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Review

The Effects of Using Socio-Scientific Issues and Technology in Problem-Based Learning: A Systematic Review

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Abstract: Currently, a growing number of learning institutions at all educational levels are including problem-based learning (PBL) in their curricula. PBL scenarios often utilise technology and socio-scientific Issues (SSI), which enables the simultaneous learning of content and creative thinking and working skills needed in generating new knowledge for the future. In this sense, using SSI and technological tools in PBL learning environments can be viewed as a starting point for acquiring and integrating new knowledge. However, there is no comprehensive knowledge regarding the possibilities of this approach. The objective of this systematic review is to produce this knowledge via the PRISMA method. The strategy is used to explore the effects of the described approach through implementations conducted at secondary and undergraduate levels. The data consisted of 33 research articles that were categorised via qualitative content analysis. According to the results, PBL scenarios exploit mainly local SSIs that link scientific knowledge with a meaningful context for students. Technology is principally used in offering technical support for teaching tasks. Lastly, these results are discussed from the technological pedagogical science knowledge (TPASK) framework perspective, which proposes guidelines for achieving the Sustainable Development Goals (SDG).

Keywords: problem-based learning; socio-scientific issues; science education; technology education; sustainable development goals; TPASK

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1. Introduction

Various reports indicate low levels of scientific knowledge in students from Europe, Latin America and the Caribbean [1,2], which are mainly due to traditional teaching methodologies that are often decontextualised and focus on teaching rather than learning.

The Organisation for Economic Co-operation and Development (OECD) declared scientific literacy as the ability to teach sciences at a global level [3]. In this vein, the United Nations Educational, Scientific and Cultural Organization (UNESCO) developed the Sustainable Development Goals (SDG) as an opportunity to develop knowledge, skills, attitudes and values in all actors of the educational process to achieve quality education.

Quality education seeks to foster creativity and knowledge, as well as the development of high-level cognitive, interpersonal and social competencies and skills that enable citizens to make knowledge-based decisions, lead healthy, fulfilling lives and respond to local and global challenges, and thus contribute to the construction of a fairer and more sustainable society [4,5].

In terms of this last point, the technological pedagogical science knowledge (TPASK) framework emerges as a guiding axis for science teachers' training and instruction that contributes to what teachers need to know about technology in science education [6]. In this framework, where the teaching of science must be contextualised, centred on students and pay tribute to the formation of competent citizens, technology emerges as an improvement in students' learning and understanding of science. However, a teacher must know how to use technology and understand what kind of technology can be used in the teaching process [6].

Based on this background, a systematic review of the literature is proposed to examine the main findings reported in the scientific literature based on socio-scientific issues (SSI) in problem-based learning (PBL) settings that integrate technological tools.

1.1. Problem-Based Learning

Since its inception, the PBL methodology has been positioned to involve students in their learning process and as a strategy to link real-world situations as a starting point for the acquisition and integration of new knowledge [7].

Students are presented with original and challenging problem sets, which can be semi-structured or unstructured before instruction. The work is carried out between students, who assume specific roles within each team to resolve the proposed situation [8].

According to Pepper [9], PBL engages students with profound learning since it is constructive, self-directed, collaborative and contextual. There is ample evidence of the effectiveness of this methodology regarding the participation and motivation of students, the promotion of group work, problem solving and contextual learning, creative thinking, self-regulated learning skills, autonomy, self-evaluation, creativity, collaboration, synthesis, communication, development of useful laboratory skills such as collecting data and extracting and analysing samples [10–15]. However, this evidence differs when disaggregated between educational levels.

For example, a growing number of kindergartens and primary schools are including PBL in their study programs. However, there are also improvements in social skills [16], the incorporation of a larger vocabulary [17] and work with tangible materials [18]. However, the current research does not report conclusive evidence on the direct benefits of using this methodology at this educational level [19,20]. According to a systematic literature review by Ferrero et al. [21], many studies lack the methodological consistency that allows them to be replicated or analyse the real effects of the conducted implementation. In secondary education, this perspective differs, since there is more research conducted, both for problem-based learning and projects [22–25]. There are reports of growth in the gained knowledge, classroom atmosphere and students' motivation [26–28]. There is more development of research and areas where the PBL has been used in higher education since it is an excellent way to engage students with work and professional contexts that they may encounter in the future [10]. In this regard, positive effects have been reported on improving communication, learning skills, student performance, critical thinking, evaluating self-assessments and promoting better knowledge retention [14,29–31]. Concerning the appropriate selection of learning content for the resolution of a real environmental problem (REP), recently, Cáceres-Jensen et al. [12] proposed a module termed socio-scientific environmental chemistry (SSECh), which considered the learning content "Kinetics" to obtain the sorption kinetic parameters of herbicide sorption in volcanic ash-derived soils (VADS) to solve the following REP: "Which VADS is more efficient in retaining a herbicide (glyphosate, metsulfuron-methyl, or diuron) to prevent the potential risk of groundwater pollution?". To provide a real-world context for this REP, the authors: (i) selected herbicides that were among those most widely used in the world and the most commonly sold in Chile; (ii) selected VADS that represented 70% of the agricultural area of Chile; (iii) considered the variability of physicochemical properties of the herbicide-soil (adsorbate-adsorbent) system; and (iv) examined the morphological characteristics of VADS and its interaction with these herbicides.

In this regard, (i) sorption kinetic parameters used in this REP allowed the students to evaluate the potential risk of groundwater contamination, and (ii) learning content selected for the resolution of a REP allowed for the evaluation of the potential risk of groundwater and the processing of real sorption. Consequently, kinetic data processing allowed students to develop critical and technological thinking skills, which are fundamental analytical and reflective skills within environmental chemistry due to its complexity and interdisciplinarity. However, this effect is indebted to the methodology and not to the learning content part of the "problem". This situation indicates that there is a need for more research, which is something that this systematic review aims to achieve.

1.2. Socio-Scientific Issues

Science education is an academic and practical discipline that deals with teaching, learning and assessing science and technology knowledge such as scientific content, scientific technology, scientific processes, scientific skills and the nature of science [32] (p. 86). In this sense, science education should promote an understanding nature, reliable knowledge, its relationship with society and scientific literacy [33].

Scientific literacy refers to a continuum along which an individual progresses in the knowledge and understanding of scientific concepts and processes to make personal decisions and participate in civic and cultural affairs. This continuum considers multiple phenomena, from a recognition of vocabulary to conceptual and contextual understandings. It also finds depth that involves an understanding of scientific concepts, scientific inquiry and the processes of science [32] (p. 92). Nevertheless, although scientific literacy is one of the main objectives of science education, there is no single globally accepted definition but instead three different views. Vision-I accounts for scientific products and processes. Vision-II is examines social situations with scientific components. Vision-III broadens the latter's scope, leading to a scientific commitment and participation aligned with equity and social justice [34–37].

Based on the broad concept proposed by vision-III, science learning must involve value and political, scientific and social aspects [38–40]. Along these lines, science education today leans towards the use of research-based frameworks that promote SSI, i.e., scientific issues that directly impact society and become an essential input in the training of students [41–43].

Following Presley et al. [44], instruction using SSI is based on three fundamental aspects: (i) curriculum design, where SSI must be linked to the curriculum and must allow what has been learned in solving a problem to be applied to new situations; (ii) students must take an active role and be open to reflecting on and understanding diverse perspectives; and (iii) the characteristics of the teacher and the classroom, through which the teacher must become a facilitator and the classroom environment must be collaborative and respectful.

In this vein, Cáceres-Jensen et al. [12] indicate that there is great concern among scientists in assessing the potential risk of environmental contamination to avoid the contamination of non-renewable natural resources, for which they propose the SSECh module to solve an REP that allows us: (i) to contextualise a certain learning content that allows for the evaluation of the potential risk of contamination of natural resources; (ii) transfer this awareness from scientists to students; and (iii) develop critical thinking skills and technological–analytical–reflective skills. In this previous study, we proposed a PBL environment that allows for the solving of global problems such as an REP within education for sustainable development (ESD), and to inspire students to act sustainably.

Numerous investigations describe the positive impact of the use of SSI on the development of argumentation skills [45,46], motivation [47], environmental awareness [48] and critical thinking [49]. However, this effect does not necessarily follow from specific learning content but instead comes from the methodology that uses an SSI as support. This ambiguity is also reported by Bell et al. [50], who detail that explicit instruction on scientific learning content is as effective as instruction that integrates learning content based on an SSI, indicating the need to generate new studies in this field.

1.3. Technology in PBL and SSI Contexts

Technological developments have made it possible to incorporate various tools into traditional teaching and learning methods. Effective integration of technology should encourage teachers to engage in student-centred activities. Many authors indicate the need for further studies that reveal the importance of technology for teaching and learning in various areas [51–53].

According to Pilten et al. [54], technology can be incorporated into learning from various fields such as learning management systems (LMS), visualisation of information and multimodal material that explains complex phenomena. In this sense, PBL allows versatile technology integration in the learning process.

A study by Rahmawati et al. [55] demonstrates that the most used technological aspects integrated into the PBL are social networks and LMSs, emphasising the teacher's importance as the most influential factor of successful integration. Likewise, several authors indicate that using digital environments linked to PBL optimises application times and favours reception by students [56,57]. Recently, Cáceres-Jensen et al. [12] used a REP in an SSECh module that combined chemical and environmental sciences. The design of this module revealed how digital resources and mathematical models using spreadsheets facilitated the representation of numerical data and graphs of herbicides' kinetic sorption on agricultural volcanic soils in a PBL learning environment. In this case, the students learned to interpret sorption kinetics data and rationalise their results to respond to an REP.

However, the scant evidence regarding the use of technological tools in SSI-based PBL environments reveals a gap in technological advances utilised in these settings.

There is a need to investigate in more detail how technology can be used to support working in SSI-based PBL scenarios. Based on the theoretical rationale presented above, two research questions are formulated to guide our research:

RQ1: What are the effects of using SSI contexts in PBL scenarios on high school and undergraduate levels?
RQ2: How do technology tools support working with SSI in PBL scenarios?

2. Materials and Methods

This study was carried out as a systematic literature analysis through PRISMA guidelines [58,59]. This guide was used to obtain a complete, precise and transparent results report, based on a checklist with recommendations for each study item (see Table S1 in Supplementary Materials). This methodological strategy enables a comprehensive understanding of the field's current state by analysing the existing academic research [60]. The databases used, search criteria, inclusion/exclusion terms, validity, reliability and other parameters are detailed in the following subsections.

2.1. Data Sources and Search Strategy

A systematic literature search was conducted using the following databases: Education Resources Information Center (ERIC), Web of Science (WoS), Scientific Electronic Library Online (Scielo) and Scopus. These databases are selected because they are the most established databases and include all of the central knowledge in the educational and scientific fields. In this sense, selected databases meet the broad coverage criterion and represent an optimal database combination. The special topic database ERIC was added because it specialises in education topics. The Scielo database was added to incorporate Latin American scientific journals, which provide open access. The search was carried out via the following terms and phrases: "Socio-scientific or Socio-scientific or Real Proble*" and "Pro* Based Learning". The search gathered all articles where the search criteria were present in the article's title, abstract or keywords. Due to the dynamism of SSI and technological development, we targeted information retrieval in the articles and conference proceedings published between January 2010 and December 2020, considering English and Spanish. The systematic literature search was conducted during April 2021.

2.2. Inclusion and Exclusion Criteria

Based on the search strategy, studies that met the following inclusion criteria were considered to be the following: (i) quasi-experimental research (ii) that described the effects of socio-scientific problems in PBL settings. Concerning the exclusion criteria, these accounted for (i) absence of the concept "PBL" in the abstract of the article; (ii) absence of an SSI in the abstract of the article; (iii) review articles; and (iv) articles whose sample was positioned at another educational level.

2.3. Data Analysis

The data were analysed using qualitative content analysis [60]. The study was conducted by reading the article abstracts and identifying sentences including relevant terms. Next, the analysis units were reduced to subcategories, and lastly, subcategories were classified by connecting main categories. For example:

- " ... Students collected water quality data at three points in the valley, analysed trends, researched information online and through other strategies, and argued what should be done to optimise water quality ... " [61];
- Subcategory: Water quality;
- Main category: Environmental issues.

The validity and reliability of the analysis process were confirmed using the interrater reliability process, where another researcher repeated the categorising process. The inter-rater reliability is the average Kappa value between four reviewers (J.H.-R., J.P., L.C.-J. and J.R.-B.), where over 0.8 is considered a strong agreement [62].

3. Results

3.1. Study Selection

Based on the search and study selection criteria, 409 records were initially identified, of which 71 papers were removed due to duplication. Subsequently, 138 records were removed that did not indicate the use of PBL in the title, abstract or keywords of the study. Additionally, 39 unavailable records were removed (for example, documents without access to download or retrieve). Finally, 161 articles were chosen for complete review, within which 33 met the inclusion criteria (see Figure 1).

Table 1 provides an overview of the methodology and selected parameters concerning educational level, type of problem or project and reported technology.

Table 1. General description of the methodology and parameters reported for each article.

No.	Author(s)	Database	Educational Level	Type of Problem/Project Present in the PBL Scenario	Technology
1	Belland et al. [63]	SC	High School	Water quality	Connection log
2	Ge et al. [64]	ER	Undergraduate	Asthma control	Web-based learning environment
3	Belland et al. [61]	SC	High School	Water quality	Connection log
4	Dos Santos and Pinto [65]	SC	Undergraduate	Develop mobile devices	no reported
5	Rodríguez-Becerra et al. [8]	SC	Undergraduate	Intermolecular forces	Avogadro Autodock
6	Glazewski and Ertmer [66]	SC	High School	The Human Genome Project	not reported
7	Mebert et al. [67]	SC	High School	Water quality	not reported
8	Marklin and Hancock [68]	SC	Undergraduate	Interconnected bioreactors to develop life support in space	not reported
9	Pinninghoff et al. [69]	SC	Undergraduate	Develop a physical connection using optic fibre	Google Earth
10	Alves et al. [70]	SC	Undergraduate	Calculate the area of a region in a country that has social or ecological importance	Google Earth, Google Maps, Geogebra
11	Machado et al. [71]	ER	Undergraduate	Water quality	not reported

Table 1. *Cont.*

No.	Author(s)	Database	Educational Level	Type of Problem/Project Present in the PBL Scenario	Technology
12	Belland et al. [72]	SC	High School	Water quality	Connection log
13	Newman et al. [73]	SC	High School	Water quality	not reported
14	Martinez et al. [74]	SC	Undergraduate	Measurement of temperature of housed dairy livestock	Thermographic camera
15	Lawless et al. [75]	SC	High School	Water quality	Online communications platform
16	Current et al. [76]	SC	Undergraduate	Chemical formulas and limiting reagents, properties of gases, molecular geometry and atomic spectra	not reported
17	Sedaghat et al. [77]	ER	Undergraduate	Drive systems for use in industry	Arduino microprocessor programming
18	Bashir et al. [78]	SC	High School	Web site and PHP problem	not reported
19	Chua et al. [79]	SC	Undergraduate	Design a small dryer	not reported
20	Wan et al. [80]	ER	High School	Energy, transportation, wireless communication and urban infrastructure	not reported
21	Guo and Tahernezhadi [81]	SC	Undergraduate	Solar-powered warning light	Multisim simulation
22	Purwati et al. [82]	ER	Undergraduate	Recombinant DNA, cloning, IVF and hybridoma techniques	not reported
23	Ling-Ling [83]	SC	Undergraduate	Generate biogas and produce high-quality organic fertilisers	not reported
24	Nurtamara et al. [84]	ER	High School	Planting transgenic plants and cloning pets	not reported
25	Rubini et al. [85]	SC	High School	Global warming	not reported
26	Munezero and Bekuta [86]	ER	Undergraduate	Forests and natural resource conservation	not reported
27	Wijnen et al. [87]	SC	Undergraduate	Criminal law	not reported
28	Travassos et al. [88]	SC	Undergraduate	External lighting project	Gira Sol, sunflower simulator
29	Domínguez-García et al. [89]	SC	Undergraduate	Distribution of heat through a thin bar made of a homogeneous material	e-portfolio
30	Mora et al. [90]	SC	Undergraduate	Design a small-scale model that simulates the operation of a tanker	Social networks, mobile devices and the Internet
31	Overton and Randles [91]	SC	Undergraduate	Design a microgeneration sustainable village	Virtual learning environment
32	Seddon et al. [92]	SC	Undergraduate	Animal breeding and molecular genetics	SBL interactive platform
33	Gratchev and Jeng [93]	SC	Undergraduate	Soil origin and constituents	not reported

SC = Scopus, ER = ERIC.

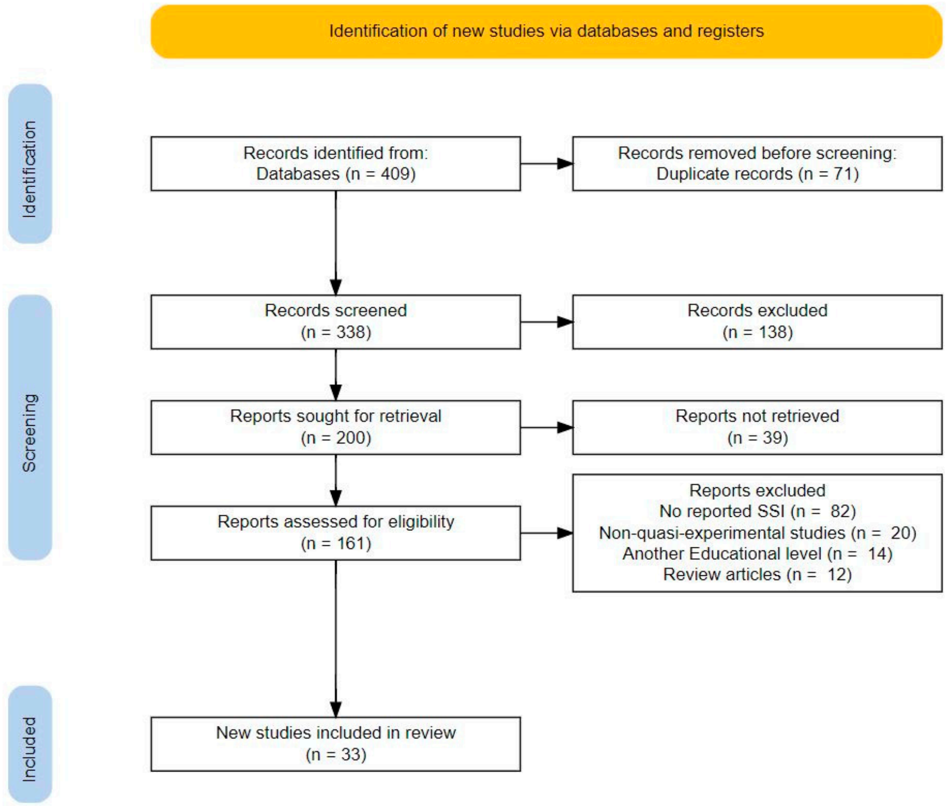

Figure 1. Search procedure of literature according to PRISMA guidelines [58].

3.2. *Effects of Using SSI in PBL Scenarios (RQ1)*

From the SDGs, it is possible to identify learning contents that have been incorporated into curricula of educational institutions [94,95], which pay directly to the SSI and can be linked to the PBL scenarios. For example, the SDGs are closely related to environmental issues such as ensuring the availability and sustainable management of water and sanitation for all (SDG 6) [96] or ensuring access to affordable, reliable, sustainable and modern energy for all (SDG 13) [97]. Topics related to good health and well-being (SDG 3) or economic productivity through diversification, technological modernisation and innovation promote decent jobs for all (SDG 8); these categories are crucial for identifying teaching and learning focuses [98].

Concerning the aforementioned, thirty-three records indicated the use of one or more SSI in PBL scenarios; these can be classified into the following groups: (i) Environmental issues, which arise from the concern of citizens about a wide range of environmental problems, such as climate change, soil erosion, deforestation and forest degradation, water quality and others; (ii) health, where issues related to disease prevention and applied biotechnology problems in medicine stand out; (iii) engineering, where the manufacturing of products and various production processes are mainly reported; and (iv) other issues linked to social issues, computational issues and specific scientific issues (See Table 2). This categorisation presented a Kappa value of 0.879, which indicated an almost perfect concordance.

From the SSI implemented in PBL scenarios, the records present categories related to the effects on high school and undergraduate students. These categories are presented as "preliminary categories" since the authors can use different terms for the same effect or skill (See Table 3).

Table 2. The SSIs are reported in the literature and associated categories.

Category	SSI Reported	Total	Ref.
Environmental issues	Climate change Soil quality Deforestation and forest degradation Water quality	12	[61,63,67,71–73,75,80,85,86,91,93]
Engineering	Manufacturing process	7	[65,69,77,79,81,88,90]
Health	Biotechnology issues Medical issues	7	[64,66,68,74,82,84,92]
Other	Social issues Computational issues Physical or chemical issues	7	[8,70,76,78,83,87,89]

Table 3. Frequency of effects reported in the literature related to the use of SSI in the PBL framework.

Preliminary Category	Total	Ref.
Team working	13	[65,67–69,74,77,79,81,86,88–91]
Improved technical skills	9	[8,65,74,77,79,81,86,89,90]
Problem-solving skills	7	[64,66,68,71,78,85,91]
Improved of academic performance	5	[65,69,79,88,92]
Improved argumentation skills	4	[63,72,82,84]
Autonomous work	4	[8,86,89,90]
Engagement in the learning process	3	[68,69,93]
Recognize problems of an interdisciplinary nature	3	[70,83,86]
Scientific skills development	3	[8,75,84]
Improved self-regulation	3	[8,79,87]
Improved communication and discussion skills	2	[71,80]
Improved civic engagement	2	[73,83]
21st-century skills (digital age literacy, inventive thinking, effective communication and spiritual values)	1	[80]
Decision-making skills	1	[84]
Improved academic engagement	1	[73]
Improved school motivation	1	[71]
Science literacy	1	[85]

3.3. Technological Tools as a Support for Working with SSI in PBL Scenarios (RQ2)

As mentioned in Section 1.3, although technology supports various educational processes, students and teachers must present the necessary technological skills to use it, especially in the current context where the use of technologies, a product of confinement, has become essential at all educational levels. In this regard, LMS is positioned as a critical tool and a focus of recent research [99–101], incorporating word processors or spreadsheets in school contexts or electronic devices in various settings [102]. Nevertheless, there is little evidence of technological tools supporting SSI use in PBL scenarios, with only 19 records shown. These tools were grouped into four categories: (i) Virtual learning environments, understood as information-access platforms that include the PBL stage, audio-visual support material, forums and chat rooms; (ii) area-specific digital tools, mainly focused on simulators or the use of devices; (iii) digital office tools, mainly linked to the use of word processors, spreadsheets or slide presentations; and (iv) research-grade software, understood as computer programs for use in scientific research and that can be used in teaching [8] (See Table 4). This categorisation presents a Kappa value of 0.834, which indicates an almost perfect concordance.

Table 4. Types of technologies reported in the literature related to the use of SSI in the PBL framework.

Category	Example	Total	Ref.
Virtual learning environment	Connection log system Virtual resource bank MOOC platform	7	[61,63,64,72,75,91,92]
Area-specific digital tools	Arduino microprocessor Sun flower simulator	5	[69,74,77,81,88]
Digital office tools	Google Hangouts Google Documents Google Drive e-portfolio	2	[89,90]
Research-grade software	Autodock Geogebra	2	[8,70]

4. Discussion

4.1. The Effects of Using SSI Contexts in PBL (RQ1)

4.1.1. Type of Problem Present in the PBL Scenario—Vinculate to SSI

There is evidence of deep interest from teachers in SSI related to environmental issues (see Table 2). They mainly focus on wastewater and effluent treatment [61,63,67,71–73,75] and the preservation of forests and soils [86,93], directly related to SDG 6 and SDG 15, respectively. In these examples, the SSIs are positioned according to the immediate context of their application; that is, they are used to set learning content that directly affects the sectors where the studies are carried out. To a lesser extent, global issues are presented, such as the impact of climate change [85] or non-polluting urban transport [91], which are related to SDG 13 and SDG 7, respectively.

Something similar occurs with the second most frequent category, which encompasses manufacturing processes and the development of prototypes and products that contribute to SDG 8 and SDG 9, respectively. Consequently, these processes are linked to the development of engineering in industry, such as the development of mobile devices [65], machinery for agricultural use [79] and electronic devices [69,77,81,88]. Consequently, the SSI are contextualised to resolve local situations.

In third place, the category that accounts for uses related to health aspects is located, so the SSIs are globally positioned in this line, directly related to SDG 3. Such is the case of studies linked to the control of diseases such as asthma [64], as well as genetic cloning processes [66,92] and transgenic crops [84] from bio-technology. Finally, the lower frequency category includes problems related to computing [78], laws [87] and the study of thermodynamic variables [8,89].

From these findings, it is possible to determine that the use of SSI in PBL scenarios reported in the literature is primarily geared towards the approach and tentative solution of a local problem. Additionally, although it is not explicitly observed, it can be inferred that the SSIs used depend clearly on the scientific knowledge of the teacher, which, by linking it to local problems for pedagogical purposes, allows students to analyse and resolve situations that directly involve them.

Furthermore, according to educational level, the results show that 33.3% of the implementations are applied to secondary school students. In this case, SSI is mainly related to environmental issues (72.7%). In contrast, the remain 66.7% of the implementations are at the university level. At this level, the manufacturing of products (31.8%) and medical issues (22.7%) show a higher frequency of SSI used in PBL. Based on these results, the trend linking secondary and university education with local themes is observed, directly contributing to the vision-II of scientific literacy, linking scientific knowledge with a meaningful context for students [34].

4.1.2. Type of Problem Present in the PBL Scenario—Effects on Students

Although educational levels have different purposes, secondary education seeks to incorporate and strengthen skills necessary for higher education; the latter aims to develop professional skills [103,104]. The reported effects do not present a relevant difference when disaggregated by educational level. In secondary education, the effect mainly accounts for improvements in the development of argumentation skills, decision making, commitment and the so-called skills of the 21st century. The same occurs when reviewing the effects reported from higher education, which contributes to improving speech, problem solving, academic performance, autonomy, teamwork and self-regulation skills.

Based on what is proposed by Choi et al. [40], these effects are mainly positioned in the dimensions related to mental habits, character, self-management and self-evaluation, i.e., fostering skills integral to science and scientific literacy and forming the foundation for building scientific knowledge. However, these skills do not necessarily come from applying an SSI in a learning environment since they can be promoted from a PBL scenario that incorporates problems from other areas. For example, the Cold War in history classes [105] or the elaboration of graphic ensembles in visual arts [106] have been used in PBL scenarios

On the other hand, and to a lesser extent, there are effects related to developing scientific skills and understanding the nature of science [107], which depends on the type of SSI used in the PBL scenario. For example, Rubini et al. [85], through a global theme such as climate change, show improvements in students regarding skills related to the explanation of scientific phenomena, the evaluation and design of research and the interpretation of scientific evidence. The same occurs in what is proposed by Lawless et al. [75], using a problem scenario based on water resources, which describes an improvement in literacy and scientific inquiry skills in students.

4.2. Technology as a Support for PBL Scenarios (RQ2)

The scant evidence found in the literature about technology tools support working with SSI in a PBL environment accounts for an initial stage of a field of study. An example is that only four studies examine technological aspects in secondary education [61,63,72,75], all of which are focused on virtual learning environments based on web platforms. These tools simplify student access to audio–visual support material, discussion forums and chat rooms to develop the problem scenario.

The largest variability in technological tools used is in higher education, with twelve studies [8,64,69,70,74,77,81,88–92]. At this educational level, specific technological tools of each area stand out and are linked to SSI, such as simulators or electronic devices, which are used mainly as technical tools that visualise, measure, or demonstrate the problem situation. To a lesser extent, technological tools will enable office tasks, such as word processors, spreadsheets and online portfolios. Their function is to give digital support to present the problem scenario and present the results. In last place are research-grade technologies, which involve software that is used to teach, although these are initially focused on scientific research. We could explain these results by a lack of technological knowledge on the part of the teachers aligned with what Gavgani et al. [56] indicate as the importance of teachers when it comes to planning a PBL framework.

Technology as PBL Scenario Support—The TPASK Framework

In terms of teaching work that depends on the TPASK framework, it is possible to distinguish both science knowledge (SK) and pedagogical science knowledge (PSK), since the scenarios proposed to use SSI in the PBL methodology are based on both constructs. Teachers need knowledge of concepts, theories, practices and applications related to SSI to determine the SSI to use in class. Furthermore, they must know the pedagogical aspects present in the PBL to generate a learning environment that is able to develop skills related to scientific literacy [5,6].

On the other hand, aspects related to the use of technology focus on technological knowledge (TK), technological science knowledge (TSK) and technological pedagogical knowledge (TPK). They use computers and specialised instruments to develop scientific concepts and adapt technologies to various teaching tasks.

Although evidence shows the use of TK by teachers, what happens with the TPK is interesting, since the most significant number of reports presented in this vein is mainly based on management and methodological design. Rodríguez et al. [8,108] reported advances that linked the TSK to the use of research-grade software. Their results open a door towards the link between scientific research using technology and its extrapolation with science teaching, such as has been reported in this paper.

The evidence is in line with that reported in the literature on practising teachers, which shows teachers' limited progress in using technology linked to TPK and TSK [109]. Something similar occurs when studying the reports on teachers in training. The main findings indicate that, although there are advances in the area, such as studies by Rodríguez et al. [8,108], integrating technology in training processes is arduous since teachers cannot relate technologies to instructional purposes [110,111]. More research in this field is essential for improving the training of teachers at the initial level, and potential refresher courses could be offered to current teachers.

4.3. Towards Sustainable Development, Projections for Teachers and Students

The deep global crisis as a result of COVID-19 revealed the fragility of the educational system but it also represented an opportunity to make a fundamental change to said system [29]. The ESD is positioned as a vehicle to mobilise these educational changes and achieve the SDGs from ecological, economic and social points of view. Additionally, ESD addresses four aspects: (i) learning content, (ii) pedagogy and learning environment, (iii) learning outcomes and (iv) the transformation of society [4].

While, in terms of international public policy, there is a plan that contributes to the strengthening of education for sustainable development, the need to turn resources towards research in this area and strengthen its link with education remains vital; thus far, only initial efforts are apparent [112].

The work carried out by the GlobalEd2 project in charge of the United States Department of Education's Institute for Education Science examines SSI from the previously mentioned (i) ecological, (ii) economic and (iii) social approaches [75]. It is interesting to note that learning content is based on positioning SSI as the starting point for all types of learning. The relationship between pedagogy and a learning environment accounts for using student-centred pedagogies, such as PBL, to generate a comprehensive approach to teaching. The learning results are understood as being the contribution to society generated from the effects reported in the previous points, and in these three points, to achieve social transformation.

The objective is clear; however, there are still gaps in how this proposal can be carried out, and it is here where teachers play a key role.

From the initial training of teachers, the promotion of the development of all the bodies of knowledge present in TPASK is relevant, and evidence shows that there is an initial development in both TPK and TSK [8]. This development becomes even weaker in practising teachers who have not taken advanced courses. In this sense, the training and development of teachers in all learning contexts related to technology should be strengthened, since a teacher who manages to position themselves in a good way from the TPASK framework will be able to select scientific–technological resources and tools that provide adequate support to student teaching and learning [6].

Additionally, this line of teacher development can contribute towards vision-III of scientific literacy, which is directly linked to the SDGs and whose ultimate goal is social transformation brought about by education [39].

5. Conclusions

The reported effects of SSI use in PBL settings are diffuse, both at the secondary and at the undergraduate level, since the earlier literature mainly accounts for effects linked to the methodology and not to the subject. Therefore, there is a need for research exploring experiences of SSI and its effects related to the different problem scenarios that integrate emergent technologies in their design. In this regard, the SDGs are an excellent input from which the SSI can be derived.

It is noteworthy that technology in the PBL scenarios mainly focuses on technical support for teaching tasks. Although there is an incipient development towards the use of scientific technologies, it is not yet representative. In this sense, it is necessary to integrate diverse emergent scientific technologies in the pre/in-service teacher training related to STEM education in the context of EDS. In this line, more research is needed at all educational levels to design new educational scenarios that, based on active learning methodologies, SSI and emerging scientific technologies, allow the expansion of the TPASK of future teachers to promote ESD.

Finally, equally important is the need to focus on teachers' training and subsequent development. They are important actors in the development and achievement of the SDGs. Based on their teaching experience and ability to foster the development of their TPASK, they can reformulate, optimise and modify their current work in the classroom.

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