JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Need For Biotechnology PjBL-STEM Based Learning Programs Associated with Local Contexts to Enhance Creative Problem Solving and Entrepreneurial Skills: Teacher and Student Perspectives

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Received: May 29, 2024
Revised: September 08, 2024
Accepted: November 25, 2024
Published: November 30, 2024

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DOI: 10.29303/jppipa.v10i11.9092

Abstract: This study evaluates the need for biotechnology PjBL-STEM Based Learning programs associated with local contexts to enhance Creative Problem Solving Skills (CPSS) and Entrepreneurial Skills (ES) from the perspectives of students and teachers. Using a mixed-methods approach with a sequential explanatory design, data were collected through questionnaires from 144 science teachers in Lampung Province and in-depth interviews with three teachers and three students. The findings reveal that 66.70% of teachers consider the current learning programs inadequate for developing students' CPSS and ES, while 68.10% believe that a PjBL-STEM program would facilitate a more engaging understanding of biotechnology. Furthermore, 89.60% of teachers agree on the necessity of developing biotechnology PjBL-STEM based learning programs to enhance students' CPSS and ES. The results from the questionnaires and in-depth interviews also revealed that both teachers and students agreed that the use of local context can make learning more relevant for students. Overall, both quantitative and qualitative data indicate a strong support for the implementation of biotechnology PjBL-STEM based learning programs grounded in local contexts to better develop students' CPSS and ES.

Keywords: Biotechnology; CPSS; ES; Local context; PjBL-STEM

Introduction

The learning process in schools must support the achievement of competencies that are the goals of the education system (Lestari et al., 2024). One of the goals of education in the 21st century is to develop students' ability to think creatively in solving problems (Santoso & Wulandari, 2020). Creativity is considered an integral part of twentyfrst century skills (Altan & Tan, 2020). The combination of creative thinking and problem solving is known as Creative Problem Solving Skills (CPSS), which is part of the life skills that are indispensable today (Khamcharoen et al., 2022; Mukhlis & Oktalina, 2018). However, Mukhlis & Oktalina (2018) revealed that the high expectations for students' CPSS are not yet reflected in their academic achievements in Indonesian schools, this finding is supported by empirical data obtained from CPSS test results in their research. This indicates a gap between educational goals and actual learning practices.

Just as importantas CPSS, another crucial skill in the 21st century era is Entrepreneurial Skills (ES) (Jardim, 2021; Pathan et al., 2024). ES is a muchneeded ability to support a country's advancement, as entrepreneurship plays a central role in development (Akmal et al., 2020; Jardim, 2021). However, students' ES in Indonesia remain low, this may be due to the lack of learning experiences that foster entrepreneurship in school (Susantiningrum et al., 2023). Although the Merdeka Curriculum right now highlights

How to Cite:
Utari, D., Abdurrahman, Lengkana, D., & Hasnunidah, N. (2024). The Need For Biotechnology PjBL-STEM Based Learning Programs Associated with Local Contexts to Enhance Creative Problem Solving and Entrepreneurial Skills: Teacher and Student Perspectives. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9078–9086. https://doi.org/10.29303/jppipa.v10i11.9092

entrepreneurship as a key theme in the Strengthening Pancasila Student Profiles Project (Satria et al., 2022), its implementation has not been fully optimized, leading to a gap between educational policy and real-world practices.

Local contexts plays an important role in the development of students' CPSS and ES. However, it isnot yet integrated into learning due to a lack of understanding among teachers about how to incorporate local contexts into their teachingstrategies (Hairida & Junanto, 2018). One way to incorporate local contexts in learning is to identify the realities of the surrounding environment and the environmental issues that arise, then integrate these into the learning process (Suryawati et al., 2020). For example, Lampung Province is one of the largest rubber producing areas in Indonesia (Hidayati et al., 2020), but has local potential such as rubber seed that has not been fully optimized (Purnomo et al., 2023). Rubber seeds, which are often considered as waste in Lampung, actually have high nutritional value and can be processed into valuable food (Sitompul et al., 2023). However, this potential has not been widely explored in the context of education, indicating an opportunity for further research.

To ensure the learning process is relevant to real-world situations, teachers should implement a Science, Technology, Engineering, and Mathematics (STEM) approach that incorporates local contexts into their lessons (Busyairi et al., 2022). While STEMbased learning provides a strong foundation for using local contexts, there are still challenges in effectively integrating it with environmental issues (Kamal, 2021), such as the processing of rubber seed wasted. To address the challenges of integrating the STEM learning approach with local contexts, Kamal (2021) in his research proposed concrete steps such as developing environmentalbased learning projects and conduct training for teachers.

The STEM approach integrated with the Project-based Learning (PjBL) model can improve students' CPSS and ES. Research by Fiteriani et al. (2021) showed that making simple binoculars with a PjBL-STEM approach can improve students' CPSS, while research by Sudarmin et al. (2023) revealed that the PjBL approach integrated with Ethno-STEM can foster students' entrepreneurial character. Nevertheless, further research is needed to focus on how PjBL-STEM can be implemented in local contexts such as rubber seed wasted to improve students' CPSS and ES.

As a practical step in implementing PjBL-STEM-based learning, biotechnology can serve as a relevant topic particularly in the production of fermented foods (Ma'wa et al., 2022). This activity not only enhances students' creativity in processing raw materials into biotechnology products, but also contributes to the development of ES considering that these products have increased economic value (Siswati et al., 2024). Therefore, PjBL-STEM-based biotechnology learning associated with a local context such as rubber seed waste processing has the potential to be used to enhancing students' CPSS and ES.

Teachers play a crucial role in enhancing students' CPSS and ES. Therefore, it is important to examine how effectively teachers have integrated these skills into their learning process. This leads to the question of the necessity to develop more effective learning programs aimed at enhancing students' CPSS and ES. Based on these thoughts, this study aims to explore the need for a PjBL-STEM-based biotechnology learning program associated with local contexts, such as rubber seed wasted processing to improve students' CPSS and ES by reviewing the perspectives of teachers and studentsspecifically in Lampung.

The novelty of this research lies in using rubber seeds as teaching material in biotechnology to enhance CPSS and ES, an area that has received limited attention in prior research. While previous research have mainly concentrated on the development of CPSS and ES, this research specifically examines the local potential in Lampung, such as the processing of rubber seed waste for educational purposes. This research is important because tapping into local environmental problem can help students connect with their surroundings and make their learning more relevant (Suryawati et al., 2020), but this local potential has not yet been fully optimize.

Method

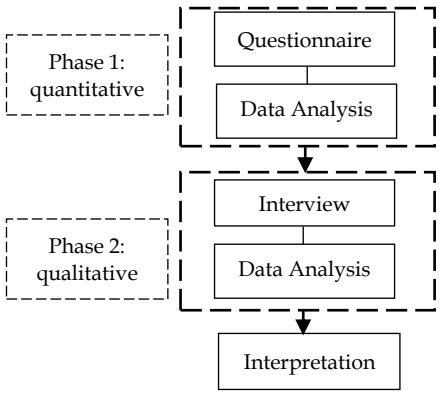

Figure 1. Schematic of research design

This study used a mixed-method (Creswell & Clark, 2018) with a sequential explanatory design that included two phases of data collection. In the first phase, quantitative data were gathered through a questionnaire distributed to science teachers across Lampung Province, with at least five respondents from

each district or city to ensure representation. The questionnaire was shared via Google Forms. The responses were categorized, scored based on established criteria, and analyzed using the following formula 1.

$$\%J_{in} = \frac{\sum J_i}{N} \times 100\ \% \quad (1)$$

Information:
$\%\ J_{in}$ = Percentage of answer choices - i
$\sum J_i$ = Number of respondents who answered choice - i
N = Total number of respondents

In the second phase, qualitative data were collected through interviews to gain deeper insights into the perspectives of both teachers and students. Three science teachers and three student representatives from the same schools were selected for this purpose. The research design scheme of this study presented in Figure 1.

Resultand Discussion

A total of 144 science teachers in Lampung Province completed the questionnaire. The distribution of respondents was as follows: 6 teachers from Bandar Lampung, 7 from Metro, 6 from Lampung Barat, 43 from Tanggamus, 8 from Lampung Selatan, 9 from Lampung Timur, 5 from Lampung Tengah, 6 from Lampung Utara, 5 from Waykanan, 11 from Tulang Bawang, 7 from Tulang Bawang Barat, 7 from Pesawaran, 9 from Pringsewu, 7 from Mesuji, and 8 from Pesisir Barat. The results of the questionnaire are presented in Table 1.

Table 1. Result of interpretation of teacher's perception questionaire

Question	Percentage (%)	
	Yes	No
Do you know about STEM?	88.90	11.10
Have you ever applied STEM in teaching Biotechnology content?	45.10	59.90
Do you feel it is necessary to integrate the STEM approach in science learning?	83.30	16.70
Are you confident in your ability to teach STEM-based learning?	61.80	38.20
Do you know the syntax of the PjBL model?	97.90	2.10
Have you ever applied PjBL model in teaching Biotechnology content?	63.20	36.80
Do you think that PjBL helps students better understand the material being taught?	84.70	15.30
Do you think that using local contexts can enhancing students' understanding?	89.60	10.40
Have you ever used local context as part of the teaching material?	89.60	10.40
Are you aware of the potential of rubber seeds to be used in teaching biotechnology?	34.00	66.00
Do you think that the CPSS of your students meet your expectations?	22.90	77.10
Have you ever evaluated your students' CPSS during science instruction?	37.50	62.50
Do you feel that students' CPSS can be enhanced through the PjBL-STEM based learning?	34.00	66.00
Have you ever evaluated your students' ES during science instruction?	39.60	60.40
Do you think that the ES of your students meet your expectations?	23.60	76.40
Do you feel that students' ES can be enhanced through the PjBL-STEM based learning?	89.60	10.40
Have you ever encouraged students to gather significant information related to a specific topic or problem?	88.20	11.80
Have you ever encouraged students to express their thoughts or opinions?	91.70	8.30
Have you ever asked students to create solutions to a given problem?	88.20	11.80
Have you ever asked students to evaluate the solution they created for a problem?	87.50	12.50
Have you ever given students the opportunity to create new product ideas or innovations that add economic value to those products?	80.60	19.40
Have you ever given students the opportunity to test new ideas even though there is a possibility that those ideas may not succeed?	87.50	12.50
Have you ever prompted students to consider whether an idea or innovation could have future sustainability benefits?	64.60	35.40
Do you think that the current learning program you are using is not adequate enough to develop students' CPSS & ES?	66.70	33.30
Do you believe that a PjBL-STEM based learning program can help students better understand biotechnology material in a more engaging and applicable way?	68.10	31.90
Do you think it is necessary to develop a PjBL-STEM based biotechnology learning program to improve students' CPSS & ES?	89.60	10.40

Qualitative data were obtained from interviews aimed at gaining a deeper understanding of the perceptions of both teachers and students regarding the need for biotechnology PjBL-STEM based learning program associated with lokal contexts to enhance CPSS and ES. Three science teachers were selected for interviews based on their questionnaire responses, focusing on those who provided the most relevant feedback. This method allowed for a more detailed understanding of their experiences and views on integrating local contexts into education. The results of these interviews are presented in Table 2.

Tabel 2. Teacher's interview results

Question	Teacher' Responses (TR)		
	TR 1	TR 2	TR 3
How important do you think it is to develop biotechnology PjBL-STEM based learning program by raising local issues in schools?	It is essential to make learning more relevant to real life.	It is important because it can help students think more critically and creatively.	Important, but needs support from the school
Why do you think PjBL-STEM has not been widely applied in teaching biotechnology?	Lack of training	Limited time to develop Project	There is no full support from the school yet
What is needed to help students get better at creative thinking and problem solving in biotechnology lessons?	Further training	Projects that are challenging and relevant to real life	Support from the school
Do you see the potential for using local materials, such as rubber seeds, in biotechnology learning?	Great potential to make learning more relevant to real life	Yes, it will make learning is more interesting and relevant	High potential, especially for linking theory with practice
In your opinion, what is the biggest challenge that might be faced if a PjBL-STEM program is developed in your school?	Teachers need further training to effectively understand and apply the PjBL-STEM approach	Takes longer than traditional methods, making it challenging to fit within the curriculum schedule	Teacher and student readiness

Interviews were also conducted with three student representatives from the same schools as the selected teachers. Involving students in this process was essential for gathering their perspectives. The results of these interviews are presented in Table 3.

Tabel 3. Student's interview results

Question	Students' Responses (SR)		
	SR 1	SR 2	SR 3
What is your opinion on science lessons in your school so far?	The lessons are decent, but sometimes a bit boring	Interesting, but if there is practice, it will be more exciting	The lessons are fun, but I don't like memorization
What do you think about using local materials, such as agricultural or plantation waste, in your learning?	It's a great idea because we can utilize materials that are around us	It's a great idea because you can utilize materials that are usually wasted and make them useful	Interesting because it can prevent pollution and learn how to utilize materials around us
How do you feel about learning science through projects or experiments?	I feel that PjBL is more enjoyable as it allows us to gain practical experience. Furthermore, it enables us to think more freely and explore different solutions	Learning through projects is more interesting and helps us understand the material better	I prefer it because it's more fun than just reading and memorizing
Do you think learning science through projects to solve local problems can help you become more creative?	Yes, learning through projects can help us think more freely and explore different solutions	Yes, learning this way can help me find new ideas	Yes, because we have to think for ourselves and find a way to solve the problem
What challenges might you encounter when learning biotechnology through a project?	It can be difficult if the concepts are too complex and there isn't enough explanation from the teacher	Iam worried about doing project if I'm not guided by the teacher.	It will be difficult to work in groups if not supervised by the teacher

The questionnaire results show that most teachers (88.90%) have knowledge of STEM, but only 45.10% have applied it in learning biotechnology materials. This reflects a gap between knowledge and practice that requires special attention. In fact, STEM integration in education is very important for improving teaching strategies to meet current (Mater et al., 2022; Setiawati et al., 2024). This approach enables students to think creatively so meet 21st century standards (Asrizal et al., 2023; Nazifah & Asrizal, 2022; Velychko et al., 2022). STEM also positively affected the students' conceptual understanding (Addido et al., 2023; Loof et al., 2022; Ozkan & Topsakal, 2021). STEMbased intruction can develop student's creative thinking skills (Dewanto et al., 2024; Ilafi et al., 2024; Iskandar et al., 2020; Nurhaisa et al., 2023) and student's problemsolving skills (Dewi et al., 2023; Johan & Rohaeti, 2024; Rosiningtias et al., 2023) which are relevant to CPSS. However, teachers' confidence in applying STEM is still low, with only 61.80% of teachers feeling confident in teaching STEM-based materials to students. This indicates the need for more intensive training to improve teacher competence in implementing STEM into science learning (Ardiansyah et al., 2020; Velychko et al., 2022).

As for the application of Project-Based Learning (PjBL), 97.90% of respondents understood the syntax of the PjBL model, but only 63.20% had applied it in learning biotechnology material. Many teachers still have not adopted PjBL for science topics that involve extensive hands-on activities, such as Biotechnology. This is unfortunate, as PjBL model is recognized for its effectiveness in increasing students' understanding. Sujud et al. (2024) stated that the implementation of PjBL in science learning allows students to learn deeply through the exploration of real problems. Reszearch by Rahmazatullaili et al. (2017) and Subari & Mercuriani (2024) also showed that the implementation of PjBL can improve problem solving and creative thinking skills, which are very relevant in the development of CPSS.

Furthermore, the questionnaire also revealed that 89.60% of teachers agreed that the use of local contexts can enhancing students' understanding. This is significant because there is a positive correlation between scientific creativity and scientific knowledge, suggesting that a solid understanding of scientific concepts can foster greater creativity (Zainuddin et al., 2020). Additionally, 57.60% of teachers believe that integrating local contexts in learning process can enhance students'creativity. In line with the results of the questionnaire, the research findings of Kaliongga et al. (2023) proved that learning that is associated with local contexts can shape students into individuals who are able to think critically, creatively, innovatively, and integratively in dealing with various problems. However, only 34.00% of teachers are aware of the potential of rubber seeds as a biotechnology learning material, which indicates the need for further exploration of how local potential such as rubber seed wasted can be utilized in education. This potential can be optimized through integration science material in the curriculum that is relevant to local contexts, as suggested by the research of Annisha (2024).

When it comes to Entrepreneurial Skills (ES), only 23.60% of teachers felt that students met expectations, while only 39.60% of teachers had evaluated ES during science instruction. However, Sudarmin et al. (2023) point out that ES are essential for driving economic growth. The literature review indicates that a holistic approach to enhancing students' creativity and ES has been a significant concern in educational research to prepare students for future challenges (Mulyany et al., 2023). By incorporating entrepreneurship into the educational curriculum, students can build these important skills (Kurata et al., 2023; Mulyany et al., 2023; Sudarmin et al., 2023). This is why both formal and informal education should focus on helping students develop them (Kurata et al., 2023). The majority of teachers who filled out the questionnaire (89.60%) believe that the PjBL-STEM approach can be an effective solution to improve ES. This aligns with the findings of Akmal et al. (2020) which showed that PjBL-STEM is able to develop ES through projects based on real problems. Subari & Mercuriani (2024) also found that the ethno-STEM integrated bio-entrepreneurship PjBL is effective in enhancing creative thinking abilities and entrepreneurial interest.

Based on the questionnaire answers, it is known that teachers' efforts to improve CPSS and ES have also been made although these efforts have not yet yielded the desired results.There are 88.20% of teachers have asked students to collect important information and 80.60% teachers have provided opportunities for students to generate new product ideas. This aligns with the principles of PjBL-STEM, which emphasize hands-on experience and learning through action (Subari & Mercuriani, 2024). However, 66.70% of teachers feel that current learning programs are inadequate to develop CPSS and ES. This is indicating an urgent need for more relevant and applicable learning programs, such as PjBL-STEM-based learning programs associated with local contexts which can offer learning experiences that promote higher-order thinking skills and meet 21st-century demands (Fitriyani et al., 2020). The implementation of PjBL-STEM can train students in problem-solving which is relevan with CPSS (Chistyakov et al., 2023).

The findings from the questionnaire results confirm that it's important to strengthen the use of PjBL-STEM based learning programs while using local contexts in learning, especially in biotechnology

material. By enhancing CPSS and ES with a more relevant approach, education in Indonesia can help students better prepare for future challenges as well as make a positive contribution to economic and social growth (Kurata et al., 2023; Mulyany et al., 2023; Sudarmin et al., 2023).

In line with the questionnaire results, interviews with teachers and students showed a high interest in the PjBL-STEM based learning programs associated with local contexts. One of the teachers emphasized, "It is essential to make learning more relevant to real life" when asked about developing biotechnology PjBL-STEM based learning programs with local issues. This suggests that a learning-based approach that connects theory with real practice would be more effective (Zhao et al., 2020). Another teacher also stated, "It is important because it can help students think more critically and creatively", reinforcing the view that this biotechnology learning program will encourage students' creativity.

Students showed enthusiasm for learning through projects. One student mentioned, "Learning through projects is more interesting and helps us understand the material better".This shows that students feel more motivated and engaged when they can directly apply concepts in real life (Almulla, 2020; Sujud et al., 2024). In addition, a student also emphasized that PjBL helps them think more creatively, saying, "I feel that PjBL is more enjoyable as it allows us to gain practical experience. Furthermore, it enables us to think more freely and explore different solutions". This align wtih the finding of Rahmazatullaili et al. (2017) and Subari & Mercuriani (2024) which showed that applying PjBL can enhance problem-solving and creative thinking abilities.

Based on the interview answers, it is known too that both teachers and students recognize the challenges. The teacher revealed, "Lack of training" as one of the main obstacles, in addition to limited time to develop projects. Full support from the school is also needed, as one teacher emphasized, "There is no full support from the school yet". Despite these challenges, the teachers still see great potential in using local contexts such as rubber seeds to make learning more relevant and contextualized.

While teachers highlighted the lack of training and full support from the school as the main barriers to implementing PjBL-STEM, some students were concerned if the concepts were too complicated or if they did not get enough guidance from the teacher. This suggests that while interest in this approach is high, more effort is needed to ensure adequate readiness and support for teachers and students. However, to ensure successful implementation of PjBL-STEM, this study also emphasizes the importance of teacher training and school support, as also mentioned by the teachers in the interviews. This support is crucial so that teachers can design challenging yet appropriate projects for students and provide the necessary guidance during the learning process.

Conclusion

The analysis of the questionnaire and interview results confirms the significant need for a biotechnology PjBL-STEM learning program associatedwith local contextssuch as rubber seed waste processing. This program is crucial for improving students' CPSS and ES. Both teachers and students agree that integrating local issues into the learning process enhances its relevance and effectiveness in developing these skills.

Acknowledgments
Praise be to Allah SWT for all his grace and presence. Thank you to the supervisors and examiners, for their guidance and input in this research. Furthermore, thanks to my parents, my younger brothers, my younger sister, and my close friends who always support and encourage me and strengthen me in conducting this research.

Author Contributions
D.U.: conceptualized and selected the methodology, prepared to write the original draft, carried out analysis according to the methodology, conducted research, and wrote down the results and discussed the research results. A., D.L., and N. H.: as supervisors and research data validators.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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