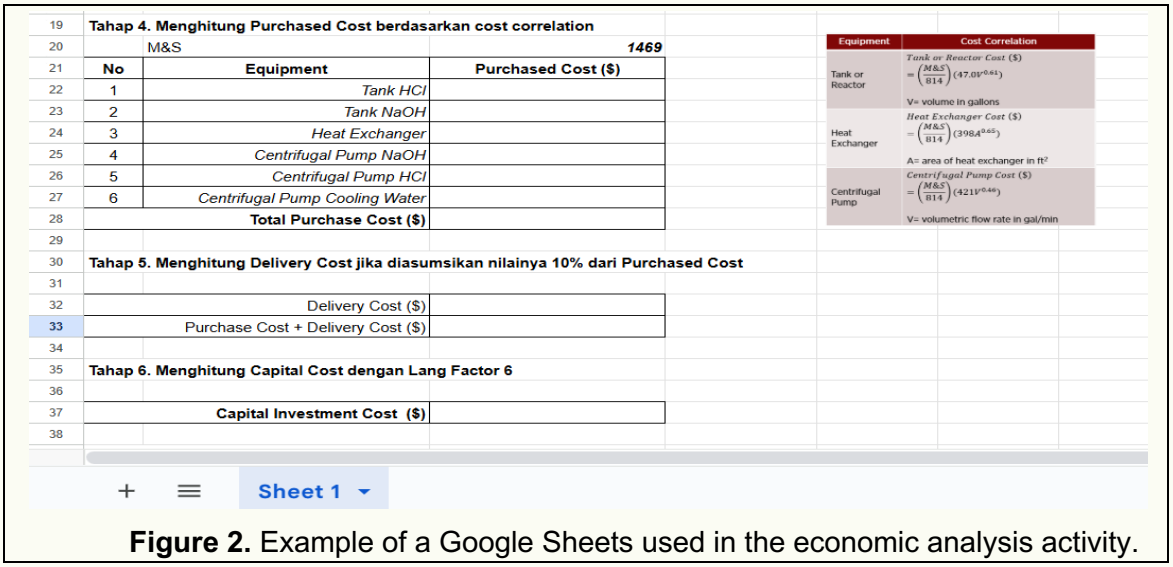


Figure 1. An example of a Google Slides used in the process control activity.

2.3 Use of Google Sheets for Economic Analysis (Week 13)

In week 13, students were provided with different pre-designed Google Sheets links for a group-based task focused on economic analysis, although the content and task were identical for each group. Students collaborated to perform calculations related to the economic feasibility of a chemical engineering project. The shared Google Sheets

allowed students to manipulate data, execute calculations, and visualize results in real time. This setup encouraged teamwork and enabled immediate feedback from the instructor, who guided both the technical and collaborative aspects of the activity. A screenshot of a sample Google Sheets used in the activity is shown in Figure 2, illustrating how students interacted with the data to complete the required calculations.



19	**Tahap 4. Menghitung Purchased Cost berdasarkan cost correlation**		
20		M&S	***1469***
21	**No**	**Equipment**	**Purchased Cost ($)**
22	1	*Tank HCl*	
23	2	*Tank NaOH*	
24	3	*Heat Exchanger*	
25	4	*Centrifugal Pump NaOH*	
26	5	*Centrifugal Pump HCl*	
27	6	*Centrifugal Pump Cooling Water*	
28		**Total Purchase Cost ($)**	
29			
30	**Tahap 5. Menghitung Delivery Cost jika diasumsikan nilainya 10% dari Purchased Cost**		
31			
32		Delivery Cost ($)	
33		Purchase Cost + Delivery Cost ($)	
34			
35	**Tahap 6. Menghitung Capital Cost dengan Lang Factor 6**		
36			
37		**Capital Investment Cost ($)**	
38			

Equipment	Cost Correlation
Tank or Reactor	$Tank\ or\ Reactor\ Cost\ (\$) = \left(\frac{M\&S}{814}\right)(47.0V^{0.61})$ V= volume in gallons
Heat Exchanger	$Heat\ Exchanger\ Cost\ (\$) = \left(\frac{M\&S}{814}\right)(398.4^{0.65})$ A= area of heat exchanger in ft²
Centrifugal Pump	$Centrifugal\ Pump\ Cost\ (\$) = \left(\frac{M\&S}{814}\right)(421V^{0.46})$ V= volumetric flow rate in gal/min

Sheet 1

Figure 2. Example of a Google Sheets used in the economic analysis activity.

2.3 Real-time Monitoring and Feedback

During the activity, the instructor monitored the students' progress via shared documents on Google Slides and Google Sheets. This allowed for immediate assessment and direct feedback, ensuring that students stayed on track and addressed any misunderstandings promptly. The instructor also facilitated the collaborative process by providing timely guidance on the tasks and encouraging group discussions during the activities.

2.4 Data Collection and Evaluation

Data for this study was collected through direct observation of student activities and a follow-up questionnaire designed to assess their experiences with using Google Tools. The questionnaire focused on students' perceptions of collaboration and the effectiveness of Google Slides and Google Sheets in completing the assigned tasks. Out of 11 students, 8 (72%) completed the questionnaire. The results will be used to evaluate the impact of these tools on student learning and their ability to facilitate real-time collaboration and assessment.

The questionnaire consisted of 10 key questions, as described in Table 1, including both multiple-choice and open-ended items. The responses provided valuable insights into students' experiences and were analyzed using descriptive methods. Closed-ended question responses were evaluated based on frequency distribution, while open-ended responses were categorized and summarized to identify key themes. The reliability of the 8 closed-ended questions was assessed using Cronbach's Alpha, which yielded a value of 0.897, indicating good internal consistency among the items.

3. Results

3.1 Student Engagement and Collaboration

Based on the instructor's observations, all students were actively involved during the collaborative activities using Google Slides and Google Sheets. Each student

accessed both Google Slides and Google Sheets to participate in the tasks. In the process control activity, each student moved sensors on the Process and Instrumentation Diagram (P&ID), which could be seen from the initials of their accounts as they worked. A similar level of participation was observed in the economic analysis task, where students worked together on Google Sheets, performing calculations and editing data in real-time.

Table 1. Questions on the Use of Google Slides and Google Sheets in Collaborative Activities

No	Description	Option for Answer
1	How was your experience using Google Slides and Google Sheets for this class activity?	Very Satisfied, Satisfied, Somewhat Satisfied, Fairly Satisfied, Dissatisfied
2	How easy was it to use Google Slides and Google Sheets during the activity?	Very Easy, Easy, Somewhat Easy, Difficult, Very Difficult
3	To what extent did Google Slides help collaboration within your group during the process control activity (Week 12)?	Very Helpful, Helpful, Somewhat Helpful, Fairly Helpful, Not Helpful
4	To what extent did Google Sheets help collaboration within your group during the economic analysis activity (Week 13)?	Very Helpful, Helpful, Somewhat Helpful, Fairly Helpful, Not Helpful
5	Did you feel that using Google Slides and Google Sheets increased collaboration within your group?	Strongly Agree, Agree, Neutral, Somewhat Agree, Disagree
6	How effective did you feel the real-time feedback from the instructor on Google Slides and Google Sheets was?	Very Effective, Effective, Somewhat Effective, Fairly Effective, Not Effective
7	Did you feel that using Google Slides and Google Sheets in this class helped your understanding of process control and economic analysis?	Very Helpful, Helpful, Somewhat Helpful, Helpful, Not Helpful
8	Would you recommend using Google Tools (Slides and Sheets) for similar collaborative activities in future online classes?	Yes, Maybe, No
9	What do you think was the most beneficial aspect of using Google Slides and Google Sheets during this class activity?	Open Ended
10	What suggestions do you have for improving the use of Google Tools in future class activities?	Open Ended

Based on the questionnaire responses, three questions specifically addressed collaboration and engagement, namely questions 3 to 5. For question 3, which asked about the effectiveness of Google Slides in facilitating collaboration during the process control activity (Week 12), 4 students (50%) found it very helpful, while the other 4 students (50%) considered it helpful. Regarding question 4, which focused on the use of Google Sheets in the economic analysis activity (Week 13), 6 students (75%) rated it as very helpful, and 2 students (25%) found it helpful. Finally, question 5 asked whether the use of Google Slides and Google Sheets increased collaboration within their group; 5 students (62.5%) strongly agreed, 2 students (25%) agreed, and 1 student (12.5%) was neutral.

These findings highlight that both Google Slides and Google Sheets were highly effective in fostering collaboration and engagement. Most students felt that the tools

significantly enhanced their ability to work together in real time, share ideas, and solve problems collaboratively. The strong positive responses indicate that the tools provided an interactive and dynamic platform for teamwork, enabling students to engage more deeply with the content and with each other. Overall, the integration of Google Tools into the class activities contributed to a more engaging and collaborative learning environment, which was highly appreciated by the students.

3.2 Real-Time Assessment and Feedback

During the collaborative activities, real-time assessment and feedback played a key role in supporting student learning. The instructor was able to observe where students encountered challenges by tracking the movement of their account initials on Google Slides and Google Sheets. If a student had doubts or made a calculation error, the instructor could immediately identify the issue and provide direct feedback on the document. This allowed students to respond and correct their mistakes in real time. Additionally, the instructor monitored which groups were facing difficulties based on the time taken to complete each activity, enabling timely intervention and support when needed.

The questionnaire results further reflect the effectiveness of real-time feedback. When asked about the effectiveness of the instructor's real-time feedback on Google Slides and Google Sheets, 4 students (50%) rated it as very effective, 1 student (12.5%) considered it effective, and 3 students (37.5%) felt it was somewhat effective. These responses suggest that most students found the real-time feedback valuable in helping them promptly address issues, while a smaller group still found it helpful but less impactful. This aligns with the instructor's observations, where timely interventions provided opportunities for immediate clarification and correction, thereby improving the overall learning experience.

3.3 Effectiveness of Google Tools

To measure the effectiveness of Google Slides and Google Sheets, several questions were included in the questionnaire. The first question addressed students' overall experience using these tools during the class activities. The results showed that 3 students (37.5%) were very satisfied, while 5 students (62.5%) were satisfied with the tools. This suggests that most students had a positive experience and found the tools beneficial for collaborative activities. The second question aimed to determine whether students felt that using Google Slides and Google Sheets helped improve their understanding of process control and economic analysis. In response, 6 students (75%) found the tools very helpful, while 2 students (25%) considered them helpful. This indicates that most students believed these tools significantly contributed to their comprehension of the course content, particularly in the areas of process control and economic analysis.

Overall, the questionnaire responses indicate that both Google Slides and Google Sheets were perceived as effective tools for enhancing student understanding and engagement. The interactive and real-time nature of these tools allowed students to collaborate more effectively, thereby contributing to a deeper understanding of the subject matter.

3.4 Usability, Recommendations, and Student Feedback

To assess the usability of Google Slides and Google Sheets, students were asked how easy they found the tools to use during the activities (question 2). Most students reported a positive experience, with 5 students (62.5%) stating that the tools were very easy to use, and 3 students (37.5%) finding them easy. This indicates that the tools were

user-friendly and accessible, enabling students to focus on learning tasks without difficulties related to the software.

When asked whether they would recommend using Google Slides and Google Sheets for future online class activities (question 8), 7 students (87.5%) responded "Yes," while 1 student (12.5%) answered "Maybe." This suggests strong endorsement for the continued use of these tools in similar educational contexts.

Regarding the most beneficial aspects of using Google Slides and Google Sheets during the activities (question 9), several themes emerged. The most common feedback highlighted the tools' ability to facilitate real-time collaboration and interaction, which enhanced students' understanding. Some students noted that Google Slides made it easier to engage with the content by actively participating in determining process control methods and matching them to relevant components, rather than passively listening to explanations. Google Sheets was appreciated for its ability to automate calculations, saving time and reducing the need for manual work. The speed of data entry and immediate feedback during calculations were emphasized as key advantages.

Additionally, students valued the real-time interaction with both peers and the instructor. The collaborative environment allowed for immediate support, and many students felt that the direct involvement of the instructor helped clear up confusion and reinforced their understanding of the material.

When asked for suggestions to improve the use of Google Tools in future activities (question 10), the feedback was overwhelmingly positive. Some students suggested maintaining the use of these tools, as they felt the current implementation was already effective. A few students appreciated the tools' integration into the activities but had no further suggestions for improvement, indicating overall satisfaction.

4. Discussion

4.1 Implications for online chemical engineering education

The use of Google Tools, specifically Google Slides and Google Sheets, had a significant impact on collaboration and engagement during the online chemical engineering activities. These tools allowed students to work together in real-time, even when they were not physically in the same place. Google Slides made it easier for students to position sensors on the Process and Instrumentation Diagrams (P&ID) because the flexibility of moving images made the task simpler and less complicated. Google Sheets helped students with economic calculations, providing all the necessary functions like other spreadsheet tools, which allowed them to complete the tasks effectively. The interactive nature of these tools kept students engaged, as they could view each other's work and discuss ideas in real time. This finding aligns with the results reported by Tin (2024) and is supported by Amin (2020) and Handayani and Amelia (2021), who found that Google Apps enhance collaboration and real-time feedback in learning environments. The ability to collaborate easily and receive real-time feedback helped students understand the material better and stay involved in the activities. Overall, Google Tools proved to be an effective platform for improving student engagement and teamwork in an online learning environment.

The interactive nature of these tools kept students engaged, as they could see each other's work and immediately discuss ideas. This instant collaboration and real-time feedback helped students deepen their understanding of the material and stay actively involved in the activities. This is in line with the findings of Deep et al. (2024) and Nabhan and Sa'diyah (2021), who identified key factors that promote student engagement in online classes, such as interactive platforms and clear communication

strategies. Overall, Google Tools proved to be an effective platform for enhancing student engagement and teamwork in an online learning environment, allowing for a more interactive and collaborative approach to learning.

4.2 Real-time assessment and immediate feedback

Real-time assessment and immediate feedback were crucial in enhancing the learning experience during the activities. By monitoring students' progress through the real-time changes made in Google Slides and Google Sheets, the instructor could quickly identify where students were struggling or making errors. This immediate feedback allowed the instructor to provide guidance on the spot, helping students stay on track and correct their mistakes before they moved forward. The ability to interact in real time also kept students engaged and motivated, as they received instant clarification on any issues, leading to a more effective learning process. This aligns with Deep et al. (2024) and is supported by Marwan et al. (2022) and Sinclair et al. (2020), who highlighted the importance of adaptive and immediate feedback to optimize learning outcomes and instructional practice. They also noted that creating a positive and supportive online environment helps students overcome challenges and improves the learning experience.

In the economic analysis task, one group took longer to finish the activity compared to the others. The instructor was able to see their progress in Google Sheets and noticed where they were having trouble. This allowed the instructor to directly intervene, discuss the challenges with the group, and guide them through the difficulties. The instructor could wait until the task was completed and ensure the answers were correct, providing immediate support throughout the process. In the process control activity, some groups took longer to complete the task, which highlighted areas where students might have struggled with the material. This observation provided valuable feedback for the instructor, who was able to identify which concepts required further clarification. As a result, for the next session, the instructor could revisit and explain those challenging topics in more detail, ensuring that students had a better understanding before moving on. The ability to track the time spent on each activity not only helped with immediate support but also contributed to adjusting future lessons to address students' needs more effectively (Al-Mansouri, 2024; Hooda et al., 2022).

Another significant advantage was that there was no need for separate submissions. Students didn't have to upload their work to a Learning Management System (LMS) or email it to the instructor. Once the task was finished, the instructor could immediately review the work, making the assessment process smoother and more efficient.

4.3 Suggestion for improvement

The feedback from students on the use of Google Tools in future activities was generally positive, with no major suggestions for change. Many students recommended that Google Slides and Google Sheets should continue to be used in future online class activities, as they found the tools helpful for collaboration and understanding the material. Some students emphasized the effectiveness of real-time interaction and immediate feedback in improving their understanding and engagement. However, one student mentioned that they had no further suggestions, as they felt the current usage of the tools was already effective and well-integrated into the activities.

4.4 Future research direction

Future research could investigate using other Google Tools, like Google Docs, Google Drive, or Google Forms, to improve collaboration and assessment in chemical engineering education. It would be helpful to explore how these tools can be used for different parts of the curriculum, such as simulations or data collection, to better

understand their full potential. Expanding the study to include more students from different backgrounds could also provide broader insights into how Google Tools work in various learning settings. Additionally, future research could focus on the long-term effects of using these tools on student learning and retention of important concepts. By exploring these areas, future studies could help improve the use of digital tools in engineering education, making learning more effective and engaging.

5. Conclusion

This study examined the use of Google Tools—specifically Google Slides and Google Sheets—in enhancing student engagement, collaboration, and learning outcomes during online chemical engineering activities. The findings indicate that these tools significantly facilitated real-time collaboration and interaction among students, allowing them to work effectively on tasks related to process control and economic analysis. The ability to receive immediate feedback from the instructor further supported students' learning, helping them stay on track and address challenges promptly.

Google Slides and Google Sheets proved to be user-friendly, with most students reporting positive experiences. They found the tools beneficial for understanding complex concepts, promoting teamwork, and improving their overall engagement in the online learning environment. Furthermore, real-time assessment and feedback were highlighted as crucial elements in enhancing the learning process, providing students with timely clarification and guidance. From a theoretical perspective, this study adds to research on digital tools in online education, especially in engineering. It shows how tools like Google Slides and Google Sheets can support collaboration and engagement in online learning, providing a more interactive approach that fits with constructivist teaching methods.

Although the findings offer useful insights, the study has some limitations. The sample size was small, and the research was done in just one course, which may affect how broadly the results can be applied. Future research could explore the use of other Google Tools in different courses and with larger, more diverse groups of students. It would also be helpful to look at the long-term impact of these tools on student learning and retention to better understand their effectiveness in online education.

In summary, Google Tools offer a promising platform for improving student engagement and collaboration in online education, making them an asset for enhancing the quality of learning experiences in chemical engineering and beyond.

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