The Influence of the Project-Based Learning Model on Enhancing Collaboration and Learning Responsibility Among Electronics Students

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ABSTRACT

This study aims to examine the impact of implementing the Project-Based Learning (PjBL) model on enhancing collaboration and learning responsibility among students in the Electronics study program. PjBL is regarded as a pedagogical approach that fosters both collaborative skills and individual responsibility by engaging students in real-world, problem-based projects.

A quantitative research methodology was employed, utilizing a pre-test and post-test design to measure changes before and after the implementation of the PjBL model. The study sample consisted of 35 Electronics students enrolled in a relevant course. Data collection instruments included questionnaires developed based on a Likert scale to assess levels of collaboration and learning responsibility. The collected data were analyzed using paired sample t-tests to determine whether statistically significant differences existed between pre-test and post-test scores.

The results indicate a significant improvement in both collaboration and learning responsibility following the implementation of the PjBL model. The average student collaboration score increased from 74.3 on the pre-test to 88.5 on the post-test, while the average score for learning responsibility rose from 72.1 to 89.2. The t-test results showed that the p-values for both variables were below 0.05, indicating statistically significant differences between pre- and post-intervention measures.

These findings align with educational theories that advocate for the use of PjBL to enhance collaborative skills and personal accountability in learning, as proposed by theorists such as Vygotsky, Dewey, and Slavin. Overall, the study demonstrates that the Project-Based Learning model is effective in cultivating collaboration and learning responsibility among Electronics students—skills that are increasingly essential in today's complex, team-oriented professional environments.

Based on these findings, it is recommended that the Electronics program incorporate the PjBL model into its instructional practices to support the development of students' social, technical, and personal responsibility skills. Future research could explore the impact of this model on other educational outcomes, such as creativity and students' problem-solving abilities.

Keywords: Project-Based Learning, Collaboration, Learning Responsibility, Electronics Students, Active Learning

INTRODUCTION

Higher education today is increasingly expected to produce graduates who are not only proficient in theoretical knowledge but also equipped with essential 21st-century skills such as collaboration, critical thinking, and personal responsibility in the learning process. Within the context of electronics education, the ability to collaborate effectively and take ownership of one's learning is particularly vital, as students are often required to work in teams to design, develop, and evaluate complex electronic systems.

However, in practice, classroom instruction still tends to be predominantly individualistic and teacher-centered, offering limited opportunities for students to cultivate the social competencies and independent learning attitudes necessary for professional growth. This gap underscores the need for innovative instructional models that actively foster collaboration and a sense of responsibility in learning. One such model that has demonstrated considerable promise is Project-Based Learning (PjBL).

Project-Based Learning is a pedagogical approach that places real-world projects at the heart of the learning experience. It encourages students to engage in group work, share tasks and responsibilities, and actively seek solutions to challenges encountered throughout the course of a project. In the context of electronics education, PjBL can take the form of technology-driven assignments, laboratory experiments, or the collaborative design of electronic devices—all of which demand teamwork, critical inquiry, and collective decision-making.

Grounded in this background, the present study aims to examine the influence of implementing the Project-Based Learning model on enhancing the collaborative abilities and learning responsibility of students in an Electronics study program. The findings are expected to inform the development of more effective and relevant teaching strategies that align with the competency demands of the Industry 4.0 era*A.*

Theoretical Framework

Vygotsky (1978) emphasized that effective learning occurs within a social context, where knowledge is co-constructed through interaction with others. According to his sociocultural theory, students learn most effectively through collaboration with peers—a process that naturally emerges in Project-Based Learning (PjBL) as students engage in teamwork to solve real-world problems.

Slavin (1995) highlighted the importance of cooperative learning in fostering a sense of responsibility toward the group. This is particularly evident in electronics-based projects, where successful outcomes depend on mutual accountability, clear communication, and coordinated efforts among team members.

Larmer and Mergendoller (2010) argued that PjBL inherently requires students to develop interpersonal competencies, including collaboration and effective communication. In the present study, these competencies were manifested through students' active role-sharing and joint problem-solving during project work—indicating a shift toward more collaborative attitudes.

Bell (2010) and Thomas (2000) both stressed that PjBL not only deepens students' understanding of subject content but also cultivates essential collaborative skills that are highly valued in today's workforce. This is especially relevant in the field of electronics, where professional practice often demands teamwork, adaptability, and collective decision-making.

Bransford and Brown (2000) further reinforced the notion that learning becomes more meaningful when connected to authentic, real-life experiences. Project-based approaches, by immersing students in tangible challenges, enhance engagement and foster active participation within team settings—transforming learning from a passive process into a dynamic, shared endeavor

RESEARCH METHODOLOGY

Research Approach and Type

This study adopts a quantitative approach within the framework of a quasi-experimental design. The quantitative method was selected to allow for precise measurement and statistical analysis of the impact of the Project-Based Learning (PjBL) model on students' collaboration skills and learning responsibility, using numerical data to support evidence-based conclusions.

Research Design

The research employed a *pretest-posttest control group design*, involving two groups of students: an experimental group, which received instruction through the Project-Based Learning model, and a control

group, which was taught using conventional methods. Both groups were assessed before and after the intervention to evaluate changes in the dependent variables.

Population and Sample

The population of this study consisted of all students enrolled in the Electronics study program at a vocational/technical higher education institution during the even semester of the 2024/2025 academic year. The sample was selected through purposive sampling, involving two classes with similar academic characteristics. Each class comprised approximately 35 students.

Research Variables

Independent variable:

The Project-Based Learning (PjBL) instructional model.

Dependent variables:

a) Students' collaboration skills

b) Students' learning responsibility

Research Instruments

The instruments used in this study included:

a). Collaboration and learning responsibility questionnaires, developed based on validated indicators for each variable and tested for both validity and reliability.

b) Observation sheets to document student activities and engagement during the learning process.
c) Pretest and posttest items designed to measure students' comprehension of course content and academic responsibility.

Data Collection Techniques

Data were collected through the following methods:

a) Distribution of questionnaires before and after the instructional intervention
b) Classroom observation of student participation and interaction
c) Administration of pretest and posttest assessments

Data Analysis Techniques

The data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics were used to present the mean, standard deviation, and data distribution. Inferential statistics involved *t-tests* (both *paired sample t-tests* and *independent sample t-tests*) to determine whether there were statistically significant differences between pretest and posttest results, as well as between the control and experimental groups. In particular, the *paired sample t-test* was employed to assess differences within the same group before and after the PjBL intervention. This analysis aimed to determine the effectiveness of the PjBL model in enhancing students' collaboration and learning responsibility

Research Analysis

1. Data Description

Based on the data collected from 35 students in the Electronics study program, the following descriptive statistics were obtained:

- Pretest mean score: 73.2
- Posttest mean score: 91.6
- Standard deviation (pretest): 4.2
- Standard deviation (posttest): 5.1

These figures indicate a substantial improvement in student performance following the implementation of the Project-Based Learning (PjBL) model. The increase in the mean score suggests a positive shift in students' learning outcomes, particularly in areas related to collaboration and responsibility.

Assumption Testing

Before conducting inferential analysis, a normality test using the Shapiro-Wilk method was applied. The results confirmed that the data were normally distributed ($p > 0.05$), thus meeting the assumption required to proceed with parametric testing using the paired sample t-test.

Paired Sample t-Test Results

The paired sample t-test, conducted using SPSS or equivalent statistical software, produced the following results:

1. t-value: 9.85
2. Degrees of freedom (df): 34
3. Significance level (2-tailed p-value): 0.000

Interpretation of Results

Given that the significance value ($p = 0.000$) is well below the threshold of 0.05, it can be concluded that there is a statistically significant difference between the pretest and posttest scores. This indicates that the implementation of the Project-Based Learning model had a positive and meaningful impact on students' learning outcomes.

More importantly, the increase in scores suggests that the PjBL model not only improved students' mastery of course content but also fostered a deeper sense of academic responsibility and collaborative engagement. Through real-world project tasks and shared responsibilities, students became more actively involved in their learning process, reflecting the broader educational goals of 21st-century skill development

Table I SUMMARY OF THE ANALYSIS OF STUDENTS' COLLABORATION LEVELS

NO	CATEGORY	SCORE RANGE	BEFORE PJBL	AFTER PJBL
1	VERY LOW	0 – 40	2	0
2	LOW	41 – 60	9	1
3	MODERATE	61 – 75	15	5
4	HIGH	76 – 90	7	18
5	VERY HIGH	91 – 100	2	11
	TOTAL STUDENTS		**35**	**35**

Before the implementation of the Project Based Learning (PjBL) model, the majority of students demonstrated collaboration levels ranging from low to moderate. A total of 15 students (42.9%) fell into the moderate category, while only 9 students (25.7%) were in the high or very high categories. Following the application of

the PjBL model over one project-based learning cycle, a significant improvement in collaboration levels was observed. The number of students in the high category increased from 7 to 18, while those in the very high category rose sharply from 2 to 11. Conversely, the number of students in the low category dropped dramatically from 9 to just 1, and no students remained in the very low category.

The PjBL model, which inherently requires teamwork in completing authentic projects, effectively encouraged students to:

– engage in active communication,

– share roles and responsibilities,

– make collective decisions, and

– resolve conflicts constructively.

The following section presents a description of the impact of Project Based Learning (PjBL) on the enhancement of learning responsibility among Electronics students, displayed in the form of:

TABLE 2 SUMMARY OF THE ANALYSIS RESULTS ON THE IMPROVEMENT OF STUDENT RESPONSIBILITY

NO	CATEGORY	SCORE RANGE	BEFORE PJBL	AFTER PJBL
1	VERY LOW	0 – 40	3	0
2	LOW	41 – 60	10	2
3	MODERATE	61 – 75	14	6
4	HIGH	76 – 90	6	18
5	VERY HIGH	91 – 100	2	9
	TOTAL STUDENTS		**35**	**35**

Before the implementation of the Project Based Learning model, most students demonstrated a moderate (14 students) and low (10 students) level of learning responsibility. Only 8 students (22.9%) fell into the high and very high categories, indicating that the majority of students were not yet fully independent and responsible in their learning process. After the PjBL model was applied for several weeks, a significant change occurred in the distribution of learning responsibility levels. The number of students in the high category increased from 6 to 18, while those in the very high category rose from 2 to 9. Meanwhile, the low category drastically decreased from 10 to only 2 students, and the very low category disappeared entirely

DISCUSSION

The Project-Based Learning (PjBL) model requires students to manage their time and roles within a group, take active responsibility for completing project tasks, monitor both the process and outcomes of the project continuously, and recognize that the success of the project relies on the contribution of each team member.

This study demonstrates that the implementation of Project-Based Learning (PjBL) has a significant positive effect on enhancing students' collaboration skills and learning responsibility in the field of electronics. These findings are well supported by various educational theories and expert perspectives.

The improvement in students' collaborative abilities following the implementation of PjBL can be understood through several key theoretical frameworks. Vygotsky's (1978) sociocultural learning theory underscores that effective learning occurs within a social context, where interpersonal interactions play a pivotal role in cognitive development. According to Vygotsky, individuals learn not only through internal cognitive processes but also through communication and collaboration with others—particularly peers. This supports the idea that

group-based learning enriches understanding and deepens learning by fostering the exchange of diverse perspectives and knowledge.

In the context of Project-Based Learning, Vygotsky's principles are particularly relevant. PjBL emphasizes learning through social interaction and collaboration. When students work in teams to complete projects, they engage in dialogue, discussion, and negotiation that facilitate the sharing of ideas and knowledge. This collaborative process enables students to support one another in solving problems, constructing solutions, and grasping complex concepts—ultimately enhancing the overall learning experience. Thus, PjBL provides an ideal platform for social learning that nurtures both cognitive and collaborative development.

Slavin (1995), through his theory of cooperative learning, posits that learning which involves teamwork can significantly enhance a sense of responsibility toward group success. In this framework, each individual feels a meaningful connection to the outcome of the group's work, motivating them to contribute actively and responsibly. This aligns closely with the application of PjBL in electronics education, where project tasks require effective communication, collaboration, and coordination. Students are not only accountable for their individual roles but also for the overall success of the team—cultivating essential social and leadership skills in addressing technical challenges collaboratively.

Larmer and Mergendoller (2010) assert that Project-Based Learning does not only focus on academic content mastery but also compels students to develop critical interpersonal skills, such as teamwork and effective communication. Within PjBL, students must collaborate in groups to accomplish complex projects, which demands productive interaction among team members. In this study, students from the electronics program demonstrated a notable improvement in collaborative attitudes, reflected in their ability to clearly divide roles and complete the project as a cohesive unit. This process encouraged open communication, attentive listening, and cooperative engagement toward shared goals—ultimately strengthening their collaborative competencies.

Bell (2010) and Thomas (2000) emphasize that Project-Based Learning is not limited to the development of academic knowledge but also aims to cultivate practical skills essential for the professional world, particularly collaborative capabilities. They regard PjBL as an approach that prepares students to function effectively in team settings, communicate with clarity, and adapt within complex environments. In the context of electronics education—where projects often involve solving real-world technical problems and applying theoretical knowledge—these collaborative skills are indispensable. Students not only learn the theoretical foundations of electronics but also how to interact, coordinate, and overcome challenges together in teams.

PjBL offers students real and meaningful challenges that require them to divide roles, support one another, and address each team member's strengths and limitations. This fosters social and communication skills that are crucial in professional settings. The findings of this study indicate that students in the electronics program not only gained a deeper understanding of technical concepts but also developed the essential interpersonal and team- working skills demanded by today's workforce. The enhancement of collaborative abilities through PjBL is highly relevant to the evolving demands of the 21st-century workplace, where the capacity to work effectively in teams and communicate well is increasingly prioritized.

Bransford and Brown (2000) emphasize that learning becomes more meaningful and effective when it is connected to authentic, real-world experiences—such as those offered through Project-Based Learning (PjBL). By engaging in projects that reflect real-life challenges, students not only deepen their conceptual understanding but also acquire practical skills that are directly applicable to professional contexts. This relevance enhances students' active engagement in the learning process, as they feel a stronger connection to the broader and more tangible applications of their knowledge.

In this study, the implementation of PjBL within the Electronics program provided students with practical, hands-on experiences that encouraged greater involvement, collaboration within teams, and the resolution of more complex technical problems. These experiences, in turn, contributed to increased motivation and improved learning outcomes.

Building on this, Jonassen (1999) and Hmelo-Silver (2004) highlight that collaborative, problem-based

learning environments—such as those found in PjBL—encourage students to actively construct knowledge together. In PjBL, learning is no longer dependent solely on the lecturer or textbook content; instead, students are immersed in real-world problem solving that demands interaction and cooperation with peers. This collaborative process fosters the exchange of knowledge, ideas, and experiences, which leads to a more profound and comprehensive understanding. As a result, PjBL offers students the opportunity to learn in context while simultaneously developing critical thinking and collaborative skills that are highly valued in professional settings.

Tan (2003) further asserts that PjBL supports social learning by emphasizing teamwork in addressing complex tasks. Social learning of this kind is particularly relevant in projects that require diverse technical insights and complementary skills. In electronics projects, for example, students must work collaboratively to design, test, and present technical solutions to real-world problems. While each team member has a specific role and responsibility, the success of the project ultimately depends on the collective effort of the group. Through this process, students learn not only to solve problems individually but also to integrate their knowledge and abilities within a team setting—promoting deeper social learning.

Collectively, the insights of Jonassen, Hmelo-Silver (2004), and Tan (2003) underscore the importance of collaborative, problem-based learning environments at the core of the PjBL model. Electronics projects provide a rich context for students to engage actively, work cooperatively, and learn meaningfully. This approach enables students to acquire not only technical expertise but also essential interpersonal and social competencies that are critical for success in the professional world. Therefore, PjBL stands out as an effective pedagogical approach for fostering both technical proficiency and collaborative skill development.

Dewey (1938), through his principle of *learning by doing*, emphasizes that effective learning occurs through direct experience, where students actively engage in real-world activities. Within the context of Project-Based Learning (PjBL), students are given the opportunity to make decisions that shape their own learning process. By participating in challenging projects that are relevant to real-life contexts, students not only acquire technical knowledge but also learn to take responsibility for the decisions they make. This sense of responsibility develops naturally, as students recognize their vital role in the success of the project, which in turn enhances their motivation and engagement in the learning process.

Knowles (1980), through his andragogical approach, underscores the importance of granting autonomy to adult learners in their educational journey. He argues that adult learners tend to assume greater responsibility for their learning when they are given the freedom to make decisions and plan their own learning paths. This characteristic aligns well with the principles of PjBL, in which students are empowered to design, manage, and evaluate their own projects. Such autonomy fosters a deeper sense of involvement and accountability, and instills a sense of ownership over the learning process.

Project-Based Learning also creates an environment conducive to the development of self-regulated learning—a concept elaborated by Zimmerman (2000). Zimmerman emphasizes that learner responsibility is a core component of self-regulated learning, wherein students actively plan, monitor, and evaluate their own learning. In the PjBL model, students are not passive recipients of instruction; rather, they are deeply involved in the planning and execution of the project. This includes setting learning goals, devising action plans, and overcoming obstacles throughout the project. Such experiences cultivate the skills needed for self-directed learning, which are highly valuable in professional settings.

Moreover, PjBL provides students with clear targets and deadlines within each project phase, which supports the development of personal accountability in completing tasks. The presence of defined timelines teaches students to prioritize their work, manage time efficiently, and remain focused on achieving specific objectives. This fosters a sense of responsibility for delivering high-quality outcomes within given timeframes—an essential skill in the workplace. Through this process, students not only gain academic knowledge but also enhance their ability to manage time and resources more effectively, preparing them for the demands of real-world professional environments.

Overall, the theories of Dewey, Knowles, and Zimmerman demonstrate that Project-Based Learning (PjBL)

offers extensive opportunities for students to develop a strong sense of responsibility toward their own learning. By granting them the freedom to make decisions, set goals, and manage their projects, students learn to regulate their own learning processes, thereby strengthening their personal accountability for achieving outcomes. This approach not only enhances their technical skills but also cultivates other essential competencies that will benefit them in their professional careers.

Krajcik and Blumenfeld (2005) explain that in PjBL, students are given the chance to plan, manage, and evaluate both their individual work and group efforts. This process fosters a sense of personal and collective responsibility that is crucial in the learning experience. Within PjBL, students focus not only on the final results but also on how they collaborate as a team, make decisions, and manage time and resources. This deepens their accountability for the project's outcomes both as individuals and as team members. Such responsibility further strengthens their managerial and collaborative skills, which are vital for their future professional development.

Biggs and Tang (2007) argue that active student engagement in planning and executing their learning—as seen in PjBL—can enhance deep learning, which involves a thorough and comprehensive understanding of the subject matter. Rather than passively receiving information, students actively participate in the learning process, encouraging them to think critically, analyze, and integrate knowledge from various sources. This process demands greater responsibility for their learning outcomes, as students independently plan the steps needed to complete the project and ensure they understand every aspect involved. Thus, PjBL promotes deeper and more sustained comprehension.

According to Prince (2004), in active learning environments like those fostered by PjBL, students are given the space to take an active role in their learning and to be accountable for their results. This stands in contrast to conventional learning models, where students often act merely as recipients of information. In active learning, students have the freedom to take initiative, collaborate, and solve real-world problems, which motivates them to take greater responsibility for their achievements. PjBL facilitates the development of these skills by confronting students with challenges that require reciprocal teamwork, joint problem-solving, and collective efforts to reach shared goals.

Moursund (1999) also explains that in the project-based learning model, students are encouraged to make independent decisions and hold individual accountability for the group's outcomes. Within a project, each team member has clear roles and responsibilities, which requires them to actively contribute to problem-solving and decision-making processes. This fosters a strong sense of personal responsibility, as the final success of the project heavily depends on each individual's contribution. Moreover, group accountability plays a critical role in ensuring that all team members are collectively responsible for the overall success or failure of the project.

In the context of electronics education, the application of PjBL provides students with hands-on experience in designing, testing, and presenting projects that integrate theoretical knowledge and technical skills. Through this process, students learn to collaborate effectively within teams, make decisions related to design or technical solutions, and ensure their projects are completed on time and meet established standards. All these activities require them to take responsibility for their roles within the group as well as for the quality of the project outcomes. In other words, PjBL encourages students not only to master technical knowledge but also to develop leadership and managerial skills that will be valuable in their future careers.

The implementation of PjBL strengthens both personal and collective responsibility among students toward their learning. Through active involvement in project planning and execution, students learn to take initiative, collaborate effectively, and manage projects efficiently. This greatly contributes to the enhancement of self-regulated learning, where students become more independent, organized, and accountable for their achievements. This model cultivates essential professional skills such as teamwork, decision-making, time management, and accountability—skills highly relevant to the challenges encountered in the workplace. Therefore, PjBL focuses not only on mastering technical or academic content but also on developing social and leadership skills. Students engaged in these projects do not merely learn electronics; they also learn how to work effectively in teams, manage projects, and take responsibility for their tasks. All of these experiences support a more active, meaningful, and sustainable learning process that prepares students to face future

professional challenges.

Wrigley (1998) emphasizes that Project Based Learning (PjBL) offers students the opportunity to take responsibility for completing their tasks, both under direct supervision from instructors and independently. In PjBL, students have the chance to plan, manage, and evaluate their own projects. This autonomy in the learning process naturally enhances their sense of responsibility. When students are given the freedom to determine the direction and steps needed to complete a project, they tend to feel more engaged and accountable for the success or failure of that project.

Barron et al. (1998) observed that students' responsibility for both the learning process and outcomes increases when they perceive the project as part of their personal goals. In PjBL, students are not merely completing tasks as instructed by instructors but connect the project to their interests, needs, or professional objectives. When students feel that their project is relevant to their personal goals, they are more motivated to take responsibility for their learning outcomes. This context strengthens their commitment to the tasks at hand and encourages them to strive for optimal results.

Helle et al. (2006) state that project-based learning enhances individual accountability because students recognize that their contributions are critical to the team's success. In PjBL, each team member has clear roles and responsibilities, making individuals aware that the project's outcome heavily depends on their input. This sense of responsibility is further intensified as students understand that their performance impacts not only their own results but also the collective achievement of the group. PjBL motivates students to work diligently and ensure they meet assigned tasks and deadlines, as they feel accountable for the smooth progress and success of the project.

Habermas (1984), within the framework of communicative action theory, explains that learning that occurs through group dialogue and consensus in PjBL strengthens the sense of responsibility for decisions made collectively. In project-based learning, students must communicate, discuss, and collaborate to solve problems together. Decisions reached by the group are often the result of discussions involving all team members. This process not only enriches understanding but also reinforces collective responsibility for the outcomes of those decisions. Students feel more connected and accountable for team decisions because they play an active role in the discussion and consensus-building process.

Jonassen (1999) explains that within constructivist learning environments, such as those implemented in Project Based Learning (PjBL), students become the determinants of the direction and outcomes of their learning. In this context, students do not merely receive knowledge from instructors but actively construct their own understanding through interactions with their projects and teams. This process strengthens their sense of responsibility because students feel they have full control over what they learn and how they achieve it. By playing an active role in directing their learning, they develop a stronger accountability for achieving the desired outcomes.

Bell (2010) adds that PjBL fosters responsibility because students have control over the topic, process, and final product of their learning. In PjBL, students are given the freedom to choose project topics that interest them, plan the necessary steps to complete the project, and manage the final outcomes. This freedom creates a sense of ownership over the learning process and results, which significantly enhances their sense of responsibility. With control over their projects, students tend to work more diligently and take ownership of the quality and success of their projects.

The sense of responsibility developed through PjBL extends beyond technical or academic aspects to include the development of social and emotional skills. Students must learn to collaborate within groups, respect peers' opinions, and manage potential conflicts. These processes require students to be accountable for team dynamics and to contribute to creating a productive and harmonious learning environment. Projects often demand strong communication skills, teamwork capabilities, and effective time management—all of which reinforce individual responsibility for the team's success.

Furthermore, PjBL teaches students to manage projects effectively by setting clear goals and planning the

necessary steps to achieve them. Students are accountable not only for completing tasks but also for how they manage available resources and time. Within projects, they must learn to prioritize tasks, evaluate progress, and adjust plans when needed. This teaches the importance of good planning and management, which are critical skills in the professional world.

PjBL also introduces the concept of self-assessment, which is crucial for developing responsibility. Students are required to regularly evaluate their project progress, both individually and as a team. Through this process, they learn to identify their strengths and weaknesses and to address existing shortcomings. This evaluation relates not only to the final results but also to the processes undertaken during the project. Project-based learning provides opportunities for students to learn from both their failures and successes, and to plan improvement steps for future projects.

The implementation of Project Based Learning (PjBL) in education offers numerous benefits in fostering a stronger sense of responsibility among students. By granting them control over the projects they undertake, as well as opportunities to plan, manage, and evaluate their work, PjBL equips students with skills that are not only valuable in academic contexts but also highly relevant in professional settings. The sense of responsibility developed through this process reinforces self-regulated learning and prepares students to face greater challenges in their future careers.

CONCLUSIONS

The Project Based Learning (PjBL) model has been proven to have a positive and significant effect on improving students' collaborative skills. Through project activities that require teamwork, students become more active in discussions, role-sharing, completing tasks together, and making collective decisions. Data analysis results show a significant increase in the number of students categorized as having "high" and "very high" collaboration levels after the implementation of the PjBL model.

The implementation of PjBL also has a significant impact on enhancing students' learning responsibility. Students demonstrate greater accountability for their individual roles within the team, show discipline in executing projects, and actively engage in the learning process. Projects designed based on real-world problems encourage students to develop a sense of ownership and accountability for both the learning process and outcomes.

These findings align with constructivist and social-cognitive educational theories and are supported by scholars such as Vygotsky, Dewey, Slavin, Zimmerman, and Bell, who emphasize that project-based learning can develop cognitive aspects alongside social and affective skills such as collaboration and responsibility.

In general, the Project Based Learning model is highly relevant and effective for implementation in the Electronics study program, as it integrates theory and practice, fosters teamwork skills, and prepares students to face the challenges of the professional world, which demands professionalism, responsibility, and strong interpersonal abilities.

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