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REVIEW

Technological and Project-Based Learning Models for the Development of Informational Skills

Modelos tecnológicos y de aprendizaje basado en proyectos para el desarrollo de habilidades informacionales

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ABSTRACT

This study systematizes theoretical and empirical evidence on the integration of technological models and Project-Based Learning (PBL) in higher education, analyzing their impact on the development of informational skills. Through a review, key principles for effective implementation were identified: analogical deduction, logical consistency, systemic character, and operational simplicity. The results reveal that technology-enhanced PBL significantly improves critical thinking, collaboration, and information management. However, contextual gaps persist, underscoring the need for local adaptations. The study proposes an action framework for educators and highlights the urgency of integrating AI tools into PBL methodologies to address scalability challenges.

Keyword: Technological Models; Project-Based Learning; Informational Skills and Competencies.

RESUMEN

Este estudio sistematiza evidencia teórica y empírica sobre la integración de modelos tecnológicos y el Aprendizaje Basado en Proyectos (ABP) en educación superior, desde el análisis del impacto en el desarrollo de habilidades informacionales. Mediante una revisión se identificaron principios clave para la implementación efectiva: deducción por analogía, consistencia lógica, carácter sistémico y simplicidad operativa. Los resultados revelan que el ABP potenciado con tecnología mejora de forma significativa el pensamiento crítico, la colaboración y la gestión de información. No obstante, persisten brechas contextuales, lo que subraya la necesidad de adaptaciones locales. El estudio propone un marco de acción para educadores y resalta la urgencia de integrar herramientas de IA en metodologías ABP para abordar desafíos de escalabilidad.

Palabras clave: Modelos Tecnológicos; Aprendizaje Basado en Proyectos; Habilidades y Competencias Informacionales.

INTRODUCTION

Higher education in the context of 21st-century society demands the integration of active methodologies to meet the challenges that arise from it. The convergence between technology and pedagogy has enriched

the teaching-learning process and boosted the development of essential skills, such as critical thinking, collaboration, and information management.

However, the mere incorporation of technological tools does not guarantee effective results; a systemic approach that articulates theory, practice, and the educational context is needed. This implies applying pedagogical approaches adapted to the needs but with an innovative approach that leverages the potential offered by new technologies.[1,2]

Project-Based Learning (PBL) stands out among the active methodologies that have been implemented to foster autonomy, constructive inquiry, and the achievement of objectives.[3] It has become a fundamental axis for responding to the demands of a society in constant evolution, where technological integration enables synergy between these trends in education.[1,4,5]

PBL promotes the active participation of students in their educational process and offers an opportunity to approach teaching around technology.[6] It helps to improve technological innovation competencies, where information management plays a crucial role.[7,8,9,10,11]

In this scenario, educational models that embrace these innovative trends not only facilitate the acquisition of key skills and competencies but also act as bridges between pedagogical theory and technology-mediated educational practice. The implementation of these requires reflection on how these approaches, together with technological frameworks, can optimize the development of informational skills and, at the same time, redefine educational processes in higher education.[12,13,14,15,16]

This article examines the integration of technological models and PBL in higher education, as well as their impact on information skills training and their contribution to the transformation of educational environments. Based on a review of empirical studies and international experiences, this examination considers the epistemological principles underlying these models, as well as their application in various university contexts.

In this sense, the objective is to systematize the foundations that support the implementation of technological and ABP models in the development of information skills. The aim is to systematize elements related to innovation in educational policies.

METHOD

This study is framed within a qualitative review approach aimed at systematizing theoretical and empirical references on the integration of technological models and Project-Based Learning (PBL) in higher education. An analytical-synthetic method was employed to organize, evaluate, and interpret the available evidence, ensuring rigor in the selection and analysis of sources.

An exhaustive search was conducted in academic databases, including Scopus, SciELO, PubMed/Medline, Semantic Scholar, and Google Scholar. Artificial intelligence algorithms were used to identify the most relevant articles resulting from these searches. The key terms used were: 'technology models,' 'project-based learning,' 'higher education,' 'information skills', and 'technology-education integration' combined with Boolean operators (AND, OR). The inclusion criteria included studies published between 2010 and 2024 in Spanish, English, and Portuguese that addressed educational interventions with PBL and technology in university contexts.

From an initial total of 126 million records, 50 articles were filtered based on thematic relevance and methodological quality. Five criteria guided the final selection:

- Formal educational setting: studies conducted in higher education institutions.
- Technology-enhanced PBL: Interventions combining project methodology and digital tools.
- Information management skills: Assessment of information competencies (search, analysis, data organization).
- Type of research: Empirical papers (quantitative, qualitative, or mixed) or systematic reviews.
- Outcome measure: Clear evidence of impact on learning.

The selected studies were organized in a synthesis matrix (table 1) that categorized authors, year, methodology, technological tools used, skills assessed, and main results. For the qualitative analysis, open and axial coding were applied, where thematic patterns were identified, including the effectiveness of hybrid models, the role of the teacher as a facilitator, and challenges in implementation. Triangulation of sources enabled us to contrast findings and validate the consistency of our conclusions.

RESULTS AND DISCUSSION

Overview of modelling

Modeling is a method of scientific knowledge and a component of the scientific method used in research. It is the process of reconstructing the reality of an object of study in a contextualized way. It establishes the basis for arriving at the answers that the researcher seeks about the reality they intend to study and learn about. This method is a systematic and methodical process that favors inquiry, as well as the projection and representation of the said object of study.[17,18,19,20] For Valle[21], 'the representation of those essential characteristics of the

object being investigated, which fulfills a heuristic function, as it allows new relationships and qualities of the object of study to be described and studied to transform reality.'

Boullosa Torrecilla et al.[22] Modelling is 'an auxiliary, material or ideal intermediate system, the result of a creative process of abstraction and generalization which, with its theoretical-practical foundations, explains and represents, with the logic that characterizes the object of study, the necessary relationships.'

As a method, it makes it possible to obtain a 'model' of the universe of discourse that is the subject of study. The term 'model' has received different definitions; however, it is agreed that it is a structure of symbols and operational rules that provides a set of relevant facts about a given process.[14,19] They are conceived as a means to relate the main entities and factors involved in the phenomenon under study, which in the educational field is related to training processes.[23]

As defined by Pereira[24], a model is 'the representation of the object of study to be transformed with a systemic structure characterized by specific features, methodological aspects, and scientific theoretical foundations.' This definition is assumed and coincides with the approach of Magalhães de Sá et al.[25] regarding the same, where they state that the models implemented in terms of the teaching-educational process favor the improvement of skills in the context in which students receive teacher accompaniment.

Corona et al.[20] states that modeling as a scientific method:

- It constitutes a gnoseological procedure (of knowledge),
- It limits the diversity of known phenomena,
- Organises the amount of information,
- It relays the information (from the phenomenon being studied to the researcher).

There are essential principles that models must comply with:[18,20,26]

- Deduction by analogy is the logical process that allows inferring properties, relationships, or behaviors of a modeled system. For this purpose, knowledge of the similarity with other systems is taken into consideration. This principle is based on abductive reasoning. In other words, structural and/or functional relationships are established between the entities represented.
- Logical consistency: there must be internal coherence between the postulates of the model to avoid contradictions in the theoretical formulation of the model. This consistency implies compatibility between the parts based on the rules of deductive or inductive validity. This principle is fundamental in avoiding fallacies and ensuring that the model is falsifiable and reproducible.
- Systemic character: the model is conceived as a set of interrelated elements that generate properties or relationships that do not function independently. It requires identifying causal or feedback relationships between entities. In addition, it is essential to analyze the patterns of complex organization within the recognized boundaries of the system's environment that makes up the model. It enables more holistic approaches to multifaceted phenomena.
- Simplicity and affordability establish a preference for the simplest representation that requires the fewest assumptions for understanding the model. It implies explanatory efficiency. Unnecessary overfitting and complexity should be avoided to ensure the model's operational viability. The clarity in communication, replicability, and adaptability to diverse empirical contexts are sought without losing rigor.

These principles are crucial for constructing model proposals, particularly in the educational context. These principles address an epistemological and pragmatic need in model construction, legitimizing them from an academic perspective and grounding them in praxis. This triangulation between theory, systematicity, and applicability is what makes it possible to propose a solid conceptual framework.

For this reason, the model acquires special relevance by allowing the identification and analysis of new connections and attributes in the object of study, oriented towards transforming reality from a simplified perspective.[27]

According to their degree of abstraction, models can be organized into three fundamental categories:[28]

- Iconic model: represents the real object through a scale replica, which preserves the shape, proportions, and distinctive features.
- Analog model: It does not reproduce all aspects of the original system, but it highlights the structural relationships and specific key properties of the phenomenon.
- Theoretical model: utilizes a symbolic system to describe the properties of the object of study, enabling it to represent essential relationships, provide interpretations of the phenomenon, and serve as a basis for formulating hypotheses.

Various authors have proposed multiple criteria for classifying models, among which categories such as technical, experimental, biological, natural, iconic, analogical, theoretical, logical-mathematical, symbolic,

digital, educational, pedagogical, and didactic stand out.[14,25] Although some sources present equivalent or parallel classifications, it is decided to assume those mentioned above, as they do not conflict with the existing systematizations in the specialized literature.

According to Giere[28], in the study of how methods are used to represent reality, he considers that model classifications are not exclusive and can respond to different needs in establishing relationships between elements. Based on this logic, the author assumes the classification of the theoretical model, according to the level of abstraction, for the design of the proposal.

Technological models

With the technological development mentioned above, the increasing complexity of training work has led to a reevaluation of the roles and functions of teachers and tutors. In this context, professionals are needed who are focused on providing students with access to information and generating new knowledge.[29]

Hence, the integration of technologies in educational models not only represents the incorporation of new tools but also implies a profound transformation of teaching and learning processes. This integration enables the creation of more complex, collaborative, and interactive learning environments where technology serves as a facilitator for the development of information skills and the personalization of educational processes.

The technological model has its roots in the United States during the 1970s, a period in which computers began to be incorporated into various spheres of human activity. Over time, this model has evolved and reached higher levels of maturity. It is based on the integration of information and communication technologies within an integrated approach to interaction, oriented towards both prevention and development.[30]

Alvarez[31] proposes the technological model as a resource that enriches the role of the teacher, whether as a teacher, tutor, or counselor. This model is conceived as an interactive system capable of generating stimuli and providing feedback to the student by simulating the entire process. Thus, it not only acts as a simplified representation of reality but also as a guiding reference for educational action.

In the technological approach, the tutor assumes the role of mediator in the process, acting as a facilitator who intervenes when the situation demands it or when the student requires it. Moreover, in this model, administrative or bureaucratic processes -such as the management and correction of tests, improvised suggestions, or superficial arguments- are relegated to the background since the student, by the time they come to the counselor, has already identified the problem and has had enough time to analyze and prepare possible solutions.[31]

According to Álvarez[31], the defining characteristics of these models are as follows:

- Remote intervention.
- Directed at both individuals and groups.
- Located outside the institution.
- Directed towards prevention and development.

Technological models (which can be integrated with other types of models) emerge as a critical proposal in the face of training approaches that focus only on the instrumental use of educational technology. It is a holistic model that seeks to transform the various dimensions of teaching work, understanding digital technology as a mediator that facilitates professional updating, collaborative interaction, improved learning management, and the promotion of innovation.[32,33]

The technological model considers the integration of new technologies in the design and implementation of the educational intervention project. It is oriented towards solving problems detected in the academic context to achieve the expected results both within and outside the academic context, thereby promoting the improvement of educational quality.[34]

It is a comprehensive approach that incorporates digital resources to facilitate the teaching and learning process in various contexts. They aim to address the challenges of education in the information society, including the need for efficient hybrid systems. They include multiple modalities and approaches, such as ubiquitous learning and the flipped classroom, which utilize information and communication technologies (ICTs) to enhance the educational experience.[35,36,37]

According to Olmos-Peña et al.[36] and León-Garrido et al.[35], technological models aim to adapt to the evolving needs of higher education. This can be achieved through the integration of cloud-based platforms and resources, facilitating more flexible and personalized learning.

However, the mere incorporation of information technologies into education does not, by itself, guarantee improvements in learning outcomes. For implementation to be effective, it is necessary to integrate them into a coherent and theoretically supported design. In this sense, the technological model is linked to a university organizational structure that promotes flexible and personalized teaching, free from the traditional restrictions of time, space, materials, and human resources.[30]

In concrete applications, this model is materialized in digital platforms hosted on institutional portals,

where guidance, tutoring, and academic support functions are articulated. These platforms must incorporate diverse tools that facilitate attention to the individual needs of students, address specific learning difficulties, strengthen study skills, and support the development of comprehensive guidance programs.[30]

Project-Based Learning Models

In recent decades, Project-Based Learning (PBL) has emerged as one of the most effective pedagogical methodologies for promoting active student participation and enhancing the development of critical thinking skills.[38] This type of learning experience has been dramatically enhanced by the use of digital technologies.

PBL, as a pedagogical approach, is supported by a variety of methodological and technological resources aimed at strengthening discipline-specific skills and competencies. This strategy encourages students to adopt an iterative approach as they encounter challenging situations in real-world contexts through dynamic processes of communication, idea generation, and collaborative implementation. It has contributed to a greater capacity for adaptation in work environments based on empathy and individual empowerment, which in turn has had a positive impact on the efficiency and speed of professional practice.[39]

As Cruz et al.[39] point out, PBL has provided educational actors with a space for developing skills through an innovative training process focused on resolving problem situations. These are approached flexibly and creatively, taking as a starting point the prior knowledge of both students and teachers.

According to Romero-Carbonell et al.[40], this is an active methodology that promotes group work through collaborative tasks or dynamics. Its value lies in fostering student autonomy, inquiry-based learning, the achievement of specific goals, teamwork, communicative exchange, and critical reflection, all framed within projects connected to real-world situations.

PBL maintains a solid theoretical foundation centered on collaboration, grounded in the principles of constructivism and cooperative learning. It is a complex methodological proposal that requires careful planning and strategic management, as it seeks transformations in both the environment and the organizational structure, as well as in the knowledge and attitudinal dispositions of the participants. This strategy involves tackling an unpublished or as yet unresolved challenge, which requires the articulation of knowledge and resources beyond traditional schemes, with a commitment to resolve it within a set timeframe.[41]

Evidence highlights the benefits of PBL as a catalyst for the meaningful acquisition of interdisciplinary knowledge and for strengthening student motivation and responsibility. This approach requires active student participation, as well as the adoption of new pedagogical strategies, flexible teaching management, systematic monitoring and evaluation processes, and a collaborative framework that fosters the collective construction of knowledge.[41]

A relevant example of its successful implementation has been documented by Mulyahati et al.[42], who applied a hybrid model of PBL in the Language and Literature Learning Development course in primary education. The results indicated a positive impact on the development of critical and creative thinking skills, as students' active knowledge construction and problem-solving were stimulated. Although this experience is at an elementary level of education, its contributions are valuable for understanding the potential of PBL in fostering critical thinking across various educational contexts.

At Stanford University (United States), PBL has proven to be an effective strategy for achieving the intended learning outcomes of the curriculum. This methodology provides students with the opportunity to face real challenges during project execution, enabling them to design concrete products as a result of their learning experience. Furthermore, the process contributes to the development of key skills for solving complex tasks by actively integrating digital technologies into the academic environment.[43]

It is increasingly being implemented in various university degrees across different contexts, and the online adoption of this methodology is becoming more frequent. For this reason, linking this learning with technology plays a crucial and empowering role in 21st-century society.

Technologies have contributed to the accessibility of diverse educational resources, as well as the consolidation of skills for the administration of highly complex academic projects.[44] Collaborative and information management platforms have proven to be highly effective in the structuring and management of projects for teaching or research purposes. These tools enable students to improve their technological management skills while tackling real-life problem situations.[38]

In the development of information skills, the use of the PBL approach is timely, as it contributes to the improvement of critical thinking skills, which were identified as a shortcoming in the previous chapter. It is shown to be a holistic methodology conducive to the continuous improvement of tutors' skills.

Technology and Project-Based Learning Models

The authors systematized the implementation of models that fit the characteristics of technology and project-based learning models. Given that no contextualized references were found for the field of higher education in Health Technologies in Cuba, the context in which the object of study is framed and to which the

modeling method is intended to be applied in subsequent studies, a more comprehensive and in-depth search was necessary for elements that would demonstrate the relevance of these types of models.

An exploration was carried out based on the question, 'How does a technological educational model of project-based learning impact the development of information management skills?' To answer this question, a search was conducted using artificial intelligence algorithms across more than 126 million indexed academic articles. As a result, the 50 most relevant articles were retrieved according to the algorithm's relevance criteria. A screening process was carried out where the papers were ranked according to compliance with the following criteria:

- Educational setting: was the study conducted in a formal educational setting?
- Technology-enhanced PBL: Does the study examine an intervention that combines technology tools and a project-based learning methodology?
- Information management skills: Does the study measure at least one aspect of information management skills (finding, evaluating, organizing, or using information)?
- Type of research: Is the study (a) original empirical research (quantitative, qualitative, or mixed methods) OR (b) a systematic review/meta-analysis?
- Measurement of outcomes: Does the study include specific measures or assessments of information management skills development with clear learning outcomes?

Table 1 presents the distribution of the 50 identified studies, categorized by the level of agreement with the selection and evaluation criteria applied. The most widespread criterion was the contextualization of the studies in formal educational settings, with a total of 40, where the level of agreement was high. Only 14 studies examined models of technology-enhanced PBL, and nine were limited to information management or information literacy skills. Measurement of outcomes has not been a frequent focus of such studies.

From this screening, data extraction was carried out from the studies that showed results closer to what was expected. This allowed for a closer examination of the experiences reported regarding the impact of technology-supported PBL models.

Table 1. Screening of studies all 50 studies according to selection and evaluation criteria

Criteria	Definition	Matching level		
		High	Medium	Under
Educational environment	Was the study conducted in a formal educational setting?	40 (80,0 %)	5 (10,0 %)	5 (10,0 %)
Technology-enhanced PBL	Does the study examine an intervention that combines technological tools and a project-based learning methodology?	14 (28,0 %)	23 (46,0 %)	13 (26,0 %)
Information management skills	Does the study measure at least one aspect of information management skills (searching, evaluating, organising or using information)?	9 (18,0 %)	23 (46,0 %)	18 (36,0 %)
Type of research	Is the study (a) original empirical research (quantitative, qualitative or mixed methods), or, (b) a systematic review/ meta-analysis?	34 (68,0 %)	8 (16,0 %)	8 (16,0 %)
Outcome measurement	Does the study include specific measures or assessments of information management skills development with clear learning outcomes?	6 (12,0 %)	31 (62,0 %)	13 (26,0 %)

In this way, five studies were identified that provided evidence of the impact of PBL models incorporating technology to enhance the development of information management skills. All of these achieved a transition to higher levels in the skills that enable them to search for, organize, analyze, integrate, use, and evaluate information using various types of technological platforms, including virtual environments, simulators, mobile devices, and collaborative spaces.[38,45,46,47,48] Other studies provide specific evidence (table 2).

Table 2. Characteristics of selected studies on technology-enhanced PBL

Study	Type of implementation	Methodology	Technological tools used	Skill type	Results
Cano et al.,[45] 2011	PBL using virtual libraries	Action research	Virtual libraries, online platforms	Skills in digital library navigation and information integration.	12/14 students demonstrated advanced information integration skills.
Mendoza et al.,[46] 2013	PBL with the use of mobile digital tools	Case studies	Mobile learning platforms	Skills in searching, filtering and using information.	Improved higher order cognitive tasks on enriched platforms.

Campos et al.,[48] 2017	PBL with ICT	Action research	ICT tools for information management	Skills in the use of ICT	Individuals achieve effective use of ICT to search, process and share information.
Castro Tesén,[47] 2018	Integration of digital tools	Pre-experimental design	Mindomo, Cmap Tools, Prezzi, wikis	Skills in the use of information technology tools	Significant improvement from low to normal/high levels.
Quiroz Moreira et al.,[38] 2024	PBL with the use of digital tools	Quasi-experimental	Google Workspace, interactive simulation tools and collaborative applications	Skills for the organisation and analysis of data	Improved data organisation and analysis skills.

Campos et al.[48] describe the effective use of ICT tools to search, process, and share information, while Cano and Maldonado-Salazar[45] report that 12 out of 14 students in a medical program improved the integration and analysis of information through the use of virtual libraries. Castro-Tesén[47] reports significant improvements, as measured through pre-and post-tests, in the handling of digital tools by university students, evidenced by higher-quality academic documents and a shift in attitudes towards the use of information. These studies demonstrate the effectiveness of integrating these typologies of models in developing information skills.

It has also been identified that the use of collaborative platforms, mobile applications, simulation, and reference systems is associated with the promotion of higher-order tasks.[38,46] This element, in particular, is relevant, given that it was a weakness recognized in the characterization that took place in the previous chapter, where it was found that the least developed skills in tutors were of a higher order.

CONCLUSIONS

The study systematized the rationale underpinning the implementation of technology and PBL models in the development of information literacy skills. It showed that the combination of these elements significantly enhances the development of such skills in higher education. The analyzed cases demonstrated measurable improvements in higher-order skills, including critical thinking and collaborative work.

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CONFLICTS OF INTEREST

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