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Active methodologies in Science Teaching: analysis of knowledge production in scientific articles between 2010 and 2019

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Abstract: Active methodologies emerged to bring students to the center of the teaching and learning process, placing them in the condition of subjects of the educational process and having the teacher as a mediator. This article aimed to make a panorama of the academic production of scientific articles on active methodologies in Science Teaching published between 2010 and 2019. The research revealed that all the authors of the articles were linked to Brazilian educational institutions and most worked in the North region. Two active methodologies stood out: problem solving and blended teaching. In carrying out their research, the authors used various means to propose activities anchored in active methodologies, with emphasis on the use of Digital Communication and Information Technologies. Diverse contents of Science were worked, with a prevalence of issues involving environmental problems and themes related to the health area.

Keywords*:* Active Learning. Science Teaching. Active Methodologies.

Metodologías activas en la enseñanza de las Ciencias: análisis de la producción de conocimiento en artículos científicos entre 2010 y 2019

Resumen**:** Las metodologías activas surgieron con el objetivo de acercar a los estudiantes al centro del proceso de enseñanza y aprendizaje, colocándolos en la condición de sujetos del proceso educativo y teniendo al docente como mediador. Este artículo tuvo como objetivo hacer una panorámica de la producción académica en artículos científicos sobre metodologías activas en la Enseñanza de las Ciencias publicados entre 2010 y 2019. La investigación reveló que todos los autores de los artículos estaban vinculados a instituciones educativas brasileñas y que la mayoría trabajaba en la región Norte. Destacaron dos metodologías activas: resolución de problemas y enseñanza híbrida. En el desarrollo de su investigación, los autores utilizaron diversos medios para proponer actividades ancladas en metodologías activas, con énfasis en el uso de Tecnologías Digitales de Información y Comunicación. Se trabajaron diversos contenidos de la ciencia, con predominio de temas relacionados con problemas ambientales y temas relacionados con el área de la salud.

Palabras clave: Aprendizaje Activo. Enseñanza de la Ciencia. Metodologías Activas.

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Metodologias ativas no ensino de Ciências: análise da produção de conhecimento em artigos científicos entre os anos 2010 e 2019

Resumo: As metodologias ativas surgiram com o intuito de trazer os alunos para o centro do processo de ensino-aprendizagem, colocando-os na condição de sujeitos do processo educativo e tendo o professor como mediador. O presente artigo teve como objetivo traçar um panorama da produção acadêmica em artigos científicos sobre as metodologias ativas no ensino de Ciências publicados entre 2010 e 2019. A pesquisa revelou que todos os autores dos artigos eram vinculados a instituições de ensino brasileiras, e que a maioria atuava na região Norte. Duas metodologias ativas se destacaram: a resolução de problemas e o ensino híbrido. Na execução de suas pesquisas, os autores utilizaram-se de meios variados para a proposição de atividades ancoradas nas metodologias ativas, tendo destaque o uso das Tecnologias Digitais da Informação e Comunicação. Foram trabalhados conteúdos diversificados de Ciências, com uma prevalência para as questões envolvendo problemas ambientais e temas relacionados à área da saúde.

Palavras-chave: Aprendizagem Ativa. Ensino de Ciências. Metodologias Ativas.

1 Introduction

Emerged in the 1980s, the active methodologies aim to create environments where students assume a more active and responsible role in their learning, developing diversified skills as an alternative to methods and techniques that prioritize the transmission of knowledge (MOTA and ROSA, 2018). These ideas align with Freire (2015), who refers to education as a process that the students do not carry out independently but by interacting with various subjects through actions and reflections. So, active methodologies consist of interactive processes that involve knowledge, analysis, studies, research, and individual and group decisions to seek solutions for a given problem, case, or project execution (OLIVEIRA, 2013).

The need for this type of school interaction, with students at the center of the teaching-learning process, has intensified with the critical changes of the last decades, mainly the exponential increase in information (DIESEL; BALDEZ and MARTINS, 2017). In this context, active methodologies have become urgent, making students take part in the process of building their own knowledge, i.e., participating more in the classroom from reading, research, observation, formulation of hypotheses, interpretation, decision-making, and planning of research projects (SOUZA; IGLESIAS and PAZÍN-FILHO, 2014). Those practices and the resulting skills adopted in science teaching have become essential elements for life and for facing the daily challenges of contemporary society (SEGURA and KALIL, 2015).

However, for active methodologies to be viable, the teacher's role is

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indispensable (ROCHA and LEMOS, 2014), placing students at the center of the teaching-learning process and providing conditions for them to strengthen their autonomy (SILVA *et al.*, 2019). Teachers' attitudes, such as valuing students' conceptions, being empathetic and willing to answer their questions, encourage them to ask questions, contributing to their motivation (BERBEL, 2011). Teachers are the only ones who have the power to mediate and create conditions to facilitate students' actions. First, however, teachers must recognize the students as subjects of learning, i.e., that they are the ones who perform the actions that make learning an individual, internal process (DELIZOICOV; ANGOTI and PERNAMBUCO, 2009).

The teachers hold the mission of awakening in students a critical attitude toward their realities (KOCH, 2002). Koch's words align with Sanmartí's (2002), who states that teachers must not only know the content to be addressed but, above all, keep in mind the situations that provide for student learning. Behrens (2000) complements the two authors by stating that teachers must know new ways that can lead them to deal with different situations and pay attention to the teaching context so that the ways of learning change. For this, the teachers must develop an investigative stance on their practice to identify problems and propose solutions (DIESEL, BALDEZ and MARTINS, 2017).

According to Perrenoud (2002), the teachers do not know in advance the solution to the problems in their practice, however, they must constantly build solutions, not rejecting comprehensive, academic, and specialized knowledge from their experience. Thus, the qualification processes of science teachers must consider that today's society coexists with different values and attitudes, which requires the presence of new methodologies and teaching possibilities to reduce the contrasts between society and education. In this way, it is possible to change the conventional education of science teachers, still anchored to the basic and specific knowledge of the disciplines and apart from the pedagogical knowledge necessary for the formation of biology, chemistry, and physics teachers (GALIAZZI, 2000).

Given the initial details, this work provides an overview of the academic production about active methodologies in natural sciences teaching through the analysis of scientific articles published between 2010 and 2019. Therefore, this research seeks to answer the following problem: What are the characteristics, trends, and gaps found in the academic production about active methodologies in the teaching

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of natural sciences?

2 Methodology

This study is a systematic literature review. The term *systematic review* is defined as a method that allows expanding a given search to find a considerable number of results, not just a simple description of works but productive work with critical reflections (COSTA and ZOLTOWSKI, 2014; MELO and PARAGUAÇU, 2021).

The procedures for searching and analyzing the articles included the actions listed below, following what is established in Costa and Zoltowski (2014):

a) Access the portal of e-journals of the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and search for works through the fields “Buscar Assunto” and “Busca Avançada” [Search Subject and Advanced Search]. The highlighted fields are on the portal, and the keywords about what one wants to search are there;

b) Use the descriptors “Metodologias Ativas” and “Ensino de Ciências” [Active Methodologies and Science Teaching] and the Boolean operator “AND” in the search fields of the CAPES portal;

c) Select the parameters “Qualquer” and “Exato” [Any and Exact] in the search fields, defining that, in the article, there were exactly the descriptors searched for in the previous item in any section of the text;

d) Specify the “Data de publicação”, “Tipo de material”, and “Idioma” [Publication date, Type of material, and Language] in the search fields of the portal for researching the academic works that would be analyzed. Only scientific articles published between 2010 and 2019 and in any language were considered;

e) Floating reading of the articles obtained and screening of those that, coming from Brazilian research, met the research objectives, i.e., that dealt with the adoption of active methodologies in Science teaching;

f) Analyze the articles looking for the type of active methodology, school contents of Natural Sciences, number of publications per year, regions of the main authors’ affiliation institutions, teaching levels, types of research and approach, teaching instruments, and theoretical contributions.

A codification was adopted for the articles through letters defined according to

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the Science contents: C if the article referred to the Science discipline in general; B if they were characteristic of Biology; Q if the contents were specific to Chemistry; or P if the contents were specific to Physics. These codes will be presented in the other tables during this work.

3 Results and discussion

The systematic literature review resulted in a total of ten articles, described in the chart below.

Chart 1: Codes of scientific articles published between 2010 and 2019 that address active methodologies in Science teaching available on the CAPES Journal Portal.

Code	Articles
C1	SEGURA, E.; KALHIL, J. B. A metodologia ativa como proposta para o ensino de Ciências [The active methodology as a proposal for Science teaching]. Revista REAMEC, Cuiabá – MT, v. 3, n. 1, p. 87-98, 2015. Available at: https://periodicoscientificos.ufmt.br/ojs/index.php/reamec/article/view/5308
C2	ROCHA, C. J. T.; MALHEIRO, J. M. S. Interações dialógicas na experimentação investigativa em um Clube de Ciências: proposição de instrumento de análise metacognitivo [Dialogical interactions in investigative experimentation in a Science Club: proposition of a metacognitive analysis instrument]. Amazônia – Revista de Educação em Ciências e Matemáticas, v. 14, n. 29, p. 193-207, 2018. Available at: https://periodicos.ufpa.br/index.php/revistaamazonia/article/view/5476
B1	STEINERT, M. E. P.; HARDOIM, E. L.; PINTO. O, M. P. P. C. De mãos limpas com as tecnologias digitais [Clean hands with digital technologies]. Revista SUSTINERE, Rio de Janeiro, v. 4, n. 2, p. 233-252, 2016. Available at: https://www.e-publicacoes.uerj.br/index.php/sustinere/article/view/25055
B2	MARÍN, Y. A. O. O. Ensino da Biodiversidade: Tendências e desafios nas experiências pedagógicas [Teaching biodiversity: trends and challenges in pedagogical experiences]. Revista Góndola, Enseñanza y Aprendizaje de las Ciencias, v. 12, n. 2, p. 173-185, 2017. Available at: https://revistas.udistrital.edu.co/index.php/GDLA/article/view/11599
B3	STEINERT, M. E. P.; HARDOIM, E. L. Leigos ou excluídos? A criação de um aplicativo educacional e seu uso via ensino híbrido em uma escola pública. [Layperson or excluded? The creation of an educational application and its use via blended learning in a public school]. Revista SUSTINERE, Rio de Janeiro, v. 5, n. 1, p. 90-113, 2017. Available at: https://www.e-publicacoes.uerj.br/index.php/sustinere/article/view/25067
B4	SILVA, C. S. S.; SOUZA, D. S. O enfoque CTSA e o uso de metodologias ativas no Ensino Superior: uma análise baseada na discussão de notícias sobre acidentes ambientais envolvendo produtos químicos [The STSE approach and the use of active methodologies in higher education: an analysis based on the discussion of news about environmental accidents involving chemical products]. Ensino em Revista, Uberlândia – MG, v. 26, n. 3, p. 919-941, 2019. Available at: http://www.seer.ufu.br/index.php/emrevista/article/view/50993
B5	BORGES, J. O. A.; SANTOS, E. T. G. Disciplina Eletiva e Aprendizagem Significativa: Um relato de experiência na Escola Plena de Confresa – MT [Elective discipline and meaningful learning: an experience report at Escola Plena de Confresa – MT]. Revista Prática Docente (RPD), v. 4, n. 2, p. 713-727, 2019. Available at: http://periodicos.cfs.ifmt.edu.br/periodicos/index.php/rpd/article/view/555

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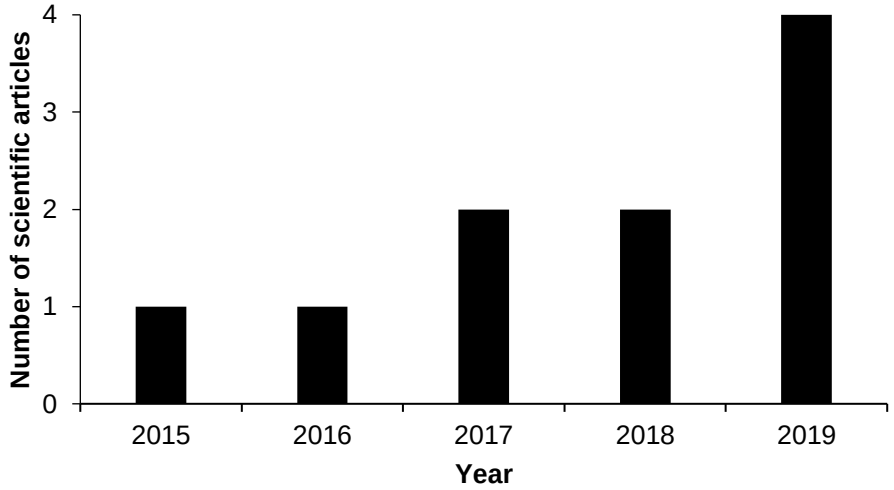
Q1	GIROTTO-JÚNIOR, G.; PAULA, M. A.; MATAZO, D. R. C. Análise do conhecimento sobre estratégias de ensino de futuros professores de Química: vivência como aluno e reflexão como professor [Analysis of knowledge about teaching strategies for future chemistry teachers: experience as a student and reflection as a teacher]. Revista Góndola, Enseñanza y Aprendizaje de las Ciencias, v. 14, n. 1, p. 35-50, 2019. Available at: https://dialnet.unirioja.es/ejemplar/510404
P1	FRANTZ, D. S. F. S.; NUNES, J. F.; MARQUES, I. L.; MARQUES, N. L. R. Ensino híbrido com a utilização da plataforma Moodle [Blended teaching using the Moodle platform]. Revista Thema – Ensaios e Relatos, Plotas – RS, v. 15, n. 3, p. 1175- 1186, 2018. Available at: http://periodicos.ifsul.edu.br/index.php/thema/article/view/1070
P2	SITKO, C. M.; POZZO, B. R. D; LOBO, C. C. Jornada a Marte: Adaptação do RPG para o Ensino de Física e Astronomia [Journey to Mars: adaptation of RPG for teaching physics and astronomy]. Revista EDaPECI – Educação à Distância e Práticas Educativas Comunicacionais e Interculturais, São Cristóvão, v. 19, n. 2, p.134-149, 2019. Available at: https://dialnet.unirioja.es/servlet/articulo?codigo=7021745

Source: Research data (2021)

Despite the research done on the CAPES e-Journal Portal covering the years from 2010 to 2019, we observed that the articles were published between December 2015 and December 2019 (Graph 1). The number of published articles doubled every two years, with the largest number of publications dating from the year 2019. This demonstrates a gradual increase in the production of knowledge on the subject. Works C1 and B1 were published in 2015 and 2016, respectively; B2 and B3 in 2017; C2 and P1 in 2018; and works Q1, B4, B5, and P2 in 2019.

Graph 1: Number of scientific articles published between 2010 and 2019 that addressed active methodologies in Science teaching, available on the CAPES e-Journal Portal



Source: Research data (2021)

As for the Brazilian regions of the main authors' affiliation institutions, most of the publications came from the North region (Chart 2). Of the institutions to which the authors of the articles were linked, six were of public initiative (UFMT, IFMT, UFAC, UFPA, UNICAMP, and UNIFESSPA), and three were of private initiative (Universidade

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Nilton Lins, UFN – RS, and ULBRA – RS).

Chart 2: Number of scientific articles by the Brazilian regions published between 2010 and 2019, addressing active methodologies in Science teaching, available on the CAPES e-Journal Portal

Brazilian regions	Bonding institutions	Work codes	Quantity
Northern Region	Universidade Nilton Lins, UFAC, UFPA, UNIFESSPA	C1, B2, C2, P2	04
Midwest Region	UFMT, UFMT, IFMT	B1, B3, B5	03
Southern Region	UFN – RS, ULBRA – RS	P1, B4	02
Southeast Region	UNICAMP	Q1	01

Source: Research data (2021)

The active teaching methodologies that stood out the most in the analyzed scientific articles were *problem solving*, present in four articles, and *blended learning*, cited in three articles (Chart 3).

Chart 3: Active methodologies (indicated by the authors of the articles), codes and year of publication of scientific articles published between 2010 and 2019 that address active methodologies in Science teaching, available on the CAPES Journal Portal

Code	Active Methodologies	Year of publication
C1	Problem solving; case study; projects.	2015
B1	Blended learning (Blog and mobile app).	2016
B2	Problem solving; projects; investigation.	2017
B3	Blended learning (mobile app).	2017
P1	Blended learning (Moodle platform).	2018
C2	Problem solving.	2018
Q1	Simulated jury.	2019
B4	Debate.	2019
B5	Parodies; multimodal texts; theater.	2019
P2	Problem solving	2019

Source: Research data (2021)

Problem solving or *problem-based learning* has as its fundamental principle the problematization of reality*:* “In the context of the classroom, problematizing implies analyzing reality as a way of becoming aware of it. In another instance, there is a need for the teacher to instigate the student’s desire to learn, problematizing the *contents*” (DIESEL; BALDEZ and MARTINS, 2017, p. 275).

In this way, this methodology starts from a question the teacher asks intentionally -but that students might have asked too- to encourage students to investigate, study, and reflect so that, from there, they can migrate to the search for

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solutions to a problem (ROCHA and MALHEIRO, 2018). El Chaer (2013) states that in *problem-based learning*, students are first grouped into small formations under the guidance of a tutor. Next, the group discusses a problem and develops hypotheses to solve it. The group must also develop objectives, research, and studies on the problem found. Subsequently, new discussions are proposed by the groups for the application and sharing of knowledge.

In *problem-based learning*, the student becomes the center of the teaching and learning process, with the teacher as an advisor and mediator. Autonomy is an essential aspect to be developed in this active methodology (DIESEL; BALDEZ and MARTINS, 2017). However, this characteristic becomes somewhat uncomfortable at first, since learning to be an autonomous subject requires the student to mature, especially in the academic world (SEGURA and KALHIL, 2015).

It is vital to distinguish between problematization and problem-based *learning*. In problematization, by observing reality, the students identify problems they will study and problematize independently, without restrictions or control over the ideas included in the formulation. On the other hand, in *problem-based learning*, a specific group of individuals propose problems to achieve knowledge relevant to the curriculum (BERBEL, 1998).

Blended learning as an active methodology is based on the execution of activities that involve station rotation, laboratory rotation, the rotational laboratory, flipped classes and apps. According to Valente (2014), station rotation is the student's movement around the classroom. The students circulate through several stations, mainly in online learning: project construction, teamwork, or interaction with the teacher. In laboratory rotation, the students move around several physical locations of the educational institution. One of them is the laboratory, to develop practical and specific activities.

The rotational laboratory is where students can work individually and independently to meet the objectives established by the teacher in an activity. In this modality, students may wander around the class, working alone on their content (BACICH and MORAN, 2015). In this way, Blended Teaching aggregates methods and techniques that contribute to the development of autonomy and teamwork, which are the principles of active methodologies (DIESEL; BALDEZ and MARTINS, 2017).

Blended learning can also add to the *flipped class*, defined as the teachers'

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provision of *online activities* to students, which can occur in environments other than the school. For example, they can take place in the students' homes, as long as they have access to the internet to carry out the proposed activities (STEINERT; HARDOIM and PINTO, 2016). Mobile applications are defined as a category of programs that bring a wide variety of uses, precisely covering applications intended for browsers contained in mobile devices (PRESSMAN and MAXIM, 2016).

About blended learning and the functioning of the Moodle platform, specified by the P1 code article, the authors Frantz *et al.* (2018) claim to be a device in which, through access, the students create their online student identity in the system since, for students access, they must create an email account, through which they can access numerous applications, mainly online video classes on YouTube, news, translator, and maps, besides posting and sending activities, such as images, text documents, videos, links, spreadsheets, and presentations.

Regardless of the methodology used, Barbosa and Moura (2013) point out that what really matters is that the students use their mental functions, relating them to reasoning, thinking, observing and reflecting. These attitudes may contribute to an active learning environment as opposed to the passive attitudes acquired with traditional teaching methods. In the same context, active methodologies allow students to act, think, and give meaning to their actions, putting their knowledge into practice more independently. These methodologies, which embrace the students' interaction with the teacher and peers, promote the learning of the contents addressed, considering the attitudes and values students acquired as a team, which are necessary for their formative trajectories (VALENTE; ALMEIDA and GERALDINI, 2017).

Regarding the educational levels in which active methodologies were used in Science teaching, Elementary School was the most cited (Graph 2). Only one scientific article did not clearly specify which level of education it was addressing. Article C1 did not have the level of education specified because it was a bibliographic research. Articles B2, C2, B5, and P2 focused on Elementary Education, and the first two did not specify whether the school institution was public or private, while the third identified the school as public, and the fourth as a private school. Works B1 and B3 focused on High School, working in public schools. Articles P1, Q1, and B4 were built in Higher Education, being P1 in a public institution, while the other two did not specify the administrative character of the institution.

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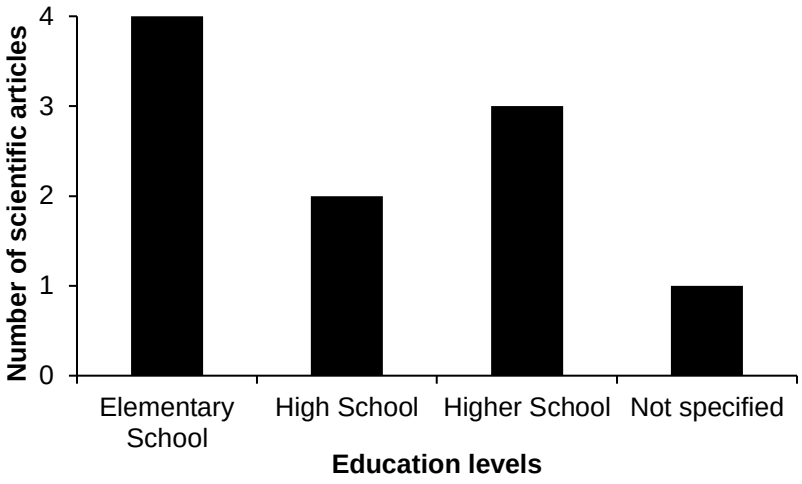
Graph 2: Education levels focused by the authors of scientific articles published between 2010 and 2019 that addressed active methodologies in Science teaching, available on the CAPES Journal Portal



Source: Research data (2021).

The scientific article by Rocha and Malheiro (2018) stands out in the works done with Elementary Education. In the article, the authors focus on dialogic interaction between students and teachers in environments such as Science clubs. For Rocha and Malheiro, the distinguishing factors of the quality in those interactions include, above all, the form of knowledge organization on the occasion of the emerging questions and answers, and the interactions are exactly involved in *problem solving*. Furthermore, they function as a means of understanding how students organize the knowledge with which they are dealing. In the same line of reasoning, Zimmerman (2016) points out the students' protagonist role, which only becomes permanent when they are presented with experiences that place them in the active role of the functions they perform.

One of the obstacles to knowledge production is how learning can become meaningful to students (BORGES and SANTOS, 2019). In this context, Mauri (2009) states that for meaningful learning, students must carry out activities to attribute relevance to school content, making a connection with other knowledge they have already acquired.

Regarding the works involving Higher Education, the author observed that they mentioned using current digital technologies and documents that bring students closer to everyday facts, as is the case of the journalistic news used in Silva and Souza's (2019) work. The main characteristic of today's society is the rapid changes caused by the advancement of technology, primarily focused on the individuals' development in

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their human and social aspects. Added to this is the role of education in their formation as citizens, which allows them to make decisions, understand, and act using technologies, thus exercising their autonomy (SILVA *et al.*, 2016). However, for learning to occur in this context, educating to promote autonomy becomes a political-pedagogical act, i.e., active in the teacher and student education fields through active teaching methodologies, which require students to take risks, research, make choices and, above all, learn by discovering (BERBEL, 2011; SILVA and SOUZA, 2019).

Regarding Science content, five articles were focused on the discipline of Biology (B1, B2, B3, B4, and B5); two for Natural Sciences, in general (C1 and C2); one of them for the discipline of Chemistry (Q1); and two referred to the discipline of Physics (P1 and P2). Only articles with codes C1 and C2 did not specify the content worked on; and six of them addressed cross-cutting themes (B1, B2, B3, B4, B5, and Q1) (Chart 4). We can also realize that most of the works were related to Biology.

Chart 4: Main Science contents worked by the authors of scientific articles published between 2010 and 2019 that address the active methodologies in Science teaching available on the CAPES Journal Portal

Article code	Science contents	Year of publication
C1	Unspecified	2015
B1	Prevention of infectious diseases	2016
B2	Biodiversity	2017
B3	Health: diseases and conditions associated with the five kingdoms of living beings	2017
P1	Hamiltonian dynamics	2018
C2	Unspecified	2018
Q1	Fuels, combustion, environmental problems	2019
B4	Environmental accidents involving chemicals	2019
B5	Dengue, recycling, landfill, dump	2019
P2	Celestial bodies, laws of motion of bodies	2019

Source: Research data (2021)

The chart analysis emphasizes two themes of all the contents seen: health and environmental issues. According to the Base Nacional Comum Curricular (BNCC), those topics should be approached, preferably, in a transversal and integrative way, in order to keep students connected to the issues that occur in their daily lives, and which could be applied and contextualized to different local, regional, and global realities (BRASIL, 2018).

From the perspective of Environmental Education, it is pertinent to mention that

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B5 used several activities to promote interaction between students and was developed in a public school located in the municipality of Confresa, Mato Grosso, a *Escola Plena*. The principles of *Escola Plena* use the methodologies that place students as the main subjects in constructing knowledge (DIESEL; BELDEZ and MARTINS, 2017). In this education system, the so-called “elective subjects” are part of the curriculum structure, differing from other subjects by their choice process, which includes student participation (BORGES and SANTOS, 2019). It is also worth mentioning article B2, authored by Marín (2017), which deals with biodiversity and places the conservation of life forms as one of the main challenges of contemporary society. Therefore, adopting educational practices such as active methodologies under the ecological aspect becomes a fundamental factor, especially in Brazil, a country that embraces countless species and life forms.

The inclusion of the environmental theme in the curricula of Brazilian schools began in the 1980s and was boosted after the Rio-92 event. The theme is mentioned in several other legislations, including Law n. 9394/96 —Diretrizes e Bases da Educação (LDB); Plano Nacional de Educação (PNE) and Diretrizes Curriculares da Educação Básica (MATO GROSSO, 2010). Several damages are constantly caused to the environment, often by accidents involving chemical products, the most serious being those related to the release of toxic gases. Effects like these have disastrous consequences, including acid rain and the destruction of the ozone layer (SILVA and SOUZA, 2019). Freitas and Amorin (2001) defend that preventive measures be adopted regarding the occurrence of environmental accidents and that the impacts caused by them evaluated.

Modern society has several challenges and obstacles due to increased production and consumption patterns, causing disrespect for nature, which is only mentioned for individual and collective interests (MATO GROSSO, 2010). Environmental accidents are unforeseen events that directly or indirectly damage the environment or human health. As an example, we can mention the releases or leaks of substances of solid, liquid, or gaseous substances in water, soil, or atmosphere and forest fires or industrial establishments (SILVA and SOUZA, 2019). From this perspective, the study of environmental issues and their implications, especially in society, health, and educational institutions, becomes essential from the moment that schools maintain a social role with a view to the formation of critical, reflective, collective, and solidary citizens, aware of the respect for nature and the human rights

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(BORGES and SANTOS, 2019).

Other relevant contents were those related to health. School learning is, in a way, linked to the development of individual health since, in this teaching and learning space, information about the world and social relationships are addressed (STEINERT; HARDOIM and PINTO, 2016). Moran, Masetto, and Behrens (2000) follow the same line of reasoning when pointing out that it is important to always maintain the connection between teaching and the student's daily life. Steinert, Hardoim, and Pinto (2016) developed a work using a mobile phone application, SAMBI, to study diseases and disorders related to the five kingdoms of living beings, which is in the app description. Regarding health, the authors of the study also mention that Biology brings as an object of study the world of disease-causing microorganisms, which points out the need for hand hygiene when handling electronic devices, thus preventing the transmission of diseases caused by infectious agents.

Regarding the type of research, two articles were bibliographic research (C1 and B2); five were an experience report (B1, B3, F1, B4, and B5); two were characterized by their authors as participatory research (C2 and Q1), and one was classified as a case study (P2). As for the research approach, four articles reported the quantitative and qualitative approach (B1, B3, B4, and B5); three brought the qualitative approach (B2, C2, and Q1); and three did not specify (C1, P1, and P2).

The authors used different teaching tools to work with active teaching methodologies. However, the most used means included Digital Information and Communication Technologies (DICT) (Table 5). The presence of the DICTs has altered the modes of communication. However, the changes have not yet impacted education, since it has not yet fully appropriated the resources offered by those technologies (VALENTE, 2014). According to Silva (2014), in a world surrounded by DICTs, we must analyze teachers' attitudes, aware that they should no longer be seen as the only sources of knowledge in educational institutions.

Chart 5: Teaching instruments used by the authors of scientific articles published between 2010 and 2019 that address active methodologies in Science teaching available on the CAPES Journal Portal

Article code	Teaching instruments used	Year of publication
C1	-	2015
B1	Digital Technologies (mobile phones, computers, *blog*, mobile app	2016

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B2	-	2017
B3	Digital Technologies (mobile phones and computer)	2017
P1	Digital Technologies (computer)	2018
C2	Data Analysis Plan	2018
Q1	*Score*; semi-structured interviews	2019
B4	Journalistic news	2019
B5	Multimodal texts; parodies and theaters	2019
P2	SOLO taxonomy; character sheet adapted to teaching	2019

Source: Research data (2021).

To better understand the other means used, it is also important to address the Data Analysis Plan, Score and the SOLO Taxonomy, cited in works C2, Q1, and P2, respectively. Articles C1 and B2 do not present teaching instruments, as they were bibliographic research that used academic works as sources.

The Data Analysis Plan, posed by the C2 code work, focuses on the actions of teachers related to efficient dialogic interaction with their students and is described in six steps: requesting information; forwarding information; re-mirroring; problematizing; restructuring, and renewing (ROCHA and MALHEIRO, 2018).

Score is defined as a research medium adapted from the Core (Content Representation), a kind of questionnaire containing a total of eight questions that collects information about the teachers' knowledge on a specific subject by placing ideas that are considered primordial (GIROTTO-JÚNIOR; PAULA and MATAZO, 2019). With it, practical activities were developed so that students could reflect as prospective teachers on teaching strategies used in Chemistry. It is worth recalling that work Q1 used the *simulated jury*, a methodology that allows a concrete and contextual approach to real issues, where students can develop a reflection on chemical contents, relating them to daily life and contributing to the establishment of more active forms of assessment (GOMES, 2013; GIROTTO -JUNIOR; PAULA and MATAZO, 2019).

P2 consisted of developing a reality simulation game, the *Rolling Playing Game*, which mentions the *SOLO* taxonomy. According to Amantes and Oliveira (2012), the SOLO taxonomy, created by scholars John Biggs, and Kevin Collis in 1982, allows evaluating and analyzing the result of a task used in learning, taking into account the cognitive development that occurs in stages or phases, considering that a subject may present several stages, depending on the teaching area in which the activity or task is applied. Sitko, Pozzo, and Lobo (2019) state that this model is classified into five

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phases: pre-structural, uni-structural, multi-structural, relational, and extended abstract. The authors point out that, by executing this simulation game, students can practice problem solving, associating the contents studied in class with their reality.

Those different instruments align with the principles that characterize active methodologies, which place the student at the center of the teaching-learning process, developing autonomy, reflection, and teamwork (DIESEL; BELDEZ and MARTINS, 2017).

Regarding the theoretical contributions addressed in the analyzed scientific articles, C1 was the work that the following authors most used, as it was bibliographic research: Galiazi (2000); Pozo and Crespo (2009); Oliveira (2013); Delizoicov; Angoti and Pernambuco (2009); and El Chaer (2013). Galiazi (2000) states that in teacher education courses, there is a mismatch between pedagogical and specific disciplines. Pozo and Crespo (2009) claim that there are three main characteristics of science teaching in today's society: we are facing an information society, multiple knowledge, and continuous learning. Oliveira (2013) states that teaching based on active methodologies aims to form world citizens. Delizoicov, Angoti, and Pernambuco (2009) point out that in the teaching and learning process, the teacher must know the student as a subject. Finally, El Chaer (2013) proposes learning based on problematization, considering it an activity that involves the entire school community.

Frantz et al.'s (2018) academic work P1 brings the author Behar (2013), who defends the distance education model supported by organized content and technological resources based on *blended learning*. This article also cites authors Bergmann and Sams (2018), who defend the efficiency of the flipped classroom methodology.

The scientific article B5, authored by Borges and Santos (2019), brings Gil (2002), who deals with descriptive experience reports and states that the descriptions of an event, as well as the way of obtaining the results, are essential elements to achieve the desired goals. Steinert, Hardoim, and Pinto (2016) and Steinert and Hardoim (2017) academic works identified with codes B1 and B3, respectively, are based on George Siemens' theory of Connectivism, which points out the theme of the DICTs in teaching. This theory agrees with the authors' ideas since, in their work, they defend the use of digital technological resources in the application of activities to engage students, using an app that details infectious diseases related to the kingdoms

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of living beings to make students aware of the importance of hand hygiene.

In C2, by Rocha and Malheiro (2018), we have the authors' own words about studies in Science clubs. They focus on the interactive processes (OLIVEIRA, 2013) that occur between teacher and student, pointing out that, through them, diversified ways of thinking arise for solving problems.

The work by Girotto-Júnior, Paula, and Matazo (2019), identified with the Q1 code, addressed the theoretical contributions of Shulman (1987), who discuss the term *Pedagogical Content Knowledge (PCK)*. This term is linked to a specific content the teachers worked and transformed, considering several factors that exist during the teacher's professional practice, such as the students' difficulties, the curriculum, the forms of assessments, the context, and the instructions directed to the students. All items establish a link with the teaching experience (GIROTTO-JÚNIOR; PAULA and MATAZO, 2019).

Finally, work P2, using the term *constructivist alignment*, based on Constructivism, quotes the words of Biggs (1999), for whom this term substantiates thinking about teaching and developing learning, since it aims to favor an efficient pedagogical planning through practices that are coherent and aligned with the learning assessment, to ensure that students are subjects of the process.

The different theoretical frameworks adopted establish a dialogue with the principles of active methodologies. They point to a teaching centered on the students and focused on their reality in a problematizing way (BIGGS, 1999; DELIZOICOV; ANGOTTI e PERNAMBUCO, 2009; El Chaer, 2013; ROCHA e MALHEIRO, 2018). They appropriate digital technologies in the instrumental sense to provide the conditions, on the one hand, for the development of autonomy and, on the other hand, for learning through teamwork. The teachers must act as a mediators, facilitators, and activators (ROCHA and LEMOS, 2014).

Regarding inserting active methodologies in teaching, it is considered a slow process, since many teachers still remain stuck to the traditional, focused on memorizing and exposing information orally (SILVA et *al.*, 2019). Moreover, teachers still resist experimental environments: on the one hand, because this type of environment demands great attention from them when preparing activities, and on the other hand, because some do not consider that, in this type of class, there is enough time for student learning (MOTA and ROSA, 2018). Before these difficulties, teachers

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become responsible for looking for continuing education to help them adopt a teaching that aims not only at learning the contents covered in each subject but that leads the student to learn to learn, i.e., to seek knowledge in different ways and outside the school environment.

4 Conclusion

The analysis of the production of knowledge about active methodologies in Science teaching allowed us to observe some trends. Academic production in the form of articles on the subject began five years ago and is on a gradual rise. Most articles cite the qualitative approach and are characterized as experience reports. The most cited active methodologies were *problem solving*, followed by *blended learning*. Although the authors have used different teaching instruments, we observed greater use of DICTs, which are increasingly present in contemporary society, establishing connections and access to information. Regarding the Science contents discussed in the articles analyzed in this research, they tended to approach themes on health and environmental issues, mainly linked to Biology.

From these results, we can conclude that there is still a vast field for analysis and debate on active methodologies in Science teaching. As suggestions for future work, we can highlight the need for more research that addresses this issue quantitatively and presents more than experience reports. There is also a lack of knowledge regarding the practice of active methodologies in other areas of Science besides Biology. Another point is the lack of knowledge about whether and how those active methodologies are used in Science teaching in the Northeastern region of the country.

This work is relevant for the development of Science teaching not only because it presents gaps and trends in the production of knowledge about active methodologies but also because it serves as a guide for researchers and educators in the area of Science intending to delve deeper into the subject. Thus, we expect to contribute to improving teaching and learning in Science, substantiating the debate on how active methodologies can provide students' knowledge construction.

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