Improving Collaboration of Building Information Modeling and Design Students through Google Workspace Based Digital Project Based Learning in Technical Drawing

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Article History
Received: 2 September 2025
Revised: 10 October 2025
Accepted: 11 October 2025
Published: 16 October 2025

Keywords
Classroom action research
Collaborative learning
Google workspace
Technical drawing

Abstract
This study aims to improve students' collaboration skills through the implementation of digital collaborative project-based learning media using Google Workspace in the Technical Drawing subject. The problem faced by students was the lack of collaboration skills due to limited interactive media and the dominance of conventional teaching methods. The research method employed was Classroom Action Research (CAR) conducted in two cycles involving 11th-grade Building Information Modeling and Design students. Data were collected through observation, learning implementation assessments, and student project portfolios using a 4-point Likert scale. The results showed that in Cycle I, 72.2% of students demonstrated improved collaboration skills, although not optimally, with an average score of 32%. After improving strategies by strengthening team roles and providing more intensive guidance in Cycle II, 88.9% of students showed significant improvement, with an average score of 53%. These findings indicate that implementing Google Workspace-based collaborative learning media is effective in enhancing vocational students' collaboration skills and supports their readiness for industrial practice.

How to cite: Siswantoro, A. G. & Sugandi, R. M. (2025). Improving Collaboration of Building Information Modeling and Design Students through Google Workspace Based Digital Project Based Learning in Technical Drawing. *Ilmu Pendidikan: Jurnal Kajian Teori dan Praktik Kependidikan, 10*(2). 141–148. doi: 10.17977/um027v10i22025p141-148

1. Introduction

The rapid development of technology and industry in the 4.0 era requires vocational education to prepare graduates who are competent in both technical and collaborative skills (Wardina et al., 2019). The government through the Ministry of Education, Culture, Research, and Technology has made continuous efforts to improve the quality of vocational education so that graduates are able to compete in the workforce (Santika et al., 2023). In the construction sector, the industry demands not only mastery of technical knowledge but also collaboration and digital literacy as essential competencies for students (Nasution et al., 2024).

Technical Drawing is a core subject in the Department of Building Information Modeling and Design (DPIB) that equips students with the fundamental ability to design safe and functional buildings (Kemendikbud, 2018). This subject serves as a foundation for students to face challenges in the construction field and prepares them for industrial practice (Wibowo, 2022). However, initial observations revealed that students faced several problems such as the lack of interactive learning media and limited opportunities to collaborate effectively (Anggelita et al., 2020). These problems made it difficult for students to apply abstract concepts into practical projects, resulting in low engagement and motivation.

Collaboration skills are essential for vocational students because they train teamwork, communication, and problem-solving abilities (Vygotsky, 1978). Learning through collaboration also prepares students to adapt to the dynamics of the industrial environment, which requires flexibility and cooperation (Trilling & Fadel, 2009). In addition, the use of well-designed digital media can reduce cognitive load so that students can focus on solving problems and completing tasks collaboratively (Mayer, 2012).

Google Workspace provides digital tools that enable students to collaborate in real time, distribute tasks, and communicate efficiently in the learning process (Hafid & Barnoto, 2022). The platform integrates various applications such as Google Docs, Google Sheets, Google Slides, and Google Meet that support both communication and project management (Irani, 2022). Digital platforms also facilitate the implementation of problem-based learning because they offer communication channels, information sharing, and collaboration management (Hung, 2008). At the global level, UNESCO emphasizes that integrating technology into education is necessary to create inclusive and innovative learning. Previous studies have shown that digital learning media

doi: 10.17977/um027v10i22025p141-148

ISSN: 2549-7774

can motivate students and improve collaboration in group projects (Zekri et al., 2020). Other research found that Google Workspace improves classroom management, assessment, and student involvement during online and project-based learning (Rahmawati et al., 2022).

To bridge this gap, this study introduces the Digital Collaborative Project-Based Learning Media using Google Workspace. The novelty lies in the integrated, structured implementation of Google Workspace (specifically Google Docs and Google Slides for real-time drafting and presentation, enhanced by clear role assignments) within a Project-Based Learning (PBL) framework in the Technical Drawing subject. While previous studies explored Google Workspace for general education or digital media for motivation, this research specifically demonstrates the unique effectiveness of a structured Google Workspace-PBL model in a vocational (DPIB) Technical Drawing context to address practical collaborative weaknesses like unequal participation and unclear roles.

Based on these conditions, there is a need for innovative learning media that can combine project-based learning with digital collaboration (Mahsus & Latipah, 2021). The initial challenges, such as the lack of interactive media, reliance on conventional teaching methods, limited opportunities for effective collaboration, and the absence of clear role distribution in the classroom, clearly constitute the research gap. These conventional approaches fail to address the industry's demand for graduates proficient in digital literacy and collaborative skills. Therefore, this study unequivocally aims to investigate the practical effectiveness of implementing Google Workspace-based digital collaborative project learning media to significantly improve the collaborative skills of 11th-grade DPIB students at one of vocational high school in Malang in the Technical Drawing subject. The use of this learning medium is expected to strengthen students' collaboration skills and prepare them more effectively for industrial practice.

2. Method

This study employed Classroom Action Research (CAR) following the model developed by Kemmis and McTaggart (1988), which emphasizes a cyclical process of continuous improvement through four main stages: planning, action, observation, and reflection. CAR was chosen because it enables teachers and researchers to directly improve learning practices in the classroom while simultaneously solving practical problems. In this study, the CAR approach was implemented in two cycles, with each cycle designed to address students' collaborative weaknesses and gradually improve their skills through digital project-based learning using Google Workspace.

2.1. Research Subject and Setting

The research was conducted at Nasional Malang Vocational High School in the Department of Building Information Modeling and Design. The participants were 18 students from the 11th grade, consisting of 14 male and 4 female students, during the 2024/2025 academic year. The choice of this class was based on the fact that 11th-grade students were being prepared for industrial practice, thus requiring strong collaborative and technical drawing skills. The study was carried out over a three-month period, integrated into the Technical Drawing subject, which is one of the core competencies in the DPIB curriculum.

2.2. Research Design and Procedure

The Classroom Action Research (CAR) procedure was conducted in two cycles, each consisting of the four stages of planning, action, observation, and reflection, with improvements introduced in the second cycle based on the evaluation of the first.

In Cycle I, the researcher began by preparing lesson plans, teaching modules, worksheets, and digital media that would support the implementation of collaborative project learning. Indicators of success were established, focusing on students' understanding of technical drawing concepts and their ability to collaborate effectively using Google Workspace. To measure these aspects, observation sheets and assessment rubrics were developed to capture student participation, communication, task distribution, and the quality of group outcomes. During the action stage, the teacher explained the objectives of the lesson and divided the class into heterogeneous groups of four to five students. Each group was given three project-based case studies to complete collaboratively. Students used Google Docs for drafting and Google Slides for preparing their presentations, while the teacher facilitated and monitored discussions to encourage active participation. At the end of the session, every group presented their work in front of the class. The observation stage involved three observers the subject teacher and two colleagues who systematically recorded student engagement, role distribution, communication patterns, and the use of digital tools by using structured observation sheets. Reflection at the end of the cycle revealed that although some students showed progress in collaboration, challenges such as unequal participation, unclear role assignments, and limited digital literacy persisted. These findings became the basis for planning improvements in Cycle II.

In Cycle II, adjustments were made to address the weaknesses identified previously. Planning focused on creating clearer role assignments within each group, explicitly designating leaders, note-takers, editors, and presenters. The teacher also prepared explicit guidance, provided examples of ideal collaboration, and revised the teaching module to incorporate better time management strategies. During the action stage, students were again divided into groups and assigned project-based tasks, but this time the teacher clarified the responsibilities of each role, modeled effective teamwork practices, and offered closer supervision throughout the process. Students continued to work collaboratively using Google Workspace applications and presented their outcomes at the end of the cycle. Observations were again carried out by the same three observers, with attention directed toward whether the improvements role clarity, balanced participation, and more effective use of digital tools had been achieved. In the reflection stage, data from observations, student work, and presentations were analyzed, showing a clear enhancement in collaborative performance. Participation became more evenly distributed, communication improved, and the overall quality of the projects was higher than in the previous cycle. Since the criteria for success had been met, the CAR process was concluded after Cycle II.

2.3. Data Collection and Instruments

Data collection in this study was carried out using three complementary techniques that provided a comprehensive picture of students' collaboration skills. The first source of data was obtained through classroom observations, which were conducted systematically to capture students' engagement during group activities. The observation focused on indicators such as participation in discussions, the way tasks were distributed among members, and the quality of interactions that emerged within the groups. This approach made it possible to see how students interacted in real time and how effectively they applied collaborative principles while working on technical drawing projects.

The second source of data was derived from the assessment of learning implementation. This involved evaluating the extent to which students applied collaborative learning during the action stage of each cycle. The assessment emphasized aspects such as student activeness, responsibility in completing tasks, and the strategies used to coordinate work within the group. These assessments provided valuable insights into whether the interventions designed by the teacher and researcher had successfully encouraged students to work together more effectively.

The third source of data was taken from student portfolios, which consisted of the project outputs produced collaboratively by each group. These portfolios, which included technical drawing assignments and group presentations, served as tangible evidence of students' collaborative efforts. The quality, accuracy, and timeliness of the projects, as well as the delivery during presentations, were considered indicators of the level of collaboration that had taken place within each group.

To ensure consistency and accuracy, each of these instruments was supported by structured rubrics. Observations were conducted using sheets that rated student behavior according to predetermined indicators of collaboration. The assessment of implementation followed checklists that ensured each aspect of collaborative learning was measured, while the evaluation of portfolios was guided by rubrics that addressed both technical and collaborative dimensions of the students' work. All three types of data were analyzed using a four-point Likert scale, which was chosen to avoid neutral responses and to encourage more definitive judgments regarding student performance. The combination of these instruments allowed the researcher to triangulate findings, thereby increasing the reliability of the data and providing a more holistic understanding of the development of students' collaborative skills.

The collaborative skills were the main variable observed and measured using a structured observation sheet throughout the learning process. The success of the collaborative process was assessed by three independent observers, using a 4-point Likert scale (where 1 = Very Poor, 2 = Poor, 3 = Good, and 4 = Very Good) to prevent neutral bias.

The indicators defining collaboration skills in this study, operationalized through observable student actions within the Google Workspace-based projects, are as follows (Table 1):

Table 1. Indicators Collaboration

Indicator Operational	Definition (Observable Student Action)	Measurement Instrument
Participation in Discussion	Student's initiative and active involvement in voicing ideas, asking questions, and responding to group discussion topics.	Observation Sheet
Task Sharing and Responsibility	Student's ability to divide the workload equitably, fulfill their individual roles (e.g., coordinator, editor, presenter), and actively assist other group members.	Observation Sheet
Inter-Member Communication	The quality and effectiveness of verbal and digital interaction (e.g., using Google Workspace features like comments/suggestions) to convey information, coordinate tasks, and provide constructive feedback.	Observation Sheet

Indicator Operational	Definition (Observable Student Action)	Measurement Instrument
Active Contribution to Project	Student's demonstrated effort and commitment to contribute significantly to the group project completion, ensuring the team successfully finishes the task effectively and on time.	Observation Sheet
Use of Group Strategy	The team's ability to agree upon and implement a systematic, efficient work strategy to manage the project steps and optimally utilize the digital tools for problem-solving.	Observation Sheet

2.4. Data Analysis

The data collected from observations, learning implementation assessments, and student portfolios were analyzed using a descriptive statistical approach combined with narrative interpretation. The purpose of this analysis was not to test hypotheses through inferential statistics, but rather to capture the practical impact of the interventions on students' collaborative skills and to describe the changes that occurred across the research cycles. The process of analysis was carried out systematically to ensure that the findings reflected the real conditions observed in the classroom.

The first step in the analysis was data reduction, in which all raw data gathered from observation sheets, implementation checklists, and portfolio assessments were examined and organized according to the research focus. This step allowed the researcher to filter out irrelevant information while highlighting key aspects such as participation, role distribution, communication, and project outcomes. The reduced data were then presented in the form of descriptive tables, percentages, and mean scores to make patterns of improvement easier to interpret. These displays helped to identify the progress made by students from the pre-cycle condition through Cycle I and finally Cycle II.

The final stage of the analysis was drawing conclusions and verification. At this point, the data were carefully reviewed and compared across cycles to confirm whether the interventions had produced meaningful improvements. The researcher, together with the collaborating observers, reflected on the patterns that emerged to ensure that the interpretations were accurate and grounded in the evidence. The success criterion was established beforehand: at least 80 percent of students had to show improvement in collaborative skills, with their average performance reaching the "good" category. This benchmark served as a practical indicator of whether the Classroom Action Research had achieved its objectives.

Through this process, the analysis provided a clear picture of the progression of students' collaboration, from the limited participation and weak role distribution observed in the pre-cycle, to the partial improvements in Cycle I, and finally to the more balanced and effective collaboration achieved in Cycle II. By combining descriptive statistics with reflective interpretation, the study was able to demonstrate convincingly that the use of Google Workspace as a collaborative learning medium was effective in enhancing vocational students' ability to work together, communicate, and share responsibilities in technical drawing projects.

3. Results and Discussion

The data collected from classroom observations, learning implementation assessments, and student project portfolios were analyzed descriptively to identify improvements in students' collaboration skills across the research cycles. The results are presented in stages, starting from the pre-cycle condition, followed by the outcomes of Cycle I and Cycle II. Each cycle's findings are described in relation to the criteria of success and are further discussed by comparing them with relevant theories and previous studies.

3.1. Pre-Cycle

Before the implementation of the Classroom Action Research (CAR), an initial analysis was conducted to identify the existing conditions of students' collaborative skills in the Technical Drawing subject. At this stage, the learning process still relied heavily on conventional methods such as lectures and limited group discussions. The teaching module emphasized cognitive achievement and mastery of drawing techniques, but it lacked explicit strategies to foster collaboration. These circumstances suggested that the existing learning design had not yet provided students with the opportunity to develop the collaborative competencies required in vocational education.

As a result, several difficulties emerged in the classroom. Many students showed low participation in group work, preferring to complete tasks individually, while group activities were often dominated by only a few active members. Communication among students was also limited and ineffective, which frequently led to misunderstandings during the completion of drawing projects. Furthermore, the absence of clear role distribution within groups caused overlaps in tasks or, conversely, left some students disengaged from the activity. Another important issue was the lack of digital media integration, as most of the learning still relied on traditional tools such as textbooks and manual sketches, without utilizing digital platforms that could facilitate

collaboration in real time. These findings indicated that the approach was not sufficient to prepare students for real-world industrial practices, where teamwork and digital proficiency are essential. Therefore, the implementation of collaborative project-based learning media using Google Workspace was expected to provide a solution to these challenges.

3.2. Cycle 1

In Cycle I, students were introduced to Google Workspace applications, particularly Google Docs and Google Slides, as collaborative tools to complete project-based tasks. Each group was given three case studies related to technical drawing, which they were required to complete collaboratively and present at the end of the cycle. This stage was intended to familiarize students with digital platforms that could support real-time collaboration and project sharing.

The results of Cycle I showed that 72.2% of students demonstrated some level of improvement in collaboration skills, but the progress remained limited, with the average score of collaboration indicators reaching only 32 percent. Several obstacles were identified during this stage. Group participation was often unequal, as some groups were strongly dominated by one or two active members while others remained passive, with certain leaders taking over most of the tasks without distributing responsibilities fairly. Technical challenges also emerged, since several students were still unfamiliar with the functions of Google Docs and Slides, which slowed down the collaborative process. In addition, many groups faced time management problems, struggling to complete their projects within the allocated period due to ineffective communication and lack of coordination. The quality of the presentations further reflected these limitations, as although the groups managed to present their outcomes, the delivery was uneven and in some cases poorly prepared. Despite these shortcomings, Cycle I was still considered a positive starting point because it created initial awareness of the importance of digital collaboration. The introduction of Google Workspace motivated students to explore new methods of working together, although stronger guidance and more structured support were clearly required for the next cycle. Based on the observations, the results are as follows (Table 2).

Table 2. Learning Implementation in Cycle I

Activity Indicator	Collaborative Aspect (O)	Learning Implementation (P)	Portofolio (T)
Total Score per Aspect	97	95	98
Average	32.3	31.7	32.7

Based on the observation results during the learning process in Cycle I, the percentage of student achievement was as follows (Table 3):

Table 3. Student Collaboration Observation Results in Cycle I

Number of Students	Description	Percentage
17 students	Collaboration skills improved (not yet optimal)	72.2%
2 students	Collaboration skills improved fairy well	11.1%
3 students	Collaboration skills did not improve	16.7%

In addition, several notes from the observer indicated some non-technical issues experienced by several students, as follows (Table 4):

Table 4. Observation Sheet in Cycle I

Notes on Students Activities	Number of Students
Toward the end of the material presentation, focus began to fade	6
Contribution in the group was less visible	1
Difficulty focusing and too often joking during tasks	1
Frequently joking and not focused on own task	1
Too often joking while completing assigned tasks	1
Sick (absent due to illness)	1

3.3. Cycle 2

Based on the reflection of Cycle I, several improvements were implemented in Cycle II. The learning design was revised by assigning clearer roles within each group, such as leader, note-taker, editor, and presenter. The teacher also provided explicit examples of what effective collaboration should look like, offered more intensive supervision during group activities, and applied better time management strategies to help students organize their work.

The implementation of these improvements produced significant positive changes in the classroom. In Cycle II, 88.9 percent of students demonstrated clear progress in their collaboration skills, with the average

score rising to 53 percent. Participation became more balanced across group members because the assigned roles encouraged each student to take responsibility for a specific part of the project. Students who had been passive in Cycle I began to contribute more actively during discussions and task completion. Communication also improved as students made better use of the comment features in Google Docs and engaged more productively in Google Meet discussions, which allowed them to clarify task distribution and provide feedback more effectively. The quality of the projects reflected this progress, as the technical drawings produced in Cycle II were more accurate, better organized, and more consistent with the subject requirements, while deadlines were met more consistently than in the previous cycle. Presentations also showed noticeable improvement; with designated presenters and stronger preparation, the delivery was more structured and every member contributed to the final performance, reflecting greater confidence and understanding of the material. Overall, the findings from Cycle II demonstrate that the strategic use of Google Workspace not only facilitated smoother collaboration but also created a more inclusive learning environment in which every student played an active role.

Table 5. Recapitulation of Student Scores in Cycle II

Activity Indicator	Collaborative Aspect (O)	Learning Implementation (P)	Portofolio (T)
Total Score per Aspect	157	162	161
Average	52.3	54.0	53.7

Compared to Cycle I, where the averages were 32.3%, 31.7%, and 32.7%, there was an increase in all aspects. Based on these observations, the percentage of students achieving collaborative skills was as follows (Table 6):

Table 6. Percentage of Students' Collaborative Skills Achievement in Cycle II

Number of Students	Description	Pecentage
5 students	Collaboration skills improved significantly	27.8%
11 students	Collaboration skills improved fairy well	61.1%
2 students	Collaboration skills did not improve	11.1%

In addition, several notes from the observer indicated some non-technical issues experienced by students, as follows (Table 7):

Table 7. Observation Sheet in Cycle II

Notes on Students Activities	Number of Students
Sick (absent due to illness)	2
Contribution in the group was less visible	1
Contribution in the group was less visible, often silent in discussion	1
Occasionally unfocused and joking with group members	1

3.4. Comparative Analysis between Cycles

The comparison between the two cycles clearly illustrates the effectiveness of the interventions. In Cycle I, the collaboration process was still hindered by unequal participation, unclear role distribution, and low digital literacy. However, after adjustments in Cycle II, students were better able to distribute tasks, communicate effectively, and use technology to support their collaborative efforts.

This improvement aligns with Vygotsky's (1978) theory of social constructivism, which emphasizes the role of social interaction in cognitive development. By engaging in structured group activities, students moved beyond individual limitations and learned from their peers. Furthermore, the findings support Trilling and Fadel's (2009) framework of 21st-century skills (4C: critical thinking, creativity, collaboration, and communication), demonstrating that technology-enhanced collaboration fosters not only technical competence but also essential soft skills.

Johnson and Johnson's (1999) principles of positive interdependence and individual accountability were also reflected in the results. In Cycle II, students realized that their contribution was critical to group success, which encouraged them to take responsibility for their roles. Similarly, Slavin's (2017) assertion that cooperative learning increases motivation and academic outcomes was confirmed in this study, as students were more motivated and produced higher-quality work when the collaborative structure was strengthened.

A crucial part of the implementation was overcoming initial challenges. In Cycle I, the primary challenge was the uneven distribution of workload and participation, where students lacked clarity on their specific roles within the Google Workspace platform, leading to social loafing. This gap highlights a potential pitfall in implementing any digital collaborative tool: technology alone does not guarantee collaboration; structure is

necessary. Furthermore, technical differences emerged: some students faced minor difficulties in real-time document synchronization or navigating the collaborative features efficiently. Addressing these differences required direct intervention, including dedicated time in Cycle II to explicitly define roles (e.g., Coordinator, Documenter) and provide detailed technical guidance on using Google Docs and Slides simultaneously. This demonstrates that the successful implementation of Digital Collaborative PBL media heavily depends on the pedagogical strategy used to structure digital roles.

3.5. Limitations and Suggestions

This study, conducted using the Classroom Action Research (CAR) method, inherently possesses specific limitations. First, the study's findings are confined to a small sample size (11th-grade DPIB students) at a single vocational high school, limiting the generalizability of the results to other subjects or educational contexts. Second, the data collection relied heavily on observer subjectivity, although mitigated by using multiple trained observers and a clear operational definition of indicators. Third, the study duration was limited to two cycles, which only provided a short-term assessment of the improvement. Future research should consider employing a quasi-experimental design with a larger sample to validate the effectiveness of the Google Workspace-PBL model in a control group setting. Furthermore, research could explore the model's impact on long-term project quality and the transferability of these digital collaborative skills to other vocational subjects.

4. Conclusion

This study aimed to investigate the effectiveness of the Digital Collaborative Project-Based Learning Media using Google Workspace in improving the collaborative skills of DPIB students in the Technical Drawing subject. The Classroom Action Research (CAR) method, implemented across two cycles, decisively confirmed the effectiveness of the model. The findings indicate a significant and systematic improvement in students' collaborative skills after the media's structured implementation. Specifically, the improvement strategies implemented in Cycle II focusing on explicitly defining group roles and providing intensive guidance on digital collaboration features were pivotal in enhancing student engagement and eliminating uneven workload distribution, leading to the achievement of the predefined success criteria.

The research makes several important contributions. Theoretically, it strengthens the argument that digital tools, when integrated with a strong pedagogical framework like Project-Based Learning, significantly enhance collaborative learning as theorized by Vygotsky's social constructivism. Practically, this study provides a validated, structured model for vocational schools, demonstrating that the Google Workspace-PBL model with clear role assignments is highly effective for fostering essential 21st-century skills such as collaboration and digital literacy in technical subjects. This model can serve as a direct template for educators seeking to bridge the gap between classroom teaching and industry demands.

Based on the findings, it is recommended that vocational teachers integrate structured digital collaborative methods, moving beyond conventional teaching to utilize Google Workspace features for real-time teamwork and defined role allocation. For future research, it is suggested to employ a quasi-experimental design to compare the effectiveness of this structured model against a control group, ensuring broader external validity. Furthermore, future studies could explore the long-term impact of the model on the students' job readiness and project quality in subsequent industrial practice programs.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

This research was funded by Universitas Negeri Malang through a undergraduate thesis research assistance scheme with internal Universitas Negeri Malang or non-APBN funding sources.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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