The effectiveness of the SPjBL learning model in improving creative thinking skills of electrical engineering students

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Abstract One of the problems that is often encountered in the current study of the electrical engineering department is students’ low level of creative thinking skills. Therefore, this study aimed to test the effectiveness of the Sustainable Project Based Learning (SPjBL) learning model in improving the creative thinking skills of electrical engineering students. The experimental model used in this research was classroom action research. The research method used was an experiment with data obtained from 69 respondents from two groups of students. The obtained data were analyzed using an independent t test and NGain Score. The results showed that the SPjBL learning model was effective in improving the thinking skills of electrical engineering students. Furthermore, this research is expected to provide a comparison in determining the type of learning model that is suitable for teaching-learning activities at schools.

Keywords: creative thinking skills, SPjBL, learning model, electrical engineering students

1. Introduction

Creative thinking skills are skills that everyone needs to master to be successful in facing 21st-century problems and challenges in life and careers (Harris & de Bruin, 2018; Quieng et al., 2015; Yusuf et al., 2022). One of the 21st-century skills is creative thinking, which is very important and is seen as a life-sustaining force (Ayob et al., 2012; Putri et al., 2018). Therefore, creative thinking can be seen as the most desirable quality of a person (Alrubaie, & Daniel, 2014). According to Atmojo et al., (2019), creative thinking is one of the recommended ways for people to see problems from many perspectives. Almeida et al., (2008) stated that creative thinking is a process of paying attention to problems, gaps, and deficiencies in knowledge, identifying difficulties, finding solutions, and finally communicating results. In this case, creative thinking requires a process of creativity in increasing or developing it (Binkley et al., 2012; Pantiwati, 2013).

Based on the results of questionnaires and interviews with 170 twelfth-grade electrical engineering students in Klaten, students’ creative thinking skills tended to be low and the learning process could not improve their creative thinking skills optimally. This was indicated by the minimal variation of the resulting products. The percentage of products sold as learning outcomes also tended to be low (below 5%) (Dalyanto et al., 2021). The results of the questionnaire were also reinforced by the results of observations during PKK (Produk Kreatif dan Kewirausahaan/Creative Products and Entrepreneurship) learning in three classes with different supporting teachers. The teachers had used the project-based learning (PjBL) model in their learning process, but it was not able to improve students’ creative thinking skills.

The problems identified in the interviews and observations were obstacles to supporting the electrical engineering students’ creative thinking skills. Therefore, low school students’ thinking skills need to be improved. Several studies have shown that learning innovative models can improve creative thinking skills (Lince, 2016).

Khoiri et al. 2016; Nugroho and Prayitno (2017); Sari and Angreni (2018), who conducted research as a form of implementing project-based learning, stated that the project-based learning model can develop students’ creative thinking skills. Thus, an innovative learning model that can improve students’ creative thinking skills is needed in science learning, which is often considered an objective and ordered science in the universe (Suban, 2022), in this case, electricity engineering. The learning model applied must be able to provide a stimulus to electrical engineering students to be creative in creating ideas. One learning model that can improve creative thinking skills is sustainable project-based learning (SPjBL). This learning model is in line with the agenda of sustainable development goals (SDGs) that were formulated at the global level by involving the leaders of 193 UN (United Nations) member countries at the end of September 2015. As a global action plan implemented until 2030, sustainable development has five basic principles—people, planet, prosperity, peace, and partnership—in three dimensions: economic, social, and environmental harmony (Jani, 2022).
The SPjBL learning model consists of 5 stages. The first is the challenging problem stage. At this stage, it is advisable to write down the main problem or question in the form of “eliciting questions” that focus on the task before designing and carrying out a project. This stimulating question is based on the problems faced in the environment or nearby places. The next stage is student choice. At this stage, students can choose to control many aspects of the project, such as the generated questions, the resources that are used, the tasks, and the roles to be taken as team members.

The third stage is the project design. At this stage, students plan a design, find ways to solve problems, and ask deeper questions. This process is repeated until a satisfactory answer is obtained. The fourth stage is reflection, which involves the knowledge and understanding gained to help students reinforce what they have learned and think about how it might apply elsewhere outside of the project. The last stage involves the development of a sustainable product. It is a product that minimizes environmental impacts throughout the product life cycle until the product is no longer usable (Larmer et al., 2015). The goal of this stage is to help students reduce waste and maximize resource efficiency. This product is marketed with a green marketing strategy to communicate product value. Creative thinking skills need to be mastered by electrical engineering students because there are some aspects of 21st-century skills that they must have in terms of way to think, way to work, tools to work, and how to live in the world (Binkley, M., Erstads, O., Herman, J., Raizen, S., Ripley, M., & Rumble, M., 2010).

Therefore, this study aimed to improve electrical engineering students’ creative thinking skills. The benefit of using the SPjBL learning model is to improve students’ creative thinking skills. This research can be used as a reference for efforts to improve creative thinking skills for other researchers.

2. Literature Review

2.1. Creative Thinking

Creative thinking skills are skills that need to be mastered by everyone to be successful in facing problems and challenges in life and careers in the 21st century. One of the 21st century skills is creative thinking, which is very important and is seen as a life-supporting force (Ayob et al., 2012). Therefore, creative thinking can be seen as the most desirable quality of a person. According to (Atmojo et al., 2019), creative thinking is one of the recommended ways for people to see problems from many perspectives. Torrance (1980) stated that creative thinking is a process of paying attention to problems, viewing gaps in knowledge, identifying difficulties, looking for solutions, and finally communicating results. In this case, creative thinking requires a process of creativity in improving or developing it.

Coon & Mitterer (2014) state that creativity is a problem-solving process carried out through an unconscious experiential stage that includes fluently expressing ideas, flexibility, and producing novel ideas or solutions. Wallas’s theory, which was put forward by his book "The Art of Thought" (Georgsdottir et al., 2003), became the first formal theory of creative creation. Wallas’s theory states that creative insight consists of five stages: (1) preparatory, namely, working on problems that focus the individual’s mind; (2) incubation, which is where the bottleneck is internalized into the subconscious mind; (3) intimacy, which is a solution underway; (4) illumination, namely, the process of precociousness becoming awareness; and (5) verification, namely, ideas are consciously implemented, elaborated, and then implemented. Wallas stated that creativity is a process of human change to quickly adapt to changes in the environment. Simonton (1999) provides this view in his book, Origins of Genius: in line with Darwin’s view of creativity. Guilford (1950) was the first to distinguish between divergent and convergent thinking. Convergent thinking is the ability of applying rules to arrive at the correct solution to a problem. Dijikic & Oatley (2017) suggest a different way to improve creative thinking, namely, by accurately perceiving oneself and the environment. This process is carried out by reducing methods that inhibit creativity through self-deception, self-knowledge, and experimental weight. Self-deception is achieved by observing thoughts, emotions, and, most importantly, behavior. Self-identity is realized by cultivating many flexible self-narratives. The most difficult of the three is the experimental weight achieved with meditation-based mindfulness (Torrance & Safter, 1999). Several indicators used to measure creative thinking skills include the following:

1) Fluency (fluency) is the ability to generate many ideas.
2) Dexterity (flexibility) is the skill of producing various approaches.
3) Authenticity (originality) is the skill of exploring ideas that are on track.
4) Detail (elaboration) is the skill of filling in details.
5) Reformulation (redefinition) is the skill of defining in a different way.

Based on the description of developmental methods and approaches for measuring the creative thinking process, researchers have used figural and verbal TTCT to measure creative thinking skills. The measurement of creative thinking skills is based on the Fluency, Flexibility, Originality and Elaboration indicators with the following details: Fluency indicators. It is hoped that someone will be able to generate many ideas, many answers, considerable problem solving, and many questions. In addition, people are also able to provide many ways or suggestions for doing various things. They are able to think of more than one answer to the problem or question they are facing. As an indicator of flexibility (flexibility), it is hoped that someone will be able to solve a variety of problems, generate varied ideas, answers or questions, and see a problem from different
points of view. By looking for many alternatives or different directions, a person can change his or her approach or way of thinking. As an indicator of authenticity (originality), it is hoped that someone will be able to solve problems with new ideas and be able to give birth to new and unique expressions, think of unconventional methods, and able to make unusual combinations from parts. With regard to the indicator of detail (elaboration), it is hoped that someone can understand what is known in a coherent manner and be able to develop and develop an idea or product. Someone can also add or satisfy the details of an object, idea.

2.2. Project Based Learning

The project-based learning model is a student-based learning model (Boss, & Krauss, 2007). The use of project-based learning can increase knowledge and skills that are meaningful in the long term (Markham, 2020). Project-based learning is based on constructivist learning theory, where knowledge grows and develops based on the experience received. The essence of constructivist learning is to increase knowledge in the academic, personal and social domains simultaneously (Bruce., Joyce, Weil, M. & Calhoun, E., 2009). Students carry out processes of interpretation, exploration, assessment and synthesis of problems encountered through practical activities as a form of learning (Nurrochman, O.C., 2015;66). Students gain experience by asking questions, finding learning resources, and creating informative projects (Farris, 2012). The application of this learning model is suitable in the classroom because the class will become more “alive” and fun so that students are more enthusiastic and more attentive to the environment (Permadi, 2016). According to (Sutirman, 2013), the stages of the project-based learning model are (1) asking basic questions; (2) designing the project; (3) preparing a schedule; (4) project progress; (5) test results; and (6) evaluating experience. Based on the opinions above, the project-based learning model is characterized by problems being raised, meaningful learning experiences, real products, and an evaluation process.

2.3. Sustaintable Development Goals (SDGs)

Sustainable development goals (SDGs) aim to maintain a sustainable increase in the economic welfare of society, development that maintains the sustainability of the social life of the community, development that maintains the quality of the environment and development that guarantees justice and the implementation of governance that is able to maintain an improvement in the quality of life from one generation to the next. SDGs are a global and national commitment in an effort to improve society, including 17 goals, namely, (1) no poverty; (2) no hunger; (3) healthy and prosperous life; (4) quality education; (5) gender equality; (6) clean water and adequate sanitation; (7) clean and affordable energy; (8) decent work and economic growth; (9) industry, innovation and infrastructure; (10) reduced inequality; (11) sustainable cities and settlements; (12) responsible consumption and production; (13) handling climate change; (14) ocean ecosystem; (15) land ecosystem; (16) peace, justice and strong institutions; and (17) partnership to achieve goals.

The development of the learning process requires a learning environment that combines real practice (learning by doing) and explicit reflection about what and how to learn from that practice (learning by reflection). Rowe (2007); De Kraker (2007), and Brundiers et al. (2010) proposed addressing real-world sustainability problems in various settings. In this way, it is possible to fundamentally develop and update sustainable skills education. SDGs have begun to be applied to problem-based and project-based learning (Brundiers et al., 2013; Wiek et al., 2016; Cazorla & Pasten, 2019). Student learning is shifting from passive (course instructor gives, students receive) to active (students give, course instructor provides feedback), and students work on real-world problems by engaging directly in small group work or collaborating with stakeholders in developing solution options for problems identified (Brundiers & Wiek, 2011). Specifically, (Cazorla-Montero et al., 2019) categorized the implementation of sustainable development in learning as follows: (1) perspective: defining contextual skills that must be directed within and in the wider environment; (2) practice: experiential learning with connecting back to real life; and (3) personal: the person and interpersonal skills necessary to succeed in ongoing projects, programs, and portfolios. The main factor for success in learning strategies is continuous reflection of experience (sustainable).

3. Research Methods

This research was conducted on electrical engineering students at SMK Negeri 2 Klaten, Central Java Province, Indonesia. This research was conducted for 6 months, starting from January to July 2022. The research approach used was classroom action research (Bakker, 2004; Elliot, 1991). This research was conducted in three cycles. Each cycle consisted of three meetings. The data used in this study were qualitative and quantitative (Lucas, 2016). The qualitative data were collected through observation, interviews, and documentation (Garcia & Mayorga, 2018). The quantitative data in this study were in the form of test results of students’ creative thinking skills. The creative thinking skills test referred to creative thinking instruments based on (Dalyanto et al., 2021; Almeida et al., 2008). The data were validated for content validity (Alrubaie, & Daniel, 2014). The data were analyzed using the N-Gain score test, which was previously tested by an independent sample t test to determine whether there was a significant difference between the average posttest scores of the experimental group and the posttest scores of the control group (Hake & Reece, 1999; Sa’diyah & Santos, 2022). The test results of the students’ creative thinking skills based on the level of creativity are categorized as effective if they achieve
a score of more than 76%, quite effective if they achieve a score of 56% to 75%, less effective if they achieve a score of 40% to 55%, and ineffective if they achieve a score of less than 40% (Hake & Reece, 1999).

4. Findings

The main conceptual model of SPjBL was constructed based on constructivist learning theory as a learning outcome and was developed by referring to Joyce and Weil’s (2009) learning model with five main elements, namely (Figure 1), (1) syntax as the step of the learning process, (2) social system (social system), (3) principles of reaction (principles of reaction) to describe how teachers treat and respond to students, (4) support system (support system) for all the facilities, infrastructure up to the classroom environment that supports learning, and (5) instructional and nurturing effects (the impact of teaching and accompaniment) learning objectives or outcomes obtained directly in accordance with predetermined learning objectives and learning outcomes outside of the specified objectives.

Sustainable products are products that are designed to have the least impact on the environment. Sustainable products are products that minimize environmental impacts throughout a product’s life cycle until the product can no longer be used (LCA; Larmer, et al., 2015). This product can be made from recycled materials that can be reused, are biodegradable, are free of toxins and hazardous materials, and are made from environmentally friendly renewable resources. The goal of this stage is for students to be able to reduce waste and maximize resource efficiency. This product is marketed with a green marketing strategy to communicate the right product value. The following is the conceptual design of the SPjBL model.

The instrument used in this research was a test of creative thinking skills in the form of descriptive questions. Before the instrument was used for data collection, validity and reliability tests were carried out. The stages in the validity test were as follows:

4.1. Content validity test

The validity test was performed using the calculation of V-Aiken. The V-Aiken test was carried out using expert judgment. The value of the Aiken validity index had a range of values between 0V1 (Budiyono, 2015). Expert judgment was conducted by asking for consideration from experts or experienced people. Based on the aspects measured, it can be concluded that an average of 0.812 was obtained so that the instrument was feasible to use.

4.2. External validity test

The external validity test is conducted by testing the instrument on a different sample from the research sample used. It aims to find an instrument that can be generalized to the population. There are two aspects of the test carried out in testing external validity, namely, the difficulty and discriminating power of the questions. The results of the calculation of the difficulty level of the questions showed that the difficulty index met the criteria, namely, between 0.00 and 1.0, with good results in the range of 0.30 < P < 0.70 (Budiyono, 2015). The item criteria also fulfilled the differential power index in the range 0.30 < P < 0.70.

4.3. Construct validity test

In this study, the construct validity test used the principles of confirmatory factor analysis (CFA) with the Lisrel software. The following are the results of the analysis using the Lisrel software (Figure 2).
CFA data were considered valid if the chi-square value divided by the df value did not exceed 2, the P value was >0.05, and the RMSEA value was ≤0.05. The chi-square value was 420.04, the df was 289, the P value was 0.0125570, and the RMSEA was 0.048. Table 1 below shows the description of the creative thinking skill test results in cycle I.

**Table 1** Results of the creative thinking skills test in cycle I.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Pretest</th>
<th>Posttest</th>
<th>N-Gain Score</th>
<th>N-Gain Percentage</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>51,4</td>
<td>67,9</td>
<td>0,34</td>
<td>33,6</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Control</td>
<td>54,5</td>
<td>64,6</td>
<td>0,22</td>
<td>21,8</td>
<td>Ineffective</td>
</tr>
</tbody>
</table>

Table 1 shows that the average posttest score for the students’ creative thinking skills in the experimental class increased compared to the pretest score. The average score of students’ creative thinking skills in the first cycle was 67.9%, compared to 51.4% in the pretest. The N-gain value was 0.34%, and the N gain percentage was 33.6%. This N-gain was categorized as ineffective. Moreover, the percentage of participants in the control class also increased by an average of 64.6% compared to the average of 54.5% in the pretest. The N gain value was 0.22 or 21.8%. This N gain was categorized as ineffective.

The increase in the percentage of N-Gain had not reached or fulfilled the research performance indicators that had been set, so a second cycle was carried out. Table 2 below describes the results of the second cycle of the creative thinking skill test.

**Table 2** Results of the creative thinking skill test in cycle II.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Pretest</th>
<th>Posttest</th>
<th>N-Gain Score</th>
<th>N-Gain Percentage</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>51,4</td>
<td>76,5</td>
<td>0,52</td>
<td>51,59</td>
<td>Less effective</td>
</tr>
<tr>
<td>Control</td>
<td>54,5</td>
<td>69,4</td>
<td>0,32</td>
<td>32,39</td>
<td>Ineffective</td>
</tr>
</tbody>
</table>

Table 2 shows that the average posttest score for the creative thinking skills of the experimental class students increased compared to the pretest score. The average score of students’ creative thinking skills in the second cycle was 76.5%, while that in the pretest was 51.4%. The N gain value was 0.52, and the N-gain percentage was 51.59%. This N gain was categorized as less effective. Moreover, the percentage of participants in the control class also increased by an average
of 69.4% compared to the average of 54.5% in the pretest. The N-gain value was 0.32 or 32.39%. This N-gain was categorized as ineffective.

The increase in the percentage of N-Gain had not reached or fulfilled the research performance indicators that had been set, so a third cycle was carried out. Table 3 below describes the results of the creative thinking skill test in cycle III.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Pretest</th>
<th>Posttest</th>
<th>N-Gain Score</th>
<th>N-Gain Percentage</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>51.4</td>
<td>79.6</td>
<td>0.58</td>
<td>57.93</td>
<td>Quite effective</td>
</tr>
<tr>
<td>Control</td>
<td>54.5</td>
<td>73.7</td>
<td>0.42</td>
<td>41.85</td>
<td>Less effective</td>
</tr>
</tbody>
</table>

Table 3 shows that the average posttest score of the students’ creative thinking skills in the experimental class increased compared to the pretest score. The average score of students’ creative thinking skills in the third cycle was 79.6%, while that in the pretest was 51.4%. The N gain value was 0.58%, and the N gain percentage was 57.93%. This N gain was categorized as quite effective. Meanwhile, the percentage of students in the control class also increased by an average of 73.7%, compared to the average of 54.5% in the pretest. The N-gain value was 0.42% or 41.85%. This N gain was categorized as less effective. The increase in the percentage of N gain reached or fulfilled the research performance indicators that had been set. In cycle III, the reaction was stopped because the percentage of N-Gain reached 56%.

Learning in cycle III was successful, and research performance indicators were successfully achieved. The treatment conducted in cycles I to III showed that the SPjBL learning model can improve the creative thinking skills of students who are majoring in electrical engineering. Creative thinking skills can be developed through brainstorming (Chang et al., 2015). The activities of discovering new methodologies, generating new ideas, and students’ scientific practice are part of proposing alternative ideas as part of divergent creative thinking (Antink-Meyer & Lederman, 2015; Abraham, 2013).

The five effective learning strategies used to develop students’ creative thinking are student-centered learning, the use of various learning aids, classroom management strategies, contextual materials, and open-ended questions (Horng et al., 2005). This can be optimized with the SPjBL model, which supports the improvement of creative thinking skills through fluency, breadth, originality, and detail (Anwar, 2012).

Five effective learning strategies used to develop students’ creative thinking are student-centered learning, the use of various learning aids, classroom management strategies, contextual materials, and open-ended questions (Horng et al., 2005). This can be optimized with the SPjBL model which supports the improvement of creative thinking skills through fluency, breadth, originality, and detail (Anwar, 2012).

For the SDG model to continue to engage Indonesia’s future generations, Education Sustainable Development (ESD) is needed to develop students’ understanding of physical, biological, and human skills and abilities. Motivation works through specific and useful actions, and critical thinking skills to achieve a harmonious and sustainable life. ESD emerged as a broader framework to incorporate education in traditional settings as a social and other development challenge. ESD is oriented towards real action-based values because it seeks to foster a sense of individual responsibility towards the environment to challenge sustainable and unsustainable practices and actively participate in changing them (Huang, 2019). Through ESD it is hoped that: (1) students will learn sustainable lifestyle patterns, (2) be ready to face the challenges of life’s demands, (3) if natural resources run out, they cannot be obtained on other planets, (3) have a vision of the future and think deeply. According to UNESCO (2009), ESD has seven important characteristics:

a. Interdisciplinary and comprehensive: learning for sustainable development is integrated throughout the program, not a separate topic issue
b. Values-based: adopted norms – the values and principles underlying sustainable development must be made clear so that they can be considered, debated, tested and applied
c. Critical thinking and problem solving: leads to the confidence needed to overcome the dilemmas and challenges of sustainable development
d. Multimodal: various pedagogical approaches exemplify the process. Teaching that aims solely to disseminate knowledge must be changed to an approach where teachers and students work together to gain knowledge, understand, and play a role in shaping the environment of their educational institutions;
e. Participatory decision-making: students participate in making decisions about how they will learn
f. Application: recommended learning experiences are integrated into personal life and daily personal and professional life.
g. Locally relevant: discusses local and global issues uses the language most frequently used by students and has creative ways to express new concepts (Watanabe, 2015).

The main conceptual model of SPjBL is built on constructivist learning theory as a learning outcome and was developed by referring to Joyce and Weil’s (2009) learning model with five main elements, namely: (1) syntax as a stage in the learning process, (2) social system (social system), (3) etymological response principle (reaction principle) describes how the concept and if the students respond, (4) support system ‘support system’ is all physical facilities, infrastructure up to 45 in the classroom environment that supports learning, and (5) the effects of education and care (the impact of teaching and

https://www.malque.pub/ojs/index.php/mr
support) are the goals or learning outcomes achieved that are directly relevant to the learning objectives that have been identified and the learning outcomes are outside the predetermined objectives.

Project-based learning related to ESD (Education Sustainable Development) is currently relatively effective in developing students' creative thinking skills because students are trained to develop their creative systems thinking skills by making direct observations of natural systems and they feel like they are part of that system. Developing creative systems thinking skills can train students to change paradigms to see a problem from various points of view to find sustainable solutions, encouraging them to pay more attention to their activities and take more action (Ekvelsa, 2023).

In the first stage, the orientation problem. Students are asked challenging questions to come up with a project that is identified by considering the benefits, capacity, and availability of facilities and infrastructure. The aim of this stage is related to the indicator of creative thinking ability, namely fluent, because students are required to solve questions and give multiple answers to the questions, providing many examples or statements about the concept or situation of a particular question (Zaiyar & Rusmar, 2020). Challenging problems are activities before designing and carrying out a project. It is recommended to write the problem or main question in the form of a "provoking question" that focuses on the task. This fishing question is based on problems faced in the environment or surrounding places. Identifying problems can improve students' creative thinking abilities because challenging problems are students' solutions to a problem that reflects the emerging state of knowledge. One of the activities that teachers can do to help improve students' creative thinking skills is to provide students with basic knowledge before starting learning. This question determines students' direction and goals for producing work or learning outcomes as learning products (Somphol, 2022).

In the second stage, Organizing Students. At this stage, students and their groups carry out project planning and design activities which are very important activities to carry out. It is true when the project is finished, all team members must know the procedures for creating the project. The aim of this stage is related to the indicator of creative thinking ability, namely Flexibility because students are required to use problem-solving strategies to design project activities to be implemented and provide examples of certain planning concepts (Madyani, 2020). In this stage students can choose to control many aspects of the project, starting from the questions generated, the resources that will be used to find answers to questions, to determining the tasks and roles they will take on as team members. At this stage, students prepare a project, plan, or draw up a plan. A plan is designed to facilitate the resolution or resolution of a problem. This stage requires student creativity in choosing which project to design and drawing up a plan to implement the project (Simbolon & Koewsanti, 2020). Implementation of project tasks, and selection of activities that can support project work (Ismuwardani, 2019).

The third stage is the project design stage, the activity of planning the design, finding ways to answer it, and then asking deeper questions, this process repeats until the answer is satisfactory. Project work and student assignments as project work are based on real-world problems and process realistic work stages that are relevant to learning outcomes. Carrying out project tasks is a practical activity for students with good teamwork to demonstrate quality performance and resolve problems related to the project to turn the project design into a real object. The role of the teacher at this stage is to be a guide, tutor, supervisor, and evaluator who enables students to carry out the learning process through the inquiry process and constructing work on the project tasks they are working on. In carrying out project assignments, students work according to production activity estimates, prioritizing safety, solid teamwork and consulting the teacher if problems are found (Jalinus & Nabawi, 2017). At this stage, students and their groups carry out design planning activities, find ways to answer them, and then ask deeper questions, this process repeats until the answer is satisfactory. Project work and student assignments as project work are based on real-world problems and process realistic work stages that are relevant to learning outcomes. The aim of this stage is for each student to be able to use new, unique, or unusual strategies to design projects and provide new, unique, or unusual examples or statements (Meiarti, 2020; Jalinus & Nabawi, 2017).

The fourth stage is Reflection, containing the knowledge and understanding gained to help students strengthen what they have learned and think about how it might apply in other places outside the project. This stage contains the knowledge and understanding gained to help students strengthen what they have learned and think about how it might apply elsewhere outside the project. The aim of this stage is related to the indicator of creative thinking ability, namely Elaboration. Skills to explain the procedures of the project to be implemented, answers, or certain situations in detail. The explanation must use concepts, representations, terms, or notations (Auliyah, 2021).

The fifth stage is sustainable products. Sustainable products are sustainable products that minimize environmental impacts throughout the product's life cycle until the product can no longer be used (Larmer et al., 2015). The goal of this stage is that students can reduce waste and maximize resource efficiency. This product is marketed with a green marketing strategy to communicate the right product value. SDGs have begun to be applied to problem-based and project-based learning. At this stage, students and their groups carry out sustainable projects, programs, and portfolios that have been previously planned.

The SPJBL learning model can improve students' creative thinking abilities through the third stage, namely the project stage, because at the project design stage, the activities carried out are planning the design, finding a way to answer it, then asking deeper questions, this process repeats until the answer is satisfactory. According to Rosales and Sulaiman (2016) Sustainable Project Learning (SPJBL) is a project-based learning, where students are given the task of developing
themes/topics in learning by carrying out realistic project activities. Apart from that, the application of project-based learning encourages the growth of creativity, independence, responsibility, self-confidence as well and critical and analytical thinking in students. SPjBL is an individual or group project carried out over a certain period to create a product and present the results. Apart from developing and using various learning resources, take an active or student-centered learning approach (Mursid., 2022). Creativity and innovation are primarily represented by-products, which are students’ solutions to a problem that reflect an emerging state of knowledge. Examples include creating a product, solving a problem, improving a product, and so on. Creative challenge definition, data attribution, data creation, concept selection, and presentation to users or potential customers are examples of creative and innovative skills (Somphol, 2022).

5. Final Considerations

The findings show that the implementation of the SPjBL learning model can improve students’ thinking skills in electrical engineering. This is evidenced by data showing that there is an increase in creative thinking skills in each cycle. The percentage of creative thinking skills in preaction was 0%. The percentage in cycle I was 33.62%, that in cycle II was 51.59%, and that in cycle III was 57.93%. The findings have theoretical implications for similar research (Malik & Ubaidillah, 2020; Nasir, 2018; Malik et al., 2019). This research also has practical implications for the learning process in the form of increasing creative thinking skills in the form of self-confidence, creative thinking, and innovation after the implementation of the SPjBL model (Saputri, et al., 2019; Setiawan et al., 2018).

To be able to create good learning interactions and foster students’ creative thinking and entrepreneurial skills, teachers are emphasized to have competence in their field, to be professional, to be able to guide and train students to choose challenging problems, to allow students to choose and determine goals for themselves, to design good projects, to reflect on every step and choice, and finally to be able to produce a sustainable product.

6. Limitations of the study

This research may find it difficult to generalize the findings to a wider population due to the focus on one particular field of study, namely, electrical engineering. Creative thinking skills may have different implications in different fields of study. The small sample size may limit the validity of the findings. The smaller the sample is, the more difficult it is to draw reliable conclusions about the effectiveness of the SPjBL learning model. Creative thinking skills are complex concepts and are difficult to measure objectively. The measurement methods used in research may not be able to capture all aspects of these skills. Research may be conducted over a limited time period, which may limit our understanding of the long-term effects of the SPjBL learning model on students’ creative thinking skills. It is possible that there are external factors that influence research results, such as classroom learning environment factors, student motivation levels, or teacher influence. It is difficult to isolate all these factors in a research context.

7. Recommendations

Conducting further research using a larger sample size can increase the validity and reliability of the findings. With a larger sample size, researchers can gain a deeper understanding of the effectiveness of the SPjBL learning model in improving students’ creative thinking skills. More comprehensive measurement instruments can be developed or used to measure students’ creative thinking skills more holistically. This may involve a combination of quantitative and qualitative measures to better describe aspects of creative thinking skills. Longitudinal research should be conducted to understand the long-term effects of the SPjBL model on students’ creative thinking skills. These studies may involve monitoring and measuring students’ creative thinking skills over time to determine the long-term changes that occur. A more in-depth analysis of the external factors that can influence the effectiveness of the SPjBL learning model, such as the learning environment, student motivation, and teacher support, was conducted. This may involve in-depth interviews or direct observation to understand the role of these factors in the learning context. We developed an SPjBL learning model that is more specific and adaptable to the context of electricity engineering. This can involve collaboration between researchers, teachers and industry practitioners to identify the unique learning needs and challenges in this field.

Ethical Consideration

The authors declare that consent was obtained from the participants for the interviews.

Funding

The study did not receive any funding.

Conflict of Interest

The authors declare no conflicts of interest.

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<th>Author(s)</th>
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<td>Melarti, D., Wiyanto, &amp; Yulianti, I. (2020)</td>
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**Note:** The above list includes references to a variety of sources, including journals, books, and conference proceedings, related to educational research and practice. Each entry provides a unique perspective on different aspects of education, with a focus on creativity, project-based learning, and sustainable development.