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Exploring the Implementation of Project-Based learning among Agricultural Science Teachers at Technical Schools in Northern Malaysia

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Abstract

Project-Based Learning (PBL) is a pedagogical approach that emphasizes active student engagement through problem-solving activities and the creation of tangible products. This study aims to explore the characteristics and the process of implementation of project-based learning experiences of Agricultural Science teachers in Technical Schools in Northern Malaysia in implementing PBL in their teaching practices. Specifically, the study was guided by two research questions: (i) What are the characteristics of PBL in the Agricultural Science program? and (ii) What is the impact of implementing PBL in the Agricultural Science subject? Employing a qualitative approach, the study adopted a phenomenological design and involved two teachers as informants, selected upon reaching data saturation. Data were collected through semi-structured interviews and analyzed using the constant comparative method. The findings reveal several key characteristics of PBL within the context of Agricultural Science, including: (i) Curriculum-aligned learning content; (ii) Teacher as facilitator; and (iii) PBL as a distinct approach from traditional learning. The implementation of PBL was identified to occur in three main phases: (i) Pre-implementation: Initial preparation and project planning; (ii) During implementation: Briefings and work scheduling; and (iii) Post-implementation: Rubric-based assessment. This study contributes valuable insights for educators and future teachers in understanding the effective implementation of PBL. It also offers guidance to the Ministry of Education in strengthening technical and vocational education policies by promoting more constructive and student-centered teaching strategies.

Keywords: Project-Based Learning (PBL), Teacher Experiences, Agricultural Science, Technical and Vocational Education, Student-Centered Teaching, Qualitative

1. Introduction

The agricultural sector is one of the key contributors to Malaysia's economic development. It encompasses various domains such as crop cultivation, livestock farming, and agro-based industries, while also offering vast employment opportunities for the community. According to Malaysia's National Agricultural Policy 2010, the agricultural sector is targeted to contribute sustainably to national economic growth while enhancing Malaysia's competitiveness at the global level (Dardak, 2019). To achieve this goal, agricultural education and training institutions including academic secondary schools, technical secondary schools, and vocational colleges are expected to play a crucial role in producing a professional, skilled, and semi-skilled workforce.

However, the Ministry of Education Malaysia (2013) reported that the number of students enrolled in the Science and Technical streams, including Agricultural Science, remains significantly lower than those in the Arts stream. This is partly due to the negative perception that agriculture is only suitable for students from rural areas and does not offer a promising future (Esa et al., 2009; Mallory & Sommer, 1986). Consequently, teachers play a vital role in transforming this perception through pedagogical approaches that are relevant, effective, and aligned with the learning styles of today's students (Tinto, 2010).

Project-Based Learning, particularly in Agricultural Science, has been introduced as an elective subject at the upper secondary level under the Pure Science and Technology cluster (MOE, 2016). It is also embedded within the Agricultural Technology subtopic of the Design and Technology subject at the lower secondary level. In Technical Secondary Schools, Agricultural Science is offered as a technical subject within the Vocational and Technical Elective group under the Integrated Secondary School Curriculum. Besides exposing students to agriculture-related career pathways, the subject also emphasizes scientific skills, critical thinking, and hands-on practice.

Although national policies such as the National Science Policy aim for a 60:40 ratio of students between the Science and Arts streams, achieving this target has proven difficult (Ministry of Education Malaysia, 2013; Mat Noor, 2022). Among the contributing factors are the lack of exposure to agricultural fields and the use of uninspiring teaching methods (Esa et al., 2009). Therefore, teachers play a key role in selecting effective and contextualized teaching strategies. They must be able to design systematic learning activities that are suited to students' abilities and backgrounds (Eggen & Kauchak, 2012).

One approach deemed effective in increasing student engagement is Project-Based Learning (PBL). PBL is an experiential learning method that emphasizes the production of a final product or problem-solving in the form of student-led projects, often carried out collaboratively. In this approach, teachers act as facilitators who guide the learning process. PBL is rooted in constructivist theory, as proposed by Piaget (1953), Vygotsky (1962), and Dewey (1986) which highlights active, reflective, and meaningful learning.

According to Eggen and Kauchak (2012), PBL is a student-centered learning approach that promotes knowledge construction through exploration, collaboration, and critical thinking. Previous studies emphasizes that this approach helps students develop essential social skills needed in the workforce, such as communication, leadership, and teamwork. The Malaysia Education Blueprint 2013-2025 also underscores the need to transform technical education into student-centered learning through methods like PBL (Ministry of Education Malaysia, 2013). Although PBL has been implemented in Malaysia since 2006, several studies suggest that teachers still face challenges in terms of knowledge, skills, and confidence to implement it effectively (See et al., 2015; Yang et al., 2021).

Previous studies on PBL have largely focused on subjects such as Geography (Min & Mapa, 2021) and Mandarin (Yin & Huat, 2021), but there is a noticeable gap in research concerning the implementation of PBL in Agricultural Science. Therefore, this study was conducted to explore in depth the experiences of Agricultural Science teachers in implementing PBL in Technical Schools, particularly in terms of implementation characteristics, strategies, impacts on students, and the challenges faced by teachers.

2. Theoretical Framework

This study is grounded in the principles of constructivist learning, which emphasizes the active construction of knowledge by learners based on their prior experiences, social interactions, and self-directed exploration. According to Piaget (2003), learning occurs when students actively build new understanding upon their existing cognitive structures. This approach encourages students to be directly involved in classroom activities, with the teacher serving as a facilitator or guide in the learning process. Tobin (1993) highlighted that meaningful learning arises through both social and personal knowledge construction, facilitated by group interaction and problem-solving tasks. Through such an approach, students gradually develop their understanding and skills, supported by a conducive learning environment and appropriate pedagogical strategies (Nam, 2014; Renkl et al., 2002).

To reinforce this theoretical foundation, the study also applies Needham’s Five-Phase Constructivist Model (1987), developed through the Children’s Learning in Science Project at the University of Leeds. This model comprises five key phases: 1) Orientation – Teachers stimulate students’ interest using induction activities such as videos or discussions; 2) Idea generation – Students discuss their initial ideas in small groups; 3) Idea restructuring – Students evaluate and refine their ideas through tasks or exploration; 4) Application of ideas –

Students apply their newly acquired knowledge in novel contexts; and 5) Reflection – Students compare their prior and new knowledge to consolidate their understanding. This model offers a systematic and student-friendly approach that promotes active engagement and facilitates meaningful learning.

Additionally, this study draws upon Vygotsky's sociocultural theory of learning (1978), particularly the concepts of the Zone of Proximal Development (ZPD) and scaffolding. ZPD refers to the gap between what a student can accomplish independently and what they can achieve with guidance from a teacher or a more capable peer (Belland, 2017; Eggen & Kauchak, 2012). Scaffolding involves the temporary support provided by the teacher, which is gradually reduced as the student becomes more competent and independent. This concept is critical in explaining how teachers can support students in integrating new experiences with prior knowledge to reach a higher level of learning.

In the context of this study, PBL is the main instructional approach, underpinned by both constructivist and sociocultural theories. According to Moursund (2005) and the Educational Technology Division, Ministry of Education Malaysia (2006), PBL is a structured and systematic method where students actively engage in projects involving topic selection, planning, inquiry, product development, and reflection. Holm (2011) emphasizes that PBL typically spans a longer duration and incorporates learning by doing, helping students connect classroom learning with real-world contexts.

The key features of PBL include its student-centered approach (Kolmos & De Graaff, 2014), incorporation of Higher-Order Thinking Skills (HOTS), and the use of driving questions that encourage deeper inquiry (Efstratia, 2014; Wajdi, 2017). Moreover, PBL aligns well with 21st-century learning requirements, focusing on the development of the 4Cs: communication, collaboration, creativity, and critical thinking.

Numerous studies have confirmed the effectiveness of PBL in school settings. For example, Filippatou and Kaldi (2010) found that students engaged in PBL performed better academically compared to those in traditional learning settings. Similarly, Li et al. (2019) reported improvements in students' communication skills through PBL. A local study by Hamzah and Shariff (1997) noted that Agricultural Science teachers still rely heavily on lecture-based methods, despite the Integrated Secondary School Curriculum encouraging student-centered learning. Another study by Latir et al. (2014) found that contextual and experience-based teaching approaches helped to increase students' interest in agriculture-related careers.

Therefore, the use of constructivist and sociocultural learning theories, together with Needham's Five-Phase Model, forms a critical foundation for understanding how teachers and students interact to construct knowledge and enhance learning experiences in the context of Agricultural Science through PBL.

3. Method

This study employed a qualitative phenomenological research approach to explore in depth the experiences of Agricultural Science teachers at Technical School in implementing

Project-Based Learning (PBL). According to Creswell and Poth (2018), qualitative research is appropriate for understanding the meaning and lived experiences of individuals within real-world contexts, while a phenomenological approach enables the researcher to uncover the essence of the experiences shared by participants (Wood, 2006). The focus of this study is to gain a comprehensive understanding of teachers' experiences, challenges, and the perceived effectiveness of PBL from their perspective.

3.1 Research Design

This study adopted a qualitative phenomenological design with the aim of understanding the characteristics, implementation, impact, and challenges of PBL in the context of Agricultural Science education. Creswell and Creswell (2018) explains that phenomenological research focuses on the subjective experiences of individuals who have lived through a particular phenomenon. This study seeks to answer key research questions concerning the nature of PBL, how it is implemented, its impact on students, and the challenges faced by teachers during implementation.

3.2 Study Location

The study was conducted at Technical School, which is one of only three technical schools in Malaysia offering the Agricultural Science stream. This technical school was chosen based on its long-standing history in agricultural education, curriculum relevance, and the availability of experienced teachers in PBL implementation. The school has offered the Agricultural Science stream since 1972 and has substantial experience in technical education.

3.3 Population and Sampling

The study population consisted of Agricultural Science teachers at the selected school. A purposeful sampling method was used to identify informants who had direct experience implementing PBL. According to Creswell and Poth (2018) also Meriam and Tisdell (2018) emphasize the important of selecting participants based on criteria that align closely with the research focus. In this study, two Agricultural Science teachers were selected as information-rich cases (Patton, 1990), as both participants possessed specialized expertise and experiences relevant to the implementation PBL in technical schools. The narrow and exploratory scope of the research prioritized depth over breath, allowing for detailed, context-specific understanding rather than generalizability (Harding, 2019)

Given these aims, data collection was considered sufficiently comprehensive when both participants offered consistent and in-depth insights that addressed the research questions, aligning with qualitative traditions that emphasize rich narrative data over large sample sizes (Creswell & Poth; 2018; Merriam & Tisdell, 2018). Access to teachers in this context was also limited due to logistical and ethical considerations, further reinforcing the appropriateness of a small sample. This focused approach provided the necessary depth for an initial exploration of PBL practices in Agricultural Science education.

3.4 Informants

Two Agricultural Science teachers were selected as informants using purposeful sampling.

Both met the established criteria: they were responsible for teaching Agricultural Science for Form 4 and Form 5 students and had prior experience implementing PBL in their teaching.

3.5 Researcher as Instrument

In qualitative research, the researcher functions as the main instrument for both data collection and analysis (Silverman, 2021; Merriam and Tisdell, 2018). Semi-structured interviews were used as the main method of data collection, allowing for in-depth and flexible exploration of the participants' views and experiences (Holstein et al., 2013, 2003). The interview protocol was developed based on research questions and was reviewed by subject matter experts prior to its use in the actual study.

3.6 Data Collection

Data collection in this study was collected through three main methods; i) Semi-structured interviews with Agricultural Science teachers; ii) Document collection, including Daily Lesson Plans; and iii) Informal observations and field notes.

All interview sessions were audio-recorded, transcribed, and manually analyzed to address the research questions. Ethical procedures were strictly followed throughout the data collection process, including obtaining informed consent from participants and ensuring confidentiality. These procedures complied with the guidelines approved by the Ethics Committee for Research Involving Human Subject, Universiti Putra Malaysia (JKEUPM).

3.7 Pilot Study

A pilot study was conducted with one teacher to ensure the effectiveness of the interview protocol and the informant’s ability to respond meaningfully. This step helped the researcher refine the structure of the questions and improve interviewing skills (Yin, 2015).

3.8 Data Analysis

The data were analyzed using a thematic approach. The process began with transcription of interview recordings, followed by repeated readings and coding to develop categories that would help identify major themes (Creswell & Creswell, 2018). The researcher carried out thematic analysis to organize categories into themes that addressed the research questions (Guba et al., 1994). No software was used; all analysis was conducted manually.

3.9 Trustworthiness and Credibility

Three key strategies were employed to ensure the trustworthiness of the study; i) Credibility - Achieved through triangulation of methods and data sources (Idris, 2013; Lincoln & Guba, 1988); ii) Dependability - Ensured by consistency of findings through member checking and validation by the informants (Merriam and Tisdell, 2018); iii) Transferability - Facilitated through detailed descriptions of the study context, participants, and procedures to allow applicability in other settings.

3.10 Research Ethics

This study received ethical approval from the Ethics Committee for Research Involving

Human Subjects, Universiti Putra Malaysia, with reference number JKEUPM-2022-834, dated 13 December 2022. Prior to the commencement of the study, official permission was obtained from the school, and informed written consent was secured from all participating informants. All personal information was kept strictly confidential and used solely for academic purposes. To maintain research integrity, all data collected will be destroyed upon completion of the study, in accordance with ethical research guidelines.

4. Results

4.1 Profile of Agricultural Science Teachers

In this study, two informants were directly involved, both of whom were Agricultural Science teachers at a technical school in Malaysia. According to Harding (2019) researcher as main instrument have to decide to stop data collection when no new information. In this study, the second informants have achieved data saturation where no new information. The informants were between 36 and 37 years of age and each had 11 years of teaching experience in Agricultural Science. To protect their identities, pseudonyms were used, and their participation in the study was entirely voluntary. The selection of informants was carried out through purposeful sampling, based on their direct involvement in the implementation of PBL.

Table 1. Profile of Study Informants

Informant	Age	Years of Teaching Experience (Years)	Specialization
Teacher Sofea	36	11	Agricultural Science
Teacher Rafi	37	11	Agricultural Science

4.2 Research Question 1: What are Characteristics of PBL in the Agricultural Science Program?

This study analyzed data based on the experiences of two Agricultural Science teachers at technical school at northern Malaysia in implementing PBL. The interview data, manually coded and thematically analyzed, produced three major themes that describe the key characteristics of PBL implementation in this subject: a) Curriculum-aligned learning content; b) Teacher as facilitator, and c) PBL as distinct approach from traditional learning methods.

a) Curriculum-Aligned Learning Content

PBL in the context of Agricultural Science was found to be closely aligned with the officially prescribed syllabus. According to the Curriculum Development Division of the Ministry of Education Malaysia, the syllabus refers to a systematically structured body of learning content that serves as a guide for teaching and assessment in schools. Both informants in this study—referred to as Teacher Sofea and Teacher Rafi, confirmed that the learning content in PBL is developed in accordance with the formal syllabus and remains consistent with curriculum requirements. Teacher Sofea explained:

> "…Project-based learning is more coursework-oriented. In Form 4, we have

> one coursework component, and in Form 5, another. But within the syllabus itself, there are also topics that allow us to carry out projects independently… the coursework questions come from the examination board, but the syllabus also provides topics that enable us to run our own projects…"

This statement illustrates that project implementation is not solely dependent on standardized coursework but can also be adapted based on syllabus topics, offering greater flexibility for both teachers and students. Similarly, Teacher Rafi remarked:

> "…In Agricultural Science, we definitely apply project-based learning, especially for the practical components that are already outlined in the syllabus…"

This reinforces the view that project activities in Agricultural Science are nor merely supplementary but are intentionally designed in alignment with official curriculum requirements, whether through examination board-mandated coursework or teacher-initiated projects drawn from syllabus topics. As Thomas (2000) emphasizes, the effectiveness of PBL depends on the teacher's capacity to systematically embed curriculum content into project work, a practice clearly reflected in both teachers' account.

b) Teacher as Facilitator

The role of the teacher in PBL shifts from that of a traditional instructor to a facilitator. In the PBL context, teachers do more than just deliver content; they also provide structure, resources, and ongoing support throughout the project process. Teacher Rafi shared:

> "…We act as facilitators, supervisors… we facilitate and oversee our students from the beginning of the project until the final report is submitted. If students encounter problems, they'll come to us for help, and we provide them with guidance on how to proceed with the project…"

This reflects the teacher's responsibility in continuously monitoring and guiding students, ensuring they stay aligned with learning objectives. Teacher Sofea highlighted her readiness to provide resources:

> "…I'm very open. Just let me know what they want to plant, and I'll prepare it. If they need seeds, I'll get them—I'll even buy them if necessary—as long as the students are interested. I'm here to guide them. If students don't have guidance, they won't carry it out…"

In line with Vygotsky's (1978) concept of the *zone of proximal development (ZPD)***,** the teachers' roles as facilitators in PBL illustrate how guidance and scaffolding enable students to progress beyond what they could achieve independently. Teacher Rafi's description of monitoring and supervising students throughout the project demonstrates how facilitators step in when learners face challenges, offering just enough support to help them advance. This ensures that while students maintain ownership of their projects, they are not left without direction. Similarly, Teacher Sofea's willingness to provide resources, such as seeds and planting materials, reflects how facilitators lower barriers to participation, making it possible for students to explore their interests while still aligning with educational objectives.

This balance between autonomy and guidance embodies the constructivist approach, where learning is seen as an active process of knowledge construction. As Belland (2017) notes, scaffolding in PBL does not mean giving students the answers but rather equipping them with the tools, resources, and support needed to succeed. In this way, teachers cultivate a supportive learning environment where students are encouraged to take initiative, make decisions, and reflect on their learning, while still relying on the facilitator's expertise to remain on track. Thus, the teacher as a facilitator in PBL is not a passive observer but an active enabler of student development, ensuring that autonomy is nurtured within a framework of guidance.

c) PBL as a Distinct Approach from Traditional Learning

PBL was viewed by both teachers as significantly different from traditional teaching methods. In conventional classrooms, the teacher is often the sole source of knowledge, and students are passive recipients. In contrast, PBL is student-centered, practical, and encourages two-way interaction between teachers and learners. According to Teacher Sofea:

> "…Traditional learning is more theoretical, classroom-based… if students don't practice, their understanding will be limited… when they apply theory, they understand better, their minds open up, and they really grasp the concept. For example, when feeding quails—we might know the theory, but when we actually care for them, that's when we truly understand. You learn by doing, and that's where real understanding comes from…"

Her statement underscores that deeper understanding occurs when students are actively engaged in applying what they've learned. Teacher Rafi added:

> "…In project-based learning, students are more involved. They take more initiative and there's more two-way communication. It's student-centered. But in traditional methods, learning is teacher-centered teacher gives everything, and the student just receives. There's little exploration…"

Clearly, PBL fosters active engagement by shifting the focus of learning from teacher delivery to student participation. As highlighted by Teacher Sofea and Teacher Rafi, the essence of PBL lies in students taking initiative, applying theoretical knowledge in practical contexts, and engaging in meaningful dialogue with teachers. This is consistent with Moursund (2005), who argue that PBL environments empower students to explore, question, and construct their own understanding rather than passively absorb information. Similarly, Efstratia (2014) emphasizes that PBL promotes collaborative learning and two-way interaction, where the teacher assumes the role of facilitator instead of sole knowledge provider.

This approach strongly resonates with Kolb's (2014) experiential learning theory, which posits that deeper understanding develops when learners actively engage in concrete experiences, reflect on them, and integrate them into their conceptual knowledge. Teacher Sofea's example of caring for quails reflects this cycle—students move beyond abstract theories to hands-on practice, which then enhances comprehension and retention. By engaging in such authentic tasks, learners not only acquire knowledge but also develop problem-solving skills, critical thinking, and autonomy. Thus, PBL emerges as a distinct and more dynamic alternative to traditional learning, where knowledge is constructed through doing, reflecting, and interacting, supported by teacher facilitation.

4.3 Research Question 2: What is the Impact of Implementing PBL in the Agricultural Science Subject?

The findings for the second research question aimed to explore how the PBL process is implemented by Agricultural Science teachers. Data analysis yielded three major themes representing the phases of PBL implementation: a) Pre-implementation: Initial preparation and project planning; b) During implementation: Briefings and work scheduling; and c) Post-implementation: Rubric-based assessment. These themes reflect a holistic view of how PBL is carried out in real classroom settings, based on the lived experiences of the informants.

a) Pre-Implementation: Initial Preparation and Project Planning

In the early phase of PBL implementation, the teacher plays a critical role as planner and resource provider. Teachers are responsible for preparing materials, site arrangements, and necessities to ensure students can carry out the projects smoothly. Teacher Rafi explained that providing guidance is essential to allow students to explore independently:

> "…We provide them with guidelines, not detailed instructions—just enough so they can explore and do things on their own. For example, with the quail farming activity, we explain how to care for them and feed them. We give them the guidelines and schedule, and they continue from there. We provide the basics—materials, the quails, the tools for building cages, and maybe even paperwork or supporting materials…"

This statement highlights that while students are given autonomy in project execution, the teacher remains responsible for supplying foundational support to facilitate learning. Teacher Sofea also stressed that the teacher's role extends beyond monitoring to include planning and preparing the required resources:

> "…Of course, the teacher acts as a monitor, but we also provide the materials and set up the site. So we act as the planner, while the students carry out the project. Financially too, it's more about planning and preparing the funds, materials, and equipment…"

The discussion above illustrates that in the pre-implementation stage of PBL, teachers assume a foundational role in ensuring the success of student-led projects. Both Teacher Rafi and Teacher Sofea emphasized that while students are encouraged to manage the projects independently, this autonomy is only possible because teachers establish the necessary groundwork. By preparing guidelines, materials, sites, and financial planning, teachers provide a structural framework that allows students to engage in authentic and meaningful learning.

This reflects Ravitz & Blazevski (2014) view that the teacher's responsibility in PBL is not to dictate every step, but to design a conducive and structured learning environment in which students can actively explore and take ownership of their work.

From a constructivist perspective, this phase is critical because it balances freedom with support. Students are empowered to take initiative in managing their projects, yet their exploration is scaffolded by the foundational preparations made by the teacher. In this way, teachers act as enablers, reducing logistical barriers and creating opportunities for students to focus on problem-solving, critical thinking, and experiential learning. Thus, the pre-implementation stage highlights how the teacher's role as planner and resource provider directly contributes to the effectiveness of PBL by laying the groundwork for student autonomy.

b) During Implementation: Briefings and Work Scheduling

During the implementation phase, teachers play a key role in conducting briefings and preparing systematic work schedules. These briefings serve as initial guidance to help students understand their tasks and how the project should be carried out. Teacher Sofea emphasized the need for briefings and procedural clarity:

> "…Briefings are a must. We conduct briefings and provide procedures—basically instructions on the tasks. We give them an overview of what they need to do, and they prepare a schedule…"

This demonstrates the importance of providing clear instructions before students begin their projects. Such structure helps students manage their time effectively and understand their responsibilities. Teacher Rafi added that these briefings are accompanied by written work schedules:

> "…I usually give a full briefing first. We explain what the project involves, what needs to be done, and how students should carry it out. Then, I give them a written work schedule, and they must commit to it. For example, if the quail slaughtering activity is scheduled for the final week, it must be completed during that week…"

The discussion above highlights that during the implementation phase, teacher-led briefings and structured work schedules are essential in guiding students through their projects. Both Teacher Sofea and Teacher Rafi underscored that clear initial instructions, supported by written schedules, help students understand the scope of their tasks, manage time effectively, and stay committed to deadlines. This structured approach ensures that projects progress systematically rather than in a disorganized manner. A well-organized schedule provides students with a roadmap, enabling them to take responsibility for their own learning while still adhering to the project's objectives.

This practice aligns with the principles of active and structured learning in PBL, as outlined by Holm (2011) and the Buck Institute for Education (Markham et al., 2003), who emphasize the importance of initial guidance, clarity of expectations, and student self-management. Rather than restricting autonomy, such structure empowers students to engage actively in the learning process, as they know what is expected of them and when tasks must be completed. In this way, briefings and scheduling strike a balance between teacher direction and student responsibility, ensuring that PBL remains both learner-centered and goal-oriented.

c) Post-Implementation: Rubric-Based Assessment

Assessment in PBL is conducted after project completion using a rubric provided by the Ministry of Education Malaysia (MOE). This rubric helps teachers evaluate students holistically, covering project execution, written reports, group collaboration, and final presentations. Teacher Sofea noted:

> "…The rubric is provided by the MOE, so throughout the three-month period, students are assessed based on that rubric…"

The use of rubrics brings clarity and consistency to the evaluation process and ensures fair assessment of student performance. Teacher Rafi elaborated that assessment includes multiple aspects, from the briefing stage to report preparation:

> "…We assess several elements—from the implementation of the project itself, starting from when I brief them, to the preparation of materials and tools, the execution of the practical tasks, right through to the final stage. For example, in the quail project, we assess from rearing to slaughter to selling. We also look at their teamwork. And of course, the final report—the data, the project framework, and the schedules they prepared—all of that is evaluated. So visually, we observe their work, and then assess their written reports…"

The findings above show that rubric-based assessment in PBL moves beyond traditional testing by evaluating students' learning in practical, real-world contexts. As explained by Teacher Sofea and Teacher Rafi, the assessment process is comprehensive, covering not only the final report but also the entire project journey—from preparation and implementation to teamwork, execution, and presentation. This reflects an authentic assessment approach, where students are evaluated on how well they apply knowledge and skills in practice rather than on rote memorization or isolated tasks. The rubric provided by the MOE ensures clarity, fairness, and consistency, while also encouraging students to take every stage of the project seriously, knowing that their efforts will be evaluated holistically.

This aligns with Eggen & Kauchak's (2012) perspective that authentic assessment is crucial for measuring students' abilities in ways that mirror real-world applications. By focusing on collaboration, problem-solving, project management, and reporting, rubric-based assessment captures the full spectrum of competencies that students develop during PBL. In doing so, it not only validates the learning process but also reinforces skills that are transferable beyond the classroom. Thus, assessment in PBL is not simply a measure of academic achievement but also a reflection of students' readiness to apply their learning in authentic and meaningful contexts.

5. Discussion

These finding highlights that the implementation of PBL in Agricultural Science represents more than just a change in teaching method—it marks a fundamental pedagogical shift towards active, experiential, and contextual learning. Instead of passively receiving knowledge, students learn by doing, reflecting, and collaborating, which strengthens both their academic understanding and their practical skills. This is consistent with constructivist theory (Jonassen & Rohrer-Murphy, 1999; Thomas, 2000), which stresses that learning is most effective when learners actively construct meaning from experience.

A key finding is the transformation of the teacher's role. Teachers are no longer positioned as the sole transmitters of knowledge but as facilitators who provide structure, resources, and guidance. This shift echoes Dewey's (1986) philosophy of experiential education, where effective learning happens when theory is linked to practice and students engage with real-world problems. By scaffolding students' work, teachers create an environment where students can take ownership of their projects while still being supported in their learning journey.

The study also shows that PBL's systematic process—planning, implementation, and rubric-based assessment— enhances both student motivation and mastery of content. Importantly, PBL does not only improve subject knowledge but also develops soft skills such as teamwork, communication, and time management, which are crucial in TVET contexts (Darling-Hammond et al., 2015). These outcomes demonstrate that PBL prepares students not just academically, but also for future work and life challenges.

At the same time, the study recognizes challenges. Inconsistent student commitment, overlapping school activities, and financial limitations can hinder PBL effectiveness. This reflects the reality that successful PBL requires not only strong pedagogy but also institutional support, including efficient scheduling, sufficient funding, and administrative backing (Adnan & Abdul Rahman, 2024; Himmi et al., 2025). Without this support system, even well-designed projects may not achieve their intended outcomes.

In the context of Agricultural Science, PBL has proven particularly effective because it allows students to engage directly with real agricultural practices—such as planting, animal rearing, and product development. This finding aligns with Blumenfeld et al. (1991) and Bell (2010), who argue that project-based approaches lead to deeper, longer-lasting learning and stronger academic performance.

Finally, the conclusion carries policy implications. For PBL to succeed on a larger scale, especially in TVET subjects, the Ministry of Education Malaysia should consider restructuring instructional time to accommodate projects, offering more flexible budget allocations to support resource-intensive activities, and providing continuous professional development for teachers. These measures would ensure that PBL is not just an isolated practice but an integral part of the national education strategy, fully aligned with the National Education Philosophy and Malaysia's broader goals for educational development.

6. Conclusion

This study has explored the experiences of Agricultural Science teachers in implementing Project-Based Learning (PBL) in technical schools in northern Malaysia. The findings demonstrate that PBL brings substantial value to the teaching and learning process by providing opportunities for students to actively explore subject content, construct knowledge through hands-on engagement, and increase their interest and motivation in Agricultural Science. At the same time, the approach redefines the role of teachers, positioning them as facilitators of learning while students assume greater responsibility and autonomy in managing their own learning processes.

Nevertheless, several challenges were identified in practice, particularly with regard to time management, inconsistent student commitment, and financial limitations. These constraints highlight the importance of institutional and systemic support, as teachers alone cannot overcome such barriers. Stronger collaboration from school administrators and greater attention from the Ministry of Education are therefore required to ensure that PBL can be implemented in a more structured, efficient, and sustainable manner across technical and vocational subjects.

Looking ahead, the integration of digital technologies such as smart agriculture applications, plant growth monitoring tools, and interactive learning platforms offers promising opportunities to enhance the effectiveness and appeal of PBL. Such innovations not only reinforce the STEM elements embedded within Agricultural Science but also improve project management and learning outcomes within and beyond the classroom. Overall, PBL represents a powerful pedagogical strategy to enrich technical education; however, its long-term success relies heavily on comprehensive support in the form of training, policy development, and adequate resource allocation.

7. Recommendations for Future Research

The recommendations for future research highlight several important areas that could strengthen the understanding and practice of Project-Based Learning (PBL) in Agricultural Science. First, expanding the scope of research to include Agricultural Science teachers from various technical schools across Malaysia would provide a broader perspective on how PBL is implemented in different contexts. Since schools may differ in terms of resources, student demographics, and institutional culture, such comparative research would help identify best practices as well as contextual challenges that shape the success of PBL.

Another crucial area for exploration is the financial aspect of PBL implementation. The study findings suggest that limited funding can affect the feasibility and quality of project-based activities. Future research could therefore investigate the financial barriers in greater depth, identifying mechanisms for better resource management and the types of institutional support required. This would not only guide teachers in managing projects more effectively but also inform policymakers on ways to refine educational policies to ensure more sustainable funding structures for technical and vocational subjects.

Additionally, while this study provides qualitative insights into teachers' experiences, there is a need for quantitative research to evaluate the measurable impact of PBL on student outcomes. Such studies could assess academic achievement, skill development, and students' attitudes toward Agricultural Science. By combining quantitative evidence with qualitative findings, future research would provide a more holistic and empirically robust understanding of the benefits and challenges of PBL in the Malaysian education system.

Finally, the integration of digital technologies in PBL offers a promising direction for future inquiry. The use of tools such as agricultural sensors, crop-monitoring applications, and virtual collaboration platforms could transform the way projects are designed, executed, and assessed. Research in this area would not only enhance the relevance of Agricultural Science by embedding modern technological practices but also align teaching strategies with the broader goals of STEM education and the Fourth Industrial Revolution. In doing so, future studies could provide a pathway for modernizing technical education and preparing students with the digital competencies needed in contemporary agricultural industries.

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