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SYSTEMATIC REVIEW

Strategic Analysis in Project-Based Learning Models (PJBL) To Encourage Self-Regulated Learning: Systematic Literature Review

Análisis Estratégico en Modelos de Aprendizaje Basado en Proyectos (PJBL) Para Fomentar el Aprendizaje Autorregulado: Revisión Sistemática de la Literatura

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ABSTRACT

Students' self-regulated learning (SRL) skills are one of the things that support the achievement of 21st century skills. The Project Based Learning (PjBL) model has been studied both empirically and theoretically to have suitability in its steps to teach SRL. The steps of the PjBL model and SRL are interrelated as pedagogical approaches and competencies that need to be achieved in an educational process. However, for the PjBl model to maximize students' SRL, additional strategies are needed that can be used simultaneously. Empirical research in this regard has been conducted, thus the purpose of this study is to examine the kinds of additional strategies and ways to integrate them in the PjBl model so as to promote learners' SRL. A systematic literature review method has been used. Six themes were generated related to the kinds of strategies used, namely the use of technology and digital platforms, integration of interdisciplinary approaches such as STEM/STEAM, data-driven analytic approaches, reflective and metacognitive strategies contextual and cultural learning, and self-management and social collaboration. How to integrate it in learning activities with the PjBl model is discussed next.

Keywords: Project-Based Learning; PjBL; Self-Regulated Learning; SRL; Self Eficacy.

RESUMEN

Las habilidades de aprendizaje autorregulado (SRL) de los estudiantes son una de las cosas que apoyan el logro de las habilidades del siglo XXI. El modelo de Aprendizaje Basado en Proyectos (PjBL) ha sido estudiado tanto empírica como teóricamente para tener idoneidad en sus pasos para enseñar SRL. Los pasos del modelo PjBL y el SRL están interrelacionados como enfoques pedagógicos y competencias que deben alcanzarse en un proceso educativo. Sin embargo, para que el modelo PjBl maximice la SRL de los estudiantes, se necesitan estrategias adicionales que puedan utilizarse simultáneamente. Se han realizado investigaciones empíricas a este respecto, por lo que el propósito de este estudio es examinar los tipos de estrategias adicionales y las formas de integrarlas en el modelo PjBl para promover la SRL de los alumnos. Se generaron seis temas relacionados con los tipos de estrategias utilizadas, a saber, el uso de la tecnología y las plataformas digitales, la integración de enfoques interdisciplinarios como STEM/STEAM, los enfoques analíticos basados en datos, las estrategias reflexivas y metacognitivas el aprendizaje contextual y cultural, y la autogestión y la colaboración social. A continuación, se analiza cómo integrarlo en las actividades de aprendizaje con el modelo PjBl.

Palabras clave: Aprendizaje Basado en Proyectos; PjBl; Aprendizaje Autorregulado; SLR.

INTRODUCTION

In the context of 21st century education, there is a fundamental shift from a teacher-centered learning model to an approach that emphasizes learners' self-regulated learning (SRL). This era demands individuals who are not only able to receive information, but also have the initiative, responsibility and capacity for lifelong learning. Zimmerman's (2000) SRL model is organized in three phases: forethought, performance, and self-reflection.[1] In the thinking ahead phase, students analyze the task, set goals, plan how to achieve them and a number of motivational beliefs energize the process and influence the activation of learning strategies. In the performance phase, students actually carry out the task, while they monitor how they are progressing, and use a number of self-control strategies to keep themselves cognitively engaged and motivated to complete the task. Finally, in the self-reflection phase, students assess how they have performed the task, making attributions about their success or failure.

The importance of SRL is affirmed by various recent studies. For example, Lobos et al highlighted that SRL is crucial for academic success in higher education, as it enables learners to plan, monitor and evaluate their own learning process.[2] In addition, Zabaleta & Izaguirre show that autonomy support from educators has a significant impact on the development of learner independence, emphasizing that this ability is not necessarily inherent but can be developed through appropriate learning experiences.[3] Therefore, modern education should be designed to empower learners to have SRL. This means creating learning environments that encourage learners to set goals, choose effective learning strategies, and reflect on their progress, rather than relying solely on teacher direction. Thus, the focus of education shifts from "what is taught" to "how learners learn," preparing them with relevant skills for future success.

The Project-Based Learning (PjBL) learning model is based on constructivist ideas that effectively place learners as active subjects in the process of seeking knowledge and building understanding.[2,4] In PjBL, learners engage in authentic projects that are challenging and relevant to the real world, encouraging them to construct knowledge through exploration, discovery, and problem solving.[5,6] The advantage of PjBL lies in its ability to significantly promote the development of essential 21st century skills. Recent studies have shown that PjBL substantially improves students' collaboration and communication abilities as they work in teams to achieve common project goals, share ideas and resolve conflicts.[3,7] In addition, the nature of projects that often involve real-world challenges directly exercise problem-solving and critical thinking skills. PjBL also fosters independent learning as learners have greater autonomy in planning, executing and evaluating their work, which is essential for lifelong learning.[8,9] Thus, PjBL is not just a teaching method, but a comprehensive framework to prepare learners for the complexities of the modern world.

Although PjBL is recognized as having great potential to improve learners' SRL, its implementation in the field often faces challenges that hinder its optimal effectiveness. One crucial issue is that the implementation of PjBL does not always result in the expected increase in learning independence.[3] This may be due to a variety of factors, including a lack of teacher training in facilitating projects that truly encourage student autonomy, or project designs that do not sufficiently challenge learners to take initiative and full responsibility for their learning.[4] Furthermore, there is significant variation in strategies for implementing PjBL across different educational contexts, ranging from primary to higher education, and across different disciplines.[2] Unfortunately, there is currently no systematic mapping or clear consensus regarding which strategies included in PjBL are most effective and specifically encourage and develop learners' SRL. This lack of comprehensive understanding of optimal strategies makes it difficult for educators to design and implement PjBLs that consistently maximize learners' potential to become effective independent learners.[5] Therefore, further research is needed to identify and test the strategies included in PjBL that prove to be the most effective. [5] Therefore, further research is needed to identify and test the strategies included in PjBL that prove most efficient in developing learners' SRL in diverse learning environments.

The results of this systematic literature review can be translated into practical recommendations, PjBL design frameworks, or even evaluation instruments that help educators implement PjBL more confidently and successfully, ultimately empowering students to become competent independent learners in the 21st century. Based on this background description, the research objective in this systematic literature review is to examine additional strategies and how to integrate them in the PjBl model to encourage learners' SRL.

METHOD

The systematic literature review method used to develop this report refers to the PRISMA guidelines recommended by Page et al.[01] This guide is a refinement of the PRISMA guide according to Moher et al.[11]

Eligibility Criteria

The articles reviewed in this report only use articles that have been peer-reviewed and netted from several databases. The eligibility criteria set in this report include 1) discussing the PjBl model in encouraging learners' SRL, 2) discussing additional strategies integrated in the PjBl model to encourage learners' SRL, 3) articles published after 2004 or approximately the last 20 years (this determination is based on the results of a review that shows that the trend of research related to PjBl and SRL increased during that time). This review did not include articles that only discussed one of PjBl or SRL.

Search Query

Article searches were conducted on 3 databases namely scopus, ERIC, and Sematic scholar. Keywords related to the purpose of the systematic literature review were first defined and combined using Boolean and OR operators. The keyword combinations used were (PjBL OR "Project based learning" OR "Project-based learning") AND ("self-regulated learning" OR "Self-regulated learning" OR "self-regulation" OR "Metacognition and learning").

Study selection

The initial search obtained 320 articles with details of the number of articles obtained from each database, namely sematik scholar: 39, scopus: 24, ERIC 257. A total of 251 articles were obtained after passing the duplicate check stage. The next review process was carried out by checking the titles and abstracts that did not contain keywords related to PjBl/Project Based Lerning, and Self-Regulated Learning (SRL), articles as conference papers, not in English, and systematic literature reviews were not included in this analysis. This resulted in 40 articles that met the inclusion criteria. After in-depth review, there were 6 articles that were not empirical studies and did not use additional strategies in PjBl to encourage learners' SRL. Finally, 17 articles met the criteria and were included in this analysis. The results of the screening with the described procedure can be shown in figure 1.

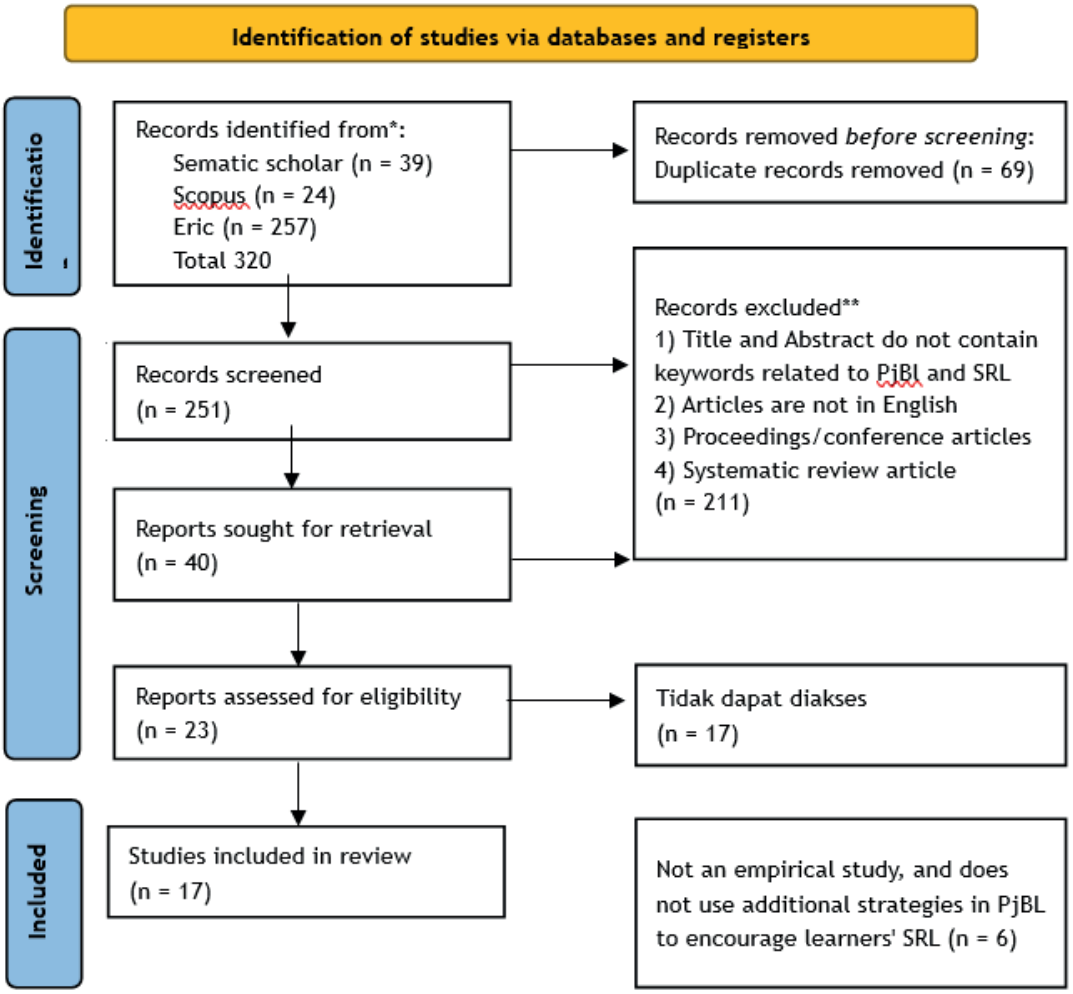

Figure 1. Flowchart of the literature selection process with the PRISMA method

These articles were then analyzed and grouped through the coding process for further discovery. The data was summarized using an excel table and then using the VosViewer facility (figure 2) to provide an overview of the most popular keyword trends used in the articles.

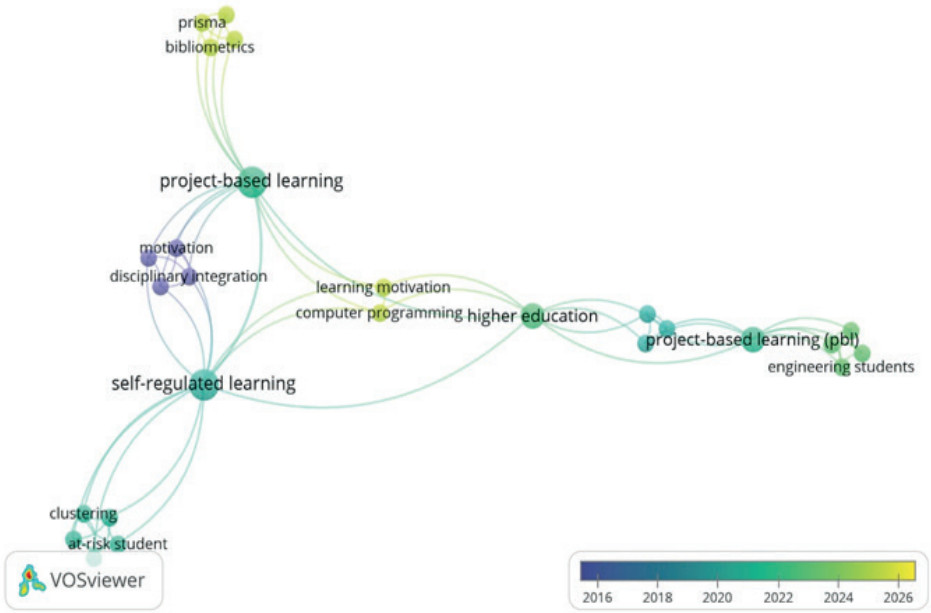

Figure 2. Vosviewer Mapping for Keywords in Reviewed Articles

RESULTS

Types of Additional Strategies Used with the PjBl Model to Promote Students' SRL and the General Scope of the Empirically Reviewed Articles

When mapping the 17 articles obtained through this search, it can be seen that the publication of empirical research related to the implementation of the PjBL model using additional strategies to encourage SRL has been carried out since 2009 (n = 1) but very rarely, then the most publications were recorded in 2024 (n = 4). The distribution of research was mostly conducted at the level of university students (n = 8), followed by high school students (n = 7), then in early childhood education and elementary school students each n = 1. Based on the distribution of research subjects, it can also be revealed that the results of this analysis can be considered to be applied to secondary school research subjects and higher education levels. The general scope of the 17 empirically reviewed articles is shown in table 1.

Table 1. General Scope of Empirically Assessed Study and Type of Strategy Used

No	Author Name (Year of Publication)	Journal Name	Research subject, field of study, and country	Type of Research	Types of Strategies integrated in the PjBl model to encourage SRL
1	Berkeley et al.[12]	Journal of Educational and Developmental Psychology	High school students with disabilities (science field) United States	Multiple case study	Creation of computer-based Serious Educational Games (SEG)
2	Chamrat & Suyamoon[13]	Journal of Technology and Science Education	Higher education students (future science teachers) Thailand	Mix Method combines qualitative and quantitative methods	A 5-activity STEM assessment strategy that integrates the DIY conceptual framework (Do It Yourself, Tinker, Maker.
3	Cohen & Magen-Nagar[14]	American Journal of Distance Education	Junior High School Students (Scientific Technology Reserve) Israel	Quantitative, two group posttest survey	Online academy program with a flipped classroom approach provided on the website
4	Fernández-Morante et al.[15]	Sustainability MDPI	Secondary School Students (Science Field) Spain	Mix Method combines qualitative and quantitative methods	STEM projects with integration of other disciplines such as Humanities, Arts, Social sciences (HASS)

5	Sáiz-Manzanares et al.[16]	Apply Science MDPI	Higher Education Student (Health Department) Spain	Quantitative based on data analysis of student activity logs in LMS	Learning method in virtual environment using Moodle LMS platform to analyze student log data with Educational Data Mining (EDM) technique.
6	Han[17]	Educational Sciences: Theory & Practice	High school students (measures how much students are asked to choose STEM majors) Korea	Quantitative descriptive and correlational, using a survey approach.	Teaching STEM in a PjBl learning environment
7	Stolk & Martello[18]	International Journal of Engineering Education	Higher education student (majoring in engineering) United States	Mixed methods combine qualitative and quantitative methods	Integration of different disciplines in engineering courses
8	Ekatini[19]	Al-Bidayah : jurnal pendidikan dasar Islam	Elementary school students (Science field) Indonesia	Experimental Pretest-Posttest Control Group Design	Using the theme of water project as an alternative energy source
9	Sagita et al.[20]	Journal of Research in Science Education	Secondary school students Indonesia	Descriptive Observational	Engage students in discussion of inquiry and thinking processes Using student learning management tactics
10	Zarouk et al.[21]	International Journal Of Emerging Technologies in Learning (iJet)	College students (majoring in economics, tourism, translation, and science of information) Portugal	Quasi-experimental Pretest-post test 4 groups	Flipped project-based learning approach (SRPBL)
11	Zheng et al.[22]	American Society for Engineering Education	College student (Engineering major) Mississippi, USA	Action researc	Combining the SRL model with Expandable Intelligence (EI) and instructed in PjBl
12	Windyaningsiwi et al.[23]	Physics Communication, Journal UNNES	Secondary school students (physics subject) Indonesia	Quasi-experimental with Nonequivalent Control Group Design.	Use of e-modules specifically designed to support learning of renewable energy topics
13	Kamtini et al.[24]	Budapest International Research and Critics in Linguistics and Education (BirLE) Journal	Early childhood Indonesia	Quantitative research type with Experimental approach	Recurrent strategies in implementing SRL-based PjBl
14	Valdivia-Yábar & Apaza-Tapia.[25]	Evolutionary Studies in Imaginative Culture (ESIC)	College students Peru South America	Descriptive quantitative	Integration of the tutor's role in fostering an environment that supports collective efficacy.
15	Chung[27]	Jurnal Asosiasi Konten Korea	College student (English major) Seoul Korea	Quantitative descriptive non-experimental	Use of reflection journals by students to track SRL use
16	Wu[28]	Heliyon. ScienceDirect	College students (In English Lessons) China	Quantitative approach with a quasi-experimental design and using advanced statistical analysis techniques	Menggunakan Microanalysis, Latent Profile Analysis (LPA), Epistemic Network Analysis (ENA).
17	Rosmayanti et al.[29]	Journal of Language Learning and Assessment	High school students (in English lessons) Indonesia	Quantitative quasi-experimental	Integrating local wisdom in the PjBl model

How to Integrate Additional Strategies in the PjBl Model to Promote Learner SRL

In table 2, a cross-study synthesis of how each strategy was integrated or used in conjunction with the PjBl

model to promote learners' SRL is presented. This synthesis also provides a grouping of findings according to the type of additional strategies, examples of implementation, mode of integration, and main effects on SRL presented in each of the articles reviewed.

Table 2. How to Integrate Additional Strategies in the PjBl Model to Teach Learners' SRL and its Effects

No	Grouping of additional strategy types	Example of implementation in the reviewed articles	How to integrate additional strategies in the PjBl model	Number of Studies (n)	Main Effects on SRL
1	Use of Technology and Digital Platforms to Support SRL	SEG based Computer[12]; Moodle LMS and Educational Data Mining/ EDM platforms[16]; renewable energy electronics modules[23]; Web-based flipped classrooms organized in an online academy[14]; Flipped project-based learning approach/SRPBL.[21]	Using digital platforms to facilitate project planning, monitoring, reflection and collaboration	6	Improved self-efficacy, engagement, and metacognitive awareness; identification of students' SRL profiles
2	Integration of STEM/STEAM/ Interdisciplinary Approach	STEM integrating the DIY, Tinker, Maker conceptual framework[13]; STEM with the integration of other disciplines such as Humanities, Arts, Social Sciences (HASS)[15]; Teaching STEM in a PjBl learning environment[17]; Integration of different disciplines in Engineering courses.[18]	Combining STEM principles with humanities/arts, or DIY-Tinker-Maker approach in projects	4	Enhance critical thinking, creativity, reflection, and collaboration; foster intrinsic motivation and learning responsibility
3	Reflective and Metacognitive Strategies	Iterative strategies in implementing SRL-based PjBl[24]; Combining SRL model with Expandable Intelligence (EI) and instructed in PjBl[22]; Integration of tutor role in fostering an environment that supports collective efficacy[25]; Use of reflection journals by students to track SRL use.[27]	Iterative strategies, self-reflection, goal setting, monitoring, and journal/tutor-based evaluation	4	Improved reflection, goal-setting, and motivation skills; social support strengthens self-regulation
4	Analytical and Data-Driven Approach	Using Microanalysis, Latent Profile Analysis (LPA), Epistemic Network Analysis (ENA)[28]; EDM on LMS.[16]	Using study data analysis to monitor students' SRL profiles and behaviors	2	Reveals variations in individual and group SRL profiles; enables adaptive interventions
5	Contextual and Cultural (Authentic Learning)	Local wisdom-based PjBL[29]; PjBL model with the theme of water as an alternative energy project.[19]	Relate the project to the local context and real issues	2	Increase students' self-directed learning, motivation, and emotional engagement
6	Self-Management and Collaborative Approach	Metacognitive discussion[20]; the role of tutor.[25]	Engage students in planning, strategy evaluation, and time management	2	Improved planning and self-control skills in group work

Based on table 2, it can be revealed that from the 17 studies reviewed, it shows that the integration of additional strategies in the PjBL model to support SRL tends to be grouped into six themes, namely: 1) use of technology and digital platforms, 2) integration of interdisciplinary approaches such as STEM/STEAM, 3) reflective and metacognitive strategies, (4) data-based analytical approaches, (5) contextual and cultural learning, and (6) self-management and social collaboration.

The results of this synthesis indicate that technology-based strategies are the most frequently used (approximately 35 % of studies). Technology types such as LMS/Moodle, computer-based SEG, e-modules, flipped

classrooms, and web-based MOOCs play a significant role in flexing student learning autonomy, facilitating reflection, and enabling independent monitoring of student progress. Although these technology-based strategies have been reported as successful by the reviewed studies, their effectiveness remains dependent on the presence of pedagogical scaffolding and structured opportunities for reflection.

Second place is occupied by STEM and STEAM-based interdisciplinary strategies (approximately 25 % of studies). These strategies have been shown to strengthen the cognitive dimension of SRL, which includes critical thinking, problem-solving, and knowledge transfer between domains. However, several studies,[13] reveal that the reflective aspect is often the weakest component and requires special attention from educators.

Reflective and metacognitive strategies (approximately 20 % of studies) were ranked third, including the use of reflective journals, personal goal setting, and the tutor's role in collective efficacy, which were consistently associated with increased self-awareness and learning motivation. These findings confirm that structured reflection and feedback are central to effective self-regulated learning. Furthermore, two studies using data-driven analytical approaches (EDM, LPA, ENA) introduced new directions in PjBL-based SRL research, ranking fourth. By leveraging learning analytics, researchers can identify students' SRL patterns and design more adaptive personalized interventions.

Finally, contextual and cultural strategies, such as the integration of local wisdom and alternative energy projects, highlight the importance of contextual relevance and authenticity in fostering self-directed learning. Learning based on local experiences not only increases students' emotional engagement but can also strengthen personal responsibility in managing the learning process.

Overall, the emerging pattern suggests that SRL does not develop automatically in PjBL, but relies heavily on additional strategies that explicitly teach and guide students in managing their learning process. Reflective strategies and social support (tutor/peer feedback) proved to be the most consistent reinforcers for the planning, monitoring, and self-evaluation phases within the PjBL model framework.

DISCUSSION

This study aims to identify additional strategies as well as ways of integration or use in the PjBl model to encourage students' SRL. Based on the presentation and synthesis results in tables 1 and 2, it can be seen that the types of additional strategies used vary greatly but can be grouped into six main themes namely 1) use of technology and digital platforms, 2) integration of interdisciplinary approaches such as STEM/STEAM, 3) data-driven analytical approaches, (4) reflective and metacognitive strategies (5) contextual and cultural learning, and (6) self-management and social collaboration. However, the most frequently used additional strategies were technology integration in the form of web-based flipped classrooms (n=3), integration of different disciplines and STEEM projects (n=4). This is supported by Marnola et al.[30]; Gambo et al.[31] who state that the use of online discussion forums and digital tools can further enhance SRL by encouraging collaboration, self-monitoring and independent problem solving, especially when combined with technology-supported learning environments. However, educators often integrate some additional strategies. Among others, a supportive learning environment is essential, including structured guidance, clear expectations and regular feedback, which helps students plan, monitor and reflect on their learning.[23,32,33] Each of the identified common themes will be discussed in detail as follows:

The first is the utilization of technology in the form of digital platforms. Technology integration in the PjBl model to support students' SRL is seen in the use of strategies such as computer-based SEG, flipped classroom, web utilization, hybrid blanded learning, e-modules, moodle/LMS platform. It can be seen that these components can be integrated singly or together in the PjBL model. According to Khalil et al.[34];Álvarez et al.[35]; Sui et al.[36], technology can promote SRL learning by providing tools and environments that support goal setting, self-monitoring, and self-evaluation, which are key SRL processes. Digital platforms, such as learning management systems and online self-assessment tools, can help students plan, track and reflect on their learning, while adaptive technologies and AI-driven interventions offer personalized feedback and guidance to develop SRL skills. In addition concept mapping software, mobile devices and teaching agents have been shown to enhance cognitive, metacognitive and motivational strategies, making it easier for learners to organize knowledge, monitor progress and stay motivated.[37,38] Blended and online learning environments, when designed with SRL in mind, can improve learning outcomes by integrating features that promote autonomy, resource management and emotional engagement.[39,40,41]

Second, interdisciplinary integration. This includes HASS integration, teaching STEM, as well as integration of different disciplines with the core being studied. According to DiDonato[42]; Bransen[43] interdisciplinary integration can significantly improve SRL by providing authentic and complex tasks that require students to plan, monitor, and adapt their learning strategies across multiple domains. When students engage in interdisciplinary projects, they are challenged to connect concepts from different fields, which promotes deeper cognitive engagement and the development of SRL skills such as goal setting, self-monitoring, and reflection. Collaborative interdisciplinary tasks also promote co-regulated learning, where students support each other's regulatory

processes, further enhancing individual SRL growth over time. In a student-centered integrated curriculum, learners develop unique strategies for managing and synthesizing information from multiple disciplines, strengthening their ability to self-regulate across the planning, performance, and reflection phases of learning.[44] Technology integration in interdisciplinary contexts can also support SRL by offering tools that facilitate independent inquiry and self-assessment.[45]

Third, Data-driven analytic approaches for in-depth detection and analysis of SRL dynamics profiles. This theme is a summary of techniques used to monitor students' reflective and metacognitive strategies (fourth theme). These techniques include the use of EDM, microanalysis, LPA, ENA, reflection journals. The detection and in-depth analysis of self-regulated learning (SRL) profiles is critical to understanding and supporting diverse learners. Research consistently shows that students exhibit different SRL profiles ranging from highly self-regulated to slightly self-regulated which are associated with differences in academic achievement, motivation, engagement and even personality traits.[46,47,48,49] Identifying these profiles through methods such as latent profile analysis or educational data mining allows educators to tailor interventions and teaching strategies to meet the specific needs of each group, rather than applying the same approach to all groups.[50,51] For example, students with low SRL benefit more from targeted support, whereas students with high SRL may require different challenges or less intensive interventions.[51] In addition, SRL profiles can be predicted by factors such as achievement motivation, teaching attendance, and learning experiences, further informing personalized educational practices. Analyses using behavioral trace data and self-reports reveal that actual learning behaviors often differ from student perceptions, which highlights the value of in-depth, data-driven profiling for accurate support.[52,53] Overall, such a nuanced analysis not only improves academic outcomes but also helps design adaptive learning environments that foster self-regulation skills in various educational contexts.

Fifth, contextualization of learning. This theme includes integrating local wisdom, using the theme of renewable energy projects, using PjBL in teaching SRL as a recurrent strategy. Contextualizing learning is increasingly recognized as important in teaching self-regulated learning (SRL). Research shows that approaches such as contextualized teaching and learning (CTL), which connect academic content to real-life situations, can significantly improve students' self-regulation skills, motivation, and engagement, leading to better learning outcomes compared to traditional methods.[54,55,56] Contextual factors including learning environment, subject matter, and social context play an important role in shaping how students organize their learning, as SRL is not just an individual process but is influenced by situational and environmental variables.[57,58,59] Research shows that students' motivation, strategy use and self-efficacy can vary across different subjects and contexts, suggesting that SRL instruction should be tailored to specific learning environments. Furthermore, effective SRL teaching involves direct strategy instruction and the creation of learning environments that require students to actively manage their learning, with contextualization serving as the primary indirect support.[60] Overall, integrating contextual elements into SRL instruction helps students better understand, apply, and adapt self-regulation strategies, making contextualization a critical component in fostering effective self-regulated learners.

Sixth, self-management and social collaboration such as strategic tutoring. This theme includes the role of tutors for collective efficacy, engaging students in thinking and discussion of inquiry projects, management of learning tactics, expandable intelligence. Strategic tutoring has been shown to significantly improve self-regulated learning (SRL) by providing personalized instruction and scaffolding that helps learners develop metacognitive knowledge, effective learning strategies, and greater self-efficacy. Approaches such as strategic content learning models and explicit strategy-based instruction have resulted in consistent improvements in students' ability to plan, monitor, and control their learning processes, as well as transfer these skills to a variety of tasks and contexts, regardless of prior achievement or experience.[61,62,63] Intelligent guidance systems and pedagogical agents that encourage and guide learners in SRL strategies further enhance learning gains, increase effective strategy use, and foster motivation and engagement.[64,65,66,67] The intervention is effective across multiple domains, including language learning and STEM subjects, and benefits both academic and non-academic outcomes.[68] Evidence suggests that strategic guidance whether provided by human tutors or adaptive technologies maximizes SRL by supporting learners in setting goals, self-monitoring and reflecting on their progress, ultimately leading to improved learning outcomes and greater autonomy.

Overall, the main mechanism that can be suggested from all these findings is that different types of additional strategies in PjBL work synergistically. Technology integration provides external support, interdisciplinary principled learning expands the context for thinking, reflection processes strengthen self-awareness, and collaboration for strategic tutoring fosters co-regulation. The combination of these components strengthens students' ability to set goals, manage time and resources, and evaluate their learning outcomes independently.

The results of this synthesis also have significant theoretical and practical implications. Theoretically, the results of this analysis deepen the understanding of SRL by showing that self-regulation is not just an individual ability, but a process formed through social interaction, technology integration, and contextualization of learning, as well as a process of reflection. The integration of the six additional strategy themes strengthens

the SRL framework by adding contextual and collaborative dimensions to the PjBL model. Practically speaking, teachers, lecturers and curriculum developers can use these findings as a basis for designing project-based learning that better supports SRL. Technology integration in the form of utilizing digital platforms and analytics systems, for example, can be used to help students monitor their own progress. Interdisciplinary integration and contextualization of learning can foster relevance and engagement, while the application of structured reflection and adaptive guidance can increase students' metacognitive awareness. Therefore, the results of this synthesis provide strategic directions that can be used to design learning with PjBl models that are adaptive and centered on student self-regulation.

This synthesis has provided comprehensive insights, but some limitations need to be noted. First, the data used comes from secondary literature, so the results are highly dependent on the context of previous studies. Secondly, most of the studies analyzed focus on higher and secondary education contexts and do not fully represent primary education. Third, the analysis process has not considered moderating factors such as learning culture, motivation, or discipline that might affect the effectiveness of additional strategies in the PjBL model to promote SRL. Therefore, future research is recommended to implement a process that can empirically verify through experimental or longitudinal studies, as well as explore how this combination of additional strategies works differently in various educational contexts. Future research also needs to consider the integration of analytic data with direct reflective practice for more accurate monitoring of SRL and impact on improving students' learning autonomy.

CONCLUSIONS

Based on the literature review, it appears that the use of additional strategies to teach SRL through the PjBl model is essential. The most commonly used strategies relate to the use of technology in mediating learning and are dominated by the use of flipped classrooms. There is also integration of disciplines, in-depth profile detection and analysis for SRL dynamics, contextualization of learning through consistent repetition of strategies, integration of local wisdom relevant to learning, as well as, the use of project themes that are in line with students' daily lives. In addition, strategic tutoring in project-based learning is no less important because teachers and peers in the group as tutors can foster collective efficacy through shared thinking, discussion of project investigations, and management of learning tactics. One aspect of strategic tutoring such as expandable intelligence (EI) can also help students in maximizing SRL especially when experiencing challenges. Students can be directed to choose other strategies that utilize these challenges as opportunities to continue to grow rather than as obstacles. Finally, the findings in this literature review report can be utilized by teachers to collaborate various strategies, or choose certain strategies that are thought to be in accordance with student characteristics, learning environment, and curriculum demands to be applied in conjunction with the PjBl model to encourage learners' SRL.

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