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Article

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Systematic Review

A Bibliometric Systematic Literature Review on the Relationship Between Problem-Based Learning Methodology and Entrepreneurship

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Abstract: The rising commitment to entrepreneurial learning, both in academic and industry settings, has prompted the development of new mechanisms and methodologies. In recent years, the literature on entrepreneurship has progressively focused on the problem-based learning (PBL) methodology, particularly in response to evolving challenges within the learning environment. This paper presents a systematic bibliographic literature review (SBLR) on the application of PBL across various entrepreneurial processes in higher education and industry. This review aimed to identify significant entrepreneurial opportunities for PBL. A comprehensive search of bibliographic databases was conducted for documents published between 2002 and May 2024, resulting in the identification of 142 empirical and non-empirical papers related to PBL in entrepreneurship. The data analysis uncovered a range of subthemes regarding the use of PBL in entrepreneurship, highlighting its applications in both higher education institutions and industry. This study was guided by the research question: “What is the relationship between problem-based learning methodology and entrepreneurship?”. This research’s central and novel contribution lies in identifying diverse applications of PBL to address the various challenges that emerge within different entrepreneurial contexts. This paper also suggests future research directions.



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Keywords: entrepreneurship; problem-based learning

1. Introduction

Entrepreneurship is often viewed simultaneously as learning in context, embracing innovation, proactivity, and risk-taking [1]. Problem-based learning (PBL) has been acknowledged as a student-centered methodology where students tackle issues through teamwork, aiming to resolve complex and engaging problems [1].

The primary objective of this paper is to identify how the PBL methodology contributes to fostering various entrepreneurship-related events. These events, which can be economic or social in nature, drive entrepreneurs toward innovation and risk-taking. Thus, the research question guiding this study was: “What is the interplay of problem-based learning methodology with entrepreneurship?” Although the existing literature suggests a growing interest in the connection between PBL and entrepreneurship, particularly in fostering entrepreneurial attitudes and enhancing practical experiences [1], no comprehensive literature review so far has directly linked PBL to entrepreneurship. Thus, this study fills a crucial gap.

This paper discusses various entrepreneurship events, both educational and industry-related, alongside diverse PBL approaches, to develop novel PBL applications in different contexts. A systematic bibliographic literature review (SBLR) was employed to identify key

contributions of PBL in entrepreneurship. PBL has proven beneficial in diverse scenarios for building new knowledge and finding suitable solutions. It provides insights into developing entrepreneurial skills, addressing challenges in educational transfer and fostering entrepreneurial mindsets and innovation [1].

The aim of this literature review is to emphasize the extensive contributions of PBL to entrepreneurship. Specifically, it examines how PBL influences entrepreneurial attitudes [1], its impact on essential entrepreneurial skills such as teamwork and communication, and its role in enhancing long-term entrepreneurial success [2]. Additionally, the review explores how PBL fosters competencies in entrepreneurship [3], including critical thinking and the ability to generate sustainable business ideas [4] that address local, national, and global issues [5,6].

PBL has been shown to influence entrepreneurial attitudes, learning motivation, and skills by shifting the focus from teacher to learner [7]. Furthermore, PBL programs centered on specific challenges significantly enhance learners' transversal skills, such as creativity and financial literacy, leading to multidisciplinary solutions [2]. Some studies have suggested that exposing people to entrepreneurial challenges in PBL courses increases their intention to become entrepreneurs [2]. Moreover, combining PBL with methodologies like action learning has been proposed as an effective approach to nurturing social entrepreneurial mindsets and fostering innovation [7].

In summary, this paper categorizes contextual learning events related to PBL theory, contributing to enhancing the linkage between PBL and entrepreneurship by identifying optimal active learning strategies for various entrepreneurship issues and solutions to organizational challenges. Using SBLR methodology, this research aims to provide key conclusions to enhance entrepreneurship at both academic and industry levels. The article is structured as follows: first, a discussion of the theoretical background of PBL; second, a presentation of the methods and data; third, a discussion of the main subthemes; and finally, conclusions are drawn.

2. Theoretical Background: Entrepreneurship Training and Problem-Based Learning

Entrepreneurship is learning in context, which varies with distinct environs [1]. In spite of the ontological and epistemological assumptions underlying such experiential learning, one can emulate those 'real problems' in order to develop the best entrepreneurial competences through different educational methodologies. Among these, problem-based learning is noteworthy.

Hence, to embrace entrepreneurship fundamentals in the curriculum demands a new paradigm. It is worthwhile to reflect on the way the education system interplays with increasingly turbulent industrial contexts. It is advisable to learn how to learn in more realistic, proactive, and innovative ways within the education system in order to better cope with contemporary critical events, instead of learning through memorization. The argument about the best ways to include fundamentals of entrepreneurship in the curriculum is a current debate regarding how to combine traditional education with the increasing demands of business. The efficacy of process-based learning through courses centred on, for example, developing business plans, has been compared with other active methodologies, such as PBL, suggesting potential challenges in conventional entrepreneurship education approaches [2].

The importance of entrepreneurship is deemed a central feature of life and should be taught accordingly, leading to collaborative pedagogical models that ease knowledge processing between academic and business actors [8]. Those collaborative models include problem-based learning, which intended to boost critical thinking, innovation, and opportunity recognition that arises amidst efforts in promoting entrepreneurship education. This has achieved strategic interest because of the weight the educational system represents in promoting economical behavioural attitudes and ensuing job creation and economic development [9].

PBL in entrepreneurship education includes varying elements that relate to the improvement of entrepreneurial competencies. On the one hand, it challenges students to learn by commitment to real issues, emphasizing active learning and critical thinking [1]. On the other hand, it embraces learning by the application of existent knowledge to cope with real issues,

promoting an entrepreneurial mindset and behavior [10]. In sum, it combines interdisciplinary knowledge and skills into pedagogy, fostering an entrepreneurial attitude in daily life [10] and therefore implying innovation, enabling students to develop innovative products to unravel troubles amidst environs such as, for instance, the agri-food sector [11].

Problem-based learning is an original didactic methodology, aiming at helping learners with their learning process whilst finding solutions to practical problems through constant commitment [5]. In a shared environment, learners work together to find the best solution to a problem [12], based on their knowledge and ongoing learning within the process. Such learning processes lead to the building of theoretical constructs while emphasizing learning routines by both reflection and discussion [13]. Problem-based learning enhances learning through engagement with real problems, promoting active learning and a combination of theory and practice [3], leading to ensuing entrepreneurial skills, which can be categorized as creativity, planning, and financial literacy [1], and interpersonal skills for students, such as teamwork and self-employment, thus fostering interaction between universities and industry [14].

Entrepreneurship should be therefore taught through collaborative models that ease the exchange and co-creation of knowledge between entrepreneurs, businesses, and communities and via problem-based learning [8]. By using a combination of elements including entrepreneurially minded learning, problem-based learning, and active collaborative learning, the entrepreneurial impact of pedagogical programs increases [15]. The combination of active pedagogies with PBL triggers self-directed and collaborative learning and improves the aforementioned learner's problem-solving skills [16].

It creates situations that imitate distinct environments, where participants are confronted with 'real-world' problems, allowing the development of entrepreneurial capabilities [17]. Hurdles arise that simulate entrepreneurial situations within a given learning environment, promoting students' capacity for entrepreneurship. In this way, PBL, as an active learning and multi-solution approach, thus resembles the "learning-by-doing" approach of entrepreneurship education [18]. PBL therefore stimulates entrepreneurial awareness among students [5], whilst lecturers act as facilitators to develop entrepreneurial competences and innovation [19].

The PBL methodology is therefore embedded in a context that simulates enterprise activities within an immersive approach, also encapsulated in the framework of 'learning by doing' [20]. Throughout the process, ill-structured problems arise, which demand autonomous thinking and ongoing problem solving, with students taking responsibility for their own learning [21]. Combined with other active methodological strategies (e.g., *gamification*), PBL promotes improvement in academic results in terms of acquisition of skills such as the development of entrepreneurship and problem-solving capacity [22]. It takes advantage of active learning environments in which educators construct active learning curricula that ultimately create entrepreneurs with broader meta-cognitive scope [23].

PBL has also the potential to feed the development of transversal attitudinal skills such as teamwork and communication, which are essential for long-term entrepreneurial success [24]. In short, PBL is paramount in relation to an emphasis on entrepreneurial capabilities and mindset. It over-enhances varying types and forms of experiential learning, in the vein of active learning, critical thinking, and learning by searching, promoting the development of a wider and more multidisciplinary entrepreneurial mindset.

PBL has had a central influence on entrepreneurial attitude, building on experience and long-term development of entrepreneurial skills. Nonetheless, it poses some constraints, such as a lack of resources for students in sparsely populated areas [25] and the need for early group formation and formative feedback, as resistance has been apparent in integrating PBL principles with traditional learning [26]. Also, the inherent complexity in combining PBL with more traditional process-based learning akin to business plans tends to lessen collaborative intentions among students [2].

3. Materials and Methods

In order to recenter the discussion, this article is about the influence of PBL upon entrepreneurship, instead of only entrepreneurial education, because entrepreneurship is deemed as an attitude made up of proactivity, innovation, and risk assumption combined [6], rather than as simple implementation of business plans for startup small and medium enterprises (SMEs). Conversely, problem-based learning (PBL) is considered a pedagogical method from the educational domain that might be applied to any knowledge area, aiming at triggering an entrepreneurial attitude. Therefore, this study focuses on the potential influence of PBL, through training, upon entrepreneurship in general (not only academic), as mentioned earlier in the abstract: ‘both at academic and industrial level. . . with regard to upcoming events from the surrounding learning context. . . within diverse entrepreneurship contexts’, as entrepreneurship is primarily learning in context. Furthermore, training, a formal learning mode, is only one entrepreneurial learning process among many (e.g., learning by doing, improvisation, networking, etc.). Learning to be an entrepreneur goes well beyond the classroom. Yet, the classroom remains central in embedding entrepreneurial learning. To examine discussions of entrepreneurial learning across varying aspects of the literature, a systematic literature review was applied. Systematic reviews are essential tools that provide comprehensive insights into topics that individual studies might not fully address. For these reviews to be beneficial to readers, authors need to offer a detailed, accurate, and transparent explanation of the research rationale, methodologies, and results [27]. To meet these standards, the researchers employed a systematic bibliometric literature review (SBLR) methodology. This method involved a structured approach to the literature review, enabling an in-depth exploration of existing studies, theories, and trends within the field of problem-based learning entrepreneurship. The use of standardized methodologies and guidelines facilitates the search, review, critique, interpretation, and synthesis of findings related to the study topic. Furthermore, SBLR’s rigorous and replicable process for selection and analysis of the literature minimizes bias by ensuring comprehensive consideration of all the relevant literature, regardless of its source or the author’s affiliations.

In contrast to traditional literature reviews, SBLR follows a replicable, scientific, and transparent process that aims to minimize bias by exhaustively searching both the published and unpublished literature related to the study topic [28–30]. The researcher also provides an audit trail, enabling readers to evaluate the quality of the studies included in the review as well as the research procedures and conclusions.

Thus, SBLR involves a thorough screening and selection of information sources across three phases and six steps [28–30], as outlined in Table 1, to ensure the validity and accuracy of the data presented.

Table 1. Process of systematic SBLR.

Fase	Step	Description
Exploration	Step 1	Formulating the research problem
	Step 2	Searching for the appropriate literature
	Step 3	Critical appraisal of the selected studies
	Step 4	Data synthesis from individual sources
Interpretation	Step 5	Reporting findings and recommendations
Communication	Step 6	Presentation of the SBLR report

Source: own elaboration.

Such a path is followed to identify a given theme, the associated set of publications, and the authors of the related journals. With regard to the building and visualization of bibliometric maps, the analysis tool we used was VOSviewer. In contrast to other bibliometric instruments (e.g., Biblioshiny and CiteSpace), VOSviewer is based upon wide bibliometric maps that are easier to clarify, manage, and display. Those features, in addition

to its open-source access, make VOSviewer 1.6.18 one of the most broadly used software applications for this type of bibliometric analysis.

Consequently, in a more disaggregated way, the research model we employed to attain the proposed aforementioned research goal is displayed in detail in Figure 1.

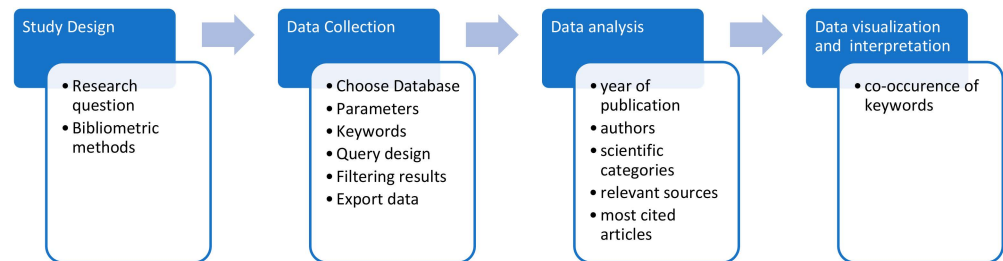


Figure 1. The research model for mapping the literature. Source: own elaboration.

3.1. Data Collection: Setting the Academic Databases

The researchers conducted their literature search using the Scopus database, which is well respected in the scientific and academic communities. However, it is important to note that this study has limitations due to its exclusive reliance on the Scopus database, omitting other scientific and academic databases. Ideally, the literature search should include peer-reviewed scientific and/or academic publications up until May 2024.

3.1.1. Setting the Search Parameters

The search parameters used included the thematic field, the language of publication, the geographical area, the period of publication, and the type of literature. We mainly searched for literature in English on the theme, with economic and environmental nuances. Concerning the time scope of the publications, this ranged from 2002 to May 2024. Peer-reviewed academic and/or scientific publications up to May 2024 were included in the literature search.

3.1.2. Setting Keywords and Designing the Queries

The selection of keywords constitutes a chief stage in the process of bibliometric analysis of a research topic. In this case, the topic was problem-based learning and entrepreneurship. The drive underlying the selection of words depended upon the distinct conceptualization of ‘problem-based learning and entrepreneurship’, that is, an active learning methodology to trigger innovation, proactivity, and risk-assumption in potential entrepreneurs [1], including study of the interplay between entrepreneurial learning and context [2]. Such conceptualization led to the classification of the following keywords: “Entrepreneurship” and “Problem-based learning”.

The literature search process began with the keywords “Entrepreneurship” and “Problem-based learning”, resulting in 21,589 document results, as shown in Table 2 and Figure 2.

Table 2. Screening methodology.

Database Scopus	Screening	Publications
Meta-Search	Keywords: “Entrepreneurship” and “Problem-based learning”	21,589
First Inclusion Criterion	Keywords: “Entrepreneurship” and “Problem-based learning” excluding duplicated documents	142
Second Inclusion Criterion	Keywords: “Entrepreneurship” and “Problem-based learning”	142
Screening	Keywords: Entrepreneurship and Problem-based learning” published before May 2024	142

Source: own elaboration.

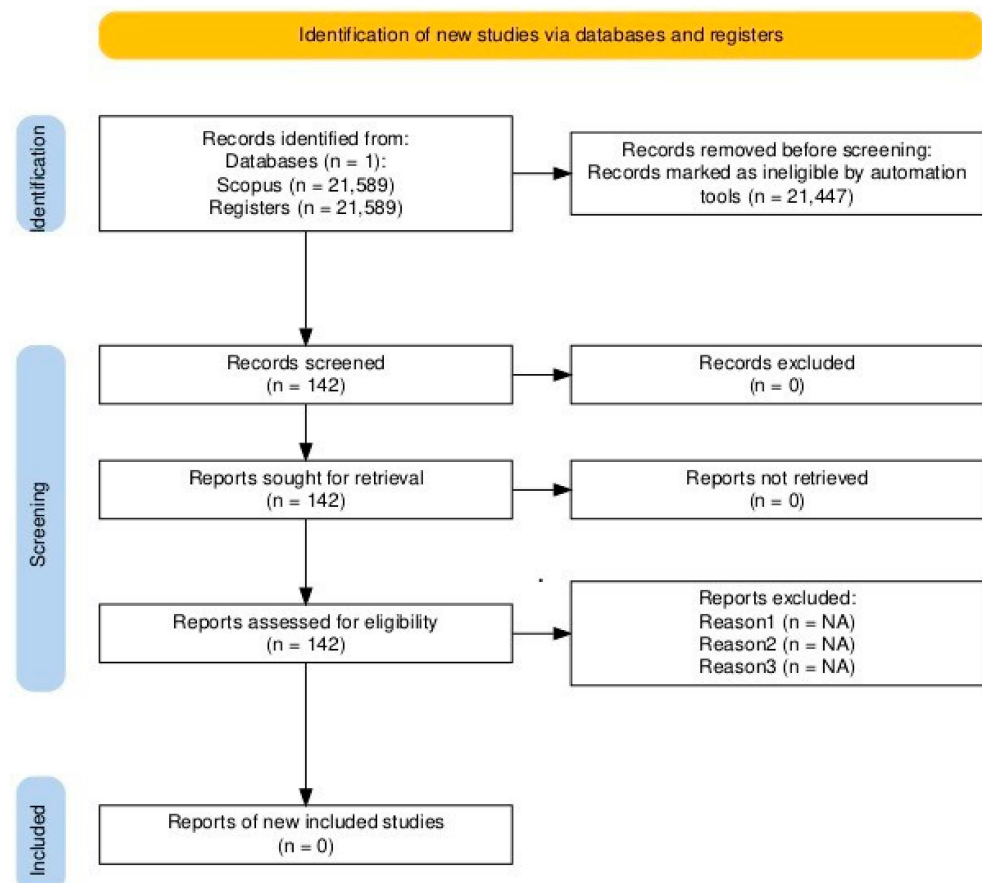


Figure 2. PRISMA flow diagram for literature search.

The Scopus dataset was used to identify potential studies. However, as shown in Table 2 and Figure 2, duplicate documents led to the exclusion of 21,447 items and reduced the document results to 142 scientific and/or academic documents.

To summarize, pertinent academic databases were chosen, bibliometric search parameters settled, keywords selected, bibliometric database queries designed, and the criteria for filtering the results established (Figure 2). It was assumed that the ensuing results would be exported to be analyzed, interpreted, and displayed. In short, the process began with the selection of the Scopus database for sourcing and identifying the relevant literature. Systematic searches were conducted using predefined keywords and phrases, with the phrase “problem-based learning entrepreneurship” yielding documents. Initial steps included removing duplicates and applying inclusion criteria to ensure the relevance of studies to the topic. Documents were screened and excluded based on their relevance to problem-based learning entrepreneurship and the rigor of their methodology. Only peer-reviewed journal articles, conference papers, books, and reports published in English were considered (Figure 2).

It is worthwhile to mention that the search for those keywords also led to some studies that focused on case-based learning, which is a related although different concept. Apparently, a couple of works with the words CBL came up, which were found to be less relevant. Furthermore, both concepts, PBL and CBL, are very close one to another, because both are based upon critical thinking and problem-solving methodologies whilst relying on collaborative, student-centered, and real-world learning. Nonetheless, PBL is centered upon an open-ended problem worked out by independent learning abilities, whereas in CBL, the issue is structured and directed by a case, aiming at understanding its concepts.

3.2. Data Analysis

Drawing upon the initial research question, this step included analysis of the evolution of research interest in the topic over time, the main research areas in which the subject has been investigated, the countries where the theme has been more broadly discussed, the major publications on the topic, critical papers on the issue of problem-based learning and entrepreneurship, and the authors of these papers. We analyzed the aforementioned data collection output including the following aspects: year of publication, scientific category, country of author, most relevant sources, and most cited authors and articles.

Content and thematic analysis methods were applied to categorize and discuss the varied documents, as recommended by Rosário and Dias [28–30]. The 142 documents indexed in Scopus were analyzed both interpretatively and by bibliometric means to enhance understanding of the content and to derive common themes that address the research question directly [28–30]. Among the selected documents, 70 were articles, 56 were conference papers, 10 were part of a book series, and 6 were books.

3.2.1. Publication Distribution

Regarding peer-reviewed articles that referred to the importance of problem-based learning in entrepreneurship prior to May 2024, (Appendix A) the year 2020 had the highest number of peer-reviewed publications on the subject, reaching 21. Figure 3 summarizes the peer-reviewed literature published up to May 2024.

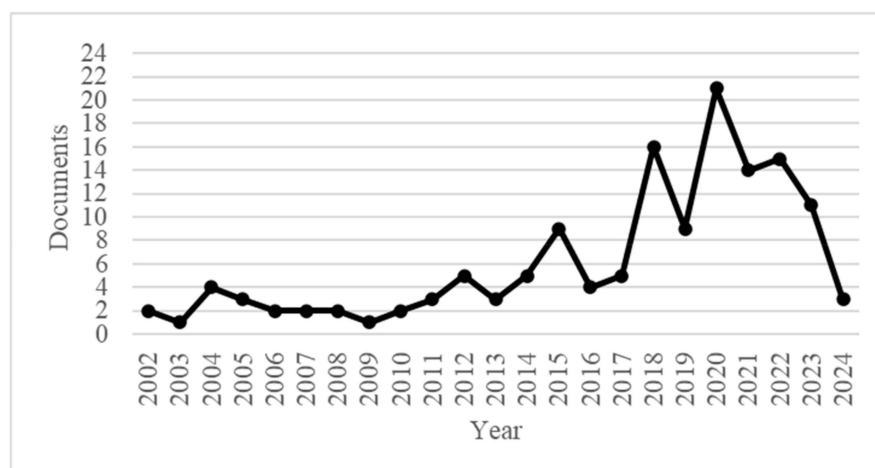


Figure 3. Documents by year, up to May 2024.

The publications were sorted. They included *ASEE Annual Conference and Exposition Conference Proceedings* (8) and *Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence*. Those with 3 examples included *Intelligence and Lecture Notes in Bioinformatics*, *Journal of Physics Conference Series*, the *International Research Symposium on PBL*, *International Journal of Management Education*; *International Journal of Engineering Education*, *Education Sciences*, and *ASEE Annual Conference Proceedings*. Those with 2 included *Proceedings of the International Conference on E-Learning*, *Proceedings of the European Conference on E-Learning*, the *Mechanical Engineering Education Handbook*, *Journal of Entrepreneurship Education*; *Journal of Commercial Biotechnology*, *International Symposium on Project Approaches in Engineering Education*, *International Journal of Innovation and Learning*, *IEEE Global Engineering Education Conference*, *European Journal of Education*, *Education Training*, *Communications in Computer and Information Science*, *Advances in Intelligent Systems and Computing*, and the *ACM International Conference Proceeding Series*, while the remaining publications were each represented by 1 document.

Similarly, Figure 4 illustrates the regions with the most abundant literature contributions on the topic. It is worthwhile to note that these are absolute numbers and thus relate to numbers of inhabitants or researchers. The USA stands out with the highest levels of

scientific output in related fields, trailed by Indonesia and Brazil, among others publishing on the subject.

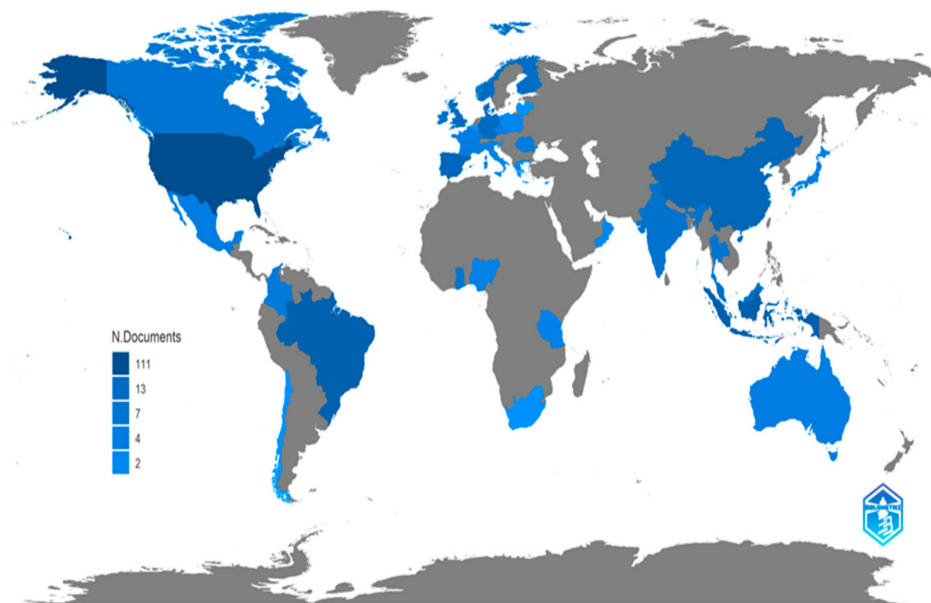


Figure 4. Documents by geographical area.

Table 3 and Figure 4 present the leading 10 nations that have made significant scientific contributions in the studied fields.

Table 3. Top 10 countries by number of publications.

Country	Number of Publications
USA	111
Indonesia	31
Brazil	27
Portugal	21
Denmark	20
China	18
Spain	17
Germany	13
UK	13
Norway	12

Source: own elaboration.

The publications were sorted as follows: Social Sciences (87); Engineering (49); Computer Science (39); Business, Management, and Accounting (26); Mathematics (10); Economics, Econometrics and Finance (7); Psychology (6); Medicine (6); Health Professions (5); Decision Sciences (5); Biochemistry, Genetics, and Molecular Biology (5); Arts and Humanities (5); Chemical Engineering (4); Physics and Astronomy (3); Energy (2); Pharmacology, Toxicology, and Pharmaceutics (1); Nursing (1); Materials Science (1); Immunology and Microbiology (1); Environmental Science (1); Earth and Planetary Sciences (1); Chemistry (1); Agricultural and Biological Sciences (1).

In Table 4, we analyze the Scimago Journal and Country Rank (SJR), the best quartile, and the H index. The results for *Computers in Education Journal* were 3.650 (SJR), Q1, and H index 232.

Table 4. Process of systematic SBLR.

Title	SJR	Best Quartile	H Index
<i>Computers in Education Journal</i>	3.650	Q1	232
<i>Innovation Technology and Knowledge Management</i>	3.370	Q1	54
<i>Nature Biotechnology</i>	18.12	Q1	511
<i>International Journal of Management Education</i>	1.260	Q1	53
<i>Thinking Skills and Creativity</i>	1.160	Q1	66
<i>Interactive Technology and Smart Education</i>	1.150	Q1	34
<i>American Journal of Pharmaceutical Education</i>	1.110	Q1	78
<i>Medical Education Online</i>	1.010	Q1	50
<i>European Journal of Education</i>	0.970	Q1	59
<i>Journal of Surgical Education</i>	0.900	Q1	72
<i>International Journal of Technology and Design Education</i>	0.810	Q1	56
<i>Frontiers in Psychology</i>	0.800	Q2	184
<i>Journal of Small Business and Enterprise Development</i>	0.790	Q1	86
<i>IEEE Transactions on Education</i>	0.790	Q1	76
<i>Journal Of Computer Information Systems</i>	0.780	Q1	77
<i>European Journal of Engineering Education</i>	0.770	Q1	59
<i>Education Training</i>	0.760	Q1	85
<i>Educational Action Research</i>	0.760	Q1	46
<i>Education and Training</i>	0.760	Q1	85
<i>Innovations In Education and Teaching International</i>	0.730	Q1	62
<i>Social Work Education</i>	0.710	Q1	50
<i>Education Sciences</i>	0.67	Q2	53
<i>Administrative Sciences</i>	0.630	Q2	35
<i>Journal of Management Education</i>	0.580	Q2	59
<i>Journal of Applied Research in Higher Education</i>	0.560	Q2	25
<i>Nursing Administration Quarterly</i>	0.530	Q2	44
<i>Entrepreneurship Education and Pedagogy</i>	0.530	Q2	19
<i>Procedia Computer Science</i>	0.510	- *	132
<i>International Journal of Engineering Pedagogy</i>	0.510	Q2	19
<i>Higher Education Skills and Work-Based Learning</i>	0.510	Q2	26
<i>Journal Of Biomechanical Engineering</i>	0.460	Q3	139
<i>New England Journal of Entrepreneurship</i>	0.440	Q2	19
<i>Eurasia Journal of Mathematics Science and Technology Education</i>	0.420	Q2	56
<i>Journal of Education and E-Learning Research</i>	0.410	Q2	12
<i>Estudios Sobre El Mensaje Periodistico</i>	0.390	Q1	17
<i>Computing in Science and Engineering</i>	0.380	Q2	79
<i>International Journal of Technology Management</i>	0.360	Q2	66
<i>Education Research International</i>	0.360	Q3	18
<i>Quarterly Journal of Speech</i>	0.350	Q1	45
<i>International Journal of Engineering Education</i>	0.35	Q2	61
<i>Lecture Notes in Business Information Processing</i>	0.340	Q3	63
<i>Journal of Emergencies Trauma and Shock</i>	0.340	Q2	39
<i>Journal of Teaching English for Specific and Academic Purposes</i>	0.310	Q3	5
<i>International Journal of Learning Teaching and Educational Research</i>	0.290	Q3	18
<i>Management Teaching Review</i>	0.280	Q3	5
<i>Science Education International</i>	0.260	Q3	8
<i>Proceedings Frontiers in Education Conference</i>	0.260	- *	46
<i>ACM International Conference Proceeding Series</i>	0.250	- *	151
<i>International Journal of Innovation and Learning</i>	0.240	Q3	29
<i>Journal of Allied Health</i>	0.240	Q3	43
<i>Journal of Commercial Biotechnology</i>	0.200	Q4	19
<i>Communications in Computer and Information Science</i>	0.200	Q4	69
<i>Journal of Engineering Education Transformations</i>	0.190	Q4	11
<i>Journal of Physics Conference Series</i>	0.180	- *	99
<i>Lecture Notes in Mechanical Engineering</i>	0.170	Q4	29
<i>Journal of Food Science Education</i>	0.170	Q4	18
<i>International Multidisciplinary Scientific Geoconference Surveying Geology and Mining Ecology Management</i>	0.170	- *	27
<i>IFMBE Proceedings</i>	0.140	- *	37

Table 4. Cont.

Title	SJR	Best Quartile	H Index
<i>International Research Symposium on PBL</i>	0.120	- *	4
<i>Proceedings of the Laccei International Multi Conference for Engineering Education and Technology</i>	0.120	- *	9
<i>Biomedical Sciences Instrumentation</i>	0.120	Q4	37
<i>ASEE Annual Conference and Exposition Conference Proceedings</i>	0	- *	28
<i>ASEE Annual Conference Proceedings</i>	0	- *	28
<i>Proceedings of the International Conference on E-Learning</i>	0	- *	13
<i>Proceedings of the European Conference on E-Learning</i>	0	- *	12
<i>Journal of Entrepreneurship Education</i>	0	- *	28
<i>International Symposium on Project Approaches in Engineering Education</i>	0	- *	7
<i>IEEE Global Engineering Education Conference</i>	0	- *	35
<i>Advances in Intelligent Systems and Computing</i>	0	- *	69
<i>Turkish Online Journal of Educational Technology</i>	0	- *	47
<i>Review of International Geographical Education Online</i>	0	- *	11
<i>Proceedings of the European Conference on Innovation and Entrepreneurship</i>	0	- *	9
<i>Proceedings of the ASME Design Engineering Technical Conference</i>	0	- *	54
<i>Proceedings of the 46th Sefi Annual Conference 2018 Creativity Innovation and Entrepreneurship for Engineering Education Excellence</i>	0	- *	4
<i>Proceedings of the 32nd International Business Information Management Association Conference Ibima 2018 Vision 2020 Sustainable Economic Development and Application of Innovation Management from Regional Expansion to Global Growth</i>	0	- *	11
<i>Proceedings of the 2019 Pacific Neighborhood Consortium Annual Conference and Joint Meetings Regionality and Digital Humanities South Connections 2019</i>	0	- *	0
<i>Proceedings of 2015 International Conference on Interactive Mobile Communication Technologies and Learning 2015</i>	0	- *	11
<i>Procedia Social and Behavioral Sciences</i>	0	- *	73
<i>IOP Conference Series Materials Science and Engineering</i>	0	- *	62
<i>International Journal of Instruction</i>	0	- *	39
<i>International Journal of Innovation Creativity and Change</i>	0	- *	21
<i>Iberian Conference on Information Systems and Technologies</i>	0	- *	24
<i>IADIS International Conference on Cognition and Exploratory Learning in the Digital Age 2012</i>	0	- *	6
<i>CSEDU 2010 2nd International Conference on Computer Supported Education Proceedings</i>	0	- *	6
<i>Chemical Engineering Education</i>	0	- *	28
<i>Asian Social Science</i>	0	- *	41
<i>Advanced Science Letters</i>	0	- *	32
<i>Administration in Social Work</i>	0	- *	43
<i>Academy of Management 2005 Annual Meeting a New Vision of Management in the 21st Century 2005</i>	0	- *	11
<i>29th Annual Conference of the European Association for Education in Electrical and Information Engineering 2019 Proceedings</i>	0	- *	4
<i>Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics</i>	- *	- *	- *
<i>Mechanical Engineering Education Handbook</i>	- *	- *	- *
<i>SEFI 47th Annual Conference Varietas Delectat Complexity is the New Normality Proceedings</i>	- *	- *	- *
<i>SEFI 2022 50th Annual Conference of the European Society for Engineering Education Proceedings</i>	- *	- *	- *
<i>Research Handbook on the Student Experience in Higher Education</i>	- *	- *	- *
<i>Proceedings of the 16th International Conference on Engineering and Product Design Education Design Education and Human Technology Relations 2014</i>	- *	- *	- *
<i>Proceedings of the 2021 World Engineering Education Forum Global Engineering Deans Council 2021</i>	- *	- *	- *
<i>Proceedings of the 2014 International Conference on Interactive Collaborative Learning 2014</i>	- *	- *	- *
<i>Proceedings of the 2013 6th International Conference on Information Management Innovation Management and Industrial Engineering 2013</i>	- *	- *	- *
<i>Proceedings Frontiers in Education Conference</i>	- *	- *	- *

Table 4. Cont.

Title	SJR	Best Quartile	H Index
<i>Proceedings 2022 IEEE International Conference on Teaching Assessment and Learning for Engineering Tale 2022</i>	- *	- *	- *
<i>Populism and Higher Education Curriculum Development Problem Based Learning as a Mitigating Response</i>	- *	- *	- *
<i>Novel Innovation Design for the Future of Health Entrepreneurial Concepts for Patient Empowerment and health Democratization</i>	- *	- *	- *
<i>Entrepreneurship Education Opportunities Challenges and Future Directions</i>	- *	- *	- *
<i>EPE 2020 Proceedings of the 2020 11th International Conference and Exposition on Electrical and Power Engineering</i>	- *	- *	- *
<i>Balkan Region Conference on Engineering and Business Education</i>	- *	- *	- *
<i>Archives of Otolaryngology Head and Neck Surgery</i>	- *	- *	- *
<i>2021 Joint 6th International Conference on Digital Arts Media and Technology with 4th ECTI Northern Section Conference on Electrical Electronics Computer and Telecommunication Engineering 2021</i>	- *	- *	- *

* data not available. Source: own elaboration.

There was a total of 22 publications in Q1, 16 publications in Q2, 9 publications Q3, and 6 publications in Q4. Publications from best quartile Q1 represented 20% of the 198 publications titles; best quartile Q2 represented 14%, best Q3 represented 8%, and best Q4 represented 5% of each of the titles of 108 publications. Finally, 55 publications without indexing data represented 50% of publications. As shown in Table 2, the significant majority of publications did have quartile Q1.

The most quoted article was “A problem-based learning approach to entrepreneurship education” by Siok and Frank (2006), with 133 quotes, published in *Education and Training*. With 0.760 (SJR), the best quartile (Q1), and H index (85), this paper presents a case to suggest that a problem-based learning approach practiced at the Republic Polytechnic in Singapore could be an effective pedagogical approach for entrepreneurship education.

In Figure 5, we analyze citation changes for documents published up to May 2024. The period 2014–2024 showed a positive net growth in citations, with an R2 of 25%, reaching 990 citations in May 2024.

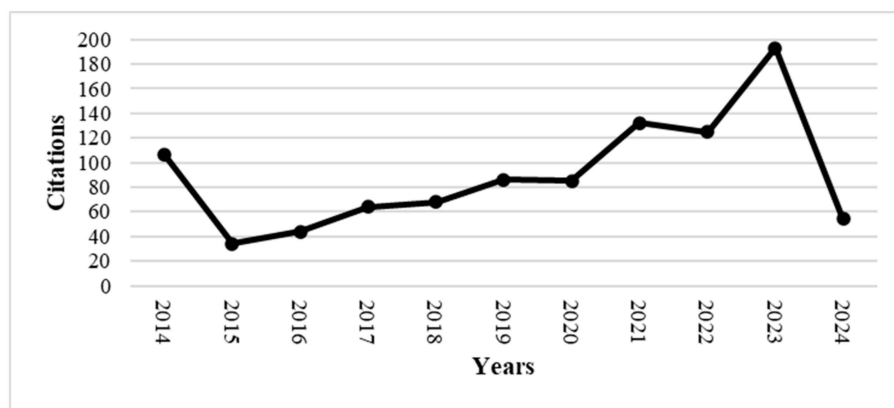


Figure 5. Evolution of citations between 2014 and May 2024. Source: own elaboration.

The H-index is used to determine the productivity and impact of a published work based on the maximum number of included articles with at least the same number of citations. Of the documents considered for H-index, 17 were cited at least 17 times.

Citations of all scientific and/or academic documents from the period ≤2014 to May 2024 included with a total of 990 citations; of the 142 documents, 48 were not cited. The self-citation of documents in the period ≤2014 to May 2024 occurred 869 times.

3.2.2. Data Visualization

Bibliometric analysis was conducted to explore and pinpoint metrics to reveal the patterns and development of scientific or academic content within documents, using principal keywords (Figure 6). In this visualization, we were able to observe most of the network nodes. In Figure 6, the size of each node indicates the frequency of the associated keyword—that is, how often the keyword appears. Furthermore, the connections between the nodes signify keyword co-occurrences, where keywords appear together. Meanwhile, the thickness of these links highlights the frequency of these co-occurrences—essentially, how frequently the keywords are found together. In this case, the following two figures illustrate the interplay between PBL and entrepreneurship along key subthemes such as entrepreneurial mindset, critical thinking, skills, capabilities, and pedagogy.

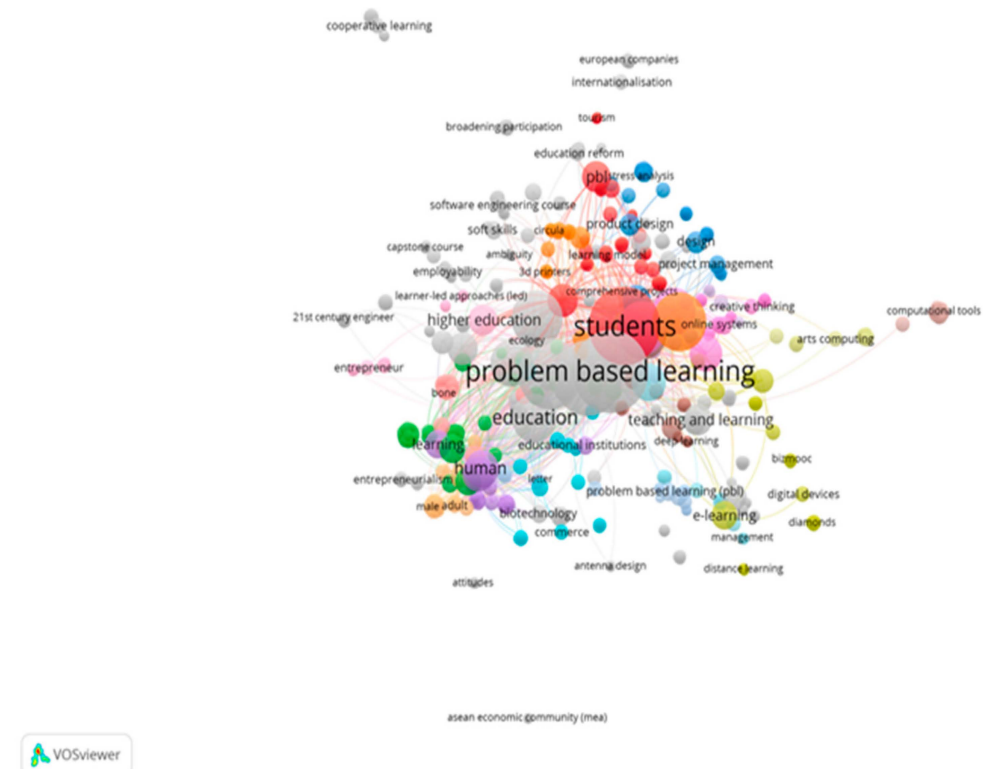


Figure 6. Network of all keywords.

In these diagrams, the size of each node corresponds to the frequency of the relevant keyword, while the thickness of the links between nodes indicates the frequency of keyword co-occurrences. Each color represents a different thematic cluster, with the nodes illustrating the scope of topics within a theme and the links showing the relationships among topics under the same thematic umbrella.

The results were derived using the scientific software VOSviewer, specifically designed to target the key search term “problem-based learning entrepreneurship”. The study utilized scientific and academic documents focusing on this area.

In Figure 7, from a different perspective, we analyze the connected keywords, illustrating the network of keywords that co-occur in each scientific article. This analysis helped in identifying the subjects investigated by researchers and pinpointing emerging trends for future studies.

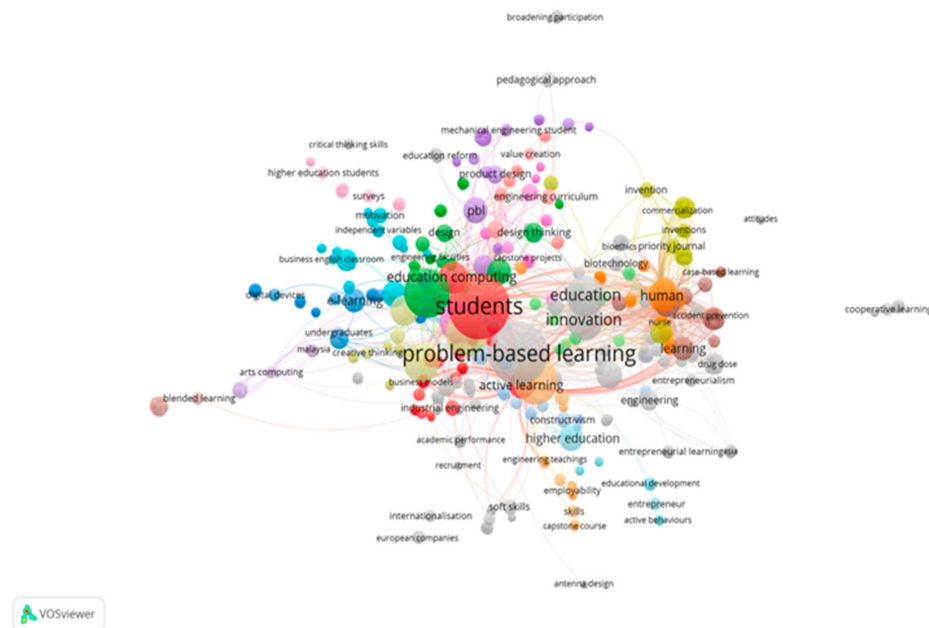


Figure 7. Network of linked keywords.

3.3. Results

In summary, the methodology selected for this study provided precision and ensured the availability of comprehensive data for other researchers interested in building upon this review. The analysis identified problem-based learning as a pedagogical methodology primarily related to the entrepreneurship field, in particular to the building of (i) entrepreneurial skills and mindset and (ii) entrepreneurial challenges and critical thinking.

In detail, following the networks of all and linked keywords, conclusions can be drawn regarding some trends. As displayed in Figure 6, PBL is intrinsically connected to educational issues, reflected by the major labels ‘students’, ‘education’, ‘higher education’, ‘teaching and learning’, ‘educational institutions’, and ‘e-learning’. Nevertheless, emerging in the background are other, smaller tags, more related to industry, which represent the ensuing outcomes of former entrepreneurship training. In particular, ‘product design’, ‘project management’, ‘design’, ‘creative projects’, ‘comprehensive projects’, ‘online systems’, ‘soft skills’, ‘human learning’, ‘management’, ‘digital services’, ‘deep learning’, ‘commerce’, and ‘digital devices’. Likewise, the same pattern follows in Figure 7: the principal labels ‘students’, ‘education’, ‘education computing’, ‘human learning’, ‘active learning’, ‘e-learning’, and ‘innovation’ are linked to the ensuing outcomes ‘engineering’, ‘industrial engineering’, ‘business models’, ‘creative thinking’, ‘capstone projects’, ‘biotechnology’, ‘commercialization’, ‘inventions’, ‘design’, ‘motivation’, ‘employability’, ‘skills’, and ‘product design’. This outline confirms the influence of PBL methodology, discussed above, on wider entrepreneurship and industry-related capabilities.

Also, by addressing those key correspondences, the methodology enhanced coherence and improved the overall validity and reliability of the findings. In this context, the established guidelines for systematic reviews and meta-analyses were observed in the current study, achieving a high methodological standard.

Below, we discuss in further detail these main correspondences in terms of attained entrepreneurial skills/mindset in relation to varied industries and the ensuing attitudes upon critical thinking.

4. Discussion

4.1. Entrepreneurial Skills and Mindset

In the vein of the aforementioned analysis, a more interpretative discussion is presented. In this way, in the light of the above-analyzed topics of ‘Education’, ‘Teaching

and Learning', 'Pedagogy', and 'Higher Education', PBL indeed enhances entrepreneurial skills and mindsets, in contrast with traditional learning methods, leading to more multi-disciplinary and interactive solutions within the community [31]. It feeds critical thinking skills that are essential for dealing with contemporary challenges, while developing an entrepreneurial mindset by emphasizing real-world experience, motivation, teamwork, and knowledge retention [6]. Furthermore, it is paramount to ameliorate critical thinking skills and learning, as this enhances the entrepreneurship activities of opportunity discovery and value creation, often in relation to challenge-based learning, in which critical thinking is encouraged as a key characteristic of the entrepreneurial mindset [14]. Overall, PBL has been proven to increase entrepreneurial learning outcomes, highlighting its long-term impact on the reinforcement of business capabilities [32]. Nonetheless, it is of value to explore what skills and mindset have been attained and under what circumstances PBL has been collaboratively applied.

The aforementioned capabilities and mindset achieved by PBL methodologies rely upon varying pedagogical resources and didactic strategies that are worth mentioning. First, some threads of the literature posit that scaffolds used in PBL positively impact learning outcomes in terms of helping potential entrepreneurs to develop their entrepreneurial attitudes, in particular with respect to engineering and related technical fields [33]. The fostering of enterprising graduates in engineering is emphasized by combining entrepreneurial learning behaviour along the curricula, enabling them to build new value through action [34]. This intention depends on the changes of traditional entrepreneurship pedagogies through, for instance, a 'hackathon' approach, an effective entrepreneurial learning methodology to attain entrepreneurial skills and self-confidence [35]. The vast array of didactic resources for PBL allows the use of collaborative pedagogical models that facilitate the exchange and co-creation of knowledge while developing entrepreneurial skills, often in conjunction with other disciplines such as, for example, design thinking [8].

Second, PBL often uses new, current tools such as digital technologies to innovate socially and promote social change through digital social innovations and ensuing entrepreneurial skills in all sectors of education and training [36]. Such entrepreneurial capabilities can, on one hand, emerge through active learning in the form of communication, collaboration, and knowledge-sharing in class that ultimately results in a new way of thinking [12]. On the other hand, it could emerge through the ability to market a product by means of a sales poster, for example, with the use of PBL, which is feasible in different contexts. It also stimulates entrepreneurial awareness in any situation [5]. PBL enables innovation to be promoted irrespective of the context and technology, providing curricula (e.g., engineering and business) and underscoring the development of entrepreneurial and intrapreneurial skills [37].

Third, in this vein, PBL can be implemented in diverse milieus. As it emulates the entrepreneurial learning based on experimental learning by doing, it relies upon a multi-solution approach that fits varying trigger events [18]. In so, it could be applied with regard either to social work or to international courses (e.g., Erasmus), exploring the potential of using active experiential learning methods in an international environ whilst building responses to critical 'real-world' events and ensuing entrepreneurial capabilities [17]. Likewise, PBL could be implemented online, shifting from a passive learning mode to an active experiential mode [38].

Fourth, behind the already mentioned set of entrepreneurial skills lies the inherent entrepreneurial mindset that triggers the appropriate business responses. The purpose of PBL is the development of such an entrepreneurial mind and subsequent responses in students [13], for effective entrepreneurship education [39]. A digital entrepreneurial mindset and digital competences for a digitized world may arise through dealing with problems from their working environ [40], within an entrepreneurial digital learning environment of active users across web platforms, e-testing, webinars, e-books, video sequences, podcasts, social networks [10], and Google Hangouts [41]. The entrepreneurial mind could also be addressed by PBL through the engagement of entrepreneurial orientation (innovativeness,

risk-taking, and proactiveness) across varied didactic components of active entrepreneurial learning (e.g., games) [42] that, along with the relevant teaching innovation, goes well beyond academic grades [43].

Fifth, those innovative didactics should put the emphasis more on customer-related problems than on technical issues [44], while imitating the industrial work environment [45], with open-ended questions applied to different institutions, student demographics [46], and a wide scope of fields (e.g., biomedicine) [47,48]. Additionally, such innovative didactics could even go further in terms of creating a smart learning ecosystem, both indoor and outdoor, underscoring participatory learning, networking, and capacity building [49].

Finally, PBL combined with related active pedagogy can also be modified to fit either a specific course, such as the traditional engineering curriculum [50,51], or a distinct sector, by settling the course according to the characteristics of the students and demanded contents/skills [52], for instance, in the tourism sector [32]. In sum, PBL promotes entrepreneurial intention and attitude by creating innovative learners with precise learning strategies and entrepreneurial self-efficacy for business planning [9,21], often supported by creative collaborators as well [2,53].

4.2. Challenges and Critical Thinking

Likewise, in the vein of the previously analyzed interrelated concepts of ‘industry’, ‘business models’, ‘creative thinking’, ‘projects’, ‘employment’, ‘motivation’, and ‘skills’ (Figures 6 and 7), problem-based learning (PBL) is an active hands-on pedagogical approach that holistically engages participants in realistic challenges (e.g., small business constraints, legal issues) related to their context, demanding a solution as a challenge. It thereby improves the critical thinking skills behind the entrepreneurial attitude of risk assumption, proactivity, and innovation [6]. Likewise, it positively impacts entrepreneurs by enhancing their problem-solving capabilities [3], with emphasis on their critical thinking, which is key for decision-making in the context of entrepreneurial action [39]. It is therefore worthwhile to ascertain how critical thinking is contextually built, including ways of fostering entrepreneurial attitude, innovation, and collaborative models.

PBL is an experiential learning methodology that can assume varying forms according to either similar or different environments. It can be applied to bioengineering education and training [54,55] at both at graduate and postgraduate level, such as, for example, in innovative food studies programs [11], and across distant geographies such as employment agencies in Nigeria [56] and East Java, Indonesia [1]. Improvements in critical thinking learning activities [6], a higher retention rate, augmented motivation, and the growth of high-quality work [57] have been evidenced across diversified curricula worldwide.

First, intensive entrepreneurship learning methods (e.g., hackathons) may be more effective for developing entrepreneurial self-efficacy than conventional courses [35]. These types of curricula use a constructivist approach allowing students to build their understanding in relation to their own tech innovations [58], either through experiences from live-in entrepreneurship program studies [59] or via blended learning models employing integrated modular course frameworks [60] and new developments in digital devices along the learning process [61]. Processes may include new approaches to how we embed entrepreneurial capabilities by facilitating entrepreneurial projects in a problem-based learning environment [62]. The projects performed in universities tend to involve team members with common interests in entrepreneurship aiming at start-up business plans [63], and can improve student learning activities as well as student learning outcomes [64] among entrepreneurs [65]. These projects may assume different forms, such as the STEAMPUNK Girls Program, funded by the Australian Government, that uses project-learning and design thinking strategies to enable the girls to be change makers [66], or the Teaching Factory (TEFA), which is a combination of production-based learning and competency learning [67], often relying upon innovation [68] in the context of a new “way of disseminating knowledge” [69].

Second, the PBL pedagogy is intended to shape a business-oriented curriculum designed to help students learn about creativity techniques [70] by promoting entrepreneurship in the classroom for a given company [71]. It is suggested that work-life experience should be merged with studio training in a multidisciplinary and multi-professional environment [72], combining varying pedagogical models and methods pursued in entrepreneurship education, aiming at encouraging students to be self-directed [73] and committed [74], often through case studies [75] and integration in distinct academic courses [76]. Such pedagogy offers a “scalable” model to reduce teacher load, whilst promoting student interaction [77] and lecturers’ facilitative capabilities [19]. Ill-structured problems are posed and demand autonomous thinking, with students taking responsibility for their own learning [21] in different ventures [78], educational portfolios [22], and geographies [79,80], including work at master’s level [81]. PBL also relied on computer-aided activities [20], e-learning in sparsely populated areas [25], reverse online classes [82], and online learning methods during the lockdown period due to the COVID-19 pandemic [83].

Third, PBL turns out to be an extremely useful method with respect to promoting entrepreneurial attitudes in potential entrepreneurs. This is particularly true for Generation Z, who, on average, are entrepreneurial and have shorter attention capacity and a huge desire for customized curricula and hands-on approaches [84]. Also, PBL enhances motivation toward achievement [1], experienced meaningfulness [7], and self-centred learning models [31]. It emphasizes positive learning [85], partly through cooperative efforts within the community, for instance, by municipality and industry cooperation [86,87] or between universities, industry, and government [88], where the integration of PBL fosters self-directed and collaborative learning and improves problem-solving skills [16]. Moreover, interdisciplinary learning is inherent to PBL, for instance, in the full-day ‘Start-Up Sprint’ to emulate a start-up event [89] and in singular case studies that enable learners to approach real-world problems [90,91].

Fourth, those experiential, collaborative, and motivating tools of PBL aim at building entrepreneurial capabilities and ensuing innovation among varied actors. Innovation may arise by spreading entrepreneurial culture and innovative ideas amongst stakeholders [92], through start-up companies and patent disclosures [93], and amidst varying participants [94]. It may occur through the creation of accessible products and services under universal design [95] and prototype-based experiences aiming at value creation [96] within real contexts [97].

Fifth, such innovation is intended to develop over varied sectors [98]. PBL has introduced entrepreneurship in terms of learning engagement and innovation to the biotech sector [99] and in undergraduate nursing education [100]. It has contributed to entrepreneurship education for both secondary- and tertiary-level students [101], and as a foundation for entrepreneurship education [102] and medical education [103,104]. Furthermore, it is key in empowering potential entrepreneurs to become more entrepreneurial and innovative, irrespective of their age [105], emphasizing active learning tools that, along with conventional curricula, make them set for industry [106], whilst enhancing their capacities to respond to challenges [107]. This is particularly true with regard to biomedical engineering applications, which are very valuable and engaging for students in terms of combining medical device design [108] with economic competencies [109].

Sixth, in PBL, the emphasis is on achieving new entrepreneurial capabilities [110] through active learning and methodologies [111] fitted for different disciplines [23]. To attain this goal, varying tools are employed, such as rapid prototyping devices [112,113], computer simulation [114], and learning by doing [115,116], to achieve transversal capabilities [14] and entrepreneurship abilities [4] in cooperation with industry [117]. The goal is to blend theory with real-world practices beyond technical knowledge [118], focusing on honing students’ capacity for criticism [119], which results in increasing learning and ameliorated design and communication competences, together with improvement of teamwork [120]. Moreover, teaching styles heavily influence the interplay between hands-on learning approaches and attitudes [121].

Seventh, the regional level of development is paramount regarding entrepreneurial education. In this way, PBL has been applied throughout varying environs of distinct levels of development. In fact, the literature reveals an increasing concern with sustainable issues, mainly in developing regions and with respect to the circular economy in terms of entrepreneurial learning and sustainable value creation [122], namely, how courses could be designed combining teaching and real-life projects into new sustainable business ideas [123]. Overall, in light of PBL, there has been a positive impact of entrepreneurial learning on entrepreneurial intentions within distinct milieus [124]. Nevertheless, some constraints may emerge in developed regions while implementing PBL methodology, for instance, in terms of group arrangement and problem analysis stages [26], curricula creation appropriate to social and economic needs of Africa [125], and the carrying out of relevant PBL sustainable entrepreneurship approaches in Africa [126], Indonesia [127], and India [128].

Ninth, the prominence of PBL has risen substantially in related technical fields, aiming at promoting entrepreneurial learning activities within existing curricula in engineering courses to develop new capabilities [34], either to provide opportunities for students to try out new skills [129] or to foster collaboration in entrepreneurship initiatives between engineering and other relevant disciplines [130]. Such initiatives allow learners to acquire relevant entrepreneurship competences to be applied for product design [131], innovation networking within diverse contexts [132,133], and experiential learning on a daily basis, centred on entrepreneurial problems [134]. Furthermore, they deliver a focus on creativity and customer-oriented design within varied engineering disciplines [135] in order to institutionalize engineering entrepreneurship [136], providing PBL opportunities in context [137].

Lastly, PBL has been applied in the context of social entrepreneurship [138], relying on the productive learning principle of social entrepreneurship in student project work [139], for instance, based on social company innovation [140,141], toward authentic creation of entrepreneurial learning and real-world value [15,142]. In sum, problem-based learning plays a key role in enhancing critical thinking skills [143,144] for entrepreneurs by delivering a stage for active engagement [6,145], proper mindset, and real problem-solving, which are essential for entrepreneurial and business success.

5. Conclusions

Problem-based learning (PBL) is an educational approach that uses complex and authentic problems as a starting point for the acquisition of new knowledge. This method is particularly effective in entrepreneurship education and entrepreneurship in general, as it motivates students by mirroring the real-world challenges that entrepreneurs often face, while emphasizing the basic entrepreneurship principles of risk assumption, innovation, and proactivity. In the light of the initial research question, “What is the interplay of problem-based learning methodology with entrepreneurship?”, this study has explored and clarified the particular interactions of PBL with diverse entrepreneurship events over varied circumstances, either education- or industry-related, thereby providing a worthwhile and novel review of PBL approaches to varied contexts.

In this way, as aforementioned, problem-based learning and entrepreneurship are linked in the field of innovative education and beyond, allowing identification of constructive real-world challenges and ensuing solutions achieved by critical thinking. In addition, this study identified that the PBL framework provides a vast array of tools that are likely to trigger varying learning modes and types, e.g., learning by doing, or more planned methods, e.g., planning. Likewise, it also reveals that PBL builds on different contexts and sectors at diverse levels of development, technology, and knowledge absorption toward value creation and output, while enduring potential setbacks in relation to the learning process, as revealed in the Figures 6 and 7 and clarified in Section 3.3. Furthermore, PBL considers the issues of sustainability and social responsibility along its decision process. On can conclude that this pedagogical method effectively prepares for entrepreneurial challenges throughout varying milieus, while underscoring the foundations of entrepreneurship.

Table A1. Cont.

Documents		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
A design and effectiveness evaluation of the Maker spirit–PB...	2023	-	-	-	-	-	-	-	-	-	-	-	-
Problem-based learning in the online flipped classroom: Its...	2023	-	-	-	-	-	-	-	-	-	-	-	-
Entrepreneurship education through sustainable value creatio...	2023	-	-	-	-	-	-	-	-	1	1	-	2
Universal Design: A Problem-Based Exercise in a Fast-Paced C...	2022	-	-	-	-	-	-	-	-	-	-	-	-
Teaching entrepreneurship to life-science students through P...	2022	-	-	-	-	-	-	-	-	1	2	3	6
Problem-Based Effectual Action fuels Digital Mindsets	2022	-	-	-	-	-	-	-	-	-	1	-	1
The Effect of E-Problem Based Learning on Students' Interest...	2022	-	-	-	-	-	-	-	-	-	4	2	6
INNOVATE	2022	-	-	-	-	-	-	-	-	-	6	1	7
Teaching Strategies and Psychological Effects of Entrepreneu...	2022	-	-	-	-	-	-	-	-	-	1	1	2
Discovering Entrepreneurship Competencies through ProblBa...21	2022	-	-	-	-	-	-	-	-	1	4	1	6
Using the EntreComp framework to evaluate two entrepreneursh...	2022	-	-	-	-	-	-	-	-	1	7	1	10
Lenses on the post-oil economy: integrating entrepreneurship...	2022	-	-	-	-	-	-	-	3	1	1	-	5
A project-based learning approach to promete innovation and...	2021	-	-	-	-	-	-	-	-	1	3	2	6
Success Through Failure: Towards a Problem-Based Approach to...	2021	-	-	-	-	-	-	-	1	3	1	1	6
Implementing studio-based learning for design education: as...	2021	-	-	-	-	-	-	-	1	2	2	1	6
Start-Up Sprint: Providing a Small Group Learning Experience...	2021	-	-	-	-	-	-	-	1	-	2	-	3
POPBL Blended Learning Model to Enhance Student Performance...	2021	-	-	-	-	-	-	-	-	1	-	-	1
Towards a responsible entrepreneurship education and the fut...	2021	-	-	-	-	-	-	3	6	8	11	3	31
Improving activities and learning outcomes of biology educat...	2021	-	-	-	-	-	-	-	1	-	-	-	1
A Capstone Course Linking Geography Knowledge and Entreprene...	2021	-	-	-	-	-	-	-	-	1	-	-	1
Teaching Z Generation Engineers. Using Entrepreneurship Educ...	2020	-	-	-	-	-	-	-	-	1	1	1	3
The effects of hackathons on the entrepreneurial skillset an...	2020	-	-	-	-	-	-	-	2	1	11	2	16
Understanding How to Engage Black HS Boys in Computer Scienc...	2020	-	-	-	-	-	-	-	4	1	3	1	9
ICT Methodologies in Entrepreneurship: Business Models and...	2020	-	-	-	-	-	-	-	-	-	1	-	1
The Influence of Entrepreneurial Mindsets on Student Design...	2020	-	-	-	-	-	-	-	5	4	4	4	17
Entrepreneurship education through sustainable value creatio...	2020	-	-	-	-	-	-	-	1	-	1	1	3
The effect of problem-based learning (PBL) model on student...	2020	-	-	-	-	-	-	-	-	1	1	-	2
Engaging High School Girls in Interdisciplinary STEAM	2020	-	-	-	-	-	-	-	3	3	7	-	13
Teaching social entrepreneurship through problem-based learn...	2020	-	-	-	-	-	-	-	1	1	2	1	5
Master StudentTeaching and Training in an International Con...	2020	-	-	-	-	-	-	-	-	1	-	-	1
Engineering Design Entrepreneurship and Innovation: Transdis...	2020	-	-	-	-	-	-	-	2	3	4	1	10
Developing professional and entrepreneurship skills of engin...	2020	-	-	-	-	-	-	2	4	6	7	1	20
A critical review of learning approaches for entrepreneurshi...	2019	-	-	-	-	-	-	2	3	5	9	5	24
The Curriculum Development for Global AGILE Problem-Based Le...	2019	-	-	-	-	-	-	-	1	-	-	-	1
STEAM for STEM, including 'Art' in STEM (Science, Technology, E...	2019	-	-	-	-	-	-	-	1	-	-	-	1
Creative entrepreneurship—A proposal to 2030's education	2019	-	-	-	-	-	-	-	1	-	-	-	1
Application of digital toais for the development of entrepre...	2019	-	-	-	-	-	-	-	1	-	3	-	4
The role of engineering education for innovation in the 2lst...	2019	-	-	-	-	-	-	-	-	-	-	1	1
Bad to the Bane: Multifaceted Enrichment of Open-Ended Biorne...	2018	-	-	-	-	-	-	1	-	-	1	-	2
BFab for Faculty: Using Making to Empower Entrepreneurially-...	2018	-	-	-	-	-	-	2	-	-	1	-	3
The Surgery Innovation and Entrepreneurship Development Prog...	2018	-	-	-	-	2	2	2	4	2	3	-	15
Preparation of the professional engineer: Outcomes from 20 y...	2018	-	-	-	-	-	1	-	-	-	2	-	3
The implementation of interest-based entrepreneurship curric...	2018	-	-	-	-	5	1	1	-	1	-	-	8
Can TEFA (teaching factory) be realized with a creative econ...	2018	-	-	-	-	-	-	-	-	-	-	1	1
Promoting PBL through an active learning model and the use o...	2018	-	-	-	-	-	4	2	-	-	3	-	9
One design issue—many solutions. Different perspectives of...	2018	-	-	-	-	1	10	3	1	4	3	-	22
Effective learning of innovation by engineering students in...	2018	-	-	-	-	-	-	1	1	1	-	-	3
The effect of problem-based learning (PBL) method on student...	2018	-	-	-	-	-	2	1	-	-	-	-	3
The 'case-based learning conference' model at EMINDIA2017: A...	2018	-	-	-	-	-	-	-	-	-	1	-	1

Table A1. Cont.

Documents		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Promoting interdisciplinarity through an intensive entreprene...	2018	-	-	-	-	-	-	1	1	1	1	1	5
Using PBL and Rapid Prototyping Resources to Improve Learnin...	2018	-	-	-	-	-	1	-	-	-	-	-	1
Fostering skills for digital social innovations in entreprene...	2017	-	-	-	-	-	-	2	-	-	1	-	3
More than just a game: the role of simulation in the teachin...	2017	-	-	-	-	3	3	4	2	2	-	-	14
Innovation and entrepreneurship programs in US medical educa...	2017	-	-	-	-	1	6	7	8	7	23	3	55
Creativity and problem solving: Closing the skills gap	2017	-	-	-	-	3	3	5	3	6	3	-	23
The Relevance of Problem-based Learning for Policy Developme...	2016	-	-	1	4	2	7	3	4	7	3	-	31
Fostering Entrepreneurship in Higher Education, by Problem-B...	2016	-	-	-	-	1	-	-	1	-	1	-	3
The LAB studio model: Enhancing entrepreneurship skills in h...	2016	-	-	-	1	1	3	-	1	-	3	1	10
Creative thinking experimentations for entrepreneurship with...	2015	-	-	1	-	-	1	-	1	1	1	1	6
A creative and entrepreneurship project promotion of primary...	2015	-	-	-	2	1	-	-	1	-	-	-	4
How do Finnish teacher educators implement entrepreneurship...	2015	-	-	1	2	12	4	2	12	5	6	-	44
Analyzing tourism students' managerial skills by applying PB...	2015	-	-	-	2	-	-	-	-	-	-	-	2
Replica of a shaking table from the XIX century: A workshop...	2015	-	2	2	-	-	-	-	1	-	-	-	5
Fostering the entrepreneurial mindset through the developmen...	2015	-	5	3	1	1	-	-	-	1	-	-	11
Innovation to entrepreneurship in the first-year engineering...	2015	-	4	6	1	1	-	-	1	2	2	-	17
Challenges and potential of teaching engineering students in...	2015	-	1	-	1	-	-	-	-	-	-	-	2
Evaluating the effects of a problem-based learning business...	2014	-	1	-	1	1	-	-	-	1	-	-	4
Needs assessment for the development of entrepreneurship cur...	2014	-	-	-	-	-	-	-	1	-	-	-	1
Using problem-based learning to stimulate entrepreneurial aw...	2014	1	5	3	4	8	2	2	-	-	1	-	26
An assessment of educational benefits from the open orbiter s...	2012	8	7	2	5	1	1	2	-	-	-	-	23
Social Entrepreneurship and Social Work: The Need for a Tran...	2012	3	3	1	1	3	2	4	4	5	3	1	29
Stimulating learning via tutoring and collaborative entrepre...	2012	-	-	-	-	-	-	-	-	-	1	-	1
Theory to practice: Real-world case-based learning for manag...	2012	-	-	1	1	-	-	1	1	1	2	-	7
Examining competence factors that encourage innovative behav...	2012	1	1	4	2	2	7	8	7	4	4	-	40
Revisiting Vico's pedagogy of invention: The Intellectual En...	2012	-	3	1	1	1	-	-	-	-	-	-	6
The 'Ecosportech' project as an example of entrepreneurial...	2012	2	-	-	-	-	-	-	-	-	-	-	2
Preparing mechanical engineering students for product design...	2011	2	-	-	-	-	-	-	-	-	-	-	2
Developing Entrepreneurship in Social Work Through Internati...	2011	1	-	-	4	1	-	-	-	2	-	-	7
The role of project-based learning in IT: A case study in a...	2011	5	-	2	-	4	3	6	-	3	3	-	22
Improving lecturers' facilitative approach in the problem-ba...	2010	-	-	-	-	-	-	-	-	1	-	-	1
Development of contemporary problem-based learning projects...	2009	-	-	-	-	-	-	1	-	1	-	-	2
Entrepreneurship education: Towards an industry sector appro...	2008	7	2	1	-	-	5	4	3	1	1	1	20
Utilization of problem-based learning in an entrepreneurship...	2008	3	1	-	-	-	-	2	1	2	-	1	7
Innovations in bioengineering education for the 21st	2007	1	-	-	-	-	-	-	-	-	-	-	1
A problem-based learning approach to entrepreneurship educat...	2006	31	7	6	18	12	7	9	18	11	11	3	112
A scalable problem-based learning system for entrepreneurshi...	2006	2	-	-	1	-	-	1	1	-	-	-	3
Problem-based learning approach in accomplishing innovation...	2005	8	4	-	3	1	3	2	3	2	1	1	20
A scalable problem-based learning system for entrepreneurshi...	2005	6	1	1	-	1	1	-	1	1	-	-	8
Entrepreneurs in Action!: A problem-based learning environme...	2005	3	-	-	-	-	1	-	-	-	-	-	4
Supporting Undergraduate Biomedical Entrepreneurship	2004	-	-	-	-	1	-	-	-	-	-	-	1
A problem-based learning approach in entrepreneurship educat...	2004	11	-	3	3	2	1	3	5	3	3	1	26
Assessing engineering entrepreneurship	2003	6	-	1	-	-	-	1	-	-	-	-	2
Launching an undergraduate engineering entrepreneurship prog...	2002	4	-	1	-	-	-	-	-	-	-	-	1
The center for engineering design and entrepreneurship: An...	2002	1	-	-	-	-	-	-	-	-	-	-	1
Total		106	34	44	64	68	86	85	132	125	193	53	990

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