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Active methodologies and digital technologies during remote teaching: conceptions of public school chemistry teachers in the interior of the state of São Paulo

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Abstract: During remote teaching, teachers were challenged to use methodologies and technologies that provide active and effective learning for students. This challenge results from the lack of experience and training of teachers on these subjects. This study aimed to understand the conceptions of a group of chemistry teachers from the public school system in the interior of São Paulo, regarding the use of active methodologies supported by digital technologies during the pandemic. Moran and Valente's ideas were adopted as a theoretical framework and the approach used was qualitative. Semi-structured interviews were used in data collection and for data analysis, lexical analysis was used with the Iramuteq software. It was noted that the professors did not use active methodologies and as a technological resource they mainly used simulators. The lack of structure and guidelines were some of the challenges found, which implies the need for investments in technologies and offers of teacher training on these topics.

Keywords*:* Chemistry teaching. Digital Technologies. Teacher training.

Metodologías activas y tecnologías digitales en la enseñanza a distancia: concepciones de profesores de química de escuelas públicas del interior del estado de São Paulo

Resumen**:** Durante la enseñanza remota, los docentes fueron desafiados a utilizar metodologías y tecnologías que proporcionen un aprendizaje activo y efectivo para los estudiantes. Este desafío resulta de la falta de experiencia y capacitación de los docentes en estos temas. Este estudio tuvo como objetivo comprender las concepciones de un grupo de profesores de química del sistema escolar público del interior de São Paulo, sobre el uso de metodologías activas apoyadas en tecnologías digitales durante la pandemia. Se adoptaron como marco teórico las ideas de Moran y Valente y el enfoque utilizado fue cualitativo. En la recolección de datos se utilizaron entrevistas semiestructuradas y para el análisis de datos se utilizó análisis léxico con el *software* Iramuteq. Se notó que los profesores no utilizaban metodologías activas y como recurso tecnológico utilizaban principalmente simuladores. La falta de estructura y lineamientos fueron algunos de los desafíos encontrados, lo que implica la necesidad de inversiones en tecnologías y ofertas de formación docente en estos temas.

Palabras clave: Enseñanza de la Química. Tecnologías Digitales. Formación de Profesores.

Metodologias ativas e tecnologias digitais durante o ensino remoto: concepções de professores de Química da rede pública do interior

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Resumo: Durante o ensino remoto, os professores foram desafiados a utilizar metodologias e tecnologias que proporcionassem uma aprendizagem ativa e efetiva aos alunos. Este desafio resulta da falta de experiência e formação dos docentes sobre esses assuntos. Este estudo objetivou compreender as concepções de um grupo de professores de Química da rede pública de ensino do interior paulista, quanto ao uso das metodologias ativas apoiadas nas tecnologias digitais durante a pandemia. Adotou-se como referencial teórico as ideias de Moran e Valente e a abordagem empregada foi qualitativa. Utilizou-se entrevistas semiestruturadas na coleta de dados e para análise dos dados, empregou-se a análise lexical com o *software* Iramuteq. Notou-se que os docentes não utilizaram metodologias ativas e como recurso tecnológico usaram, principalmente, simuladores. A falta de estrutura e orientações foram alguns desafios constatados, o que implica na necessidade de investimentos em tecnologias e ofertas de formação docente sobre esses temas.

Palavras-chave: Ensino de Química. Tecnologias Digitais. Formação de Professores.

1 Introduction

With the advance of digital technologies, school education has undergone numerous changes. In terms of changes in the school context, the COVID-19 pandemic emerged at the beginning of 2020. Due to the imposition of social isolation as a way of preventing the spread of the disease, schools have had to replace face-to-face classes with online classes. To this end, the meetings, previously held in person, began to be mediated by technologies (ALVES; ARAÚJO and NEPOMUCENO, 2021; OLIVEIRA; FERNANDES and ANDRADE, 2020).

According to Schneider *et al.* (2020), the replacement of face-to-face classes with *online* classes, carried out using digital technologies, as well as the adoption of remote work by the entire school management, were necessary alternatives so that the education system would not come to a complete standstill.

According to Moran (2012), digital technologies are support tools for various activities in our daily lives. Among these activities, the author highlights education, since the advance of the media and research portals has made technologies fundamental tools in teaching (MORAN, 2012).

The changes in the way we communicate on a daily basis exemplify the possibilities of digital technologies. In addition, as far as educational action is concerned, technologies can be used by educators as cognitive tools capable of enabling the creation of learning situations that stimulate the construction and understanding of knowledge by learners (VALENTE, 2014).

Still with regard to these tools, Pretto, Bonilla and Sena (2020) believe that

teachers have difficulties in using them. These difficulties arise in the process of articulating technologies and training processes, since this is imposed on educators in a plastered way by the National Common Curriculum Base (BNCC) (PRETTO; BONILLA and SENA, 2020).

Thus, the result of this difficulty, caused by the excessive demands imposed by the BNCC, is that teachers are blamed for their lack of mastery and use of digital technologies in teaching, which is intensified in the context of the pandemic (PRETTO; BONILLA and SENA, 2020). It's worth pointing out that this attribution of blame to teachers is unfair, as the use of digital technologies and active methodologies implies the need for initial and continuing training for teachers by universities, by the State Education Departments, when they work in the public network, and by school management, when they work in the private education network.

As for active methodologies, Watanabe *et al.* (2020) believe that the new teaching format imposed by the pandemic, called Emergency Remote Teaching, has made their application a challenge. However, the authors also report that teachers' lack of experience, possibly due to a lack of training, has made this challenge even greater (WATANABE *et al.,* 2020).

By definition, "active methodologies are teaching strategies centered on the effective participation of students in the construction of the learning process, in a flexible, interconnected and hybrid way" (MORAN, 2018, p. 4). These methodologies are opposed to the traditional approach, in which the teacher is the center of the entire process and is responsible for transmitting information to the students. Therefore, when active methodologies are implemented, the teacher becomes a guide, a mediator between knowledge and learners (MORAN, 2018; VALENTE, 2018).

Active methodologies have been implemented through various strategies, such as: (i) project-based learning (PBL); (ii) game-based learning (GBL); (iii) teaching case method; and (iv) team-based learning (TBL) (VALENTE, 2018). It should be noted that these strategies can be used in the teaching of chemistry and other subjects.

The fact that these methodologies are considered active is related to the implementation of pedagogical practices that aim to involve learners, i.e. engage them so that they are the protagonists of their own learning. To this end, teachers need to look for activities in which students have the freedom to do activities, think and conceptualize what they do, and thus build knowledge about the content involved

(VALENTE, 2018).

Combining active methodologies with digital technologies is seen as a strategy for pedagogical innovation. Technologies are being used in the implementation of active methodologies as a way of overcoming the challenges that the insertion of these methodologies causes. Factors such as the organization of time and school spaces, relationships between information and students, as well as the interaction between teacher and learner, have been modified by technologies in a way that facilitates the use of active methodologies (MORAN, 2018; VALENTE, 2018).

Moran (2018) and Valente (2018), believing that the proposal for less teacher-centered teaching is not new, rely on the ideals proposed by John Dewey, the American philosopher responsible for developing a teaching philosophy that aimed to integrate theory and practice (WESTBROOK, 2010).

Finally, the context of the pandemic cannot serve as an argument for using active methodologies and digital technologies in a disorganized and immediate way. According to Pretto, Bonilla and Sena (2020), in addition to the difficulties of serving students, the concrete conditions of teachers, whether from an emotional or material point of view, must be taken into account.

To this end, the following research question was proposed: *how have active teaching and learning methodologies, supported by digital technologies, been implemented by public school teachers in remote education, given the difficulties imposed by the COVID-19 pandemic?*

The general objective of this study was *to understand the use of active methodologies supported by digital technologies from the perspective of teachers during the COVID-19 pandemic*. In order to achieve the general objective, the following specific objectives were defined: a) to understand the use of digital technologies by public school chemistry teachers during remote teaching; and b) to ascertain the difficulties faced by public school teachers in implementing digital technologies and active methodologies in their remote classes.

2 A brief review of the literature

The aim of this literature review was to look at studies published in the literature on the conceptions of public school teachers about the use of active methodologies and digital technologies. Thus, authors such as Lucena and Camarotti (2017), Rabaioli

(2018), Darub and Silva (2020) and Oliveira (2020) carried out studies that fit the objectives of this review.

In the study carried out by Lucena and Camarotti (2017), four public school teachers were interviewed in order to understand their methodological conceptions. The authors concluded that teachers understand "teaching methodologies as a set of actions and methods that facilitate student learning", which characterizes a broad and simple conception (LUCENA and CAMAROTTI, 2017, p. 6).

As for active methodologies, Lucena and Camarotti (2017) concluded that the teachers taking part in the study use them in their classes, however, they do not know their theoretical basis. This data highlighted the need for teachers to receive training on the subject (LUCENA and CAMAROTTI, 2017).

In her study, Rabaioli (2018) sought to investigate the use of digital technologies by teachers who taught in the public school system. To this end, the author conducted interviews with four teachers and found that they used videos, tablets and cell phones. Despite this, the author concluded that the teachers were not able to teach using technological resources, since they do not have opportunities to take part in training (RABAIOLI, 2018).

In order to understand the perception of public school teachers about training and the use of active methodologies, Darub and Silva (2020) conducted semi-structured interviews with twelve teachers. They reported difficulties in everyday school life, such as student behavior and the lack of technological resources. In addition, the authors believe that these difficulties are exacerbated by the lack of ongoing training on the subject (DARUB and SILVA, 2020).

Seeking to analyze the implementation of active methodologies in secondary education by teachers working in public schools, Oliveira (2020) interviewed eighteen teachers and used Iramuteq software to analyze the data. The same program was used by the authors of this study.

Through the analysis of the data obtained, Oliveira (2020) noted that some teachers used active methodologies in their classes. However, the author reports that all the participating teachers recognize the potential of these methodologies. The teachers who said they used these methodologies in their classes cited the inverted classroom as the most used active methodology (OLIVEIRA, 2020).

In addition, the teachers taking part in Oliveira's study (2020) reported their difficulties: lack of continuing training and technological resources, shyness on the part of the students and lack of familiarity with active teaching methods.

3 Theoretical framework

The theoretical framework for this study was Moran's (2018) and Valente's (2018) conceptions of active methodologies as teaching strategies aimed at the active and effective participation of learners, supported by digital technologies as teaching resources.

Although these methodologies are much discussed today, Daros (2018) states that their conceptual matrices began in the mid-twentieth century. Authors such as John Dewey defended an education where theory should be linked to practice, since, in his view, learning only takes place when it is part of the learner's daily life (DAROS, 2018).

Like Daros (2018), Moran (2018) and Valente (2018) also present John Dewey's ideals in relation to active methodologies. Dewey's ideals are: students learn by doing (hands-on); the learning process must take place through action, that is, actively (learning by doing); and we learn what is relevant and meaningful to us, which is related to the context we are in.

According to Valente (2018), active methodologies consist of a series of procedures, techniques and processes that help students learn. In this way, methodological strategies are active because they are directly related to pedagogical practices that aim to involve students in activities in which they can act as protagonists of their learning (VALENTE, 2018).

With regard to learning what is meaningful and relevant to students, Valente (2018) states that active methodologies seek to create learning situations in which individuals conceptualize what they are going to do. For Moran (2018), the life project of each learner is an important axis of learning and deserves special attention from educators. To address this, it is possible to use active methodological strategies, since they allow for the active participation of each learner and take into account the life contexts in which they are inserted (MORAN, 2018).

Moran (2018) and Valente (2018) believe that the insertion of active methodologies in schools must take place in a correct, structured and intelligent

manner, i.e. integrated into the institution's curriculum and pedagogical proposals.

There are several methodological strategies that can be used to offer active learning. The following stand out: (i) inverted classroom; (ii) rotation by stations; (iii) problem-based learning (PBL); (iv) project-based learning; (v) inquiry-based learning (ABIn); and (vii) game-based learning (MORAN, 2018; VALENTE, 2018).

According to Valente (2018), in the flipped classroom, the student studies the material provided by the teacher on the selected topic in advance, and in the classroom, questions, discussions and even practical activities are carried out. With this, the classroom becomes a place for active learning, where students are encouraged to reflect, hold discussions, answer questions and carry out practical activities (VALENTE, 2014; VALENTE, 2018).

In the rotation by stations approach, students are organized into groups according to the objectives set for the lesson in question and each group must carry out the tasks available at the stations organized in the classroom or other convenient environment. The activities available at the stations can be reading a text, solving exercises, discussing a video, etc. It should be noted that at least one station requires the activity to be carried out using technological resources (BACICH; TANZI NETO; TREVISANI, 2015).

In problem-based learning (PBL), students are tasked with carrying out research in order to find possible solutions to a problem, which must be related to the topic of the lesson. In project-based learning, learners are involved in activities and challenges that encourage them to solve a problem by developing a project (MORAN, 2018).

In inquiry-based learning, students, under the guidance and mediation of the teacher, raise questions and start looking for solutions (MORAN, 2019). According to Moran (2018), this activity involves raising hypotheses with a view to solving a problem and, therefore, enables learners to work on and develop various skills. Examples of skills are: researching, evaluating situations and different points of view, taking risks, making choices individually and as a group, respecting the choices of colleagues, moving from the simplest assumption to the most elaborate (MORAN, 2018).

The use of games is a very important strategy when it comes to motivating learners for more active learning. According to Moran (2018), in this methodology, students learn by navigating through games where they are subjected to challenges and advance through stages. Learners can also follow the performance of their

classmates and earn rewards (MORAN, 2018).

With regard to the role of the teacher when using active methodologies and digital technologies, Valente (2018) believes that teachers should act as mediators for learners. For the author, the classroom becomes the environment where the learner has the presence of the teacher and other colleagues, who in turn can help them solve their activities by sharing ideas and information (VALENTE, 2018).

In the same vein, Moran (2018) believes that when teachers correctly implement active methodological strategies and technological resources in their classes, they must take a broader view of their teaching practice. This breadth should include the idea that information should not be kept to oneself, and that one should stop being a transmitter of information and become a learning guide for their students (MORAN, 2018).

Although many students already use digital technologies and some teachers exploit these resources, there are teachers who feel uncomfortable when they notice that students are not paying attention to the activities proposed with the use of technologies. As a result, many teachers have started looking for efficient and meaningful training for their teaching practices (VALENTE, 2018).

For Moran (2018), initial and continuing teacher training in active methodologies and digital technologies is a consequence of the process of implementing these methodologies and pedagogical resources. In the author's view, teacher training should involve sharing experiences acquired by teachers who already use these methodological strategies and technological resources, i.e. supervision of training courses should be the responsibility of more experienced teachers (MORAN, 2018).

4 Methodology

4.1 Nature of the research

This research proposed a predominantly qualitative approach, since the data collected was mostly descriptive and the focus was more on the process than the product. According to Lüdke and André (2018), in qualitative research, the researcher must pay attention to as many of the elements present in the study situation as possible. Another concern that the researcher must have is to verify how the problem studied manifests itself throughout the procedures adopted in the research (LÜDKE and ANDRÉ, 2018).

In order to carry out this study according to ethical standards, the project was submitted to the Research Ethics Committee (CEP) via the Brazil Platform. The research was approved on December 10, 2021, according to the Certification of Submission for Ethical Appraisal (CAAE) 54134221.4.0000.5402. The approval report indicated that the research is ethically, scientifically and socially relevant.

4.2 Research subjects and data collection instruments

The research subjects were five chemistry teachers working in different public schools in the interior of São Paulo. To carry out the research, semi-structured interviews were selected as the data collection instrument. According to Triviños (1987), semi-structured interviews start with basic questions, based on theories and hypotheses of interest. This type of interview allows the interviewer a wide range of questions, because as new hypotheses emerge during the interview, the interviewee starts to participate in the development of the content (TRIVIÑOS, 1987).

This type of interview was chosen because it allows the interviewee greater freedom and spontaneity in their responses, enriching the study (TRIVIÑOS, 1987). Another factor that makes these interviews more effective in collecting data is the possibility for the interviewer to make adaptations during the course of the interview, inserting new questions.

It should be noted that the participation of the individuals in the study was completely voluntary and that aspects such as the importance and objectives of the study were clarified in advance. The Free and Informed Consent Form (FICF) was presented and confirmed for each participant, a document in which they signed to take part in the research on a voluntary basis and highlighted their total freedom to withdraw or refuse to take part at any time during the study.

Thus, we investigated the conceptions of active methodologies and digital technologies from the perspective of public school chemistry teachers. Also, through the interviews, we sought to understand the use of active methodologies supported by digital technologies during remote teaching imposed by the COVID-19 pandemic, if they were used. In cases where this implementation did not occur, we sought to understand the reasons.

4.3 Validation of the instruments by the Judges Committee

Once the semi-structured interview script had been drawn up, the data collection

instrument was validated by a committee of judges. This procedure allows us to investigate whether the content of the data collection instrument is relevant to the study, considering aspects such as: representativeness and clarity of each question (SANTANA and WARTHA, 2020). The selection of judges should take into account their experience with the subject, scientific publications and knowledge about the construction of data collection instruments (ALEXANDRE and COLUCI, 2011).

Initially, an invitation to join the judges' committee was sent via *email and WhatsApp* to five researchers. The criteria proposed by Alexandre and Coluci (2011) for selecting the judges were taken into consideration. The researchers invited had experience in Chemistry Teaching and Teacher Training in Science Teaching.

Once everyone had accepted the invitation, the experts received a link to access an online Google Forms form, in which the previously structured questions for the interview were made available for them to validate. It should be noted that this number of researchers invited and, consequently, participating in the evaluation committee, is considered to be the minimum necessary for the process (ALEXANDRE and COLUCI, 2011).

In order to reduce subjectivity and quantify the degree of agreement between the experts' analyses, the Concordance Validation Index (CVI) was used. According to Santana and Wartha (2020, p. 42), the CVI "can be understood as the measure of consistency between the absolute value of the evaluators' ratings". In addition, for the authors, the validation of data collection instruments used in the field of Science Teaching research is important to give the instrument greater consistency, validity and reliability (SANTANA and WARTHA, 2020).

To apply the method, it was necessary for the judges to assign a score from 1 to 4 to the items in the instrument under evaluation, based on a Likert-type scale. In this study, the scoring was proposed in the same way as Piva (2022, p. 73) proposed in his master's dissertation:

> 1 for the question not suitable for the study; 2 for the question that needs major revision to be suitable for the study; 3 for the question that needs little revision to be suitable for the study and; 4 for the question suitable for the study (p. 73).

After the evaluators had assigned the scores, the CVI value was calculated using the equation:

$$CVI = \frac{number\ of\ answers\ with\ a\ score\ \text{“3” or “4”}}{total\ number\ of\ answers}$$

Thus, the CVI of each question is the value resulting from the ratio between the number of answers given by experts with a score of "3" and "4" and the total number of answers. The CVI value recommended for item validation should be equal to or greater than 0.78 and questions that do not reach this value should be revised or even eliminated (ALEXANDRE and COLUCI, 2011).

In total, the evaluators judged 18 items and were free to make comments and suggestions in the space provided on the online form. All the items obtained a CVI value above the recommended level. However, in order to take the evaluators' suggestions into account, minor changes were made to the questions that received a CVI value of 0.8, i.e. the questions that received four evaluations with a score of "3" or "4" and at least one evaluation with a score of "1" or "2". Eight questions were revised as they obtained this value.

4.4 Data analysis

To process the data, we opted for the content analysis proposed by Bardin (2016), defined as

> A set of techniques for analyzing communications in order to obtain, through systematic and objective procedures for describing the content of messages, indicators (quantitative or not) that allow the inference of knowledge regarding the conditions of production/reception (inferred variables) of these messages. (p. 48).

This set of methodological tools that can be applied to diverse discourses is made up of three phases, which are organized around three chronological poles: 1) pre-analysis; 2) exploration of the material and 3) treatment of the results, inference and interpretation (BARDIN, 2016).

The aim of pre-analysis is to systematize initial ideas so that successive operations can be conducted in a schematic way. On the other hand, the exploitation of the materials consists of the systematic application of the decisions made in the initial stage, this being the longest phase, since it requires data decomposition or enumeration. Finally, the results processing, inference and interpretation phase is the treatment of the data obtained in the study (BARDIN, 2016).

From the set of content analysis techniques, we opted for lexical analysis, since it makes it possible to understand the meaning of the speeches of each research participant, as well as comparing them with each other. This consequently provides a deeper inference and interpretation of the data obtained.

Lexical analysis is a study of semantic units, vocabularies and grammatical characteristics, which aims to understand the structure of the themes exposed in the set of documents (*corpus*) submitted to the analytical procedures (BARDIN, 2016).

The process of lexical analysis of the corpus of this study (transcripts of interviews with five chemistry teachers working in the public school system) was carried out using the Iramuteq software. This software allows for better organization of the data, making it easier to locate segments of the text and, consequently, the entire data analysis process (SOUZA et al., 2018).

Bardin (2016) supports the use of software for content analysis, provided that the study in question falls into the following cases:

> - The unit of analysis is the word, the indicator is frequency (number of times the word occurs);
> - The analysis is complex and involves a large number of variables to be dealt with simultaneously (for example: a large number of categories and units to be recorded);
> - We want to carry out an analysis of co-occurrences (appearance of two or more recording units in the same contingency unit);
> - Research involves several successive analyses; the computer makes it possible to prepare the data and store it for successive uses (p. 175).

Therefore, given the cases in which the use of software fits in, the lexical analysis of the content of the transcripts from the interviews with the chemistry teachers was pertinent. The frequency with which the words are applied and the links with other key words demonstrate the principles employed by the teachers in their practices as educators.

According to Souza *et al*. (2018), Iramuteq is software that performs statistical analysis and allows Descending Hierarchical Classification (DHC) to be carried out,

> in which the text segments are classified according to their respective vocabularies, and are mostly around three lines long, the variation of which occurs according to the researcher's transcription and the size of their corpus, characterized by the set of text they intend to analyze (p. 2).

In this study, CHD was chosen as the lexical analysis technique that could be

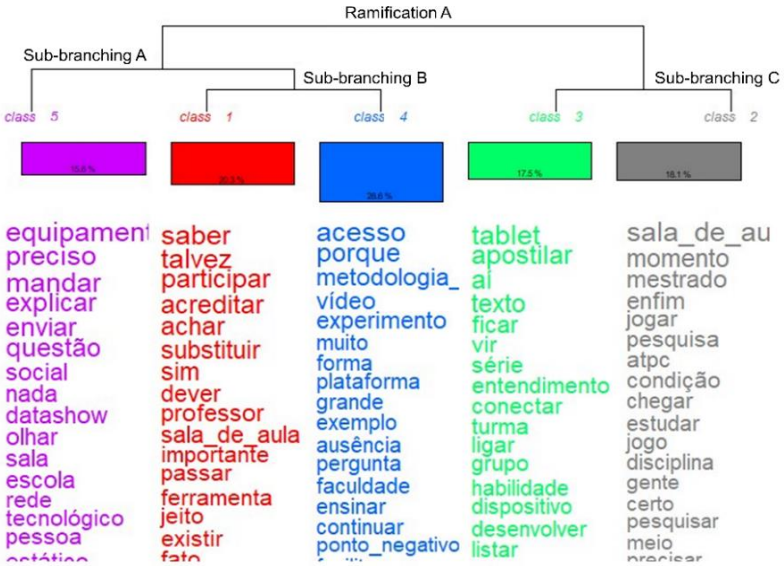
used with the Iramuteq software. In CHD, the text submitted to the software is broken down into smaller parts and the relationships between the fragmented passages are diagnosed, making it possible to understand the main issues addressed in the analyzed document.

Three stages are necessary to carry out CHD: (1) preparing and coding the text to be analyzed; (2) the descending hierarchical classification itself, carried out by the software; and (3) interpreting the classes (SOUZA et al., 2018). In this study, the first stage consisted of transcribing the interviews and coding the set of transcribed interviews as required for submission to Iramuteq. Data coding included the insertion of a command line to understand the number assigned to each participant (example: **** *individual_01) and the joining of compound words by underlining (low dash or underline, example: methodologies_active).and according to the researcher's transcription and the size of their corpus, characterized by the set of text to be analyzed (SOUZA et al., 2018, p. 2).

After transcribing and coding the interviews and merging the transcripts into a single file, both steps were carried out in Microsoft Word, the file was saved as a text document in .txt format, which uses character coding in the UTF-8 standard (Unicode Transformation Format 8 bir codeunits). The file was completely revised and then submitted to Iramuteq for analysis.

In the CHD performed by the software, the text was broken down into smaller text segments and their correlations were diagnosed, resulting in classes presented in a graphic representation called a dendogram, similar to the one shown in Figure 1.

Figure 1: Example of a dendrogram.



Source: Research collection.

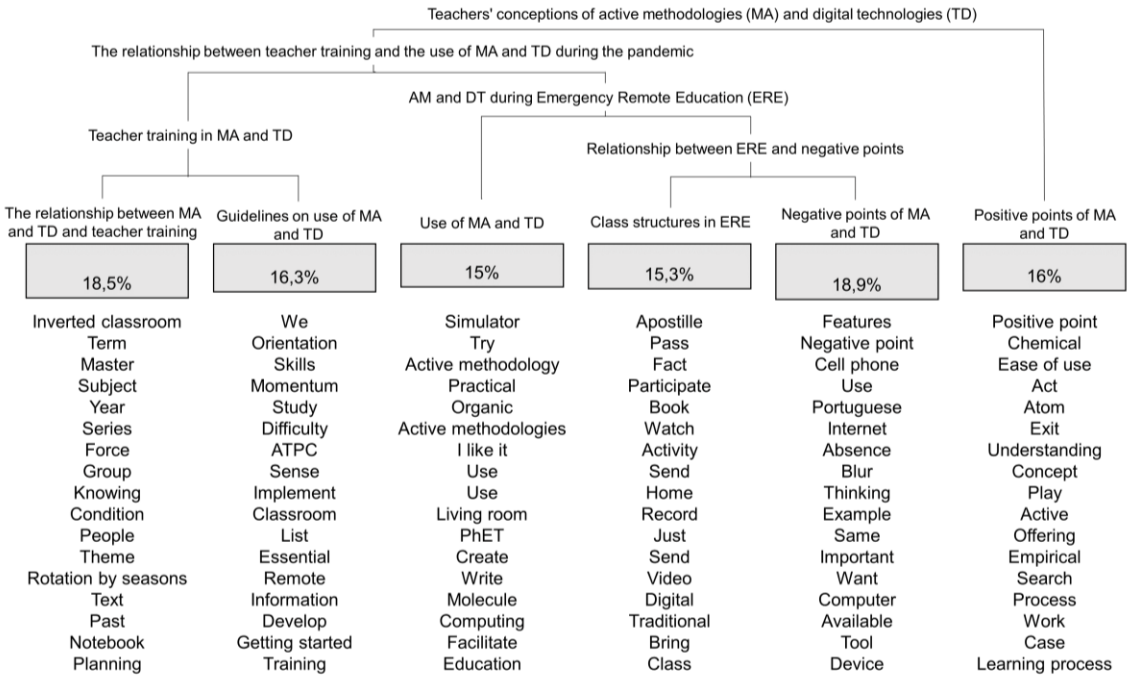
The dendrogram shows the correlation between words in a schematic way, similar to a flowchart. Figure 1 shows that the classes created by the software are represented by rectangles, which in turn show the frequency, in percentage, of the words that make up the classes. The words placed below the rectangles are those that appear most often in each of the classes and, consequently, link the parts of the text that make them up.

Later, in the class interpretation stage, each class was named, along with its branches and sub-branches. Branches were defined as the main horizontal line from which the classes originate, and sub-branches as the horizontal lines that show the connection between two or more classes. Sub-branch C, shown in Figure 1, is an example of a link between classes 2 and 3.

5 Results and discussion

The corpus was processed in 26 seconds and 388 text segments were classified, of which 313 were used, or 80.67% of the total *corpus*. This percentage indicated good use of the text segments, as it was found to be higher than 75% (SOUZA et al., 2018). The CHD dendogram obtained after analysis by the software is shown in Figure 2.

Figure 2: CHD dendogram obtained after analysis by Iramuteq and denomination of classes, branches and sub-branches.



Source: Authors.

The analysis resulted in six classes, divided into one main sub-branch and three secondary sub-branches. The main branch, called "Teachers' conceptions of active methodologies (MA) and digital technologies (TD)" gave rise to the class "Positive points of AM and TD" and, concomitantly, was subdivided into the theme "Relationship between teacher training and the use of MA and TD during the pandemic". This theme, in turn, is made up of the subjects "Teacher training in MA and TD" and "MA and TD during Emergency Remote Education (ERE)".

The sub-branch concerning teacher training is made up of the classes called "The relationship between MA, TD and teacher training" and "Guidance on the use of MA and TD". The sub-classification related to ERE gave rise directly to the class "Use of MA and TD" and was also broken down into another sub-classification, called "Relationship between ERE and negative points", which gave rise to two classes, "Structures of lessons in ERE" and "Negative points of MA and TD".

The words that appeared most and least frequently in the six classes resulting from the analysis can be seen in Table 1 below. The table also contains the words considered relevant, which had an intermediate frequency.

Table 1: Most frequent, least frequent and relevant words in each class.

Class	Most frequent words	Least frequent words	Relevant words
Relationship between MA, TD and teacher training	Inverted classroom, term, master's degree.	Past, notebook, planning.	Rotation through stations.
Guidance on the use of MA and TD	We, guidance, skill.	Develop, start, training.	Difficulty, ATPC.
Use of the MA and TD	Simulator, try, active methodology.	IT, facilitate, education.	PhET, create, write, molecule.
Class structures in ERE	Handout, pass on.	Traditional, bring, class.	Activity, send, home.
Negative points of MA and TD	Resource, negative point, cell phone.	Available, tool, device.	Internet, absence, blur.
Positive points of MA and TD	Positive point, chemical, ease.	Work, case, learning process.	Atom, understand, concept.

Source: Research data.

As shown in Table 1, the most frequent words in the class "Relationship between MA, TD and teacher training" were *inverted classroom, term and master's degree*. The least frequent words in this class were *past, notebook and planning*, while the term *rotation by stations* appeared as an intermediate word. Examples of teachers' statements in which the words that make up this class emerged include:

> *So in the flipped classroom, they (students) need to do their research before coming to class (E1).*
>
> *For example, I really like the flipped classroom, where you force the student, you put the student in a position to research (E3).*
>
> *Part of this knowledge comes from my master's degree (E1).*
>
> *If I'm going to rotate through stations, if I need to present a video, I'll offer my laptop (E1).*
>
> *And part of these methodologies, for some time now, have been talked about at training meetings, then at ATPC, in fact, at the school I work at, it's ATPA, even in the replanning, in the planning that is now provided by the Media Center (E1).*

Through the words that make up this class, as well as the statements made by teachers E1 and E3, it became clear that among the active methodological strategies that teachers are most familiar with are the inverted classroom and rotation by stations, and that their knowledge of these methodologies comes from school planning meetings and continuing education courses, such as the master's degree. With regard to digital technologies, the notebook has been a resource used frequently by teachers.

The data from this class corroborates in part with the data obtained by Oliveira (2020), in which the active flipped classroom methodology emerged as the most frequent among the statements made by the teachers taking part in his study. As for the appearance of the term active methodologies in school planning and replanning, in Moran's (2018) view, this action may be an indication of the inclusion of these methodological strategies in the school environment. However, the author reports that such action requires a structured and concrete change in the configuration of the curriculum (MORAN, 2018).

In the class "Guidance on MA and TD", the most frequent words were *we, guidance and skill*. The words with the lowest frequency were *develop, start and training*, while the terms with an intermediate appearance were *difficulty and ATPC.* Some of the statements by teachers E2, E3 and E5 included the words in this class:

> *And since we haven't explored these methodologies much, because we're trying to re-establish ourselves in the school, due to the issue of face-to-face feedback, psychosocial issues (E3).*
>
> *But we need to receive more guidance on this, more examples of good practice from those who have done it in order to implement it in our daily lives (E3).*
>
> *We had some discussions about how to adapt, how to work with essential skills, because we wanted to teach everything, "no, they can't lose, they can't stay", we wanted to teach everything (E5).*

> *So, I think there should still be a lot more training on this today (E3).*

> *In the beginning, I had a lot of difficulty because I also had to adapt. The first difficulty was that I didn't have good equipment (E2).*

> *Or in the state, in some ATPC moments, we sometimes have some readings, or an indication, a book suggestion, but then it's always a moment: "look, I'm showing you a way to use this methodology here, which is different". So it's very much up to each teacher's profile to find out (E5).*

The data obtained in this class from the teachers interviewed, especially teachers E2, E3 and E5, show that active methodologies were not implemented during remote teaching classes, since they did not receive concrete guidelines for such practices. In addition, the data shows that during remote teaching, teachers were instructed by the state to work only with essential skills with students and that in some moments of the Collective Pedagogical Work Class (ATPC), teachers were shown texts that dealt with active methodologies, but at no time were they instructed to use them in their classes. With regard to digital technologies, it is clear that they directly influenced the non-implementation of active methodological strategies in remote classes, since some teachers did not have good technological equipment to develop their work.

The need to offer training on active methodologies and digital technologies was also noted in the study carried out by Lucena and Camarotti (2017), as well as by Darub and Silva (2020). As for the lack of quality technological resources to help teachers' activities and implement active methodologies, Darub and Silva (2020) also found this in the statements of the teachers they interviewed. To this end, the search for initial and continuing training for teachers, and the support of school management at all levels, is extremely important so that they are able to use both active methodologies and digital technologies (MORAN, 2018; VALENTE, 2018).

The words *simulator, try and active methodology* appeared most frequently in the class "Use of MA and TD", while *IT, facilitate and education* appeared least frequently. The most frequent and least frequent words were: *PhET, create, write and molecule*. These words were found particularly in the statements of teachers E2 and E5:

> *I rely a lot on this type of resource, either an image, a simulator or a video (E5).*

> *There are classes like this, when I don't have access to technology, for example, I try to use styrofoam balls, for example, as an active methodology to differentiate one size from another. As I'm teaching a lot of third year classes too, I like to use them to make organic molecules as*

well (E2).

So everything I did during the pandemic was using computers, using Google Meet, using PhET, using simulators (E2).

From my point of view, this active methodology has, its main objective is to facilitate teaching (E2).

It is clear that the teachers tried to use active methodologies during remote teaching and when they returned to face-to-face classes after the pandemic. The main resource they used was the simulator, especially the PhET simulator. In addition, the teachers confess to understanding the potential of these active methodological strategies as facilitators in teaching, however, there is a lack of a theoretical basis in their statements, again highlighting the need to receive training on the subject.

According to Valente (2018), activities carried out using active methodologies allow students to feel involved and engaged, so that they become the protagonists of their learning. In this way, active methodological strategies aim to facilitate teaching and can be implemented with the help of digital technologies, such as animated simulation software, which makes it easier to visualize concepts and allows students to carry out virtual experiments, individually or in groups (VALENTE, 2018).

The class "Use of MA and TD" was directly related to the sub-class "Relationship between ERE and negative points" and, consequently, to the classes "Structure of classes in ERE" and "Negative points of MA and TD". Therefore, the data in this set shows the scenario of classes during remote teaching.

The most frequent terms in the class "Structure of classes in ERE" were *apostille and pass*, while the least frequent were *traditional, bring and class*. In between were the words *activity, send and home*. Teacher E5 reports that although they had some guidance on the inverted classroom, they always opted to pass on an activity to the students, where they were encouraged to read texts, whether or not they were taken from the handouts. His speech is presented below:

We had some guidance, mainly about, as you say, I forgot, the inverted classroom. But in the sense that we would pass on an activity to the students, direct them to a text, it could be from the handout or the book, ask them to study it and then at another time, we would do some activity so that they could show us what they understood from that text (E5).

Although teacher E5's speech presents the idea of using the inverted classroom methodological strategy, this action did not take place in its entirety, since the other teachers' speeches, as well as other speeches by teacher E5, portray the adoption of

a teaching model where they constantly sent activities to the students so that they would not lose contact with the school:

> *What I sent was activities and he (the student) had to give me feedback, he had to give me something back so I wouldn't leave him extremely isolated from school (E3).*

> *So, I would send them an activity today, Wednesday, next Wednesday I wanted them to send it to me, that I was going to give them a new activity, facing the fact that, "Oh, they're at home, so they'll have time to do it, they'll learn it here", when I only gave them one instruction (E5).*

> *Because we often had a lot of complaints from students who couldn't open or even watch our lessons, video lessons (E4).*

In this way, the teaching model adopted by teachers during the pandemic is understood to be traditional. Professor E1's speech below shows his knowledge of the differences between traditional teaching and teaching using active methodologies. This indicates that knowledge of the definitions of traditional teaching and active methodologies was not enough for teachers to opt for active methodological strategies.

> *So, when we compare it with a methodology, for example, traditional, which is still a methodology, traditional teaching, in traditional teaching, the teacher is the center, he talks all the time and the student just listens, he is in a passive position. In an active methodology, the student is active throughout the process and searches for that knowledge (E1).*

The teachers' erroneous choice may be related to the fact that they do not know the theoretical basis of active methodologies, as Lucena and Camarotti (2017) found in their study. Also, for Bacich (2018, p. 150), teacher training is the key to improving schools, "but often the training proposal is inefficient, as it disregards the gap between what teachers study and the context in which this knowledge will be applied". It is therefore necessary for teacher training courses on active methodologies and digital technologies to work on the contexts in which these strategies can be inserted, as well as their theoretical bases.

In the class called "Negative points of MA and TD", the words that appeared most frequently were resource, negative point and cell phone. The words with the lowest frequency were available, tool and device, while the words internet, absence and blur were intermediate. The five teachers interviewed present their conceptions of the negative points of active methodologies and digital technologies:

> *In the same way that these resources represent inclusion, some kind of inclusion in not leaving my student totally unassisted in the pandemic, I'm always thinking about the pandemic, there were those students too, who didn't have access to this for some reason (E3).*

> *The main negative point is the lack of focus on the student. That's the main thing (E2).*

> *I think what made it most difficult was the students' limited resources, because many students didn't have a cell phone, the students' limited internet, the students' unfamiliarity with this remote teaching, so they weren't familiar with it (E1).*

> *I believe that in order to use it, the teacher has to be trained. I think that since it's not very widespread, or at least it should be more widespread, I think that sometimes teachers have the tools available, but they don't know what to do with them. So he goes back to the old methodology (E4).*

> *He (the student) has to have a device, and sometimes that device was his father's, he had to wait for his father to get home, so at the time of the lesson he couldn't talk to the teacher (E5).*

E3 considered that the technological resources used to run the online classes, while providing inclusion for the students, putting them in contact with the teachers and the school, excluded some learners who did not have these resources to follow the activities. E1 and E5 had similar conceptions to E3, adding the issue of students having limited internet and not feeling familiar with remote learning.

Teachers E2 and E4 considered that students lose their attention when carrying out virtual activities, certainly with the help of technology, and criticized teachers' lack of mastery of how to correctly use the technological resources available to them. The data obtained further reinforces the need for initial and continuing teacher training in the implementation of active methodological strategies and technological resources.

Authors in the literature have detected in their studies aspects similar to those found in this study. According to the authors, teachers are not able to use technological resources in their classes, as they are not familiar with active teaching methods that aim to articulate technologies with learners' formative processes (BRITO et al., 2019; OLIVEIRA, 2020; PRETTO; BONILLA; SENA, 2020; RABAIOLI, 2018). It should be noted that the students' lack of technological resources was also a factor detected in the study carried out by Oliveira (2020).

According to Valente (2018), the lack of attention from students in the activities proposed with the use of technologies has been noticed by many teachers. However, the author, as well as Moran (2018), make a constructive criticism that teachers should receive efficient and meaningful training to become adept at using digital technologies. Therefore, by using the most appropriate technological resources at any given time, teachers will certainly notice that their students are engaged in the activities they have proposed.

The last class deals with the positive points of active methodologies and digital technologies. The words that appeared most frequently in this class were *positive*

point, chemical and facility and the terms with the lowest frequency were *work, case and learning process*. The words that appeared with intermediate frequency were *atom, understand and concept.* The statements made by teachers E1, E2, E3 and E5 show the aspects they listed:

> *The main positive point of using technology is the connection between what you know, what you want to convey and what the student will learn from it (E2).*
>
> *And, on the subject of chemistry itself, I'm able to illustrate, offer students a different way of explaining what I'm only explaining with words, or that image that's only in the book, in the handout, or that which isn't even in the book and I'm going to reproduce on the blackboard, for example (E5).*
>
> *I used a few platforms, those that fit my needs, that covered what I needed or part of them, and those that the students have access to and that offered some facility, some kind of facility for them to give some feedback (E3).*
>
> *So, if I can't show the student a molecule, if I can't show the student an atom, why not use software that will make them see it, even if it's a simulation, you know? (E1).*
>
> *And then, as well as facilitating for him (the student) to understand certain content, it becomes fun. So he has fun (E1).*
>
> *They (technological resources) work well, they serve as an interesting tool, but they don't take away the need for the teacher, the teacher is still the centerpiece (E3).*
>
> *I think it is, the student being the main person responsible for this process, in his case, of learning, him being active in this process. And using technology to facilitate it (E1).*
>
> *So, these are different opportunities within the list of activities that the teacher can do, which puts the student at the center of the learning process (E5).*

The main positive points of active methodologies and digital technologies listed by the teachers were: (i) they make it possible to connect the teacher's own knowledge with the knowledge of individuals; (ii) they make it easier to illustrate chemical concepts, such as atoms and molecules; (iii) they help learners to understand concepts in an interactive way; and (iv) they make students act as protagonists in their own learning process.

All these aspects are presented by Moran (2018) and Valente (2018) in their various works. The authors believe that these active methodological strategies, together with technological resources, create varied opportunities for learners to construct knowledge (MORAN, 2018; VALENTE, 2018). Therefore, it is clear that teachers make little use of these strategies, although they are aware of the benefits they can provide.

6 Conclusions

The use of active methodological strategies supported by digital technologies makes a number of contributions to the teaching of various contents, including chemical contents or objects of knowledge in chemistry. This is due to the fact that the activities developed using these strategies and resources allow students to take on the role of protagonists and no longer receivers of information, leading them to reflect on what they are doing.

It was noted that during online classes during the COVID-19 pandemic, public school chemistry teachers did not implement active methodologies. During this period, the vast majority of teachers used simulators, such as PhET, as technological resources to support chemistry teaching.

Among the main factors that influenced the lack of use of active methodologies in chemistry classes during remote teaching were: the lack of guidance and ongoing training on the use of these methodological strategies and the lack of quality technological resources, both for teachers and students.

Although they listed the challenges they faced in remote teaching, the teachers were aware of the benefits that active methodologies, together with digital technologies, bring when used in an integrated way. Thus, the class data from the lexical analysis carried out in this study points to the need to offer initial and continuing training to teachers who wish to include these methodologies and resources in their practices.

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References

ALEXANDRE, N. M. C.; COLUCI, M. Z. O. Validade de conteúdo nos processos de construção e adaptação de instrumentos de medidas. **Ciência e Saúde Coletiva**, Rio de Janeiro, v. 16, n. 7, p. 3061-3068, 2011.

ALVES, M. R. M.; ARAÚJO, Y. L. F. M.; NEPOMUCENO, A. L. O. Impacto da pandemia da covid-19 no contexto da educação socioemocional. **Revista de Ensino de Ciências e Matemática (RenCiMa)**, São Paulo, v. 12, n. 3, p. 01-17, 2021.

BACICH, L.; TANZI NETO, A.; TREVISANI, F. M. Ensino Híbrido: Personalização e Tecnologia na Educação. In: BACICH, L.; TANZI NETO, A.; TREVISANI, F. M. (Org.). **Ensino Híbrido**: Personalização e Tecnologia na Educação. Porto Alegre: Penso, 2015, p. 47-65.

BARDIN, L. **Análise de conteúdo**. 4. ed. São Paulo: Edições 70, 2016.

BRITO, A. S. *et al.* Tecnologias digitais móveis: uma tecnologia pouco conhecida entre os professores do ensino fundamental e médio. **Revista de Ensino de Ciências e Matemática (RenCiMa)**, São Paulo, v. 10, n. 4, p. 152-167, 2019.

DAROS, T. Metodologias ativas: aspectos históricos e desafios atuais. In: CAMARGO, F.; DAROS, T. **A sala de aula inovadora:** estratégias pedagógicas para fomentar o aprendizado ativo. Porto Alegre: Penso, 2018, p. 08-12.

DARUB, A. K. G. S.; SILVA, O. R. Formação de professores em metodologias ativas. In: CONGRESSO INTERNACIONAL DE EDUCAÇÃO E TECNOLOGIAS| ENCONTRO DE PESQUISADORES EM EDUCAÇÃO A DISTÂNCIA, 2020, São Carlos. **Anais do CIET:EnPED**: Ressignificando a presencialidade. São Carlos, UFSCar, 2020, p. 01-13.

LUCENA, J. M.; CAMAROTTI, M. F. Concepções metodológicas e a prática educativa dos professores de ciências do ensino fundamental II de três escolas da rede pública. In: IV CONGRESSO NACIONAL DE EDUCAÇÃO, 2017, João Pessoa. **Anais do IV CONEDU**: A Educação brasileira: desafios na atualidade. João Pessoa, UEPB, 2017, p. 01-08.

LÜDKE, M.; ANDRÉ, M. **Pesquisa em educação**: abordagens qualitativas. Rio de Janeiro: E.P.U., 2018.

MORAN, J. M. **A educação que desejamos**: novos desafios e como chegar lá. 5. ed. Campinas: Papirus, 2012.

MORAN, J. Metodologias ativas para uma aprendizagem mais profunda. In: BACICH, L.; MORAN, J. (Orgs.). **Metodologias ativas para uma educação inovadora**: uma abordagem teórico-prática. Porto Alegre: Penso Editora, 2018, p. 01-25.

OLIVEIRA, D. C. **Metodologias ativas no Ensino Médio:** um olhas dos docentes das Ciências da Natureza no município de Iguatu, Ceará. 2020. 107f. Dissertação (Mestrado em Educação) – Programa de Pós-Graduação em Educação em Ciências: Química da Vida e Saúde. Universidade Federal do Rio Grande do Sul. Porto Alegre.

OLIVEIRA, J. F. A. C.; FERNANDES, J. C. C..; ANDRADE, E. L. M. Educação no contexto da pandemia da Covid-19: adversidades e possibilidades. **Itinerarius Reflectionis**, Jataí, v. 16, n. 1, p. 01–17, 2020.

PIVA, G. M. **Diferentes olhares sobre as contribuições da Psicologia da Educação na formação inicial de professores de Química**. 2022. 168f. Dissertação (Mestrado em Educação para a Ciência) – Faculdade de Ciências. Universidade Estadual Paulista “Júlio de Mesquita Filho”. Bauru.

PRETTO, N. L.; BONILLA, M. H. S.; SENA, I. P. F. S. **Educação em tempos de pandemia**: reflexões sobre as implicações do isolamento físico imposto pela COVID-19. Salvador: Edição do autor, 2020.

RABAIOLI, S. M. **O uso de tecnologias digitais na prática pedagógica:** um estudo de caso com professores de uma escola pública. 2018. 37f. Trabalho de Conclusão de Curso (Especialização em Mídias na Educação) – Centro Interdisciplinar de Novas

Tecnologias na Educação. Universidade Federal do Rio Grande do Sul. Novo Hamburgo.

SANTANA, D. A. S.; WARTHA, E. J. Construção e validação de instrumento de coleta de dados na pesquisa em Ensino de Ciências. **Amazônia: Revista de Educação em Ciências e Matemáticas**, Belém, v. 16, n. 36, p. 39 - 52, 2020.

SCHNEIDER, E. M. *et al.* O uso das tecnologias digitais da informação e comunicação (TDIC): possibilidades para o ensino (não) presencial durante a pandemia covid-19. **Revista Científica Educ@ção**, Miracatu, v. 4, n. 8, p. 1071-1090, 2020.

SOUZA, M. A. R. *et al.* O uso do *software* IRAMUTEQ na análise de dados em pesquisas qualitativas. **Journal of School of Nursing**, Curitiba, v. 52, p. 01-07, 2018.

TRIVIÑOS, A. N. S. **Introdução à pesquisa em ciências sociais**: a pesquisa qualitativa em educação. São Paulo: Atlas, 1987.

VALENTE, J. A. A Comunicação e a Educação baseada no uso das Tecnologias Digitais de Informação e Comunicação. **Revista Unifeso: Humanas e Sociais**, Alto Teresópolis, v. 1, n. 1, p.141-166, 2014.

VALENTE, J. A. A sala de aula invertida e a possibilidade do ensino personalizado: uma experiência com a graduação em midialogia. In: BACICH, L.; MORAN, J. (Orgs.). **Metodologias ativas para uma educação inovadora**: uma abordagem teórico-prática. Porto Alegre: Penso Editora, 2018, p. 26-44.

WATANABE, F. Y. et al. Formação docente em metodologias ativas e o uso de Tecnologias Digitais de Informação e Comunicação (TDIC) no ensino remoto emergencial. In: CONGRESSO INTERNACIONAL DE EDUCAÇÃO E TECNOLOGIAS|ENCONTRO DE PESQUISADORES EM EDUCAÇÃO A DISTÂNCIA, 2020, São Carlos. **Anais do CIET:EnPED**: Ressignificando a presencialidade. São Carlos, UFSCar, 2020, p. 3.

WESTBROOK, R. B. Ensaio. In: WESTBROOK, R. B; TEIXEIRA, A. (Orgs.). **John Dewey**. Recife: Editora Massangana, 2010, p. 11-32.