Al-Ishlah: Jurnal Pendidikan
Vol.16, 1 (March, 2024), pp. 630-639
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v16i1.4364

Energizing Education: Fostering Interactive Engagement in Basic Electronics through STEM-Project Based Learning

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ARTICLE INFO

Keywords:

electronics;
learning environment;
project;
STEM

Article history:

Received 2023-06-30
Revised 2023-08-23
Accepted 2024-03-30

ABSTRACT

The learning setting refers to the combined social, psychological, and pedagogical circumstances which have the potential to impact students' learning, accomplishments, and attitudes. This research aims to analyze the STEM-Project Based Learning environment in the Basic Electronics course. The research method used is quantitative with a survey design. The research subjects are 65 students enrolled in the Basic Electronics course in the Physics Education program at the University of Jambi. Data collection is conducted through surveys. The survey instrument uses the WIHIC instrument. The research findings indicate that out of the 7 WIHIC indicators, namely student cohesiveness, teacher support, involvement, order and organization, task orientation, cooperation, and equity, data reveals that there are still issues in the implementation of STEM-Project Based Learning, particularly in the areas of teacher support and involvement. As an illustration, data indicates that 42.9% of students perceive that the teacher occasionally succeeds in engaging their attention during STEM-Project Based Learning. On the other hand, positive aspects are frequently observed in the equity indicator. This is evident in STEM-Project Based Learning, where 50% of the students feel they are given equal opportunities to answer questions during discussions.

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1. INTRODUCTION

At the university level, basic electronics forms a segment of physics studies. This course emphasizes a comprehensive understanding of concepts through a blend of quantitative and qualitative methodologies (Afriana et al., 2016; Al-Balushi & Al-Aamri, 2014). This focus stems from the necessity for students to possess the capability to comprehend and analyze circuits, a fundamental aspect of electronic learning (Breukelen et al., 2016; Nehru et al., 2020; Yuliati et al., 2018). In particular, the primary objective of the basic electronics course is to foster students' comprehension of electrical circuits, encompassing essential concepts such as potential difference, current, resistance, and their interrelations (Engelhardt &

Beichner, 2004). Furthermore, it endeavours to augment students' capacity to construct lamps, resistors, switches, and cables in diverse configurations, enabling them to collect data and formulate reasoned arguments regarding circuit properties (Kock et al., 2014). In the learning process of the electronics course, it requires activities not only in theory but also the need for direct practical work by students.

Drawing from literature studies, numerous challenges encountered by students in grasping basic electronics concepts have been pinpointed. For instance, a significant portion of students face difficulties in articulating and dissecting circuits (Nehru et al., 2020; Riantoni et al., 2017) and have difficulty connecting the concepts of current, potential difference, and resistance as a unified whole (Ding et al., 2006; Zacharia & de Jong, 2014). Some students still hold the misconception that current and resistance cause voltage (Breukelen et al., 2016). Furthermore, a prevalent issue among students involves misconceptions regarding the concept of electric current, often leading to the belief that the current diminishes as it traverses through a resistor (Campos et al., 2021). Various prior researchers have endeavored to tackle the challenges in comprehending the basic electronics course. Among these efforts are studies employing water analogies to elucidate the concepts of current, voltage, and resistance within a circuit (D. P. Smith & van Kampen, 2011; E. M. Smith & Holmes, 2020). Three-dimensional modeling is employed to offer a conceptual visualization of series and parallel circuits (Minich, 2005). Thermal imaging is utilized to distinguish between series and parallel circuits (Baird et al., 2012).

Of the various solutions proposed, many address specific skills. However, one overarching learning approach that has shown promise in enhancing students' comprehension of concepts is project-based learning (PBL) integrated with STEM (Science, Technology, Engineering, and Mathematics). The implementation of PBL in physics education has been found to improve cognitive learning outcomes (Gracia et al., 2022; Sormunen et al., 2020), foster environmentally friendly attitudes and behaviors (Kilinc et al., 2017; Tseng et al., 2013), develop scientific process skills (Korur et al., 2017) and facilitate effective learning (Siew & Ambo, 2018). Project-based learning (PBL) is particularly well-suited for interdisciplinary learning, as it inherently encompasses a diverse range of skills including reading, writing, mathematics, and integrates conceptual knowledge from various subject areas (Barak & Assal, 2018). Hence, it is anticipated that project-based learning (PBL) integrated with STEM will foster well-rounded abilities in students.

In alignment with the trends of the globalization era, contemporary education must integrate Science, Technology, Engineering, and Mathematics (STEM). The interconnection between mathematics, technology, and other fields is integral to science education. STEM represents a cohesive set of interconnected disciplines (Martin-Hansen, 2018; Tekerek & Karakaya, 2018). Indeed, science relies on mathematics as a fundamental tool for data analysis, whereas technology and engineering serve as practical applications of scientific principles (Korur et al., 2017). The STEM approach in education is anticipated to deliver meaningful learning experiences to students by systematically integrating knowledge, concepts, and skills across multiple disciplines (Tekerek & Karakaya, 2018).

Many studies on STEM-project based learning predominantly concentrate on evaluating its effectiveness in enhancing scientific literacy (Afriana et al., 2016), critical and creative thinking skills (Mutakinati et al., 2018), and problem-solving abilities (Hong et al., 2012). There is very little research that addresses the learning environment in STEM-PBL. However, a conducive learning environment is a crucial factor for students' success in a course.

Some research on project-based learning emphasizes connecting it with various learning abilities, such as critical thinking, conceptual understanding, and problem-solving. Therefore, the novelty of this research lies in the Assessment of the Learning Environment in STEM-Project Based Learning specifically tailored for the Basic Electronics Course. This approach offers benefits by enabling the observation of factors influencing success and challenges within project-based learning.

2. METHODS

The study employs a quantitative methods approach with a survey design. This aims to acquire detailed insights into the learning environment by implementing STEM-Project Based Learning in the

Basic Electronics Course. The subjects of this study are 63 undergraduate students majoring in Physics Education at Universitas Jambi. The data collection instruments used in this research are the STEM-Project-Based Learning Learning Environment survey instrument and an interview guide. The survey instrument utilizes the What is Happening in this Class? (WIHIC) Questionnaire (MacLeod & Fraser, 2010). The WIHIC Questionnaire is widely used in many countries to assess the learning environment. It has been validated and shown to be reliable. Furthermore, the WIHIC Questionnaire has been translated into multiple languages, including Indonesian, English, Turkish, and others.

Quantitative data analysis of the Learning Environment through the implementation of STEM-PBL in the Basic Electronics Course involves presenting descriptive statistics. Descriptive statistics are utilized to gather data on maximum and minimum values, means for each variable, median, and standard deviation of the learning environment data. The aim is to delve deeper into information regarding the STEM-Project Based Learning environment within basic electronics courses.

3. FINDINGS AND DISCUSSION

The learning environment analysis is undertaken to gather information regarding student challenges in the teaching and learning process of the Basic Electronics course using STEM-Project Based Learning, focusing on external factors such as the environment. Information concerning the learning environment is obtained by administering the "What is Happening in this Class?" (WIHIC) questionnaire developed by Fraser & Margianti (MacLeod & Fraser, 2010; Margianti, 2001). Based on the analysis conducted on 63 students following their experience with STEM-Project Based Learning in the Basic Electronics course, several issues requiring attention emerged to cultivate an enjoyable learning environment for both students and teachers, and to enhance understanding of the subject matter. Among the 7 WIHIC indicators—student cohesiveness, teacher support, involvement, order and organization, task orientation, cooperation, and equity—data revealed that the most prevalent issues were observed in the indicators of teacher support and involvement. Conversely, positive aspects were frequently noted in the equity indicator. The research results are discussed as follows.

3.1 Findings of the research

3.1.1 The factor of teacher support in the learning environment

The data presented in Figure 1 highlights several issues pertaining to teacher support in the Basic Electronics course. Specifically, 42.9% of students indicated that the teacher only occasionally captures their attention during STEM-Project Based Learning classes. Additionally, 20.6% of students mentioned receiving rare specific assistance from the teacher when encountering difficulties, while 28.6% stated they occasionally receive such assistance. Other notable issues include 30.2% of students reporting occasional direct interaction from the teacher and 28.6% stating that the teacher rarely pays attention to or shows interest in their problems during the learning process. These findings suggest that lecturers may not always be able to discern the challenges their students face, possibly due to insufficient communication or understanding of individual student needs.

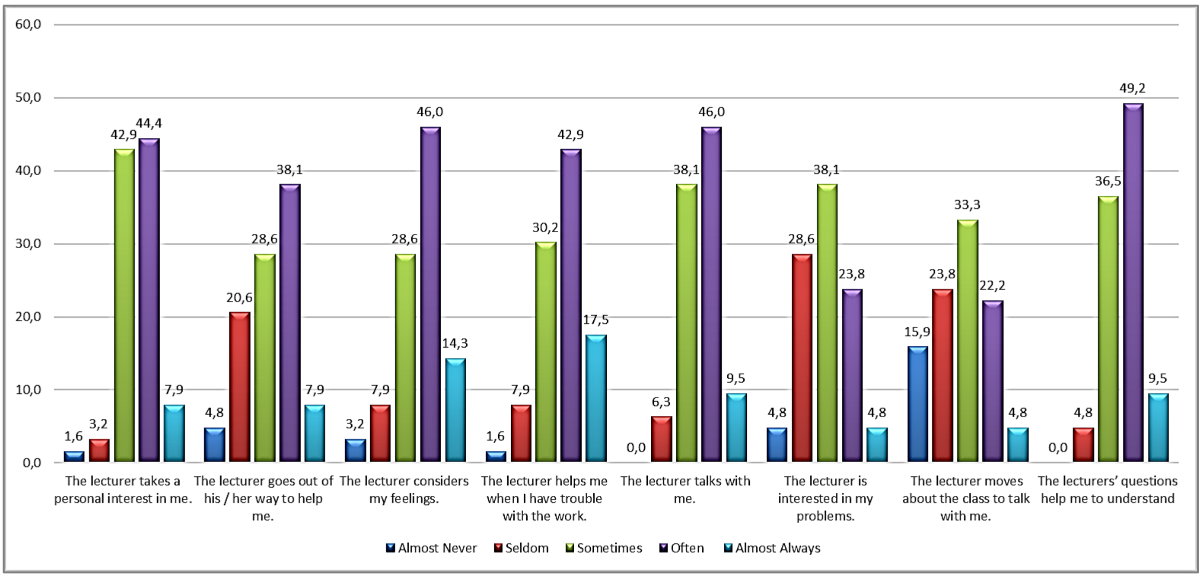

Figure 1. Data Teacher Support

3.1.2 The factor of involvement in the learning environment

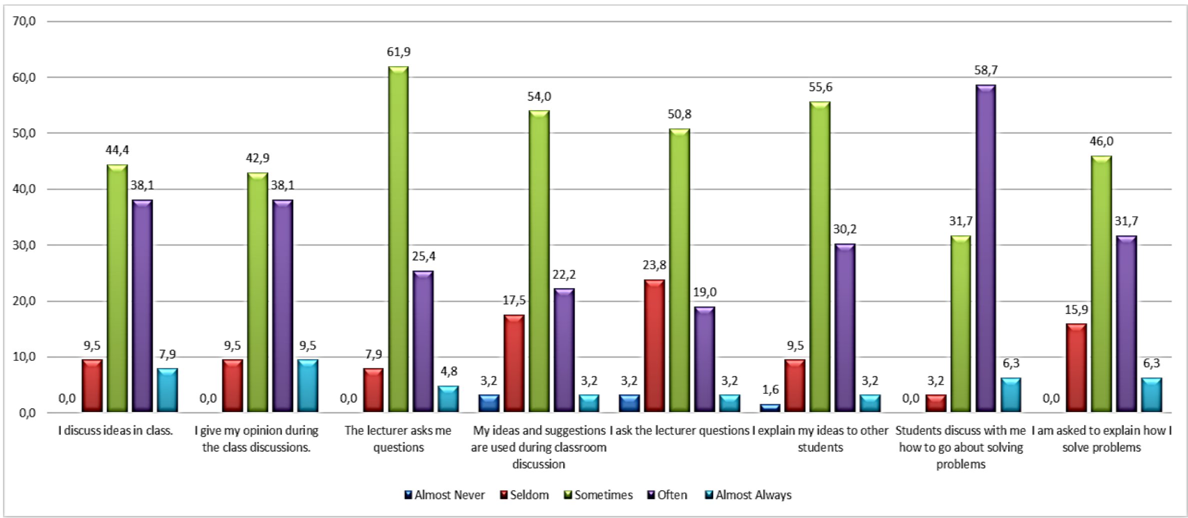

Figure 2. Data Involvement

Upon examining the involvement indicator in Figure 2, it becomes apparent that several issues necessitate attention concerning student engagement in the Basic Electronics course using STEM-Project Based Learning. The data reveals a tendency for students to indicate inconsistent involvement in learning activities, particularly in projects. This is illustrated by 44.4% of students reporting only occasional discussions of ideas or concepts in class, 42.9% mentioning only occasional participation in providing opinions during class discussions, 54% feel that their ideas and suggestions are only occasionally used during discussions, and even 17.5% indicating that their ideas are rarely utilized during discussions. Despite the prevalence of various involvement-related issues, this study also uncovered that 58.7% of students perceive a higher level of discussion in STEM-Project Based Learning, which significantly aids in their learning process.

3.1.3 The factor of equity in the learning environment

The positive aspect gained from the STEM-Project Based Learning process is in the Equity indicator (Figure 3). From the STEM-Project Based Learning process, 38% of the students stated that the teacher provides equal attention to every student during the learning process. 44% of the students mentioned that they often receive assistance from the teacher, and even 25.4% feel that they always receive the same level of assistance as their classmates in the class. In the project discussion process, 38.8% feel that they always have an equal opportunity to speak as other students, and 44.8% of the students feel that they always receive the same level of motivation from the teacher as other students. Interestingly, in STEM-Project Based Learning, 50% of the students feel that they are given equal opportunities to answer questions during discussions.

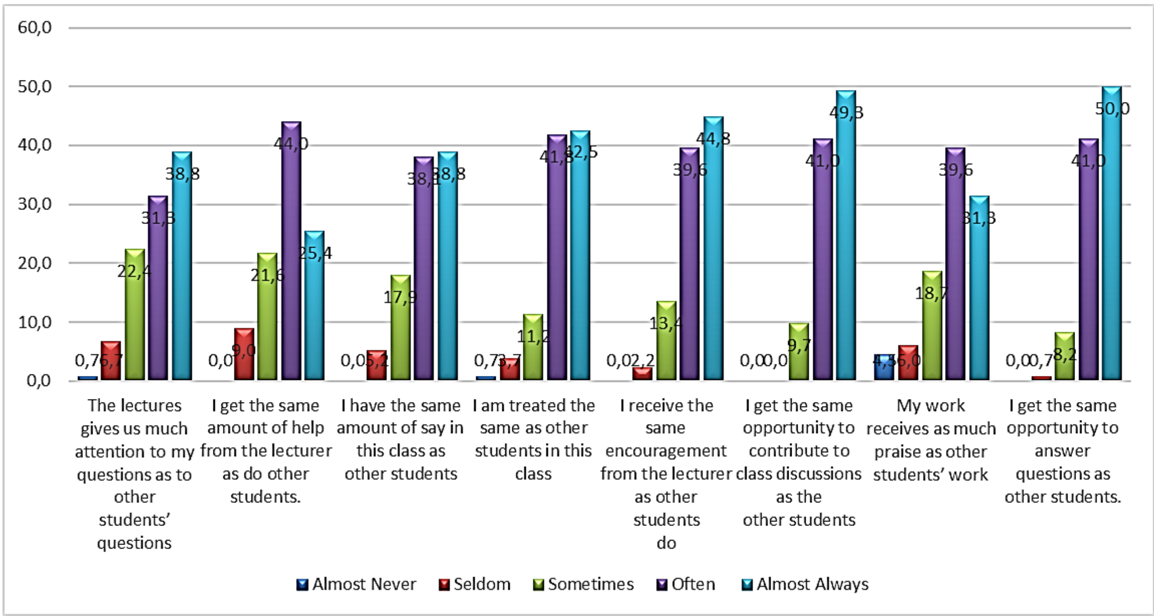

Figure 3. Data Equity

Equity factors in learning are elements that can influence the level of equal access, opportunities, and learning outcomes among all students, regardless of their backgrounds, nationality, gender, disabilities, or other factors. One of the causes or factors affecting equity in learning is the quality of teaching. The quality of the lecturer and teaching methods used can affect the level of equity in learning. Ineffective or inadequately trained professors may not be able to provide equal education.

3.2 Discussion

Project-Based Learning is an innovative approach to education that focuses on students engaging in real-life projects and solving practical problems (Anazifa & Djukri, 2017; Jaime et al., 2016). In this learning environment, students actively participate in the learning process by conducting research, collaborating with their peers, and creating tangible projects that showcase their knowledge and skills (Tiruneh et al., 2016). This type of learning environment promotes critical thinking, problem-solving, creativity, and collaboration skills- all essential for success in STEM fields (Tekbıyık et al., 2022). By working on projects that have real-world applications, students are able to see the relevance and utility of the concepts they are learning(Sormunen et al., 2020). This hands-on approach also fosters a sense of ownership and pride in their work, as they are personally invested in the outcome of their projects. In addition, Project-Based Learning provides students with the opportunity to develop important skills such as communication, teamwork, and time management (Bell, 2010). Furthermore, the project-based learning model encourages students to take ownership of their education and become active participants in their own learning process. Through project-based learning, students have the opportunity to explore their interests and passions, driving their own learning and fostering a love for STEM subjects (Tekbıyık et al., 2022). Furthermore, the project-based learning model encourages students to take ownership of their education and become active participants in their own learning process (Hall et al., 2012).

Looking at the learning environment, especially in the context of higher education, has a very important role in creating meaningful learning experiences for students (Tiruneh et al., 2016). The support provided by lecturers is key in ensuring the quality of learning (Al-Balushi & Al-Aamri, 2014). Lecturers who can capture students' attention, provide special assistance when needed, and communicate effectively are able to create a positive learning atmosphere and motivate students to learn better (Al-Balushi & Al-Aamri, 2014). In addition, student involvement in the learning process also plays a significant role. Students who are actively involved in discussions, giving opinions, and engaging in learning projects tend to have a better understanding of the material learned (Goodhew et al., 2019). This involvement also enables the formation of a solid learning community among fellow students, who can support and motivate each other. Finally, the importance of equity in the learning environment ensures that every student has an equal opportunity to participate and develop. Equality in providing opportunities to answer questions, contribute to discussions, and get help from lecturers ensures that no student is marginalized in the learning process (Pedersen et al., 2016).

This research shows how lecturers' support, involvement and equality are obtained by students in learning. The data on lecturer support shed light on some concerning aspects of teacher support in the Basic Electronics course. In particular, most students expressed dissatisfaction with the level of attention and assistance provided by teachers during STEM Project Based Learning classes. In addition, the data showed a lack of interaction and direct attention from teachers to students' problems during the learning process. These findings underscore the importance of effective communication and understanding of individual student needs by lecturers to adequately address challenges and foster a supportive learning environment. However, it is essential to consider potential mitigating factors that could influence these perceptions, such as class size, teaching methodologies, or individual student preferences. Additionally, while some students may indeed feel neglected, others might perceive the level of teacher support differently, emphasizing the subjective nature of such assessments(Bennett et al., 2020). Therefore, while the data underscores the need for improvements in teacher support, further exploration is warranted to gain a comprehensive understanding of the dynamics at play and to implement targeted interventions effectively.

Several factors may cause issues related to teacher support. Previous studies have stated that there are several reasons for the emergence of problems related to teacher support in learning. For example, poor communication between students and teachers can lead to issues (Pedersen et al., 2016). Students may feel uncomfortable or afraid to ask questions or seek help from their teachers (Brookes et al., 2021). Additionally, each student has different learning styles. Some students may struggle to understand the material if the teacher uses teaching methods that are not suitable for their needs (Tiruneh et al., 2016).

The data highlighted an inconsistent pattern of engagement among the students, especially evident in their participation in project-based activities. Most students reported only occasionally engaging in discussions of ideas or concepts and rarely contributing to class discussions and utilising their ideas during these exchanges. These findings indicate a potential gap in student participation and contribution to the learning process, which could impact the effectiveness of STEM Project Based Learning initiatives. However, amidst these challenges, it is encouraging to note that the majority of students perceived a higher level of discussion in STEM Project Based Learning, indicating a positive impact on their learning experience.

Several previous research studies support the findings related to involvement in learning. Students often face various issues related to their involvement in the learning process (Brookes et al., 2021; Kyza & Georgiou, 2019). This can occur because students may feel insignificant or lack motivation (Wang, 2013). These problems arise when they do not see the relevance or meaning of the taught materials. Additionally, some students may experience a lack of opportunities to interact with teachers and fellow students in the learning environment (Al-Balushi & Al-Aamri, 2014). This can reduce their sense of involvement and increase feelings of isolation during the learning process

Besides, there are several aspects that can lead to potential gaps in students' participation and contribution to the learning process, potentially impacting the effectiveness of STEM Project Based Learning initiatives. First, differences in students' level of skill or understanding in the material taught may affect their level of participation in learning activities (Bennett et al., 2020). Students who feel less confident in certain materials may tend to withdraw from class interactions. Secondly, unbalanced group dynamics or the dominance of some students in the discussion may hinder the participation of other students (Gümüş & Okur, 2010). An imbalance in group participation may cause some students to feel ignored or unheard in the learning process. In addition, classroom environmental factors, such as large class size or lack of facilitation from the teacher, can also be an obstacle in encouraging active participation from all students (Thao-do et al., 2016). Therefore, to improve the effectiveness of STEM Project Based Learning, it is important to pay attention to these aspects and create an inclusive and supportive learning environment for all students.

For the equality indicators, the data showed a perceived level of equality among the students participating in the learning process. Most importantly, the finding that half of the students felt that they were given equal opportunity to answer questions during the discussion underscores the commitment to equity and equal participation in STEM Project Based Learning initiatives. These findings highlight the effectiveness of this approach in promoting equity and ensuring that all students feel valued and supported in their learning journey.

Rewards to students play a very important role in motivating and improving their academic performance (Chang & Lee, 2010). By rewarding students, they feel valued and cared for by the learning environment, which can boost their confidence and motivation to learn (Shadinger & Toomey, 2014). In addition, rewards can also be an effective incentive to encourage students to achieve higher and actively participate in learning activities. Thus, rewarding students not only enhances the positive atmosphere in the classroom, but also helps to create a supportive learning environment and spur overall student achievement(Kyza & Georgiou, 2019).

4. CONCLUSION

Based on the research findings, it can be concluded that among the 7 WIHIC indicators—student cohesiveness, teacher support, involvement, order and organization, task orientation, cooperation, and equity—the most prevalent issues occur in the indicators of teacher support and involvement. For instance, data indicates that 42.9% of students only occasionally feel that the teacher captures their attention in STEM-Project Based Learning. Conversely, positive aspects are frequently observed in the equity indicator. This is evident in STEM-Project Based Learning, where 50% of students feel they are given equal opportunities to answer questions during discussions. The research exclusively focuses on the learning environment, with no data indicating the success factors for implementing STEM-Project Based Learning. For future research endeavors, it is imperative to conduct a review of the implementation of STEM-Project Based Learning. This review aims to investigate whether the issues related to the learning environment are attributable to inadequately executed implementation of the planned learning design.

Acknowledgements: We would like to express our sincere appreciation to the Research and Community Service Institute of Jambi University for the financial support they provided for this research. Without their help, this research would not have been realized. In addition, we would also like to thank the Physics Education Study Program, Faculty of Teacher Training and Education, Jambi University for the facilitation they provided in all the processes of this research. The assistance and support from these institutions and study programs have contributed significantly to the smoothness and success of our research.

Conflicts of Interest: The authors declare no conflict of interest

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