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Practice Article

Encouraging Inquiry: A Semester-Long Project Using Science Buddies

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Abstract
Project-Based Learning (PBL) is an effective pedagogical approach for developing 21st-century skills while improving English language proficiency. Unlike traditional methods, PBL uses thematic and experiential learning strategies to promote learner autonomy and collaboration, combining content-based instruction with task-based learning (TBL) to achieve practical outcomes (Petersen, 2008). This paper explores the impact of combining PBL with scientific inquiry in an English as a Foreign Language (EFL) class at a Japanese university. The aim is to promote inquiry, improve language skills, and develop essential 21st-century skills. The paper concludes by discussing the challenges and limitations associated with the implementation of PBL and the use of science as a subject matter.

プロジェクト・ベースド・ラーニング（PBL）は、英語力を向上させながら21世紀型スキルを育成するための効果的な教育手法である。従来の方法とは異なり、PBLはテーマ別・体験型の学習ストラテジーを用いて学習者の自律性と協調性を促進し、実践的な成果を達成するために内容ベースの指導と課題ベースの学習（TBLT）を組み合わせている（Petersen,2008）。本稿では、日本の大学における外国語としての英語（EFL）の授業において、PBLと科学的探究を組み合わせることの影響を探る。その目的は、探究心を促進し、言語能力を向上させ、21世紀に不可欠なスキルを育成することである。最後に、PBLの実施と教科としての科学の使用に伴う課題と限界について考察する。

The primary aim of this teaching practice is to improve students' language skills and to promote a sense of curiosity through a semester-long science project. PBL integrates authentic materials and tasks to encourage cooperative learning. By placing students at the center of the learning process, PBL increases their engagement and motivation (Virtue & Hinnant-Crawford, 2019), which, in turn, increases their self-efficacy and confidence. Unlike traditional classrooms, which often emphasize repetition, memorization, and reliance on textbooks, PBL allows students to apply their scientific knowledge through projects while simultaneously developing 21st-century skills such as critical thinking and problem-solving.

This practice-oriented paper explores the application of Project-Based Learning (PBL) in an English Project Workshop (EPW) class at Tokyo International University (TIU). The EPW course described in this paper was taught by the author and is an elective course offered to Japanese students. The project involved six first-year students majoring in English Communication. This small class size allowed for more individualized feedback and close interaction between the teacher and students, which influenced the design and implementation of the project.

In this focused classroom environment, PBL was an effective teaching approach because it gave students the autonomy to progress at their own pace and level. While this study focused on English Communication majors, the skills emphasized by using science as content, such as inquiry, research, and collaboration, could also benefit students in other fields. The course met twice a week for 100 minutes over a 15-week semester. The author had the flexibility to design the course content, projects, and assessments to suit the needs of the students.

The semester-long project involved selecting a science experiment, drafting a project proposal, conducting research, writing observation reports, and culminating in a final report and presentation (see Appendix for a detailed Sample Project-Based Learning Syllabus). These activities were designed to deepen scientific knowledge while also targeting specific language skills. For example, conducting research improves students' reading comprehension by critically analyzing texts, while writing a report refines their academic writing skills, including formatting, writing abstracts, and drawing conclusions. In addition, making presentations increases students' confidence in communicating their scientific findings and public speaking, and designing presentation slides improves their information and communication technology (ICT) skills.

Theoretical Framework

Project-Based Learning (PBL) originated in the early 20th century through the educational reforms of John Dewey and William Heard Kilpatrick. In the context of language education, PBL evolved into Project-Based Language

Learning (PBLL), which enables students to use language authentically in real-world contexts while fostering autonomy and critical thinking (Azzad, 2024).

PBL immerses students in the learning process through extended projects that begin with "driving questions or problems" and end with "meaningful products" (Simpson, 2011, p. 40). While definitions vary, in the EFL context, projects should focus on "complex, authentic questions and carefully designed projects and tasks" (Markham et al., 2003, p. 4). Research on the benefits and effectiveness of PBL in EFL classrooms is overwhelming, highlighting improvements in both language proficiency and personal development (Thuan, 2018). Studies show that PBL enhances students' writing (Barba, 2016; Cahyono et al., 2024) and motivation (Aghayani & Hajmohammadi, 2019), encourages collaboration (Astawa et al., 2017), improves communicative competence (Wu & Meng, 2010), and cultivates 21st-century skills such as critical thinking (Arabloo et al., 2021), problem-solving (Kiyokawa, 2019), creativity (Astawa et al. 2017; Talat & Chaudhry, 2014), and cooperative learning skills (Wu & Meng, 2010). Teachers also benefit from PBL, reporting higher motivation as a result of increased student engagement, and a more fulfilling classroom environment (Demir, 2011; English, 2013; Lam et al., 2010; Astawa et al., 2017).

Another instructional framework often confused with Project-Based Learning (PBL) is Problem-Based Learning. While both approaches share student-centered, collaborative principles, they differ in focus and outcomes. PBL emphasizes inquiry and creating tangible products to enhance language and communication skills (Markham et al., 2003), whereas Problem-Based Learning focuses on solving real-world problems through critical analysis (Savery, 2006). A study by Affandi and Sukyadi (2016) compared the effectiveness of these approaches in an Indonesian tertiary EFL context. The study revealed that while both methods improved students' writing, PBL promoted exploratory learning and collaboration, whereas Problem-Based Learning was more effective in developing critical thinking and problem-solving skills. These findings demonstrate the complementary strengths of the two approaches in addressing diverse EFL learning goals.

This study adopts a Project-Based Learning framework for its potential to foster inquiry, creativity, and real-world application while integrating problem-solving tasks to develop critical thinking and adaptability (Thomas, 2000). These elements align with the 21st-century skills essential for EFL learners, as demonstrated in Japanese university settings (Fujimura, 2016; Kiyokawa, 2019).

Simpson (2011) outlines several key components of PBL:

- Exploration of a topic over an extended period of time
- Student-centered learning
- Projects that revolve around topics that interest students
- Less focus on teacher-led instruction
- Regular feedback from peers and the teacher
- Practical activities that use authentic materials
- Emphasis on teamwork rather than competition
- Development of a range of skills, including communication and organization
- Build new ideas and skills throughout the project
- Create meaningful artifacts that can be shared with a wider audience
- Continuous assessment throughout the project

PBL allows students to develop language, knowledge, and communication skills by combining language and factual information in real projects (Simpson, 2011). Instructors should make considerable efforts to meet these criteria when designing PBL-based lesson plans and curricula.

PBL in EFL Universities in Japan

While Japanese universities are increasingly adopting Content and Language Integrated Learning (CLIL), many students lack the opportunity to study interesting subjects in English (Kiyokawa, 2019). This challenge is compounded by the limited experience students have in practicing English in EFL contexts, such as Japan. PBL addresses these needs by creating an environment where students are required to use their English language skills to acquire content knowledge and critically analyze information to deepen their understanding (Fujimura, 2016). Several studies demonstrate the positive impact of PBL in Japanese EFL universities.

For instance, Kiyokawa (2019) implemented the "Phone Booth" project, in which students researched a selected topic, created displays, and invited campus-wide participation through written questions and comments in an unused phone booth. Feedback collected from the pre- and post-questionnaires showed positive experiences for Japanese EFL students who were experiencing PBL for the first time. This example illustrates how a PBL project can transform a traditional classroom into an interactive learning space by involving the broader community.

Building on this, Foss et al., (2008) applied PBL in a short-term intensive English program, using four distinct projects: the Wikipedia project, the newspaper project, the small group video project, and the whole group video project. These projects encouraged students to connect English learning to real-world interests, promoted collaboration, and culminated in tangible outcomes.

Similarly, Barrs (2020) combined PBL with the linguistic landscape approach to help seminar students develop thesis topics. Students researched the use of English in their surroundings by collecting and analyzing photos in class. These analyses led students from a "driving question about English usage in their local environment to producing tangible evidence of their critical examinations in the form of working titles for their theses" (Barrs, 2020, p. 15). This integration of academic inquiry with practical, real-world experiences further illustrates the versatility of PBL.

While these studies share common elements with this teaching practice, such as fostering inquiry, collaboration, and student engagement, this approach is unique in its focus on using PBL to enhance English Communication majors' language and critical thinking skills through science-based projects. By scaffolding content with L1 resources and simplifying scientific concepts, students were able to develop technical vocabulary, improve presentation skills, and strengthen their English proficiency. This demonstrates the flexibility of PBL to address the specific needs of students in varied educational contexts.

Science Buddies

Science Buddies is a non-profit website that provides science experiment ideas and guidelines for students, parents, and educators to study and teach about various sciences. Their mission is to "inspire and educate students of all ages with hands-on STEM explorations that reflect their unique personal interests" (Science Buddies, n.d., para. 1). They achieve this by offering more than 15,000 pages of scientist-created content, where students can tailor their explorations by science discipline (physical, life, engineering, earth and environmental, behavioral and social, and math and computing), time, cost, materials needed, and grade level (elementary, middle, and high school). Furthermore, students can connect with real scientists through "Ask an Expert" and explore more than 160 STEM career profiles. This comprehensive resource aims to educate and promote a broader understanding of how science is applied in the real world.

For EFL students, the ready-made materials, tailored to individual interests and needs, can be a valuable tool to help them focus on developing their language skills including academic writing, research, and presentation. While some might argue that this resource could discourage creativity, as the research, materials list, and potential risks of the science experiments are already provided, this pre-done information actually allows students to focus more on learning English. With the groundwork laid out, students can spend more time developing a deeper understanding of the science behind their experiments.

Combining Science and EFL

PBL is a popular approach in content-based classrooms and general education, especially in science classrooms (Fujimura, 2016). Because students are already familiar with scientific concepts, they can easily grasp the related terminology and build new knowledge and skills on top of existing ones. Furthermore, science content is rich in media, charts, and graphs, which cater to diverse learning styles. Studies show that PBL in science significantly improves students' reading, writing, speaking, vocabulary, and translation skills, as they are actively involved in researching and completing projects (Poonpon, 2011).

While the Science Buddies resource is commonly associated with science-focused education, it was adapted in this study to develop English Communication majors' research, critical thinking, and presentation skills in English. By engaging students with scientific content, PBL encourages interdisciplinary learning, which helps them explore topics across disciplines, make meaningful connections, and enhance transferable skills (Habók & Nagy, 2016). Therefore, the combination of PBL and science projects has the potential to effectively improve students' English language skills in a unique learning environment.

Description of the Teaching Practice

The PBL approach implemented in the English Project Workshop (EPW) class at Tokyo International University (TIU) aimed to improve the linguistic skills of six first-year English Communication majors in the context of scientific inquiry. With a small, focused class size, the instructor was able to provide individualized feedback and closely monitor each student's progress. To achieve this, students engaged in a semester-long science project that required them to conduct research, analyze data, write reports, and give presentations, all in English (Table 1).

Table 1

Implementation Stages for the Science Project

Weeks	Description
Weeks 1-2	The first few weeks focused on reviewing the fundamentals, including the scientific method, the importance of inquiry, and the project timeline. During this period, students were introduced to the

Weeks	Description
	the Science Buddies website, which served as a structured starting point for selecting their experiments. The teacher provided initial guidance on navigating the platform, such as filtering projects by complexity, materials, and topics to align with their interests and proficiency levels. Students then began selecting their science experiments, fostering autonomy and decision-making, essential components of PBL (Habók & Nagy, 2016). This extended project allowed students to delve deeper into topics that genuinely interested them. To support the teaching of scientific methods, the instructor adapted and designed close reading exercises, comprehension quizzes, and discussion questions based on Science Buddies content.
Weeks 3-4	Project topics were chosen individually by students to align with their personal interests and levels of understanding. This approach ensured that each student could engage deeply with a topic they found meaningful, fostering autonomy and motivation. After selecting a science experiment, students drafted a project proposal outlining their objectives, methods, and materials. Fortunately, Science Buddies provides a strong foundation that allows students to simplify the language and tailor the proposal to their specific needs.
Weeks 5-7	After completing the project proposal, students gathered background information on their science experiments. While some experiments had suggested readings, students often needed to do further research to fully understand the concepts. To support this process, the teacher allowed the use of L1 websites as supplementary resources, enabling students to access information in their native language. This approach promoted a deeper understanding of the science experiments and related terminology. Additionally, by encouraging them to synthesize information from both L1 and English language sources, it allowed students to focus on developing their reading comprehension and note-taking skills.
Weeks 8-10:	After the background research, students were given a timeline to complete their science experiments outside of class, with ample time allowed. During this phase, class time was devoted to regular individual consultations and workshopping, which was crucial for monitoring student progress. The teacher scaffolded and modeled how to record data and make observations.
Weeks 11-13:	The focus then shifted to developing writing skills. Students learned to organize their scientific findings into a final report, structuring it with an abstract, introduction, body, and conclusion. They applied technical vocabulary from their experiments and learned to format and organize their reports effectively.
Weeks 14-15:	The final stage involved creating a multimedia presentation to showcase their experiments and findings. Students developed presentation skills using a variety of software tools, including Google Slides, Microsoft PowerPoint, and Canva. These tools enabled students to organize and visually communicate their findings. To simulate a real 'science fair' environment, the instructor invited other classes to attend the presentations, creating a dynamic learning environment. This stage assessed students' understanding of the project, public speaking skills, and information organization skills. Finally, some class time was dedicated to individual and whole class reflection on the process of the science project.

Reflections on the process

The semester-long PBL project, which integrated science and English language learning, aimed to encourage students' curiosity and improve their language skills in a student-centered environment. By choosing their science experiments, conducting research, analyzing data, and presenting their findings, students moved from passive learning to active inquiry. Observations of student engagement and interactions showed that cognitive presence (active learning through interaction, Kean & Kwek, 2014) motivated students to engage with their science-related challenges.

PBL offered several advantages. By exploring a science topic of interest, students were able to develop a deeper interest in and understanding of their science project. In addition, the project-based activities honed essential language skills, including research, writing, presentation, and critical thinking, consistent with studies highlighting PBL's effectiveness in developing 21st-century skills (Arabloo et al., 2021; Yadav et al., 2011). Students also gained valuable experience in using ICT tools and collaborating with peers, which accommodated different learning styles and encouraged autonomy and independent learning. This finding was observed in Yamada's (2021) implementation of PBL in Japanese EFL contexts.

This PBL-based teaching method, combined with science content, is highly adaptable to various classroom settings and levels. For beginner-level students, simpler scientific concepts and structured guidance are essential to make tasks more accessible, whereas advanced students can engage with more complex topics and enjoy greater autonomy. In mixed-proficiency classrooms, such as this one, individualized feedback between the student and teacher is crucial to address varying needs. Assigning roles based on students' strengths can foster effective collaboration, while scaffolding tools like glossaries and L1 resources can provide additional support for lower-level learners. These strategies ensure that the PBL methodology can be adapted across a wide range of educational contexts, promoting engagement and skill development for all learners.

Outcomes and Observations

The implementation of PBL in the EPW class at a Japanese EFL university setting produced several key findings. Notable outcomes included improved language skills, a deeper understanding of science concepts and their specific science experiments, and improved collaboration skills. However, the implementation also revealed challenges, such as the significant time investment required by teachers, the need for effective feedback, difficulties in promoting autonomous learning among less motivated students, and the varying levels of English proficiency among students. These findings provide valuable insights for future PBL implementations, particularly in tailoring the approach to meet the specific needs of Japanese EFL university students.

Positive Outcomes of the Teaching Practice

Teacher's observations, students' written reflections, and feedback revealed several outcomes: improved language skills (particularly in presentation), deeper understanding of science experiments, improved ICT skills, and improved collaborative skills.

Students reported feeling more confident and demonstrated improved English language skills. For example, one student wrote, "It was the first time that do presentation of my experiment. It was hard, but I could learn to make research papers and ways of presentation..." Another student commented, "My last presentation went great, I had to express what I wanted to say. And I was impression of my background research because I learned a lot of things I don't know". These students' reflections highlight the positive impact of PBL in overcoming challenges and achieving success in gaining practical skills such as research and presentation delivery. The positive attitudes of EFL learners towards PBL are in line with research by Aghayani (2024) and Virtue and Hinnant-Crawford (2019).

Students also demonstrated an increased depth of understanding of their science experiments. As the lesson progressed, students' confidence increased, and they were able to explain their experiments more easily using scientific terminology. For example, a student who initially struggled to explain why fruit turns brown was, by the end, able to confidently explain how polyphenols and antioxidants in lemon juice preserve fruit freshness and why apples with holes changed color the fastest in their experiment.

Moreover, the teacher observed that the students were becoming more comfortable with ICT skills, learning to navigate the internet for research, format academic documents using Google Docs, and use presentation software tools to create their slides. This is consistent with Arabloo et al. (2021), who found that technology-aided PBL significantly improved critical thinking and problem-solving skills.

Finally, PBL improved students' collaborative skills. Students worked together by sharing responsibilities for reading and class quizzes and providing supportive feedback at different stages of the writing process and presentation. Based on students' written feedback, this collaborative environment fostered a sense of community that encouraged students to take risks and support each other. This finding is consistent with Astawa et al. (2017), who found that PBL promoted teamwork, increased students' confidence, and helped them to express their ideas. Furthermore, the mixed-proficiency groups facilitated peer learning, allowing students with different ability levels to learn from each other.

Challenges and Limitations of the Teaching Practice

Despite its benefits, PBL is not without its challenges. The effective implementation of PBL in EFL classrooms requires considerable planning, the establishment of support structures, and the design of activities that promote deeper learning (Kavlu, 2017). Teachers often act more as guides than traditional instructors, focusing on motivating students and fostering a sense of community (Habók & Nagy, 2016). This approach requires continuous monitoring of student progress by the instructor. In this EPW class, the teacher had to invest considerable time in planning and conducting individual meetings to ensure that projects were completed on time.

Providing feedback was another essential component. The instructor emphasized the importance of constructive and targeted feedback at all stages of the project, as highlighted by Simpson (2011). At the initial stage, the instructor provided personalized feedback on the students' hypotheses and research questions. During the writing stage, the instructor helped students refine their academic writing skills and develop their ideas. Finally, for their presentations, the instructor guided students on best practices for creating and delivering presentations, as well as on effectively presenting their findings.

Another challenge was teaching students how to ask insightful questions and engage in meaningful inquiries. Thomas (2000) notes that students often struggle with initiating inquiry and managing time in complex projects. Although the EPW class emphasized open-ended questions and promoted higher-order thinking skills, the use of science as content can be challenging for students with lower proficiency levels (Islam, 2022; Larmer et al., 2015).

Finally, student motivation throughout the project also emerged as a challenge. After conducting their experiments, students' engagement levels appeared to decrease, as evidenced by lower participation and fewer completed submissions during the data analysis, report writing, and presentation preparation stages. This is inconsistent with the findings of Virtue and Hinnant-Crawford (2019), who found that students were motivated to complete the project even if they were not interested in the concept.

While this practice-based teaching approach provides insights into the implementation of PBL in a Japanese EFL classroom, its limitations should be acknowledged, particularly the lack of quantitative data to assess its effectiveness in improving students' English skills. Future research should include quantitative methods, such as pre-and post-intervention surveys, to measure language proficiency gains, collaboration, and critical thinking skills. Additionally, thematic analysis of student reflections could reveal deeper insights into the impacts of PBL on student engagement, confidence, and skill development. Addressing these challenges could lead to the development of more effective strategies for maintaining student motivation and facilitating scientific inquiry in PBL settings.

Discussion

Integrating science and English language learning in a semester-long PBL project produced positive outcomes. The student-centered environment promoted active learning and improved various language skills and 21st-century skills. However, challenges such as the teachers' time commitment, the need for effective feedback and inquiry-based learning, and the difficulty of maintaining student motivation were observed.

Although the findings of this practice-based method cannot be generalized, they provide valuable insights for future PBL implementations in EFL classrooms and highlight the importance of tailoring the approach to meet the specific needs of mixed-proficiency Japanese EFL university students.

Conclusion

The implementation of a semester-long PBL science project in the EPW class at TIU demonstrated the potential of PBL to enhance language skills, foster curiosity, and promote 21st-century skills in EFL students. By engaging students in a meaningful and authentic project, PBL transformed the EPW classroom into an active learning environment, where students took ownership of their learning and developed a deeper understanding of both scientific concepts and the English language. While the teacher's observations provide important insights, this study also incorporates student reflection. Thematic analysis of students' written feedback revealed that participants experienced a progression from initial uncertainty to confidence in their ability to communicate scientific findings in English. Additionally, their reflections highlighted increased motivation and a deeper understanding of the scientific method.

Further research on the effectiveness of PBL is needed, particularly in assessing its impact on student learning, achieving measurable outcomes, and maintaining motivation. Currently, there is no standardized framework for implementing PBL, which requires instructors to independently design lesson plans, materials, activities, and assessments. While this encourages flexibility and creativity, it may not always align with well-established, research-based practices. Additionally, a common challenge with PBL lies in addressing students' limited academic backgrounds in specific subject areas.

This study demonstrates how structured resources like Science Buddies, paired with scaffolding techniques and the use of L1 materials, can effectively bridge gaps in subject-specific knowledge. Although PBL is relatively new to Japanese universities, there is a growing interest in adopting it to promote interdisciplinary learning. The successful integration of PBL into other programs, however, will depend on factors such as institutional support, resource availability, and teacher training. The methodology outlined in this study provides a practical example of how PBL, when combined with science content, can be applied in an EFL context, offering insights for broader implementation in similar educational settings.

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