Multimodal Technologies and Interaction

Systematic Review

Active Learning Strategies in Computer Science Education: A Systematic Review

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Abstract: The main purpose of this study is to examine the implementation of active methodologies in the teaching–learning process in computer science. To achieve this objective, a systematic review using the PRISMA method was performed; the search for articles was conducted through the Scopus and Web of Science databases and the scientific search engine Google Scholar. By establishing inclusion and exclusion criteria, 15 research papers were selected addressing the use of various active methodologies which have had a positive impact on students' learning processes. Among the principal active methodologies highlighted are problem-based learning, flipped classrooms, and gamification. The results of the review show how active methodologies promote significant learning, in addition to fostering more outstanding commitment, participation, and motivation on the students' part. It was observed that active methodologies contribute to the development of fundamental cognitive and socio-emotional skills for their professional growth.

Keywords: active methodologies; teaching–learning; computer science

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1. Introduction

Active methodologies represent an effective teaching–learning strategy by promoting student participation in acquiring knowledge through interaction, experimentation, and reflection. They lead to the contextualization of a problem and the proposal of solutions in a metacognitive manner, where motivation is encouraged and thinking skills such as information analysis, inference, abstraction, and interpretation of the results obtained are developed. Moreover, these methodologies not only contribute to significant learning but also improve students' cross-curricular competencies such as collaborative work, innovation, creativity, and entrepreneurship.

These methodologies allow the integration of theoretical–practical content and its application in authentic contexts, which fosters students' interest and motivation. According to Guerrero et al. [1], "the student's motivation and active engagement in their learning process is a key success factor in higher education, especially in the fields of science and engineering".

In the field of engineering, student-centered learning methods have been used, including project-based learning, problem-based learning, and the flipped classroom, to name a few. Through the project-based learning methodology, learning is shaped through projects, which "are complex tasks based on challenging questions or problems that involve students in design activities, problem solving, decision making, or research activities" [2]; the problem-based learning method, according to Zakaria et al. [3], "focuses on learning activities useful for solving everyday problems. It focuses on real and challenging problems to help students understand real-life situations", providing them opportunities for self-directed learning; the flipped classroom methodology consists of rotating between practices and/or projects guided by teachers face-to-face during class time, and access to materials and resources on topics distributed online, outside of school hours (predominantly from home) [4]; that is, through the use of learning technology (mainly multimedia) activities that are traditionally performed in class, are performed from home and what is traditionally performed as homework, is now complemented in class [2].

Recent studies have shown that students in computer science fields have learning difficulties in subjects such as programming, algorithms, and software development because they require the possession and application of logical and computational thinking skills. Therefore, the main objective of this work is to analyze, through a systematic review, the research proposals that have used active methodologies in the teaching–learning process of the computer science area in order to identify the benefits they provide and the relevance of their implementation in the classroom. It also discusses the difficulties experienced with the use of these methodologies as teaching strategies and the main findings obtained.

The rest of this document is organized as follows. Section 2 addresses the theoretical foundations of the research; Section 3 describes the methodology used to carry out the systematic analysis; Section 4 presents the results obtained; Section 5 discusses the results; and Section 6 finishes with the conclusions.

2. Theoretical Foundations

2.1. Active Learning

According to Ayala-Ramírez et al. [5], the active learning model is based on constructivist learning theory. In this approach, the teaching–learning process is grounded in contextualization and the student's direct understanding of everyday realities, enabling them to experience and develop relationships between different areas of knowledge. Under this model, teachers must propose various contexts and guide students regarding the theories that allow them to address these contexts [6], with the goal of having students take a leading role "in their formative process, in a flexible, reflective manner and according to their own needs" (p. 43) [5]. This methodology focuses on five aspects: 1. each person learns for themselves; 2. students consciously evaluate and provide feedback on their activities; 3. knowledge is part of a personal construction (knowledge construction); 4. knowledge can be applied in context (situated); and 5. learning is a product of social interaction [6]. According to Martín-García et al. [7], the implementation of active methodologies constitutes a complex process because it involves a paradigm shift in teaching–learning, requiring both students and teachers to change their perspectives on education. Nevertheless, various studies show and recognize that student participation in active methodologies promotes learning and motivational attitudes toward mastering a subject.

2.2. Problem-Based Learning

Problem-based learning (PBL) is a pedagogical and learning approach that reflects active learning. Aiddo [8] states that PBL has been used in higher education institutions (HEIs) over the past two decades due to the challenges, needs, and learning opportunities of 21st-century students. Various definitions of PBL exist in the literature, considering it a multi-methodological and multi-didactic pedagogical approach [6], through which students construct their knowledge. In this type of learning, students actively participate in activities facilitated by an instructor, which allows them to generate a certain level of autonomy in decision making during the learning process. Consequently, PBL uses the resolution of open and relevant problems, working on real case scenarios that "enable interpreting data, constructing models, developing ideas through integrated scientific knowledge activities" [8]. Hincapie et al. [6] and Aidoo [8] agree on identifying seven steps to solve problems, although they do not name them identically. These steps are 1. problem identification; 2. problem formulation or analysis; 3. analysis (determining what is known and unknown about the topic); 4. determining solutions (what is needed to solve the problem); 5. formulating conclusions; 6. evaluation; and 7. problem resolution. One of the particularities of PBL is that group analysis of a problem activates prior knowledge (even if it is irrelevant or incorrect) to facilitate the understanding of information. Thus, knowledge itself should not be sufficient to delve into the problem but rather a trigger that leads students to develop competencies such as information search and management, critical thinking, self-directed and lifelong learning, practical reasoning and creativity, problem solving, etc. [6]. For these reasons, PBL has been implemented in various areas of knowledge such as chemistry [8], medicine [6], and informatics, engineering, mathematics, and physics [7], mainly showing improvements in conceptual understanding, academic performance, critical thinking skills, and higher levels of motivation. It is essential to highlight that PBL is not exclusive to higher education but has also been implemented in upper secondary education contexts, where it seeks to promote situated teaching as a pedagogical proposal that fosters situated, experiential, and authentic learning in students, enabling the development of skills very similar to those they will encounter in everyday or professional life [9].

2.3. Project-Based Learning

There are multiple definitions of this type of learning. According to Martin-García [7], most agree that "it is a student-centered teaching methodology that organizes learning around the development of projects contextualized in real-world problems that are meaningful to students" (p. 4). One of its main characteristics is the necessity of developing a product created for an audience or with social validity. Consequently, it is an inquiry-based learning approach that is also active and experiential, requiring students to research, share, interact, plan, make decisions, and evaluate. This type of learning is based on constructivist premises, explicitly aiming for projects to focus on issues that allow students to address and compare fundamental concepts and principles of a discipline. As observed, the learning is student-centered, enabling them to advance their theoretical and technical knowledge, develop critical, analytical, and creative thinking, work collaboratively and cooperatively, solve problems, and work independently. These skills are part of the so-called 21st-century competencies [10]. Thus, project-based learning, like PBL, has been implemented in various fields of knowledge at the higher education level, demonstrating its benefits in knowledge acquisition through concepts in biology, psychology, and programming courses [11]. Additionally, authors such as Beier et al. [12] and Pengyue et al. [11] point to the use of this type of learning in science, technology, engineering, and mathematics (STEM) courses at the higher education level, showing improvements in students' skills, abilities, and motivation to master these courses. Ferrero et al. [13] argue that the effectiveness of project-based learning has also been tested at the secondary level, although to a lesser extent than in university studies.

2.4. Flipped Classroom

The processes of change within the framework of higher education require transforming the paradigm of interventions in teaching–learning and shifting from teacher-centered instruction to student-centered learning. Due to this shift, new methodologies and tools have been introduced that enable more interactive, collaborative, and discovery-based learning, supported by technological resources to facilitate these processes [14]. According to Solier et al. [15], the formalization of the use of the flipped classroom occurred in the 1990s, with its more modern dissemination taking place in the 2000s. In this context, the flipped classroom methodology is presented as one where direct instruction occurs outside the classroom, and class time is used for activities that facilitate the development of higher-order cognitive processes with the support and expertise of the teacher. Thus, according to Aguilera et al. [16], the main objective of this teaching method is for students to take a more active role in their learning process, which implies that they perform activities (such as studying theoretical concepts) facilitated by the teachers. Class time is used to resolve doubts, practice, or discuss the content (active learning). It is essential to highlight that in the flipped classroom "what matters is not what students know, but what they are capable of doing or solving with their knowledge through practical experiences" (p. 131) [14]. Examples of the implementation of this methodology in upper secondary education include studies by Veytia et al. [17] and Madrid et al. [18], which demonstrate its development in informatics and mathematics subjects, respectively. As part of their results, Veytia et al. [17] indicate that the flipped classroom attracted students' attention through the use of videos recorded by teachers for understanding topics, and there was an increase in the number of students passing the subject, with 92% of 90 students who participated preferring the flipped classroom over traditional classes. However, in the case of Madrid et al. [18] in mathematics, no significant changes were found compared to the traditional teaching methodology. Authors such as Aguilera et al. [16] indicate that the flipped classroom can be applied in all curricular areas, as well as in primary, secondary, upper secondary, and higher education. Regarding higher education, Mingorance et al. [14] and Solier et al. [15] suggest that students have shown better comprehension of learning content and achieve higher scores on exams. Additionally, there is greater attendance, participation, interaction, and feedback.

2.5. Game-Based Learning, Gamification, and Serious Games

Game-based learning (GBL) is a methodology that uses games (analog or digital) to develop learning and the acquisition of competencies. Ormazábal et al. [19] indicate that games applied in the educational field "allow for contextualizing and assimilating situations where objects play certain roles, becoming subordinate to meaningful learning experiences based on the social environment in which they develop" (p. 2). Consequently, it is necessary to consider the context in which the game is developed, enabling students to generate their cognitive development. In this sense, games allow the construction of knowledge where imagination and collaboration play a fundamental role. In this type of methodology, as in those previously described, the role of the teacher transforms, becoming a facilitator of learning. At the same time, students construct knowledge through playful, dynamic, and functional practices. Various studies propose the use of games as a pedagogical strategy at different educational levels and in various areas of knowledge [19]. Particularly in higher education, efforts have been made to foster greater student engagement and motivation through long-term learning. Thus, Carbajal et al. [20] argue that, currently, game-based learning has acquired a prominent role because it allows for a new role for teachers, greater student participation by making their interests more effective, enhances digital literacy, and promotes quality education. Within the concept of game-based learning (GBL), different types of media are used, including gamification and serious games or video games.

2.5.1. Gamification

There are various definitions of what gamification entails. According to Gaspar et al. [21], these definitions converge on focusing student motivation, with the aim that they learn efficiently and enjoy the activities they undertake. In this same vein, Carbajal et al. [20] describe gamification as a motivation technique to achieve specific learning, motivation, and sustainability objectives. Regarding higher education, Lozada et al. [22] indicates that gamification is a tool with high potential to generate motivation for learning, as students learn in a fun way. Simultaneously, it promotes learning by shaping their cognitive, social, and emotional development, enhancing soft skills, cognitive abilities, and technological competencies. One characteristic of gamification is its versatility, as it can be adapted to remote work conditions using digital tools [20]. In this regard, Angulo-Gonzalez's work [23] shows the implementation of gamification through technology during the COVID-19 pandemic for high school students in chemistry, demonstrating greater motivation, commitment, responsibility, and fun among students. However, no significant changes were observed in academic performance. As observed, gamification can be implemented at different educational levels, as it is highly accepted by students, provided the game is designed correctly [24]. This means that gamification must be preceded by training, planning, research, and monitoring by teachers to achieve positive results in education.

2.5.2. Serious Games

Peñafiel-Rodriguez [25] states that the term serious games refers to "a group of video games and simulators whose primary objective is training rather than entertainment" (p. 93). These games have emerged as a tool that combines the attractive benefits of video games and their influence on the population, especially the youth, with the need for education and professional training. Carbajal et al. [20] establish that serious games are used with the purpose of educating, training, and informing, meaning their main goal is not fun. According to the authors, serious games have a high potential for motivation, training, and entertainment through the use of technological tools, which ensures student learning based on constructivist principles. They are named serious games due to their didactic origin, focusing on the formation and practice of skills that allow students to experience and simulate scenarios safely [25], such as piloting a commercial airplane or using surgical techniques in a medical case. A distinctive characteristic of serious games is that they allow for the simulation of reality in a three-dimensional virtual environment [25], and they have been used in various educational fields such as health, engineering, and economics. For example, in the field of economics in higher education, Urquidi-Martín and Tamarit-Aznar [26] argue that the implementation of serious games generates motivation that enables students to engage with their learning process. Among the competencies developed are decision making, problem solving, and improvement in their ability to analyze and interpret the economic–financial information of a company. These various active methodologies have been implemented in the field of computer science, as will be discussed in the following sections.

3. Materials and Methods

The advancement of information and communications technology (ICT) in education has driven the development of new pedagogical strategies, such as active learning. The use of these strategies increased due to the COVID-19 emergency, as education transitioned from in-person to virtual or hybrid formats. Various educational institutions made a considerable effort by interrupting in-person classes and adopting a virtual approach, transforming teaching methodologies, didactic materials, and the evaluation process. Particularly in computer science, a discipline with a theoretical–practical focus, innovation was required to enable virtual laboratories and the use of learning platforms with interactive content to develop activities typically conducted in person. Additionally, active methodologies were implemented with the firm purpose of offering quality education and facilitating the transition to online teaching for educators. Therefore, this research aims to compile, from 2019 to the present, the primary active methodologies used in this discipline related to engineering and technology. The purpose is to analyze case studies based on the teaching–learning strategies employed, the results obtained in terms of acquired knowledge, the competencies developed, as well as the benefits and challenges associated with their use.

The methodology used for this systematic review is based on the PRISMA statement [27] (see Figure 1), with the purpose of identifying and analyzing the active methodologies that have been used as teaching–learning strategies in the field of computer science. From this objective, the following research questions were established:

- Do active methodologies favor learning and motivation among computer science students?
- Which active methodologies have been implemented as teaching and learning strategies in the field of computer science?
- What instruments have been used to validate active methodologies within the teaching–learning process in the field of computer science?

3.1. Identification

To answer the research questions, a literature search was conducted covering six years from 2019 to 2024 in the specialized Scopus and Web of Science databases and the scientific search engine Google Scholar. The search was delimited using keywords in both Spanish and English through Boolean operators as follows: ("metodologías activas" or "active methodologies" or "teaching and learning" and "Informática" or "Computer Science").

Table 1 displays the number of research papers obtained from each source.

Table 1. Number of articles found in the sources.

Source	No. of Articles Extracted
Scopus	40
Google Scholar	37
Web of Science	10
Total	87

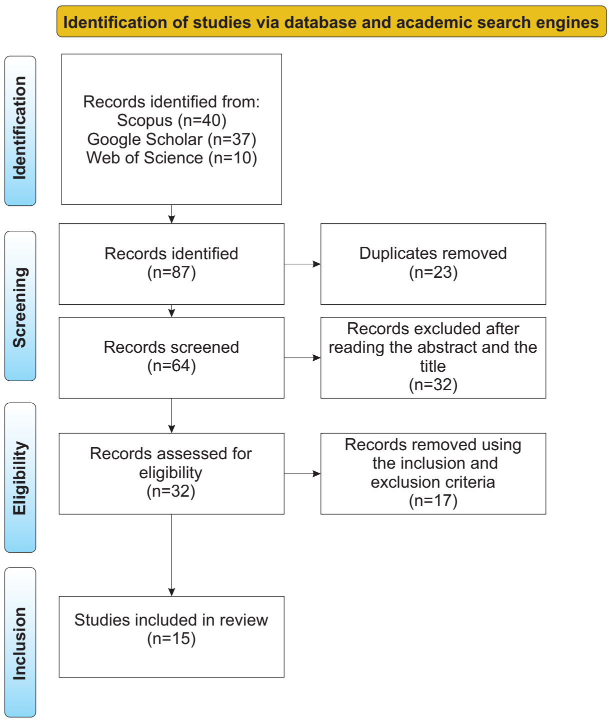

Figure 1. PRISMA flow diagram of the article selection process. This diagram outlines the steps involved in the identification, screening, eligibility assessment, and inclusion of studies for the systematic review. Initially, 87 records were identified through Scopus (n = 40), Google Scholar (n = 37), and Web of Science (n = 10). After removing 23 duplicates, 64 records were screened. Following the exclusion based on abstract and title review, 32 full-text articles were assessed for eligibility. Finally, 17 records were removed using the inclusion and exclusion criteria, resulting in 15 studies being included in the review.

3.2. Screening and Eligibility

In this meticulous process, duplicate articles found in the Scopus database and Google Scholar were meticulously removed. To ensure the utmost precision, the following inclusion and exclusion criteria were meticulously established to determine the number of articles to be analyzed in this study:

Inclusion Criteria:

- Works published between 2019 and 2024.
- Articles in Spanish and English.
- Works directly related to the search terms according to the research questions.

Exclusion Criteria:

- Works published before 2019.
- Articles in languages other than Spanish or English.
- Works not directly related to the search terms according to the research questions.
- Duplicate works.

The number of articles selected from each source is shown in Table 2.

Table 2. Number of articles selected from each source.

Source	No. of Selected Articles
Scopus	5
Google Scholar	7
Web of Science	3
Total	15

3.3. Inclusion

Table 3 presents the research papers analyzed that answer the initially established research questions. The sample consists of 15 articles, which are organized according to the year of publication, the database where they are located, the type of document, author(s), and the title of the research.

Table 3. Analyzed document sample. This table lists the research articles analyzed in the review, detailing the database source, document type, publication year, authors, and research title. The sources include Scopus, Google Scholar, and Web of Science.

Database	Document Type	Publication Year	Authors	Research Title
Scopus	Research article	2019	Moreira et al. [28]	ECLECTIC as a learning ecosystem for higher education disruption
Scopus	Research article	2021	Aires et al. [29]	Active Methodologies in Incoming Programming Classes
Scopus	Research article	2021	Estriegana et al. [30]	Analysis of Cooperative Skills Development through Relational Coordination in a Gamified Online Learning Environment
Scopus	Research article	2021	Jones et al. [31]	Metodologías activas para la enseñanza de programación a estudiantes de ingeniería civil informática
Scopus	Research article	2022	da Silva et al. [32]	A second experimental study the application of a teaching plan for the algorithms subject in an undergraduate course in computing using active methodologies
Google Scholar	Research article	2019	Sanchez-Romero et al. [33]	Design and Application of Project-Based Learning Methodologies for Small Groups Within Computer Fundamentals Subjects
Google Scholar	Research article	2020	Benavent et al. [34]	Clase invertida en asignaturas de programación usando la plataforma de e-learning Moodle
Google Scholar	Research article	2020	Crisol-Moya et al. [35]	Active Methodologies in Higher Education: Perception and Opinion as Evaluated by Professors and Their Students in the Teaching–Learning Process
Google Scholar	Research article	2021	García et al. [36]	Improvement of learning outcomes in software engineering: active methodologies supported through the virtual campus
Google Scholar	Research article	2021	Morais et al. [37]	Improving student engagement with Project-Based Learning: A case study in Software Engineering
Google Scholar	Research article	2023	Aires et al. [38]	Using the methodology problem-based learning to teaching programming to freshman students
Google Scholar	Research article	2024	Masegosa et al. [39]	Learning Styles Impact Students' Perceptions on Active Learning Methodologies: A Case Study on the Use of Live Coding and Short Programming Exercises
Web of Science	Research article	2020	Cleveland & Leger [40]	A Collaborative Learning Strategy in an MIS Development Course Using Case Method in Engineering in Information and Management Control
Web of Science	Research article	2021	García Peñalvo et al. [41]	Planning, communication and active methodologies: Online assessment of the software engineering subject during the COVID-19 crisis
Web of Science	Research article	2023	Aldalur & Perez [42]	Gamification and discovery learning: Motivating and involving students in the learning process

4. Results

This section presents the analysis of each of the articles selected for the systematic review. The article by Moreira et al. [28] presents the ECLECTIC project, which aimed to enhance the teaching–learning process in higher education through active methodologies. Conducted in an information systems management program, it focused on developing soft skills like leadership, teamwork, and problem solving, as well as digital competencies such as information literacy and communication. The project employed group projects, peer review, and teaching techniques. The ECLECTIC approach led to a high approval rate of over 80% and increased student engagement. Additionally, it promoted the development of digital skills and provided valuable study materials for final exams, demonstrating its effectiveness in improving academic performance.

In a recent article published by Aires et al. [29], a teaching strategy for the algorithms subject in a computer science course was developed using an active methodology based on problem-based learning. The aim of the strategy was to enhance the motivation and performance of students in programming classes. The authors developed the strategy through direct observation of the students and data collection using a questionnaire that allowed them to associate computer elements with daily life routines. The results of the study show that students who participated in the strategy were more enthusiastic and committed to the subject. They also demonstrated an enhanced ability to work in teams and solve problems. Furthermore, the students noted that the strategy helped them better understand programming concepts and apply them in practical situations.

Estriegana et al.'s [30] study explores an online learning environment (OLE) integrating active learning for first-year computer engineering and computer science students at the University of Alcalá, Spain. The OLE features virtual labs, videos, and game-based learning to boost motivation and participation. Game-based elements let students choose activities, watch videos, and earn badges. The study evaluates three aspects: (1) classroom interaction, (2) relational coordination's influence on cooperative development, and (3) improvement of cooperative competence. Data from 289 students, collected via online questionnaires and analyzed with structural equation modeling (SEM), indicate that the OLE enhances student relationships, cooperation, and social skills. Game-based learning fosters interaction and dialogue, improving teamwork. The authors conclude that virtual activities and instructional strategies are crucial for engaging students and promoting participation.

Jones and colleagues [31] studied active teaching methods like pair programming, manual code tracing, and problem-based learning in a computer programming course for first-semester civil computer engineering students at the University of Viña del Mar, Chile. The goal was to improve understanding and application of programming content, addressing high failure rates. The active teaching model included independent exercises, theoretical pair activities, practical pair programming, and perception evaluations. The results showed over 70% of students remembered basic concepts, with an average improvement of 66.7%. Nearly 80% understood programming concepts, with an average improvement of 87.8%. However, application-level improvements averaged 54%. The authors concluded that active methodologies effectively enhance understanding and retention of basic programming concepts, though they were less successful in applying knowledge.

A study conducted by Da Silva et al. [32] presents an implementation of a teaching plan for an algorithms course using active methodologies like virtual learning environments, Coding Dojo, gamification, problem-based learning, flipped classroom, and serious games. These were chosen to teach algorithms to university computer science students and evaluated by experts. The first experiment compared a control group (traditional methods) with an experimental group (active methodologies), each with 34 students. The second experiment, with 72 students, aimed to confirm the first experiment's positive results. Both experiments showed that the active methodologies teaching plan was more effective than traditional methods in enhancing student learning.

Sánchez et al. [33] studied the implementation of problem-based learning (PBL) with a flipped classroom model for first-year computer engineering students at the University of

Alicante, Spain. The goal was to improve academic performance in the subject of computer fundamentals by combining theoretical content with practical problem solving. Students developed a simple calculator over 15 weeks, attending weekly four-hour sessions split between theory and practice using the Logisim software. The effectiveness of PBL was measured by comparing the academic performance of the PBL group with a control group using traditional methods. Both groups took pre- and post-course exams. Initially, both groups performed similarly, but the PBL group showed significant improvement on the post-course exam, resulting in better grades. Teachers observed higher participation and effort in the PBL group. The study noted that PBL is less suitable for large groups of first-year students, as they need more teacher support. Additionally, new students often do not review theoretical materials before PBL sessions, so teachers should assess their knowledge at the start of each session.

Benavent et al. [34] studied a flipped classroom methodology for mathematics and telecommunication electronic engineering students. The approach included theoretical classes, lab sessions, and seminars, with each adapted to the subject's schedule. In theoretical classes, students took a pre-class test and received study materials on Moodle, including interactive tools and exercises. In class, students reviewed test results, discussed mistakes, and worked in teams on new exercises. Each unit ended with a Moodle workshop, with peer-reviewed exercises. Laboratory sessions involved up to 20 students taking pre-session tests to prepare for practical exercises, which increased in complexity. After two sessions, students submitted their work, receiving personalized feedback from teachers. Seminars featured teams of three to four students discussing programming exercises and presenting their work, fostering teamwork and communication skills. The study analyzed five years of mathematics and four years of telecommunication electronic engineering results. The flipped classroom model increased pass rates and improved grades in mathematics. While pass rates in telecommunication electronic engineering did not increase significantly, grades improved. Despite some students preferring traditional classes, the flipped classroom approach benefited most students, enhancing academic performance. The authors suggest raising awareness of the benefits of these methods.

Active methodologies enhance student participation, as shown by Crisol-Moya's study [35] at the University of Granada. Both teachers and students believe this approach promotes interdisciplinary learning, research skills, and collaborative work. Using validated questionnaires with a high reliability coefficient of 0.893, the study gathered objective data. Teachers see the need to adapt their roles, assessment systems, and teaching methods to individual student needs. They value combining traditional and interactive methods to boost student participation. Students appreciate active learning for its interdisciplinarity, research, self-learning tools, and teamwork opportunities. This approach helps them reflect, evaluate, and communicate effectively in real-life situations. However, the study highlights the need for better communication between teachers and students to optimize these methodologies. Additionally, large class sizes can hinder the adoption of active teaching strategies.

García et al. [36] aimed to increase motivation and participation in a software engineering course at the University of Salamanca by using active methodologies supported by a virtual campus. They used flipped classrooms, autonomous learning, collaborative techniques, and project-based learning (PBL), offering two study modes to cater to different needs. Mode A is for students attending face-to-face sessions or those who cannot attend due to work. It follows a traditional approach with tests and a final group project. Mode B emphasizes active learning with continuous assessment, requiring a final project integrating theory and practice. Face-to-face classes in mode B involve group work, exercises, presentations, and project submissions. The virtual platform tracks progress and content visibility, and Google Drive facilitates project tracking. Two questionnaires assessed the impact of these methodologies: CEVEAPEU evaluated learning strategies, and the second gathered student opinions on the redesign. The results showed improvements in mode B students' continuous assessment grades, particularly in the final project, with a 100%

submission rate in 2017–2018, indicating increased success and participation compared to 2013–2014. The virtual campus was crucial for coordinating these active methodologies.

Morais et al. [37] studied first-semester software engineering students at a Portuguese University in 2018–2019, implementing project-based learning (PBL) in information and communications technology (ICT) topics. Building on previous success in other courses, the goal was to enhance engagement, learning outcomes, and the success rate of each course, and to show the continuous process of software engineering and the connections between courses. Students worked in teams to develop an information system for a jazz festival, covering data structures (EDs), information systems development (DSI), and web languages and technologies (LTWs). There were 23 students, forming eight teams of 3 and one of 2, with additional teams for students attending two courses. The project guide detailed learning objectives and skills. The project was 50% of the DSI grade, 20% of the EDs grade, and 40% of the LTWs grade. It involved nine milestones, culminating in a final report and oral presentation. Peer evaluations and surveys indicated that PBL improved teamwork, time management, understanding of course interrelations, and skills in UML diagrams and technology identification. Specifically, students improved in abstraction, UML modeling, and requirement identification for DSI and EDs, and in creativity and data structure skills for LTWs, though less in Java Servlets. Pass rates improved significantly compared to 2017–2018: 66.7% for DSI (up from 41.9%), 62.5% for EDs (up from 43%), and 70.3% for LTWs (up from 46.7%). The study concluded that PBL is a viable alternative to traditional lectures, enhancing motivation, engagement, and learning.

The research work by Aires et al. [38] introduced a problem-based learning methodology to first-year students in the Bachelor of Computer Science program to address dropout rates in the algorithms course. This approach was applied to 177 students over three periods: 2019–2 (47 students), 2020–1/2020–2 (83 students), and 2021–2 (47 students). The implementation involved several steps. Initially, students completed a 19-question survey in teams to assess their prior knowledge about smartphone and computer usage. This was followed by a facilitated discussion comparing smartphone and computer features. Students were then challenged to create a smartphone calculator individually or in groups, using the MIT App Inventor tool for development. After installing and testing their applications, students presented their work one week later. A final questionnaire on Moodle assessed how well students connected computer science concepts to their applications. The results indicated that 81% of students achieved grades above the university's passing mark, successfully relating computer science concepts through application development. The project enhanced student participation through group work, increased motivation in peer- and instructor-led discussions, and fostered a competitive and collaborative environment. Initially concerned about their ability to develop the application, students overcame these fears through teamwork, which increased their motivation and engagement.

The study conducted by Masegosa et al. [39] investigated how different learning styles affect the perception and effectiveness of active learning strategies such as live coding and short programming exercises. The study had three main objectives: (1) to examine how effective live coding is as a learning methodology, (2) to evaluate the impact of learning styles based on the Felder–Silverman model, and (3) to provide empirical evidence on how to adapt these methodologies to the diverse learning styles in programming courses. According to the authors, learning styles play a significant role in determining how students interact with and benefit from these methodologies. For example, active learners who prefer hands-on participation tend to benefit from live coding, which offers immersive experiences and practical demonstrations of programming concepts. On the other hand, reflective learners may prefer more deliberate methods, such as short programming exercises, which allow them to process information before applying it, suggesting that they may benefit less from dynamic and rapid methodologies. To validate these methodologies, the authors conducted a case study that included surveys, interviews, student feedback analysis, and statistical tests to examine the relationship between learning styles and student perceptions.

In the study conducted by Cleveland and Leger [40], the effectiveness of various active methodologies is compared to traditional pedagogical approaches, as well as evaluating student perception and satisfaction through the case method and collaborative learning. The case method involves presenting students with real situations where they must link theory with practical application to solve specific problems. On the other hand, collaborative learning is based on the exchange of knowledge, interaction, and negotiation among students to achieve common goals. These active methodologies were implemented to promote meaningful learning, teamwork, and the integral development of students in the context of an information systems development course at the Universidad Católica del Norte. A survey was administered to the students to evaluate the study's impact and to gather their perceptions and satisfaction levels regarding the case method and collaborative learning. The results showed good acceptance from the students in terms of their performance and commitment to collaborative work, with more than 90% expressing that the learning obtained through active methodologies was more meaningful compared to the traditional methodology.

The research proposal by García Peñalvo et al. [41] focuses on adapting face-to-face teaching to an online approach in the context of the COVID-19 crisis. It analyzes how teachers transformed their assessment methods and teaching methodologies to maintain educational quality and student satisfaction during the transition to the online modality. A case of success is highlighted in the software engineering I course at the University of Salamanca, where active methodologies such as autonomous learning, collaborative learning, flipped teaching, and project-based learning were implemented. The study compared learning outcomes and student satisfaction with previous academic years to demonstrate the effectiveness of the adaptation. Among the main findings, it was shown that the transition to an online approach did not negatively affect student satisfaction, as no decrease in satisfaction results was observed compared to previous academic years. These results support the effectiveness of implementing active methodologies and educational technologies in face-to-face teaching, facilitating the successful adaptation to an online approach during the COVID-19 crisis.

The work developed by Aldalur and Perez [42] discusses the implementation of active methodologies such as gamification and discovery learning in a software engineering course within the computer science program at the University of Mondragon, Spain. A total of 41 students participated in the study. It is noteworthy that in this case study gamification was implemented during theoretical classes to motivate students at the beginning and end of each session. Games at the start of the class were designed to recall and reinforce concepts from the previous day. If the majority of students answered correctly, the teacher did not delve deeper into the concept; otherwise, the teacher would explain it again. At the end of the session, students could see their ranking compared to their peers (the one with the most points wins). The objective was to learn all the concepts explained in class, and this was achieved using the dynamic tool Wooclap, which allows students to participate in games during class through real-time interactions that provide immediate feedback. On the other hand, the practical part of the course was conducted using a discovery learning model through WebQuests aimed at helping students learn or improve their research skills. The WebQuest developed for the students was about learning and using Katalon, a free solution for web test automation. The results obtained by combining gamification and discovery learning showed that the grades obtained in the last academic year improved by 0.84 points compared to the previous year. Additionally, there was greater student motivation, increased creativity, and a better ability to apply what they had learned. Student opinions were collected through two online surveys at the end of the experience: one on gamification and the other on WebQuests. The main findings from these instruments indicated that students felt more motivated in class, enjoyed themselves, and felt positive, leading them to pay more attention in class. They also valued the WebQuests positively, indicating that they helped guide their research, use their imagination, generate creative ideas, apply what they had learned, improve their group work skills, and increase their motivation in the course.

Table 4 provides our analysis of various active methodologies implemented in computer science education, highlighting the acquired knowledge and developed competencies in students. Addressing the first research question, the table shows that active methodologies such as group projects, peer review, problem-based learning, and gamification contribute significantly to enhancing both learning outcomes and student motivation. These methodologies promote a range of competencies including teamwork, problem solving, communication, and digital content creation, which are crucial for computer science students.

Table 4. Analysis of the types of active methodologies implemented in each research work, the knowledge acquired, and the competencies developed by the students.

Authors	Active Methodology Type	Acquired Knowledge	Developed Competencies
Moreira et al. [28]	Group projects Peer review and teaching	Participation and integration of group work dynamics Information analysis to solve problems	Information literacy Communication Digital content creation Problem solving
Aires et al. [29]	Problem-based learning	Programming concepts Developing an app on a smartphone	Teamwork Problem solving
Estriegana et al. [30]	Virtual learning environments Gamification Active and collaborative learning	Simplification and simulation of circuits Karnaugh maps Analysis and synthesis of circuits Logic gates and integrated circuits	Increased interaction and dialogue among students Teamwork Development of cooperative and social skills Effective, timely, and frequent communication among students
Jones et al. [31]	Problem-based learning Pair programming Manual tracing of code	Programming language concepts	Development of skills to understand and remember programming concepts
Da Silva et al. [32]	Virtual learning environments Coding Dojo Gamification Problem-based learning Flipped classroom Serious games	Basic concepts on algorithms	Improvements in learning
Sánchez-Romero et al. [33]	Problem-based learning Flipped classroom	Fundamentals of computing Development of a digital calculator	Increased participation and effort
Benavent et al. [34]	Flipped classroom	Programming exercises	Teamwork
Crisol-Moya et al. [35]	Seminars Practical classes Tutorials	Interdisciplinary learning	Research skills Collaborative work
García et al. [36]	Problem-based learning Flipped classroom	Software engineering concepts	Academic performance
Morais et al. [37]	Problem-based learning	Programming language knowledge	Soft skills: teamwork, creativity, abstraction
Aires et al. [38]	Problem-based learning	Programming language concepts Development of a calculator for a smartphone	Improvements in academic performance Teamwork
Masegosa et al. [39]	Live coding Programming exercises	Understanding and retention of programming concepts Analysis and reflection of information Active participation	Understanding of object-oriented programming concepts Problem solving Teamwork
Cleveland & Leger [40]	Case method Collaborative learning	Skill development and responsibility	Development of technical skills Soft and personal skills Autonomy and protagonism in learning
García Peñalvo et al. [41]	Autonomous learning Collaborative learning Flip teaching approach Project-based learning (PBL)	Software engineering knowledge	Adaptability to technological environments
Aldalur & Perez [42]	Gamification Discovery learning	Software engineering concepts	Motivation and participation Research skills Creativity and imagination Practical application of knowledge Teamwork

Regarding the second research question, the table identifies several active methodologies utilized in teaching computer science, including virtual learning environments, Coding Dojos, flipped classrooms, collaborative learning, seminars, practical classes, tutorials, case methods, and autonomous learning. These strategies have been effectively implemented to engage students in the learning process, promoting an active and participatory learning environment. The diverse methodologies listed emphasize the variety and adaptability of active learning approaches in the field of computer science education.

Table 5 responds to our third research question by presenting an analysis of the type of research conducted in each case study on the use of active methodologies, alongside the types of evaluation used to validate their results, and the learning environments where these pedagogical strategies were implemented. The table indicates a variety of research methodologies, including qualitative, quantitative, and mixed approaches. The evaluation methods employed range from empirical assessments and surveys to statistical and comparative analyses, pilot tests, and expert reviews. The learning environments for these studies include classrooms, virtual platforms, laboratories, and courses, reflecting the diverse settings in which active methodologies are applied in computer science education.

Table 5. Analysis of the type of research conducted in each case study, as well as the types of evaluation used for the validation of their results and the learning environment used.

Authors	Research Type	Types of Evaluation	Learning Environment
Aires et al. [29]	Qualitative	Empirical	Classroom
Estriegana et al. [30]	Quantitative	Surveys	Virtual platform
Jones et al. [31]	Mixed	Surveys based on Bloom's taxonomy	Not specified
Da Silva et al. [32]	Quantitative	Statistical analysis	Virtual platform
Sánchez-Romero et al. [33]	Mixed	Empirical and statistical analysis	Laboratory and classroom
Benavent et al. [34]	Mixed	Empirical and statistical analysis	Classroom, laboratory, and virtual platform
Crisol-Moya et al. [35]	Quantitative	Questionnaires Pilot tests Reliability analysis Expert reviews	Not specified
García et al. [36]	Quantitative	Statistical and comparative analysis	Classroom and virtual platform
Morais et al. [37]	Qualitative	Qualitatively designed surveys and comparative analysis	Classroom
Aires et al. [38]	Qualitative	Surveys	Classroom
Masegosa et al. [39]	Quantitative	Questionnaires Statistical analysis Exercises	Classroom
Cleveland & Leger [40]	Qualitative	Ad hoc questionnaire Questionnaire from the Center for Methodological and Technological Innovation Satisfaction survey	Course
García Peñalvo et al. [41]	Mixed	Questionnaires Statistical analysis	Virtual platform
Aldalur & Perez [42]	Mixed	Surveys	Classroom

Figure 2 shows the number of competencies that were developed from the use of active methodologies in each of the works analyzed in this systematic review.

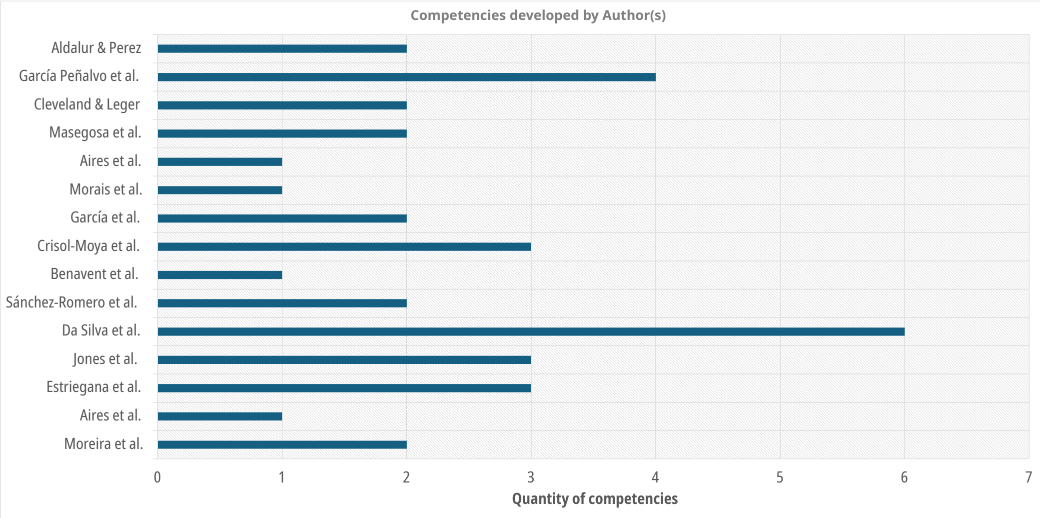

Figure 2. Number of competencies developed by students as a result of using active methodologies in each of the works analyzed in this systematic review. Aldaur and Perez [42], García Peñalvo et al. [41], Cleveland and Leger [40], Masegosa et al. [39], Aires et al. [38], Morais et al. [37], García et al. [36], Crisol-Moya et al. [35], Benavent et al. [34], Sánchez-Romero et al. [33], Da Silva et al. [32], Jones et al. [31], Estriegana et al. [30], Aires et al. [29], Moreira et al. [28].

Figure 3 shows how different researchers utilize a variety of active methodologies in education, reflecting a pedagogical approach that seeks to engage students more deeply and effectively than traditional methods. Among these methodologies, problem-based learning and flipped classrooms stand out as the most predominant, indicating their importance in the current educational paradigm. Educators are implementing a diversity of practices, including interactive, collaborative, and reflective activities, which foster student participation and active engagement. Additionally, innovative approaches such as project-based learning and gamification are emerging as key trends, as they create educational experiences that are both engaging and pedagogically sound. The integration of these strategies shows a recognition of the importance of intrinsic motivation as a driver of meaningful learning. Moreover, the use of virtual learning environments and the incorporation of emerging technologies demonstrate educators' efforts to prepare students for a digital world, providing them not only with theoretical knowledge but also with the essential digital skills required to succeed in complex technological environments.

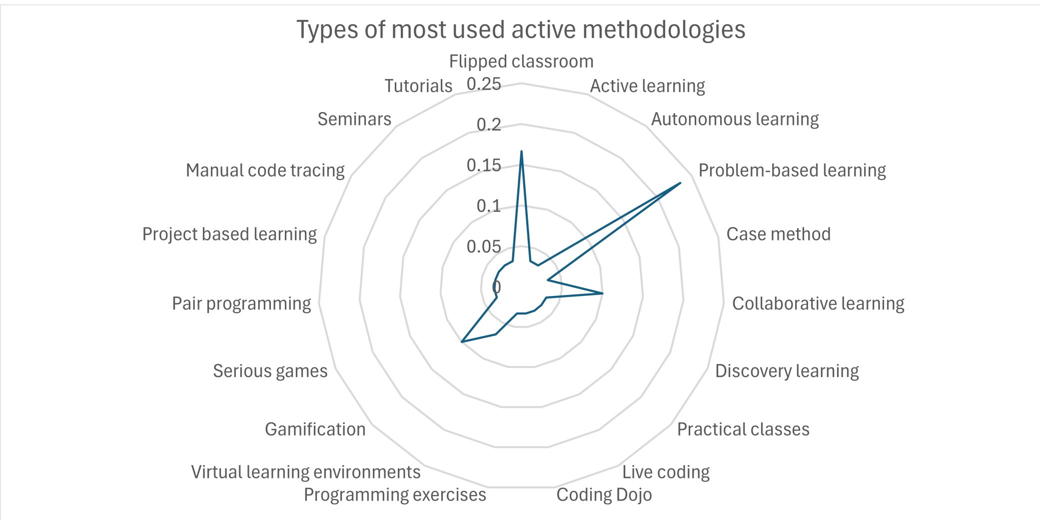

Figure 3. Most commonly used active methodologies.

Figure 4 presents a matrix that relates different teaching methodologies to the development of specific competencies and skills. It highlights that active learning methodologies and virtual learning environments are associated with the highest number of competencies, particularly emphasizing the development of teamwork skills. Methodologies such as problem-based learning are also connected with diverse skills, including abstraction, creativity, improved academic performance, problem solving, and collaborative work.

Some methodologies are exclusively associated with a single competency, suggesting a more specialized focus. At the same time, competencies like teamwork, participatory learning, and social abilities are among the most common in relation to various active teaching methodologies. This variety indicates that, while certain pedagogical practices are valuable for cultivating skills, others are particularly effective for developing specific competencies. The educational approach aims to go beyond technical knowledge, such as programming concepts, to include interpersonal and problem-solving skills, which are essential for meaningful learning and practical application.

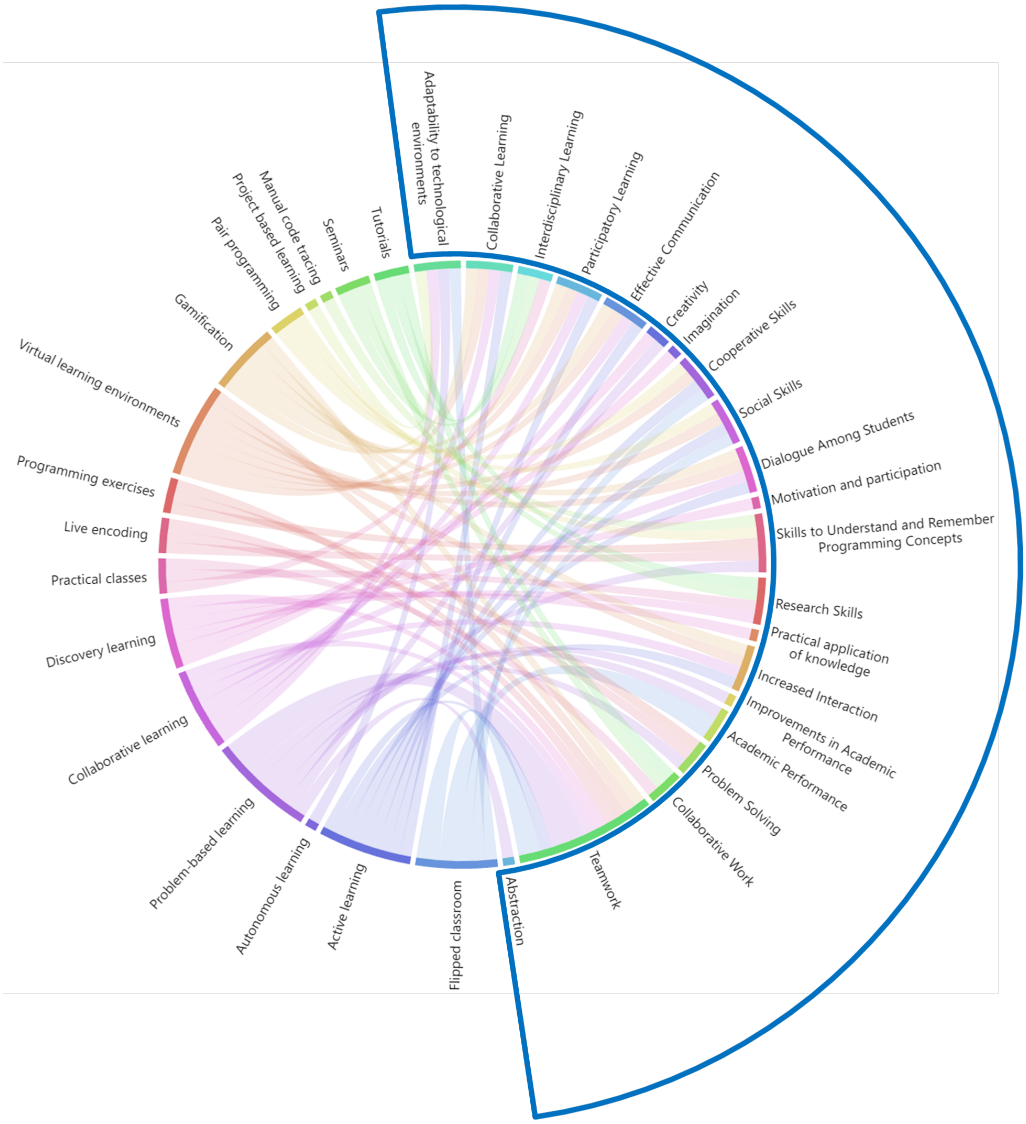

Figure 4. Analysis of the relationship between active methodologies and developed competencies (identified by the blue edge).

Figure 5 shows a bibliometric network developed using the VOSviewer software [43], where it is possible to identify the co-occurrence of relevant terms extracted from the sample of articles selected for this study.

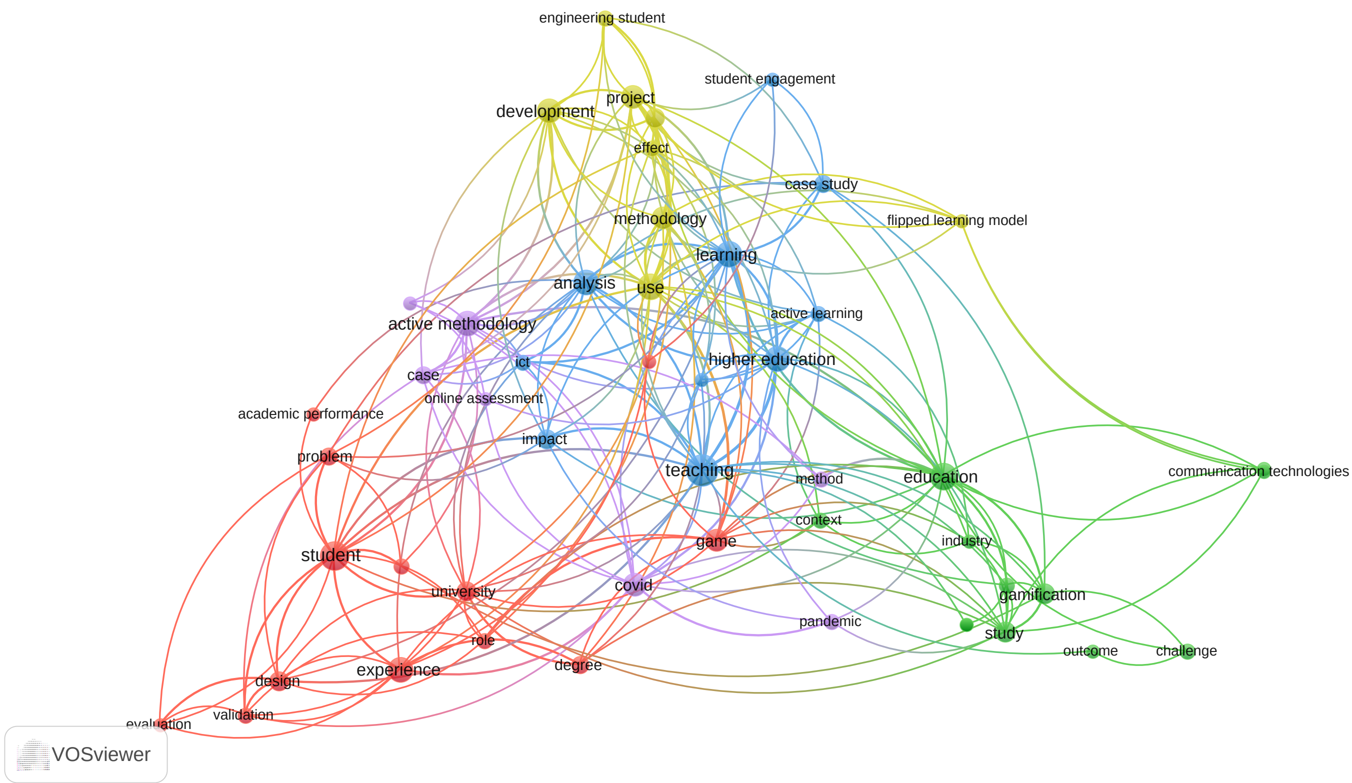

Figure 5. Bibliometric network generated with the VOSviewer software containing the principal co-occurrence terms from the analyzed sample of articles.

5. Discussion

As shown in this article, various active methodologies are used in the field of computing with objectives that address specific cases. However, they all aim to implement strategies to promote active learning in this area of knowledge that requires students to develop or enhance computational skills and thinking [2]. Below, the discussion of the main methodologies identified through the systematic review is presented, with the purpose of highlighting their benefits and relevance.

5.1. Collaborative and Participative Learning

Regarding the development of transversal competencies, most of the analyzed articles highlight teamwork and collaborative and participative learning [40,41], in the same way as addressed in the work developed by [44], which shows that cooperative learning is evidence that the use of active methodologies allows students to improve skills such as negotiation, leadership, teamwork, and reflection, among others, bringing a positive impact on learning, academic performance, and social interaction in the educational environment. The implementation of active methodologies in the field of computing has contributed to achieving learning objectives and motivating students to understand various topics in subjects such as programming, algorithms, and application development, among others. Although these subjects have a theoretical–practical approach, other studies, such as on the teaching of complex theoretical content [45], have shown where the use of active methodologies based on collaborative learning can be an effective strategy to enhance learning and maintain student motivation in various educational contexts.

5.2. Problem-Based Learning

One of the primary methodologies identified in this study is problem-based learning, which allows for the understanding of programming and computing concepts and their application to practical situations, i.e., skills of remembering and understanding [29,31,38]; it promotes enthusiasm and greater motivation, commitment, and participation of students in their learning process [29,33,36–38]; it enables the development of skills such as teamwork [29,31,38], time management, and creativity [37]. Other works that support the above are [45,46], which demonstrate the effectiveness of PBL in improving academic performance, promoting communicative skills, and fostering positive attitudes towards teamwork and creativity in the context of engineering education in computer science. Likewise, just like [33,46], they propose the need to implement the methodology in small groups, guided by the active guidance of teachers, mainly when it is carried out in the early years of the career. It is essential to highlight that the positive impact of problem-based learning has also been demonstrated in other teaching areas such as mathematics [3,47], establishing that it contributes to deploying mathematical reasoning capabilities, that is, with practical sense.

5.3. Flipped Classroom

However, authors such as Benavet et al. [34] and Estrada et al. [48] agree that one of the difficulties with using the methodology is the lack of commitment from some students to review the material available before the sessions. Consequently, teachers must perform additional work to devote more attention in both physical and virtual spaces to determine the student's knowledge level at the beginning of class sessions [34] and to resolve doubts through chats or forums on virtual platforms [48].

Another active methodology recorded in the studies analyzed is the flipped classroom, supported by the use of ICT with virtual platforms and in works such as those by [32,33,36]; it is used as a complement to problem-based learning. Thus, it is identified that it benefits students' academic performance in terms of improvements in grades and an increase in the number of students passing [33,34,36] and greater effort and participation [34,36]. In the same vein, other studies, like that of Bourbon-Lastayo et al. [49], suggest that this methodology promotes an increase in student grades, which contributes to their independence and acquisition of knowledge and skills for discussing and summarizing topics. Moreover, it has been used not only in the field of computer science teaching, Matzumara et al. [50] indicate that the flipped classroom positively contributed to the learning and better grades of university students in studying research material.

5.4. Game-Based Learning, Gamification, and Serious Games

In some of the works analyzed in this article, game-based learning, gamification, and serious games are used in conjunction with other active methodologies. The main results can be identified in two aspects: social skills and knowledge. Thus, Estriegana et al. [30] show that game-based learning enables the acquisition of cooperative competencies in the learning process because it fosters greater dialogue and interaction among students, and enables competition and teamwork, that is, the development of social skills. For their part, Da Silva et al. [32] highlight the importance of using gamification because it stimulates students' protagonism through the pursuit of knowledge, which in turn encourages more active participation during classes [42]. As for the use of serious games, they simplify the learning of key content in computer science subjects such as algorithms. In this area, authors like Lampropoulos et al. [51] establish that the use of gamification and serious games has enabled the generation of social skills such as autonomy, competence, interactions among students, increased motivation, and commitment. In addition, they enhance their cognitive development to acquire knowledge. Martins et al. [52] suggest that when students take on the role of game developers, it provides them with an opportunity for professional practice (knowledge and practice) while also allowing them to expand their teamwork skills with attitudes such as cooperation, respect, and ethics, and add that students acquire imaginative skills and logical reasoning.

6. Conclusions

This analysis reveals that the use of active methodologies in the teaching–learning process not only enhances student performance and academic achievement but also facilitates the assimilation of knowledge and the development of competencies crucial for their professional life. These methodologies have a profound positive impact in the educational field of computing, fostering meaningful learning, motivation, and the comprehensive development of students. This evidence highlights the potential of active methodologies to revolutionize education. Active methodologies are a valuable tool for educational innovation; they promote integration and collaboration among students, which contributes to strengthening their teamwork skills and their ability to solve problems jointly. However, to achieve their effectiveness, teachers have had to transform and adapt their pedagogical practices towards the implementation of these methodologies, which have shown benefits and favorable outcomes compared to traditional teaching methods. Among the active methodologies identified in this study and their application in both face-to-face and virtual classrooms are primarily problem-based learning, flipped classroom, and gamification; the effective implementation of these methodologies is linked to proper planning and design of activities, as well as to adequate teacher training that allows guiding the development of these educational strategies. The analysis conducted in this research paper indicates essential findings regarding the use of active methodologies applied to computer science. However, it is necessary to consider the limitations as well as possible future research directions that may arise. One of the limitations of this systematic review is the sample size, which is a result of the keywords used and the selected period. Although the conclusions of the reviewed research papers provide meaningful evidence on the subject, the information search could be broadened to make more comprehensive generalizations. It is also worth mentioning that this research focused on the teaching–learning process of computer science, excluding other STEM disciplines. We believe this could be a future line of research that provides more evidence on active learning and its practical implementation in other fields of knowledge.

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