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Project-Based Learning Strategy Enhancing the Environmental Awareness of the Centennials Generation: A Systematic Review

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ABSTRACT

Purpose: The present systematic review aimed to analyze and synthesize the existing scientific evidence regarding the effectiveness of project-based learning strategy in enhancing environmental awareness among students of the Centennial generation. **Methodology:** The PRISMA 2020 method was employed to conduct this systematic review. The databases utilized included ScienceDirect, Scopus, Web of Science, and university repositories, using the search strategy ("project-based learning" OR PBL) AND ("environmental awareness") AND ("alpha generation" OR "primary education" OR "primary level" OR "schoolchildren") in both Spanish and English. **Findings:** A total of 10 articles met the inclusion and exclusion criteria, containing a cumulative sample size of 455 participants. Experimental, correlational, and mixed designs were identified. Standardized instruments for creativity assessment were not found. Correlational findings revealed a significant moderate to strong positive correlation ranging from 0.517 to 0.960. **Implications to Research and Practice:** The studies indicate that PBL is a suitable methodology for enhancing environmental awareness, fostering motivation, teamwork, and problem-solving orientation. Contrary to expert suggestions, the reported number of stages is reduced without compromising effectiveness.

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1. Introduction

Environmental consciousness, defined as the understanding and concern for environmental issues, as well as individual and collective responsibility for the protection and preservation of the environment, is crucial in addressing contemporary environmental challenges (Bendix et al., 2013; Contreras Díaz et al., 2021). A relevant aspect in the development of students' environmental consciousness is the education they receive, with environmental education playing a central role. It is only through environmental education that an atmosphere of knowledge related to human interaction can be created. Another significant aspect of the development of environmental consciousness involves the psychological, cognitive, emotional, and social processes at play, as students continue to develop these processes when confronted with real-life situations. This simultaneously influences the formation of values and attitudes directed towards a sustainable and balanced communal vision, aiding in the integration of responsible environmental consciousness (Aliaga-Herrera et al., 2022; Castellanos-Navarrete, 2021; Furst et al., 2019).

Students of the centennial generation, i.e., those born between 1997 and 2010, also known as digital natives (Cristancho García, 2021; Luque-Alcaraz et al., 2022), have encountered difficulties in the development of their environmental consciousness due to information overload through the internet and social media exposure. This can lead to information fatigue and a reduction in their attention and commitment to environmental issues. Furthermore, urban living and a lack of direct connection with nature, along with the influence of a materialistic consumption culture, divert their attention away from environmental concerns and encourage a focus on personal consumption (Contreras Díaz et al., 2021; Cristancho García, 2021).

Project-Based Learning (PBL) is an instructional approach designed to provide students with the opportunity to propose or create projects that generate interest in the person-environment interaction concerning contemporary challenges. This approach allows for the development of creativity, critical thinking, and task and time management, ultimately fostering autonomy in learning. PBL emerges as an educational strategy capable of addressing these challenges and promoting environmental consciousness in the centennial generation (Ávila Romero & Periñan Pérez, 2022). PBL engages students in problem-solving or product creation that requires the application of scientific concepts, enabling them to autonomously conduct research, work collaboratively, stimulate their creativity and motivation, and seek solutions to problems (Domenech-Casal, 2018; Martinez Valdés, 2021).

However, despite the interest and increasing application of PBL in education, there is a need for an updated systematic review that rigorously evaluates the effectiveness of the project-based learning strategy in enhancing environmental awareness among Centennial students. In response to this need, this systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify, select, and critically assess relevant scientific literature, providing a synthesis of studies investigating the effectiveness of PBL as an educational strategy to improve environmental awareness among Centennial students.

This systematic review seeks to answer key questions such as: What are the effects of the project-based learning strategy on enhancing the environmental awareness of the Centennial generation? What other variables have been evaluated in previous studies? What are the contexts in which these strategies were implemented and the reported outcomes? The analysis of existing literature will allow the identification of patterns, knowledge gaps, and areas for future research. Ultimately, this systematic review would contribute to the existing knowledge about effective educational strategies for promoting environmental awareness among Centennial students, identifying strengths, limitations, and areas that require further investigation. The evidence collected and analyzed from this systematic review can provide a strong foundation for the development of future research and the implementation of effective educational interventions that address environmental challenges and foster sustainable environmental consciousness among the Centennial generation.

2. Methodology

- *Research Design*

The present study is a systematic review that adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 standards. It was designed to plan, search for, and select high-quality articles that provide an answer to the research question (Page et al., 2021). The article selection for the study was confined to quantitative research articles with experimental, pre-experimental, quasi-experimental, or non-experimental designs. The intervention variable consisted of the application of a program or strategy based on the Project-Based Learning (PBL) method, without considering the number of sessions. The outcome variable was environmental awareness, measured using instruments that demonstrated evidence of validity and reliability. The results considered statistical outcomes from T-tests and ANOVA tests, along with their significances.

- *Inclusion and Exclusion Criteria*

Several inclusion and exclusion criteria were used for the selection of articles. Included in this study were quantitative research articles with experimental, pre-experimental, quasi-experimental, or non-experimental designs. The other inclusion criteria were: the title should clearly indicate it as a systematic review; a justification for the review be presented in accordance with existing knowledge on the topic; research question(s) must be formulated taking into account participants, intervention, outcomes, and study design; there must be clear inclusion and exclusion criteria specified in each article. In addition, it was also ensured that the databases used for the search were identified; the search strategy was explicitly presented; the study selection process and data extraction method were clearly outlined; the list of PICOS elements for which data were sought was presented; and the method for assessing risk of bias was described. Keeping in view the protocol, it was also ensured that the number of studies screened and assessed for eligibility should have used the PRISMA flow diagram; the study characteristics be presented in a specific table; main findings be summarized; findings and limitations were discussed; and a general interpretation of the findings and future implications be offered.

The excluded items included the publication of the protocol, statistical summary measures, result synthesis, additional analysis for meta-analysis, and individual study results. The meta-analysis criteria were also excluded from the review process.

- *Search Strategy and Databases*

The search of articles for the current review was conducted on titles and abstracts in both Spanish and English, and it included articles published from 2017 to 2023. The search was filtered to include only printed articles while excluding reviews and books. The search involved both keywords and Boolean operators, forming the following strategy: in Spanish ("aprendizaje basado en proyectos" OR ABP) AND ("conciencia ambiental" OR "cuidado ambiental" OR "conciencia ambiental") AND ("generación alfa" OR "educación primaria" OR "nivel primario" OR "escolares"), and in English ("project-based learning" OR PBL) AND ("environmental awareness") AND ("alpha generation" OR "primary education" OR "primary level" OR "schoolchildren").

Additionally, gray literature search was conducted using the strategy ("aprendizaje basado en proyectos" OR ABP) AND ("conciencia ambiental" OR "cuidado ambiental" OR "conciencia ambiental") AND ("generación alfa" OR "educación primaria" OR "nivel primario" OR "escolares") in theses published in university repositories indexed in Google Scholar, from May 26 to May 30, 2023. Databases such as ScienceDirect (https://www.sciencedirect.com/), Scopus (https://www.scopus.com), and Web Of Science (https://www.webofscience.com/wos/woscc/basic-search), were chosen as they provide peer-reviewed, high-quality studies that aligned well with the search terms. Other databases were excluded due to lack of positive results.

The results generated by the search strategy were managed using the reference manager Zotero, which aided in removing duplicate articles. Subsequently, articles were selected based on their titles and abstracts. Full texts were requested for the selected articles, and those without full access or not available were excluded. Articles with full access were evaluated for methodological and statistical quality to determine their inclusion in the review. This process is depicted in Figure 1.

- *Data Extraction and Synthesis of Findings*

Selected articles were subject to data extraction using an Excel spreadsheet designed for the study, recording information such as publication details (author, year, country), population details (age, range, etc.), intervention information (e.g., Project-Based Learning strategy, number of sessions), and outcome details (influence on environmental awareness in primary school students, reported as significant improvement or non-significant improvement, including F or T-test results along with their significance where applicable). A descriptive synthesis of the findings was conducted, and an evidence table was constructed for the selected studies. The information gathered in the table was used to compare study details, analyze and summarize the results of each study. Data synthesis was also carried out with consideration of both methodological aspects and aspects related to effectiveness.

- *Risk of Bias Assessment*

Finally, the bias risk assessment was carried out which enabled the determination of the methodological quality of the studies included in the review. Following the guidelines

of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist, this assessment involved a rigorous analysis of key aspects such as study design, population selection, variable definitions, data collection, and statistical analysis.

3. Results and Discussion

Figure 1 illustrates the selection process, which initially identified 975 documents, consisting of 83 articles and 892 reports. After processing using the reference manager Zotero, 15 duplicate articles were eliminated. Among the remaining documents, each was reviewed based on title and abstract, resulting in a preselection of 85 files, comprising 68 articles and 17 studies. These were subjected to full extraction and review in accordance with the inclusion and exclusion criteria, yielding 7 articles and 12 studies. Following the comprehensive review, 4 articles and 4 studies were excluded. Ultimately, 10 complete documents that met the inclusion and exclusion criteria were selected for the review. These documents exhibited quality evidence and addressed the research question.

From the selected articles for this review, information was extracted and analyzed in accordance with the study's objectives. The following sections present, first, the results related to the methodological aspects of the chosen studies, and second, aspects that enable the evaluation of the effectiveness of Project-Based Learning strategies in enhancing environmental awareness among regular education students of the Centennial generation.

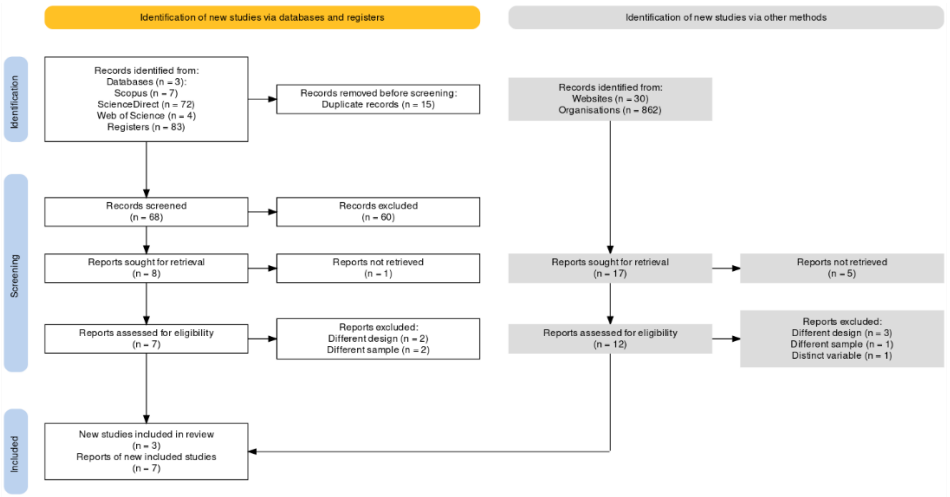

Figure 1: *Flowchart of the Article Selection Process for Inclusion in The Review. Note. Article Selection Process.*

- *Methodological Aspects*

Analyzing the methodological aspects enabled the identification of trends in the field. Table 1 presents the variables of all the ten selected articles, which include the database where the study was located, the type of research design, educational level, sample size, and the teaching area where the study was conducted.

Table 1

Methodological Aspects of Participating Studies in the Review.

Author and year	Data base	Design	Educational Level	Sample size	Teaching area
1. Derevenskaia (2014)	ScienceDirect	Pre-Experimental	Primary	30	Environmental sciences
2. Gkiolmas et al. (2020)	ScienceDirect	Pre-Experimental	Secondary	7	Environmental sciences
3. Ruiz Vicente et al. (2020)	Scopus	Pre-Experimental	Primary	30	Environmental sciences
4. Ayerbe-López and Perales-Palacios (2023)	Repository	Pre-Experimental	Secondary	26	Biology and geology
5. Hancco Huamani (2023)	Repository	Correlational	Secondary	95	Not applicable
6. Elizalde-Velázquez and Gómez-Oliván (2021)	Repository	Pre-Experimental	Primary	22	Environmental sciences
7. Flores et al. (2022)	Repository	Pre-Experimental	Secondary	27	Art
8. Limon-de la Rosa et al. (2022)	Repository	Mixed: Quantitative -Qualitative	Primary	47	Biology
9. Ñaccha Casaverde (2020)	Repository	Correlational	Secondary	76	Not applicable
10. Sánchez-Cortez et al. (2023)	Repository	Mixed: Quantitative -Qualitative	Primary	95	Natural sciences

Note. Data Extracted from the Selected Articles.

In terms of the distribution across databases and sources used in the search, out of the 10 identified articles, 70% (n = 7) were university thesis publications in repository, 20% (n = 2) were from ScienceDirect, and 10% (n = 1) was from Scopus. According to the results, it can be observed that this field has seen more development within universities. However, these results have not translated into publication in indexed journals and remain in the realm of grey literature. This underscores the need to publish such work in academic journals.

Regarding the type of research design, studies were classified as experimental, quasi-experimental, pre-experimental, and correlational. An experimental design involves intentional manipulation of independent variables within a controlled context to analyze the consequences of this manipulation on the dependent variable. For an experiment, both groups should be randomly selected (Cooper et al., 2020; Hernández-Sampieri & Torres, 2018). A pre-experimental design differs from experimental in that there is only one group, often not selected randomly, yet it aims to analyze the effects of an independent variable on a dependent variable (Hernández-Sampieri et al., 2018). Among the selected articles, 60% (n = 6) utilized a pre-experimental design, and 20% (n = 2) employed this design within a quantitative phase as part of a mixed-methods approach. These studies met the defined criteria for inclusion in a systematic review, although some non-experimental

works could have been excluded. Future reviews could focus on the qualitative production in this field to enable more extensive meta-synthesis and organization.

Regarding the sample sizes of the studies, they ranged from 7 to 95, with an average of 45, totaling 455 students. The diversity in sample sizes indicates that an appropriate number of participants for these studies has yet to be established, and recommended numbers for such studies (Cooper et al., 2020) have not been consistently followed. Concerning the disciplinary areas covered by the studies, 50% (n = 5) were conducted within environmental sciences, environmental studies, or natural sciences. A smaller proportion related to Biology (20%, n = 2), with other areas like Art also present. There is a marked predominance of the environmental sciences and related fields, indicating that environmental awareness is primarily a central focus in these subjects.

- *Aspects Related to Effectiveness*

To assess the effectiveness of the Project-Based Learning strategy as a tool for enhancing environmental awareness among Centennial generation students, the following variables were considered: the Project-Based Learning strategy, the objective of its application, the number of sessions or stages involved, the measurement instrument used for assessing environmental awareness, and the obtained results, as shown in Table 2. The selected studies reported the use of the Problem-Based Learning methodology. According to various authors, this strategy involves the application of knowledge, specifically for diagnosing, interpreting, and proposing solutions to addressed problems. Its implementation promotes collaborative work, self-learning, confidence, responsibility, and student integration (Martinez Valdés, 2021).

However, there are differences in objectives evident. While the search strategy included environmental awareness, it also yielded results related to environmental sciences. In 30% (n = 3) of cases, objectives such as improving environmental culture or environmental care were presented. This aligns with other authors' observations that the PBL strategy can foster motivation and the formation of more active and healthy social networks, facilitating significant and enriching learning experiences (Briones et al., 2023). Future research could expand the topics addressed to include other aspects of social and personal development that enable the formation of individuals capable of addressing upcoming challenges.

The study's findings revealed a significant correlation between the implementation of Project-Based Learning (PBL) and environmental consciousness, with coefficients ranging from 0.517 to 0.960. These results indicate that the application of the PBL approach is substantially associated with improvements in levels of environmental consciousness. Specifically, the use of this pedagogical strategy has a positive and significant impact on the acquisition of knowledge and attitudes that favor the protection and care of the environment by students. These results are consistently aligned with existing literature, which supports the effectiveness of PBL in improving students' knowledge and attitudes regarding environmental issues.

The effective implementation of PBL with the aim of enhancing environmental consciousness requires the selection of projects that addresses relevant and genuine environmental problems while promoting interdisciplinarity and fostering self-regulation

and critical thinking among students. Formative feedback should be employed by educators to guide students in problem-solving throughout the project. Policymakers should support ongoing teacher training, facilitate access to resources and technology, integrate PBL into educational policies, and measure outcomes in terms of environmental awareness and action. Researchers play a crucial role in identifying best practices, conducting long-term studies, and developing robust assessment tools to enrich the successful implementation of PBL and enhance environmental consciousness. Collaboration between educators, policymakers, and academics is essential for preparing future generations to address environmental challenges in an interdisciplinary and sustainable manner.

Evolving research areas in the field of Project-Based Learning (PBL) and environmental education address essential aspects of the effectiveness and sustainability of this pedagogical approach. These areas include long-term assessment of the impact of PBL on students' environmental consciousness throughout their educational and professional trajectories, the identification of crucial features of successful projects, and the potential of technology and digital resources to enhance the learning experience. It also included adapting PBL to address inclusivity and diversity, effective teacher training in PBL implementation, rigorous assessment methods to measure students' environmental awareness and competencies, and the influence of PBL on local communities and interinstitutional collaboration. Furthermore, comparing educational systems and cultures in relation to PBL in environmental education and transferring models to different contexts added valuable dimensions to this research area. These research themes offer a holistic and enlightening perspective on the contribution of PBL to promote environmental awareness and sustainability in various educational and cultural contexts, in line with the goals of the scientific journal.

Another observed variable was the number of stages considered in the application of PBL, which ranged from 3 to 5 sessions, with an average of 4 stages. Notably, 90% of studies reported the number of stages. However, there is no consensus or established standard for the number of stages, as each program adopts the number it deems appropriate. Nevertheless, among the studies that reported the number of stages, 90% (n = 9) reported the minimum recommended number, which varies between 3 and 10 (Cobo Gonzales & Valdivia Cañotte, 2017; Trujillo et al., 2015). This disparity in the number of stages highlights the need for future research to standardize the stages to enhance study outcomes.

The evaluation instrument variable identifies the impact of the PBL strategy on environmental awareness. In 70% of the studies, as seen in Table 2, researchers developed ad hoc questionnaires, while in 30% (n = 3), they used academic products as evaluation instruments. These findings align with those of other authors, who point out that there is still no single instrument to assess the effectiveness of PBL on the desired variable. Instead, it's the educators who choose the evaluation method (Cobo Gonzales et al., 2017; Rodríguez & Vílchez, 2015; Trujillo et al., 2015). Although proposals for standardized instruments to assess environmental awareness exist, they have not been widely disseminated or supported by psychometric studies (Furst et al., 2019; Torres-Soto et al., 2022). This situation hinders the comparison of effectiveness between studies since there isn't a standardized instrument to measure environmental awareness among Centennial generation students (Ding, Lenhart, & Behncke, 2014).

Table 2

Variables Relevant to Effectiveness.

Author and year	Strategy	Aim	Number of stages	Evaluation instrument	Results
1. Derevenskaia (2014)	Project Based Learning	Improve environmental awareness	3 stages	Academic product	The PBL strategy is useful to improve environmental awareness, due to its characteristics it allows children to develop responsibility and guides them towards problem solving.
2. Gkiolmas et al. (2020)	Project Based Learning	Improve environmental awareness	5 stages	Academic product	The PBL strategy allowed students to investigate in depth about the problem and look for specific solutions.
3. Ruiz Vicente et al. (2020)	Project Based Learning	Improve environmental awareness	5 stages	Ad Hoc Questionnaire	The PBL strategy significantly improved the environmental awareness of primary school children who showed better performance in the evaluations.
4. Ayerbe-López et al. (2023)	Project Based Learning	Improve environmental awareness	5 stages	Academic product	The PBL strategy significantly improved environmental awareness, increases motivation, however, students demand guidance and guidance.
5. Hancco Huamani (2023)	Project Based Learning	Improve environmental culture	5 stages	Ad Hoc Questionnaire	There is a moderate positive correlation (rho=0.517*).
6. Castillo-Velazquez and Silva-Lopez (2022)	Project Based Learning	Improve environmental awareness	5 stages	Ad Hoc Questionnaire	PBL significantly improves environmental awareness in 5th grade students.
7. Flores et al. (2022)	Project Based Learning	Improve environmental awareness through the use of the 3Rs	3 stages	Ad Hoc Questionnaire	PBL significantly improves environmental awareness, during the process children develop social skills, such as assertiveness, autonomy, leadership, cooperation, conflict resolution and empathy.
8. Navarro-Espinosa et al. (2022)	Project Based Learning	Improve environmental awareness and care for the environment in the face of climate change	4 stages	Ad Hoc Questionnaire	ABP's strategy significantly improves environmental awareness and promotes care for the environment.
9. Ñaccha Casaverde (2020)	Project Based Learning	Improve environmental culture	does not report	Ad Hoc Questionnaire	There is a moderate positive correlation (rho=0.960*)
10. Sánchez-Cortez et al. (2023)	Project Based Learning	Improve knowledge of natural sciences	3 stages	Ad Hoc Questionnaire	The PBL is an active strategy that allows to improve the knowledge about the natural sciences.

Note. Data extracted from the selected articles.

Table 3

Bias Risk Assessment.

Author and year	Study design	Setting	Participants	Variables	Measurement	Bias	Study size	Statistical methods	Main results	Overall
1. Derevenskaia (2014)	Low	Low	Unclear	Low	Unclear	Unclear	Unclear	Unclear	Low	Unclear
2. Gkiolmas et al. (2020)	Unclear	Low	Unclear	Low	Low	Unclear	Unclear	Unclear	Low	Unclear
3. Ruiz Vicente et al. (2020)	Low	Low	Unclear	Low	Low	Unclear	Unclear	Low	Low	Low
4. Ayerbe-López et al. (2023)	Low	Low	Unclear	Low	Low	Unclear	Unclear	Low	Low	Low
5. Hancco Huamani (2023)	Unclear	Low	Low	Low	Low	Unclear	Low	Unclear	Low	Low
6. Castillo-Velazquez et al. (2022)	Low	Low	Unclear	Low	Low	Unclear	Unclear	Low	Low	Unclear
7. Flores et al. (2022)	Low	Low	Unclear	Low	Low	Unclear	Unclear	Low	Low	Low
8. Navarro-Espinosa et al. (2022)	Unclear	Low	Low	Low	Low	Unclear	Low	Unclear	Low	Low
9. Ñaccha Casaverde (2020)	Unclear	Low	Low	Low	Low	Unclear	Low	Low	Low	Low
10. Sánchez-Cortez et al. (2023)	Unclear	Low	Low	Low	Low	Unclear	Low	Low	Low	Low

Note. N = 10

Regarding the results obtained by each study, all of them affirm that the PBL strategy significantly improves environmental awareness and care. It promotes teamwork, motivation, creativity, and problem-solving. This allows us to conclude that PBL is a valuable tool for educators to enhance environmental awareness among Centennial generation students, as depicted in Table 2. The full-text articles that were excluded were due to the following reasons: a different research design that doesn't allow determining the effectiveness or influence of the PBL strategy on environmental awareness (Ávila Romero et al., 2022; Barracosa et al., 2019; Castellanos-Cárdenas & Gómez-Álvarez, 2023;); studies with different age groups or populations (Polo Ahumada & González Padilla, 2022; Pratomo et al., 2019; Supadol et al., 2014); studies with different independent variables (Callagher & Cullis, 2021).

The information presented in Table 3 shows 70% of the reviewed studies exhibit a low overall risk of bias, while 30% indicate an uncertain risk of bias, suggesting that the majority of the reviewed articles possess a robust methodological quality. This consistency and quality in the evidence underpin the reliability and utility of the studies included in the review, thereby enhancing the validity of the findings and

conclusions drawn in this analysis. Analyzing the type of publication revealed that the majority were master's theses located in university repositories at 40% (n = 4), followed by academic journal articles also at 40% (n = 4). This situation highlights the need to promote the publication of academic studies in indexed journals within this field.

4. Conclusion

The results of the study address the research question of how the PBL strategy significantly can improve environmental awareness among Centennial generation students. The effectiveness of this strategy persists even when adopting a lower number of stages than suggested by proponents of programs or models like Cobo Gonzales et al. (2017) Trujillo et al. (2015) and, who propose between 3 and 10 stages. The standardization of stages becomes necessary to enhance the effectiveness of the PBL strategy. Future research could delve into defining the necessary characteristics such as the number of stages, activity development process, duration of each session, and other pertinent aspects for implementing the PBL strategy to yield optimal results.

Subsequent investigations could focus on creating measurement instruments for environmental awareness in alignment with common academic standards for each educational level. Although some instruments to measure environmental awareness exist, there is still no consensus on their widespread use in the educational realm. Particularly, investigating the evidence of validity and reliability of instruments for each educational level would be relevant.

As limitations of the reviewed studies, it has been observed that there is limited literature available in indexed journal publication databases concerning the use of PBL to enhance environmental awareness among elementary and secondary students. Most of the studies were in university repositories and followed a pre-experimental design, which could impact the robustness of their results. On the other hand, the total sample size of 455 students limits the generalizability of the results, and therefore, these findings should be approached with caution, and further research is encouraged. As a limitation of the article selection process, it should be noted that a second review of the selected and excluded articles was conducted, resulting in a 60% removal rate among the studies. Last, but not the least, the absence of a standardized instrument for assessing environmental consciousness may lead each study to have its own definition and scope of this variable, which can impact the interpretation of the results.

The current study contributes to educators and researchers by offering an updated and organized perspective on academic productions regarding the use of the PBL strategy to enhance environmental awareness among Centennial generation students. The study also presents questions and limitations revealed in the conducted research, which can pave the way for future research directions.

- *Statement of Contributions by Authors*

The authors declare that they contributed in the following roles: E.W.S.A. contributed to the management of the research process, information retrieval, data management, research development, article review, and article writing. G.J.V.C. contributed to the management of the research process, information retrieval, data management, article

review, and article writing. N.A.L.A. and F.F. S.T contributed to the management of the research process and research development. C.M.P.L. contributed to information retrieval, review, and writing.

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