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# Project-Based Learning: Theoretical Overview and Practical Implications for Local Innovation-Based Development<sup>1</sup>

**Abstract**

The *aim* of this paper is to summarise and present the main features of project-based learning (PjBL) within innovation-based development. *Methodology.* The methodology of this study involves the use of PjBL as an educational and technology transfer tool. In an educational context, it uses a structured approach where students identify real-world problems, conduct research, develop projects, collaborate on their implementation, and reflect on their experiences to deepen learning and develop critical thinking. PjBL application scenarios cover a variety of disciplines, including STEM education, social sciences, business and humanities, enabling students to apply knowledge and skills to solve real-world problems. In the field of technology transfer, a similar PjBL principle is applied to facilitate the transfer of research innovations for practical application. This involves collaborative partnerships, technology assessment, prototyping, market validation, licensing or commercialisation, fostering innovation and translating research into tangible societal benefits. This study aims to demonstrate the effectiveness and versatility of PjBL as a transformational methodology in both the educational and technology transfer contexts. *Practical implications.* PjBL encourages active, experiential learning where participants interact directly with real-world problems. This hands-on approach fosters a deeper understanding of concepts and encourages innovation by allowing participants to apply theoretical knowledge in practical scenarios. PjBL can have a long-term impact on innovation by fostering a mindset of lifelong learning and continuous improvement. The skills and experiences gained through PjBL can help people become innovative thinkers and problem solvers who will contribute to positive change in their industries and local communities. *Value/Originality.* It is substantiated that PjBL allows participants to immerse themselves in real problems or scenarios relevant to technology transfer. By working on projects that simulate the challenges faced in the transfer process, participants gain a deeper understanding of the complexities and develop practical skills that can be directly applied in technology transfer activities.

**Keywords**

project-based learning, innovations, technology transfer, projects

**JEL:** A2, B52, O31



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**1 Introduction**

In the ever-evolving landscape of education, pedagogical approaches are constantly seeking innovative methods to prepare students for the challenges of the 21st century. Project-based learning

(PjBL) has emerged as a transformative educational strategy that emphasises active engagement, critical thinking and practical application of knowledge. This research explores the importance of PjBL in fostering learning experiences, preparing students for real-world challenges and developing essential

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skills for success. PjBL transcends traditional classroom boundaries to provide students with holistic learning experiences that go beyond rote memorisation. Instead of compartmentalised subjects, PjBL integrates knowledge from different disciplines into comprehensive projects. This multidisciplinary approach reflects real-world scenarios where challenges rarely fall neatly within the confines of a single subject area. By working on projects, students learn to connect concepts, recognise patterns and apply knowledge collaboratively.

Innovation-based local development focuses on harnessing the resources and talents within a community to drive economic growth through innovation and entrepreneurship. In today's knowledge-based economy, regions that embrace innovation are better able to adapt to changing market conditions and create high quality jobs. Education plays a crucial role in this process by fostering a culture of creativity, risk-taking and lifelong learning.

Integrating PjBL into education systems can have a profound impact on innovation-based local development. PjBL equips students with the skills and attitudes needed to thrive in the knowledge economy, including problem solving, communication and teamwork. By tackling real-world challenges and working with local businesses and organisations, students develop a deeper understanding of their community's needs and opportunities.

To maximise the potential of PjBL for innovative local development, stakeholders need to work together to design and implement meaningful projects that address authentic community challenges. Professional development opportunities for educators are essential to ensure effective implementation of PjBL methodologies. In addition, policy makers should support initiatives that encourage partnerships between schools, businesses and community organisations to facilitate knowledge sharing and stimulate economic growth.

## 2 Literature Review

Project-based learning (PjBL) unfolds in the context of real problems, over a sustained period of time, and incorporates insights from multiple disciplines. When implemented and supported effectively, PjBL serves as a catalyst for the development of contemporary skills, encompassing areas such as creativity, leadership and collaboration. It immerses students in complex, real-world challenges and provides a platform for them to meet critical thinking criteria, thereby fostering a holistic and dynamic educational experience (U.S. Department of Education, 2017; Office of Educational Technology, 2015).

PjBL, which has its origins in Kilpatrick's 1918 project-based learning method and has been further developed by researchers such as Blumenfeld et al. (1991), Pecor (2015) and Severi (2006), revolves

around the organisation of learning through projects (Loyens & Rikers, 2017; Thomas, 2000). In a changing educational landscape, the combination of psychological principles and innovative pedagogy serves as a beacon to guide the creation of learning environments that inspire, empower and transform. The purpose of the article is to summarise and present the main features of project-based learning (PjBL) in the framework of innovative development.

## 3 PjBL as an Educational Tool

Consider PjBL from the perspective of modern theories of psychology and education. Albert Bandura's social learning theory emphasises the importance of social interactions in the learning process. PjBL, with its emphasis on collaborative projects, aligns with this theory by providing opportunities for students to observe, imitate and learn from their peers. Cognitive load theory, proposed by Sweller, focuses on the cognitive demands placed on learners. PjBL structures learning experiences to manage cognitive load effectively, allowing students to focus on understanding and applying knowledge rather than processing excessive information. Howard Gardner's theory of multiple intelligences proves that students have different forms of intelligence. PjBL accommodates multiple intelligences by providing opportunities for students to demonstrate their strengths and skills through a variety of project tasks. Lev Vygotsky's theory of the zone of proximal development highlights the importance of challenging tasks that are just beyond an individual's current level of competence. PjBL designs projects that are within students' zones of proximal development, providing the right balance of challenge and support for optimal learning. Experiential learning theory, developed by David Kolb, emphasises the importance of learning through experience. PjBL aligns with this theory by immersing students in hands-on, real-world projects that allow them to apply theoretical concepts to practical situations. Self-determination theory focuses on the motivation and conditions that help individuals develop and maintain intrinsic motivation. In the context of education. This theory is concerned with understanding how educators and educational environments can foster students' sense of autonomy, competence and relatedness in order to increase their motivation and engagement in learning (Chiu, Chih-Yuan Sun, Ismailov, 2022). In the symbiotic relationship between self-determination theory and PjBL, a powerful educational paradigm emerges – one that not only cultivates academic excellence, but also nurtures the intrinsic motivations and needs of learners.

PjBL projects are characterised by their complexity and challenging issues that serve as the main drivers of learning activities. According to Thomas (2000), the defining features of PjBL are as follows:

1. Projects are central to the curriculum, serving as the primary tool for students to learn new concepts.
2. Projects focus on questions that stimulate students to explore central concepts and principles.
3. Projects allow students to actively participate in the construction of knowledge.
4. Projects are largely student-driven, lacking a pre-determined path.
5. Projects maintain a realistic character.

The results of Zhang and Ma (2023) show that PjBL significantly improves students' learning outcomes compared to traditional teaching methods. The study also highlights the influence of various moderating variables (subject and course type, academic period, group size, number of students, experimental period) on the effectiveness of PjBL. This nuanced understanding underlines the need for educators to tailor project-based approaches to specific contexts, taking into account factors such as academic disciplines, course types and time dimensions to achieve optimal results.

As the use of PjBL becomes more widespread in educational settings, the optimal group size for promoting effective student learning outcomes has become a topic of considerable interest (Wei et al., 2020) and the impact of group size on academic achievement (Al Mulhim and Eldokhny, 2020).

For example, in Journey Through Hallowed Ground, a collaborative initiative with the National Park Service, students are encouraged to make deep connections with history through PjBL, specifically by creating videos documenting their visits to historic sites. Taking on different roles, students work with professional video editors to bring their stories to life. These videos enable students to articulate historical perspectives in their unique voices and share their insights with their peers. Beyond historical insights, participation in these projects cultivates students' leadership and teamwork skills (U.S. Department of Education, 2017).

Collaboration is integral and reflects the principles of problem-based learning (PBL), with educators taking on a facilitating or coaching role (Loyens & Rikers, 2017). However, a key difference lies in the role of the problem. Whereas PBL uses the problem as a means to enhance the learning process, PjBL concludes with the creation of an end product that addresses the problem or question (Blumenfeld et al., 1991). This final product serves as a reflection of the students' newly acquired knowledge or attitudes in relation to the problem under investigation and can take various forms, such as a computer animation.

The use of technology in education allows PjBL to organise learning experiences around authentic, real-world challenges. The integration of diverse digital learning tools and resources enables students to demonstrate mastery of complex concepts and content. Instead of writing a traditional research report for a limited audience of peers and a biology educator, a

student has the opportunity to publish their findings on an online platform.

In exploring the construction of persuasive arguments, another student might take a dynamic approach by designing, producing and sharing a public service announcement using online video streaming sites. Throughout the process, he actively seeks constructive feedback from his audience, encouraging continuous improvement at every stage. This shift towards technology-enhanced PjBL not only extends the reach and impact of students' work, but also cultivates a collaborative & interactive learning environment. Embracing PjBL stands out as an exceptional approach to equipping students for the demands of the digital age. This dynamic pedagogical method goes beyond traditional content delivery and uniquely promotes the cultivation of crucial skills such as effective communication, collaborative teamwork, critical thinking and the unleashing of creative potential (Gómez-Pablos et al., 2017; Castro-Vargas, Cabana-Caceres, Andrade-Arenas, 2020).

#### 4 PjBL Application Scenarios

Let's look at different scenarios and examples of the use of PjBL. By studying real-life cases and practical examples, one can gain valuable insights into the different ways in which PjBL is implemented, its impact on student engagement and learning outcomes, and the innovative approaches that educators are using to integrate PjBL methodology into the educational landscape. These case studies will provide a comprehensive understanding of the versatility and effectiveness of PjBL in different educational settings and disciplines.

The growing use of games and simulations introduces students to collaborative project experiences within the confines of their classrooms. Students actively engage in scenarios that create a sense of urgency, forcing them to decide what to measure and how to analyse data to solve complex problems. A case in point is RoomQuiver, a groundbreaking initiative that completely transforms a traditional classroom into an immersive earthquake simulation. Immersed in the reverberating echoes of earthquake sounds, students actively participate in the process by recording readings on lifelike seismographs, examining the formation of fault lines, and meticulously stretching string to accurately locate the epicentre. Another inventive application worth highlighting is the Integration of Robot-Assisted Language Learning in Education (IRALLE). In this context, Chinese language enthusiasts engage in dynamic conversations with a sophisticated robot that seamlessly uses facial expressions, gestures, and state-of-the-art speech dialogue software. The robot companion creates a unique avenue for social role-playing experiences in a new language, effectively alleviating the typical



anxieties associated with language acquisition. IRALLE not only promotes cultural sensitivity, but also catalyses the development of robust language skills and builds student confidence through a comprehensive and immersive practice environment.

Revolutionary methods are emerging that harmoniously blend physical and virtual interactions in educational technologies, erasing the divide between concrete and abstract learning encounters. Consider the groundbreaking Molecules project, where students actively manipulate a tangible ball-and-stick model representing molecules such as haemoglobin. A sophisticated camera captures the model and projects it into digital space alongside relevant scientific phenomena, revealing intricate details such as the energy field that surrounds the molecule. This seamless fusion of tangible interaction with physical models and abstract conceptualisation enables students to develop a deep and holistic understanding of the material. In a parallel innovation, primary school students use a tablet surface and stylus to illustrate mathematical scenarios, mirroring the traditional "paper and pencil" method. However, the digital medium introduces a transformative dimension, allowing them to effortlessly duplicate, move, group and morph their representations, providing a dynamic way of expressing their mathematical insights. These digital sketches are easy to share with educators, and the integration of artificial intelligence makes it easier to identify patterns in students' statements, turning their contributions into a powerful teaching resource.

The cases presented highlight the transformative potential of innovative approaches that seamlessly blend physical and virtual interactions with educational technologies. When applied to PjBL, the case suggests that incorporating interactive technologies can enhance the learning process. By using physical models and digital sketching tools, students can actively engage with complex concepts, fostering a deeper understanding of the subject matter. The dynamic nature of these approaches allows for manipulation, collaboration and exploration of ideas, which aligns well with the principles of problem-based learning. In addition, the integration of artificial intelligence to analyse students' digital sketches provides valuable insights for educators. In a PjBL context, this data-driven approach can help educators identify patterns in problem-solving approaches, tailor teaching strategies to individual needs, and facilitate more effective guidance throughout the problem-solving process.

Personalised student learning in the context of PjBL embodies a dynamic approach to education that uses technology to tailor pathways for individual student growth. The integration of technology facilitates active and collaborative learning activities, creating a learning environment that is guided by

clearly defined outcomes. In the context of PjBL, these outcomes go beyond subject knowledge to encompass interdisciplinary skills that prepare students to actively participate in the digital culture with a focus on digital literacy and citizenship.

PjBL leadership policies and teaching practices prioritise the integration of student voice and choice in the design of learning activities and the demonstration of understanding. The focus is on the creation of independent, collaborative and interdisciplinary projects and research. Assessment of these projects often includes personalised profiles or portfolios that reflect the rich nuances of students' unique learning pathways. Technology is seamlessly intertwined with these learning projects, serving as an indispensable tool for collaboration, composition and global connections (U.S. Department of Education, 2017).

In the PjBL classroom, educators take on the role of educational designers, coaches and facilitators, guiding students through their personalised learning experiences. The personalised, technology-enhanced approach to student learning not only addresses subject-specific knowledge, but also fosters essential skills such as reflection, critical thinking, persistence and perseverance – all essential components of successful project-based learning endeavours.

One of the key benefits of PjBL is its emphasis on the practical application of knowledge. Rather than memorising facts in isolation, students immerse themselves in projects that simulate authentic, real-world problems. This applied learning not only strengthens conceptual understanding, but also equips students with the skills to creatively address complex issues. Whether designing a sustainable solution, conducting scientific experiments or creating multimedia presentations, PjBL ensures that theoretical knowledge is transformed into practical expertise.

In today's world, success is often determined by an individual's ability to overcome real-world challenges. PjBL serves as a bridge between the classroom and reality, preparing students for the complexities of professional and personal life. Through projects, students develop problem-solving skills, adaptability and resilience – qualities essential for success in an unpredictable world. PjBL instils a sense of ownership and responsibility as students tackle challenges that mirror those they will face in their future careers.

Beyond academic content, PjBL prioritises the development of essential life skills. Students engaged in project-based learning naturally develop skills such as collaboration, communication, critical thinking and creativity. These skills, often referred to as 21st century skills, are crucial in a globalised, technology-driven society. PjBL empowers students to become active learners, capable of acquiring and

applying knowledge independently – a vital skill in an era of rapid information development.

### 5 PjBL as a Technology Transfer Tool

The study has shown that in the dynamic landscape of education and technological progress, PjBL is emerging not only as a pedagogical approach, but also as a powerful tool for technology transfer.

In the current landscape of the R&D&I (Research, Development and Innovation) value chain, the contemporary conceptualisation of R&D projects includes three integral components (Sterlacchini, 2008): (1) research, (2) technological development and (3) innovation transfer or entrepreneurship:

1) Research component. This strand delves into the complex relationships between variables that elucidate stress behaviour during university study. It seeks to understand their impact on performance, with a particular focus on coping strategies, an area that is an integral part of research methodology (Pateli, Giaglis, 2005).

2) Technological development component. This segment is dedicated to the creation of new ICT solutions, whether they are processes, products or services. These innovations are carefully designed to solve real-world problems encountered in professional activities and represent significant technological advances (de la Fuente, Vera, 2010).

3) Innovation transfer or entrepreneurship component. The final component revolves around the transfer and exploitation of these innovations, in particular through the service sector and targeted technology-based enterprises. These advances, rooted in the latest technological systems, represent valuable innovations ready for transfer to the professional and business sectors. Industries, technology companies and professions can actively seek and benefit from these innovations. The transfer of innovation is facilitated through various channels, including science and technology transfer seminars and the establishment of technology-based enterprise spin-offs. These mechanisms ensure an unimpeded flow of innovative ideas and technologies into the wider professional and business spheres (Oosterbeek, van Praag, Ijsselstein, 2010; Walter, Parboteeah, Walter, 2013; Pittaway, Cope, 2007).

PjBL integrates technology transfer by framing projects around real-world challenges. Students engage in projects that require the application of technological skills, reflecting the demands of the professional world. The projects, rooted in authenticity, expose students to the practical application of technology, bridging the gap between theoretical knowledge and real-world scenarios. Technology transfer is most effective when it crosses disciplinary boundaries. PjBL naturally integrates different disciplines, allowing students to apply technology in different contexts. Collaborative projects, such

as designing innovative solutions or developing technological prototypes, encourage students to draw on multiple areas of expertise, fostering a holistic understanding of the potential of technology (Ergül, Kargın, 2014). PjBL also emphasises problem-solving skills, a critical component of effective technology transfer. Students tackle complex challenges that require innovative technological solutions. The iterative nature of PjBL encourages students to think critically about the effectiveness of their technological approaches, fostering a mindset of continuous improvement.

Collaborative projects provide opportunities for students to learn from each other, share technological insights, and collectively contribute to the successful implementation of technology in their projects. PjBL gives students a sense of ownership over their projects. This ownership is a driving force for technology transfer, as students take pride in the development and implementation of their technological solutions. The entrepreneurial spirit fostered by PjBL encourages students to see technology not just as a set of skills, but as a catalyst for innovation and positive change.

The assumption that student-centred learning environments can increase student motivation is well established. The results of the meta-analysis show an overall positive, small to medium effect of PjBL on motivation. Particularly noteworthy are the positive effects on students' perceptions of control beliefs, attitudes towards learning and task value. However, in terms of students' goals and reasons for studying, a modest positive effect of PjBL was observed. It is worth noting that the positive effects span a range of studies, with larger effect sizes when implemented in higher education (Wijnia et al., 2017; Moallem, 2019). These findings have implications for policy makers and educators who wish to integrate PjBL into their teaching. They underline the importance of allowing a period of adjustment for students and educators to adapt to this method of learning. Adequate preparation and comprehensive training, as highlighted by Ertmer and Simons (2006), emerge as crucial factors for the successful implementation of PjBL.

In addition, the results suggest that PjBL has distinct effects on motivation, often exceeding the effects of problem-based learning. While some researchers use the terms interchangeably, meta-analyses emphasise the need for clear descriptions of the instructional methods under investigation (Wijnia et al., 2017). Such distinctions are crucial, as variations in such learning approaches may influence their effectiveness.

### 6 Conclusions

In summary, PjBL is emerging as a cornerstone of modern education, offering a transformative approach that meets the demands of the 21st century.

Through holistic learning experiences, practical application of knowledge, preparation for real-world challenges and the development of essential skills, PjBL equips students with the tools they need to succeed in an ever-changing world. As education evolves, the importance of PjBL in shaping engaged, critical-thinking individuals cannot be overstated – it stands as a beacon guiding students towards a future where knowledge is not only acquired, but also effectively applied.

In PjBL, leaders play a key role in shaping policies and allocating resources that provide educators with the tools and ongoing support they need to adapt personalised learning experiences in their classrooms. A spirit of collaboration among educators is central to facilitating instructional decisions based on comprehensive data analysis. This dataset includes observations, student and educator reflections, work samples, and a variety of assessment results. Integrated analytics into learning activities, combined with real-time data visualisation, supports informed decision-making.

PjBL offers a promising framework for fostering innovation and economic development in local communities. By providing students with authentic learning experiences that address real-world challenges, PjBL prepares them to become active contributors to the prosperity of their community. Moving forward, continued collaboration and investment in PBL initiatives is essential to realise the full potential of education as a driver of innovation-based local development.

PjBL is emerging as a dynamic pathway for technology transfer, positioning students as active participants in the technological landscape. By combining real-world relevance, interdisciplinary integration, problem solving, collaborative learning and an entrepreneurial spirit, PjBL equips students with the skills and mindset needed for effective technology transfer. As students engage in projects that go beyond traditional classroom boundaries, they become not only recipients of technological knowledge, but also contributors to the ongoing development of technology in society.

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