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Possibility of using Information Literacy, Mathematical Literacy and Problem-Solving methodology to teach mathematical concepts related to the contents of Spatial Geometry and Matrices to High School students

Abstract: This research aimed to investigate methodological possibilities for teaching Mathematics, in High School, based on the triad Informationl Literacy, Mathematical Literacy and Problem-Solving methodology. To this end, it was carried out bibliographic and field research, with predominantly qualitative results. The suggested methodological proposal was validated with 2nd year high school classes of a public school in Alexânia (GO). In the proposed approach, the teacher acted as a mediator of the teaching and learning process, and it was noticed that the research practice in the classroom served as a foundation for the construction of new concepts. The proposed problems were starting points, that is, introductory to the contents covered in the didactic sequences and did not aim at fixing or finalizing a content. We emphasize that Information Literacy directly influences the achievement of Mathematical Literacy, which is about giving students subsidies to understand mathematics in the modern world.

Keywords: Teaching Methodologies. Research in the Classroom. Mediating Teacher. Information Literacy.

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Posibilidad de utilizar la metodología de la Alfabetización Informacional, la Alfabetización Matemática y la Resolución de Problemas para enseñar conceptos matemáticos relacionados con los contenidos de Geometría Espacial y Matrices a los estudiantes de Secundaria

Resumen: Esta investigación tuvo como objetivo investigar las posibilidades metodológicas para la enseñanza de las Matemáticas, en la Escuela Secundaria, a partir de la tríada Alfabetización Informacional, Alfabetización Matemática y la metodología de Resolución de Problemas. Para ello, se realizó una investigación bibliográfica y de campo, con resultados predominantemente cualitativos. La propuesta metodológica sugerida fue validada con clases de 2º de Bachillerato de una escuela pública de Alexânia (GO). En el enfoque propuesto, el profesor actuó como mediador del proceso de enseñanza y aprendizaje, y se observó que la práctica de investigación en el aula sirvió de base para la construcción de nuevos conceptos. Los problemas propuestos eran puntos de partida, es decir, introductorios a los contenidos abordados en las secuencias didácticas y no pretendían fijar o finalizar un contenido. Destacamos que la alfabetización informacional influye directamente en el logro de la alfabetización matemática, que consiste en dar subsidios a los estudiantes para que comprendan las matemáticas en el mundo moderno.

Palabras clave: Metodologías de Enseñanza. La Investigación en el Aula. Profesor Mediador. Alfabetización Informacional. Metodologias de Ensino.

Possibilidade de utilização do Letramento Informacional, do Letramento Matemático e da metodologia de Resolução de Problemas para ensinar conceitos matemáticos relacionados aos conteúdos de Geometria Espacial e Matrizes para alunos do Ensino Médio

Resumo: Esta pesquisa objetivou investigar possibilidades metodológicas para o ensino da Matemática no Ensino Médio, a partir da tríade Letramento Informacional, Letramento Matemático e metodologia de Resolução de Problemas. Para tanto, realizou-se pesquisas bibliográfica e de campo, com resultados predominantemente qualitativos. A proposta metodológica sugerida foi validada com turmas do 2º ano do Ensino Médio de uma escola pública em Alexânia (GO). Na abordagem proposta, o professor atuou como mediador dos processos de ensino e de aprendizagem, e percebeu-se que a prática de pesquisa em sala de aula serviu como alicerce para a construção de novos conceitos. Os problemas propostos foram pontos de partida, ou seja, introdutórios aos conteúdos abordados nas sequências didáticas e não tinham como objetivos a fixação ou finalização de um conteúdo. Destacamos que o Letramento Informacional influencia diretamente o alcance do Letramento Matemático, que trata de dar subsídios aos alunos para compreender a Matemática no mundo moderno.

Palavras-chave: Pesquisa em Sala de Aula. Professor Mediador. Letramento Informacional.

1 Introduction

The growing use of digital technologies, which occurred from the wide dissemination of Information and Communication Technologies (ICT), created an environment in which society is organized around searching and consuming information from the internet. The environment we are mentioning is broad and allows the connection between different users and sources of information that are spread around the world, without regulatory authority to organize, qualify, and filter information and shared content, especially when it comes to its veracity and reliability (FROEHLICH, 1998; SILVA and LOPES, 2011).

In this context, we can envision a scenario in which users are required to develop behaviors and competencies in relation to information. They aim to use information rationally, critically, and ethically from its search, selection, and organization to build and raise arguments, which allow individuals to make choices, evaluate possibilities, and solve problems.

This search for the development of competencies linked to the social context is foreseen in the Base Nacional Comum Curricular (BNCC), which highlights, in some of its general competencies, the development of scientific, critical, and creative thinking, aiming at the search for: resolution of problems; the use of different media and communication languages; the development of digital culture based on the use of digital technologies in a critical, ethical, and leading role; and the ability to argue based on reliable information (BRASIL, 2018).

We hypothesize that those competencies can be achieved, albeit partially, through Information Literacy, which corresponds to "a process that integrates the actions of locating, selecting, accessing, organizing, using information, and generating knowledge, aiming at decision making and Problem Solving" (GASQUE, 2010, p. 83). This type of literacy, combined with methodological changes in the classroom context, and more significant to the Problem-Solving methodology, can favor the influence of Mathematical Literacy, which corresponds to the perception of Mathematics in everyday relationships. Considering the diversity of the environment described here and considering that it can cause changes and impacts in several areas of knowledge, we started to reflect on the relationship with Mathematics teaching, having as a reference the development of skills related to the use of information, to establish arguments and opinions of their own and not disseminating fake news.

The conscious and contextualized use of information in Mathematics is related to Mathematical Literacy, and converges to establishing relationships between the subject matter and daily life through its possibilities of reading, contextualization, reflection, and questioning (D 'AMBROSIO, 1999; PISA, 2010). Mathematics teaching is not always at the service of the development of active informational behavior, in which students are encouraged to research and propose solutions to the problems presented to them, being limited to the position of passive students, capable of routinely answering to exercises.

In this context, in this article[1], we propose as objective to investigate the methodological possibilities for Mathematics teaching in High School, from the triad Information Literacy, Mathematical Literacy, and Problem-Solving teaching

[1] This article is an excerpt from a master's dissertation defended at the Programa de Pós-Graduação em Ensino de Ciências from Universidade Estadual de Goiás, written by the first author and advised by the second author.

methodology, to teach mathematical concepts related to the contents of spatial geometry and matrices for High School students at a public school in Goiás.

In the following sections, we present the theoretical aspects that support this research regarding the themes related to Information Literacy, Mathematical Literacy, Problem-Solving, research practices in the classroom, the methodology applied, the results achieved, and final remarks.

2 Information literacy

The term *Information Literacy* appeared in the 1970s and can be defined as a continuous learning process in which conceptual and attitudinal foundations and skills related to information and its dynamics are internalized (DUDZIAK, 2003). It is a reflective process that involves the search for answers, the raising of hypotheses, and the construction of arguments to solve a problem. And it has, in general, as a starting point, actions of searching, researching, investigating, questioning, and revisiting information, whether it is already known or new.

One of the elements that will be present, whatever the literacy practice adopted, is the stimulus to questioning, accompanied by the development of argumentation and communication skills. Therefore, in the school environment, we can associate Information Literacy with research practices and proposals for investigation and problem solving promoted by the teacher and the student.

Based on this understanding, changes in the school environment can be suggested, encouraging greater student protagonism and referring the teacher to the position of mediator. The students' leading role can be achieved when they are put in an active position in the learning process, where he starts to question, seek, and reflect on the proposed themes based on their reality, and the teacher becomes a mediator, encouraging them to investigate, helping them in this process, and moving towards implementing the so-called active teaching methodologies (THADEI, 2018).

Demo (2015) highlights the need to remodel the forms of teaching in a class by saying that the students' education as a critical and competent subject takes place through the socialization of knowledge, a process that he calls as *reconstructive questioning*, and which allows the construction of knowledge through personal interpretations and formulations on a topic of interest. The questioning presupposes the search for

information currently available in different formats and supports provided by the advancement of the ICTs. In this context, and considering that such resources are part of the students' reality, it is up to the teacher to make use of this information and encourage their students to develop different skills and competencies, including mathematics.

After understanding that "questioning is the beginning of any learning process" (DE PAULA and HARRES, 2015, p. 169) and that teaching methodologies based on education mediated by research can bring new meanings and positive changes to the school context, we move forward to build knowledge from the quest for answers that meet the interests of those involved, supported by the expansion of the subjects' capacity to question, argue, and communicate.

For Demo (2015, p. 12), "research needs to be internalized as a daily attitude, not just as a special activity, of special people, for special moments and salaries", indicating the need to get rid of the "copied class as a trademark of the teacher". During this process, we must remark that "no one arrives at school knowing how to research, and this activity does not happen suddenly; rather, it must be developed with the practice and direction of new skills of locating, selecting and using information" (CARMO and DUTRA, 2016, p. 312), thus configuring the expansion of skills related to Information Literacy.

Practices and skills related to Information Literacy are based on a person's ability to read, reflect, and argue, and involve adopting a new behaviors, procedures, and techniques when dealing with information for the construction of knowledge from the impression of personal characteristics related to the data found and the establishment of relationships between them and previously synthesized knowledge.

Dudziak (2003) points out that the inclusion of Information Literacy in the educational context is still a long process, which goes through changes in educational policies and curricula, and training of education professionals so that "learning to learn and the ability to intervene alternatively are privileged, based on an educational culture that prioritizes an investigative attitude, critical autonomy, and a creative search" (p. 31).

Therefore, the inclusion of Information Literacy practices in the school environment must begin with the identification of the school culture, professional training and its relationship with information, the resources and sources of information that can be used and motivation of those involved.

Based on a compilation of information taken from Gasque's (2012) work, some skills relevant to Information Literacy for High School students are highlighted, such as: collecting data and information from different sources, such as books, magazines, and interviews on the researched subject; study planning; the uses of internet for research and *email* use; knowledge of pre-textual, textual, and post-textual elements, such as abstract, index, summary, and references; the use of different technologies for the information search and organization; knowledge and production of other forms of organization and synthesis of information, such as diagrams, notes, summaries, records, report, and review; knowledge of the need for authorship attribution, the concept of plagiarism, the organization of citations and bibliographic references; understanding of general rules for scientific work and data collection techniques; the elaboration of small articles; and understanding Information Literacy and its importance.

These skills could be worked not linearly but increasingly, according to students' level of understanding and maturity. In this way, as knowledge increases, the skills worked are expanded, modifying the forms of register and analysis. It is an objective of literacy, whatever its aspect, the ability to select and use information properly, seeking veracity and maturing information skills and competencies.

3 Mathematical Literacy

Mathematical Literacy conception is based on an individual's perception and understanding of mathematics in their daily lives and can be defined as the

> ability to identify and understand the role of Mathematics in the modern world in such a way as to make well-informed judgments and to use and engage with Mathematics, aiming to meet the needs of the individual in fulfilling his or her role as a conscientious, critical and constructive citizen (PISA, 2010, p. 1).

According to the BNCC, Mathematical Literacy is achieved through the development of "skills related to the processes of investigation, model building, and problem solving" (BRASIL, 2018, p. 529), which involve reasoning, argumentation, representation, communication, and validation on different situations and concepts built up throughout Basic Education, and through the establishment of conjectures in different contexts.

D'Ambrósio (1999), in turn, indicates that Mathematics traditionally taught can

be considered discriminatory and insufficient, requiring a curricular restructuring of the discipline to achieve the development of mathematical thinking, and suggests that such restructuring considers the *trivium* "*Literacy, Matheracy and Technoracy*" (D'AMBRÓSIO, 1999, p. 3).

In the organization proposal already mentioned, the curriculum must cover the competent "reading" of numerical data, such as: tables; graphics; code language, and other sources of information (*Literacy*); the ability to propose critical conclusions and arguments in relation to the reference data (*Matheracy*); and the incorporation of technologies, in terms of functional use, aggregation of values, and ethics (*Technoracy*) (D'AMBROSIO, 1999). In this way, comparing the suggestion of restructuring the curriculum and the guidelines of the BNCC regarding Mathematical Literacy, some advances are already occurring in the Brazilian curriculum proposal are identified.

In the context of the classroom, one must think of ways of teaching Mathematics that lead students to do mathematical readings and reflections according to their local reality, realizing their multiple functions and social applications, and using the resources they have consciously and ethically, which, in fact, constitutes Mathematical Literacy. D'Ambrósio (1999) highlights the importance of the teacher putting him/herself in the position of a researcher of his/her discipline, proposing a teaching approach that goes beyond the propaedeutic teaching that, sometimes, is superficial and empty of concepts and is restricted to a mere manipulation operational process of numbers and operations, without there being a process of reflection on the individuals and their relations with the environment in which they live.

By following an investigative and reflective line of teaching, we noticed that mathematical practices vary according to the culture and worldview prevailing at the time, being the result of human experiences and experimentation, and for which more attention should be devoted to concepts and structures that support them (BRASIL, 2018). It is necessary to keep in mind that changes in the school environment will only begin with the initial education of the teacher who, in the specific scope of Mathematics, must value the inclusion of a modern perspective, which includes the use of the ICTs and introduces new forms of thinking and reflecting on their uses in everyday life, avoiding conventional ways of teaching (D 'AMBROSIO, 2005). In other words, the Mathematics teacher initial education needs to be reviewed, including new approaches, concepts, and ways of

thinking and teaching, moving away from the rigid teaching in which the student is just a receiver and user of formulas.

Tiesen and Araújo (2020, p. 4) suggest using differentiated methodologies in Mathematics teaching, as many teachers believe that "only their experience can support teaching and learning".

We observed, therefore, two recurring needs: the first, regarding the change in the way of perceiving and teaching Mathematics, placing it in a social context, close to the student's reality; and the second, regarding the need to reformulate teaching curricula and teacher training, encouraging them to adopt new methodologies based on reflection and investigation.

Therefore, we conclude that the methodological proposal of including the reconstructive questioning (DEMO, 2015) in the idea of classroom research and the practices of Information Literacy regarding the good use of information, aiming at the construction of concepts through the Problem-Solving methodology, can favor Mathematical Literacy. It also contributes to changing the student's positioning regarding their way of learning and proposing solutions to different problems.

4 Teaching through Problem-Solving

We are aware that, in class, many Mathematics teachers apply lists of routine, often fast and mechanical, exercises to obtain a standard answer, thus considering it satisfactory learning. This teaching methodology has been modified since the Problem-Solving methodology began to be used, a teaching trend concerned with reflection and the construction of meanings (POSSAMAI, CARDOZO, and MENEGHELLI, 2018; SILVA, 2016).

Possamai, Cardozo, and Meneghelli (2018) say that, to do an exercise, the subject must know in advance the steps, procedures, and techniques that can be associated with the statement. The problem, in turn, allows reflection and the reconstruction of concepts to search for answers/solutions, serving as a "conductor, a means of making connections, used by the teacher to enable students to have a formative encounter with mathematical concepts" (LEAL JÚNIOR and ONUCHIC, 2015, p. 962).

It is noteworthy that teaching Mathematics through active methodologies based

on Problem-Solving is different from teaching Mathematics through exercises. According to Allevato (2005), the proposition of problems involves the presentation of questions that the student does not have yet the necessary means to solve, serving as a starting point for teaching content; on the other hand, an exercise serves to practice a process whose procedures/operations that lead to a specific result have already been presented.

We see that teaching methodologies focused on Problem-Solving do not expect standardized answers, summarized in "right or wrong", but in the possibility of stimulating questioning, expanding the student's ability to argue and analyze, sustaining the hypotheses, presenting solutions, and discussing them with their colleagues. In Leal Júnior and Onuchic's (2015, p. 973) words, the focus of this teaching methodology is "on the thoughts produced and engendered by the concepts and principles that can highlight the resolution of the problem to be studied and advance in the means, and not just at the ends".

We emphasize the importance that the traditional teaching methodology, centered on the teacher, gives way to active methodologies, in which the student assumes the position of the protagonist, and the teacher becomes a mediator, creating situations and problems for which students must seek solutions by using information sources in different formats and supports (THADEI, 2018). We cannot deny that there will be a change in the classroom dynamics, with the teacher's mediating action to encourage students in the process of knowledge construction.

Berbel (2011) indicates that the perception of the student as an agent of the action is fundamental for the implementation of active learning methodologies. With those methodologies, students may be given opportunities to problematize, discuss, make choices, and present creative answers to the problems presented to them.

We corroborate Polya (1985) by indicating that teaching is complex; it is not possible to say that there is a teaching method that is indisputably better than the others, as it depends on those involved and on local conditions. We do not intend to present only one method to be adopted; on the contrary, it is a possibility to be analyzed, thought, and practiced according to the reality of those involved.

The fact is that problems are part of everyday life, and mathematical problems are expected to be the center of Mathematics teaching (POLYA, 1985). When considering

this fact and planning classes based on it, the teacher will allow students to be active and will instigate the establishment of relationships between the discipline and daily life and with other subject matters, allowing the development of Mathematical Literacy.

Allevato (2005) points out that there may be difficulties in implementing this methodology, and it will involve changes in pedagogical practices and teaching curricula. Therefore, a methodological alternative that can be applied in the school context must be considered.

We should also take into account that Mathematics teaching through Problem-Solving can represent a methodological innovation, which encompasses aspects such as "the development of creativity and increase in students' interest, and giving meaning to what will be taught/learned" (BICALHO, ALEVATTO, and SILVA, 2020, p. 21).

5 Research and mediation in the school environment through ICT

Even with the large volume of information circulating in various media — internet, books, encyclopaedias, and newspapers, among others — we notice that the experiences and practices of using the internet are still restricted and used occasionally by adolescents in class, who use it for entertainment and personal and social interactions.

Neves (2011) points to a kind of false socio-digital inclusion since it is not enough to just have access to digital technologies, it is necessary to develop the information competence of users, and for that, consider the Zone of Proximal Development (ZPD), so that the students' reality and the way they deal with the means of access to knowledge are known to the teacher, who mediates in the search and use of information in terms of quality and reliability, for example.

The concept of ZPD (Figure 1) comes from the socio-interactionist theory, proposed by Levy Vygotsky, and can be defined as the part of learning between the Level of Actual Development, which has already been consolidated, and the Level of Potential Development, which is in the process of construction, close to becoming real (FINO, 2001).

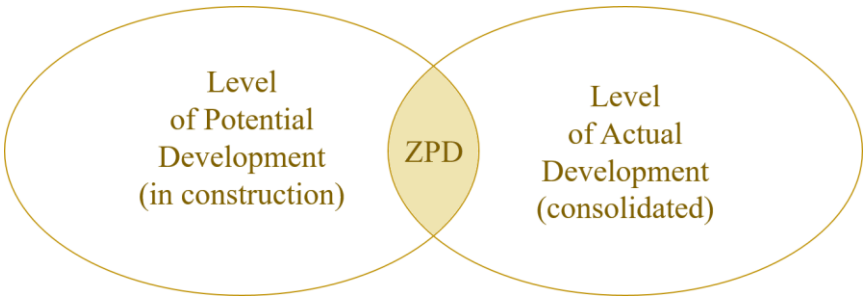

Figure 1: Zone of Proximal Development — Vygotsky's ZPD (Adapted from FINO, 2001)

In the educational field, one of the ways to promote inclusive access to the ICTs is by using research in class, seen as a knowledge mediation mechanism. For this, the possibility of the teacher's pedagogical intervention (knowledge mediation) must be considered to stimulate the advancement of the concepts that are in the ZPD to the Level of Actual Development (OLIVEIRA, 1992).

In the context of classroom research through ICTs, teacher mediation is necessary considering the characteristics of the digital environment, which, in addition to being vast, brings up sources of information that are not regulated or verified for reliability, ethics, security, and data protection. Thus, the mediator becomes essential, contributing to the development of information competence and proving the use of secure sources of information, avoiding *fake news* that may surface in the process of knowledge construction.

For Guimarães and Gonçalves (2013), researching is to question reality in a process that involves teacher and students and that seeks, in the reconstruction of knowledge, to develop critical thinking and disciplinary content. Fialho (2004, p. 20) indicates that research "involves the personal capacity for analysis, interpretation, and judgment of information". We soon realized that literacy skills come to the fore and require more attitude from the student as an individual who seeks knowledge. They also put the teacher in the position of a mediator, and for this, he/she must encourage and guide students in their research processes.

The teacher also becomes essential in the process. After all, according to Neves (2011), by appearing as a mediating agent of information, the teacher is responsible for offering stimuli and support to the subjects involved and for guiding research regarding the quality criteria of the information available on the internet, being necessary to have the so-called *information competence* which corresponds to the "attribute of knowing

what to do with the information" (NEVES, 2011, p. 418).

Information competence is shown through knowing how to seek information that meets individual needs and implies reflection, analysis, and synthesis of the subjects on the selected information. Such competence also imprints personal marks on those involved - teacher and student - which makes the construction process something that does not occur in a neutral and impersonal way. Despite that, Davenport (1998, p. 53) indicates that "people are still the best 'means' to identify, categorize, filter, interpret, and integrate information", since ICTs are still not able to guarantee the reliability and value of the information made available on the internet.

Lanzi *et al.* (2012, p. 61) point out that the efficient use of ICTs to "mobilize and enhance information skills", aiming at the construction of knowledge is one of the challenges to be overcome by the educator. It is noteworthy that, when inserting ICTs in the teaching and learning process, we will be considering Vygotsky's theory of learning, including in the teaching environment elements that make up the students' culture and that serve "as tools/instruments that mediate learning, as well as the interaction of individuals, [that] enables the internalization of culturally established forms of psychological functioning" (MAGGI and AMÉRICO, 2013, p. 7).

6 Methodology

This is a research of a basic nature aiming to "develop scientific knowledge without direct concern with its practical applications and consequences" (GIL, 2008, p. 26). As for the objectives, it is classified as exploratory because there is little structured knowledge about the research topic, for which investigations on pedagogical practices related to Information Literacy, Mathematical Literacy, and Problem-Solving in High School Mathematics classes were carried out.

To present the results, we used a predominantly qualitative approach, i.e., we are not only interested in statistical data related to the topic. For the analysis, we used the hypothetical-deductive method, formulating hypotheses and looking for results that could confirm or falsify them (GIL, 2008).

The methodological procedures adopted were based on: (1) bibliographic research, "developed from material already prepared, consisting mainly of books and scientific articles" (GIL, 2008, p. 55), on which the researcher surveys, analyses, and

registers information found related to the topic discussed; and (2) field research, which "consists of observing facts and phenomena as they occur spontaneously, collecting data that refer to them and registering variables that are presumed to be relevant, to analyze them" (MARCONI and LAKATOS, 2003, p. 186).

The field research, characterized as participatory research, involved data collection in four classes of the 2nd grade of High School (Chart 1), with students aged between 15 and 17 years old, from a state school located in Alexânia, Goiás, Brazil, under the direction of the professor-researcher, the first author of this article. The data was collected from October through December 2019, and January through March 2020, with interventions related to research practices, Information Literacy, and Problem-Solving.

The data were collected by observing the students when carrying out the proposed activities. The classes involved were divided into two sample subgroups per observed bimester (Chart 1). In classes A and C, didactic sequences involving active methodologies were applied — when the student is active in the process —; while in classes B and D, the traditional teaching methodology, centered on the teacher, was followed. The didactic sequences applied were built with the following themes: Information Literacy; area and volume of geometric solids; and matrices — themes chosen because they are part of the annual teaching plan, whose application was in progress in the school year in force.

Chart 1: Distribution of groups participating in the research

Class	Qty. Students	Activities developed	Methodology used	Month/Year of application
A	40	» Didactic Sequence 1: Information Literacy. » Didactic sequence 2: area and volume of geometric solids.	Active	October to December/2019
B	41	» Exercises on area and volume of geometric solids.	Traditional	October to December/2019
C	38	» Didactic Sequence 1: Information Literacy. » Didactic sequence 3: matrices.	Active	January to March/2020
D	39	» Exercises on matrices.	Traditional	January to March/2020

Source: Own authorship (2020)

The active teaching methodology, student-centered, was based on the application of didactic sequences based on classroom research activities — using the cell phone as a tool to access the internet, usually carried out in pairs and mediated by the teacher, who

provided guidance on sources of reliable information. After the research, they could debate the information found, culminating with the organization of ideas in the form of mental and conceptual maps as a form of register. The traditional teaching methodology, in turn, is centered on the teacher, and included the resolution of exercises, as shown in Chart 1.

7 Results and discussion

The results were prepared based on the development of didactic sequences (active methodologies) in classes A and C, with observations of student learning about the proposed content, contrasting with the results of learning assessments applied in classes B and D, followed by the implementation of classes through traditional teaching methodologies, based on routine exercises.

In the first didactic sequence, applied in classes A and C, lasting seven classes, the content worked was related to the concept of Information Literacy, research procedures, and the norms of the Associação Brasileira de Normas Técnicas (ABNT), especially for citations and bibliographic reference. Initially, the class was dedicated to the debate on the need to discuss and know the sources of reliable data - avoiding the propagation of false information (*fake news*)- and develop arguments and conclusions on different subjects.

The next classes addressed plagiarism and authorship, allowing students to research using their cell phones as a tool to access the internet. Finally, it ended with elaborating and presenting mental and conceptual maps, which are indicated as a resource that contributes to the structuring, analysis, and interpretation of information.

While applying the sequence related to Information Literacy, most students carried out their research without questioning, analyzing, reflecting on, or contesting the information found on the internet. In addition, they proved to be experts in compiling data, corroborating Guimaraes and Gonçalves (2013).

Most of them did not know the elements of an article, for example. They said they were doing research when, in fact, they were only copying information without attributing authorship. And, unanimously, they said they did not know what Information Literacy is. The speech of one of the students in class A made it clear that many had not reflected on issues related to the authorship and security of the information researched and shared.

Here is a transcribed excerpt: "*if we think about it, everyone can be telling lies around without knowing it, because we often just repost what we see, without knowing or researching, just because we find it interesting*" (Student 1, class A).

From this didactic sequence, we observed that students, both from class A and from class C, began to be more careful when seeking information and using it. When approaching themes related to sources of information, plagiarism, and authorship, the teacher's mediation changed the students' informational behavior. They started to use new criteria for the search for information.

We also noted that students already have intrinsic informational skills in using technologies. i.e., they know how to use them to seek and share information (LANZI *et al.*, 2012). However, the teacher was essential for mobilizing new skills for the search, selection, organization, and sharing of the information found.

In the didactic sequence 2, with the theme "spatial geometry - area and volume of geometric solids," which lasted six classes, students started by searching for information using their cell phones to access the internet. They were asked to define *area* and *volume*, the etymology of those words, and the historical context of the appearance of the searched terms, summarized through a conceptual map (Figure 2).

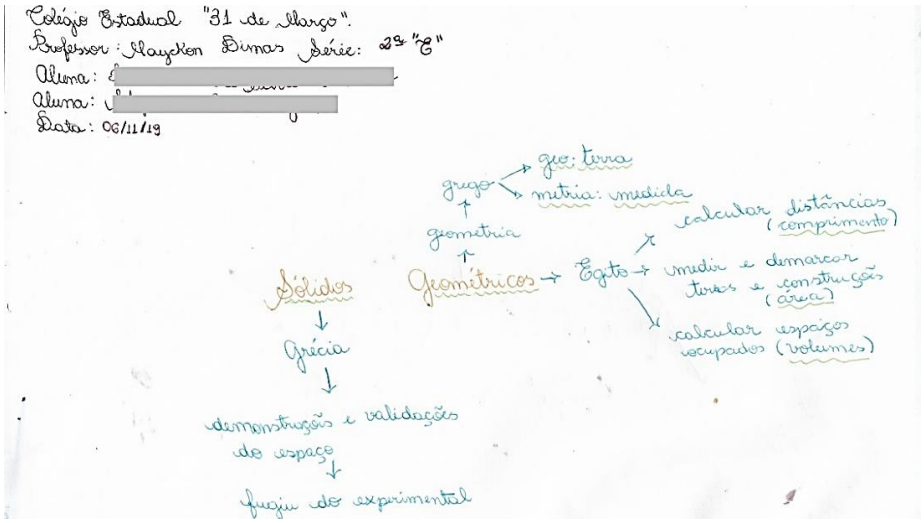

Figure 2: Example of a conceptual map on "Area and Volume of Geometric Solids", prepared by a student in class A, in a public school in the state of Goiás.

In the two following classes, students were given activities relating the content to everyday objects and situations, with a view to Mathematical Literacy. Subsequently, contextualized problems related to geometric solids were presented for individual and collective resolution to encourage students to organize the information available in the

statement and optimize the resolution, obtaining agility and assertiveness.

Students were encouraged to develop their mathematical knowledge and reasoning from an investigative process, as suggested by the BNCC, comprising practical application in everyday situations (POLYA, 1985; BRASIL, 2018). Figure 2 exemplifies one of the conceptual maps developed during the application of the didactic sequence in class A.

The didactic sequence on matrices, lasting six classes, began with a *WebQuest* aiming to introduce concepts related to matrices dynamically. The students were expected to understand that Mathematics is all around us and is not limited to a set of codes and steps to be followed.

The *WebQuest* presented guiding questions, such as: "What is the definition of matrices?"; "What is the etymology of the term 'matrices'?"; "Where do we find matrices in everyday life?"; "Which mathematicians contributed to the knowledge about matrices used today?"; "What professional areas deal with matrix content?"; "What other relevant information on the topic can we find?"

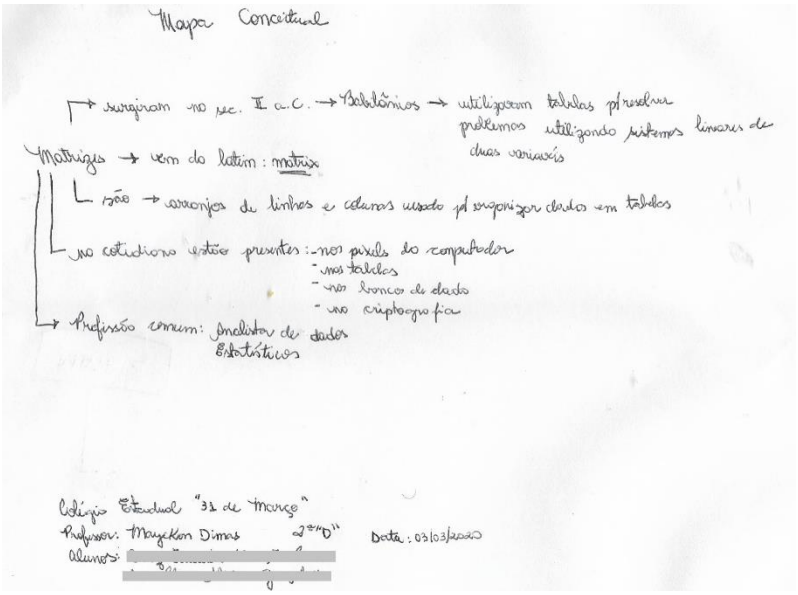

Figure 3: Example of a conceptual map on matrices, prepared by a student in class C, in a public school in the state of Goiás

The two following classes were aimed at sharing the information found and recording it in a mental and conceptual map, which was done in pairs. Finally, we proposed that students make a *Podcast* about the maps created, sharing them in the *Padlet*, an online tool for making virtual and dynamic murals or frames that allows recording,

filing, and sharing multimedia content (text, image, audio, video, and *hyperlinks*). Research related to matrices showed students the relationship between Mathematics and computer graphics and data encryption, which they did not know. One of the maps made by the students is exemplified in Figure 3.

In general, the didactic sequences served to introduce content, had as a starting point the proposition of a topic for research, and ended with the register of the information found and debates for the formation of a general concept, with contributions from all students. The students were given a problem to solve and then encouraged to search for answers on what they did not yet know. This approach attributed greater responsibility to the students (ONUCHIC and ALLEVATO, 2011).

In all the didactic sequences worked, collective discussions for the construction of concepts were promoted (ALLEVATO, 2005) through Problem-Solving and encouragement toward reconstructive questioning (DEMO, 2015). We noticed that students got more engaged, proposing ways to solve statements without waiting for the teacher to present the formula first, to then solve exercises in a repetitive way for fixation.

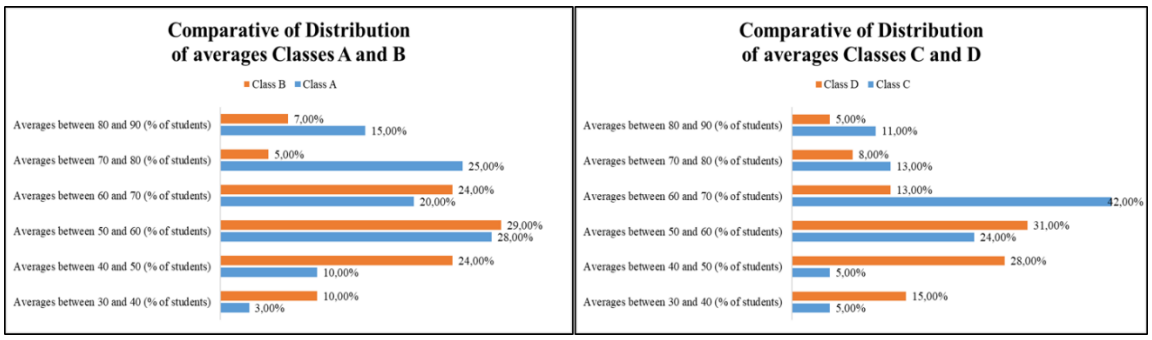

Figure 4: Distribution of averages calculated based on assessment activities carried out with four high school classes in Alexânia-GO. In which, A: Class A using active teaching methodology and Class B using traditional teaching methodology; B: Class C using active teaching methodology and Class D with traditional teaching methodology (Own authorship, 2020)

Besides observing the students, we compared the averages reached by the learning assessments in the four classes during the development of the didactic sequences. Students in groups A and C were more interested in learning the Mathematics contents, so, this subject started to make more sense for them, which impacted the learning assessments (Figure 4). In the classes where students were invited to reflect and build concepts, having research and Information Literacy as a teaching approach, students presented above-average grades.

We can see in Figure 4-A that about 60% of class A had mean equal to or greater

than 60. On the other hand, this percentage drops to 36% in class B, in which the same assessment was applied. A similar situation can be identified in Figure 4-B, when we compare classes C and D. As seen, class C presented 66% of the means equal to or greater than 60. In class D, in which the didactic sequences were not applied, the number dropped to 26%.

The results presented by classes A and C showed that students, when reading statements and solving the exercises presented in the evaluations, brought answers with arguments based on what they read and researched on the topic, not being restricted to the application of a formula. In the answers, we saw the use of argumentation and other different strategies. Therefore, the development of skills and abilities led the students of these groups to reflect on the concepts studied.

Meanwhile, in classes B and D, we realized that, when faced with situations in which they did not remember the formula and/or were unable to gather the numbers necessary to apply a formula, they just left the question blank.

In the groups whose Information Literacy was worked (Classes A and C), the students began to perceive the discipline in a less "crystalized" way, they were more active and explored the teacher's knowledge better, with, therefore, constant dialogue in class. This leads us to reflect on how important it is for the teacher to show the student that he is capable of changing the way of seeing and learning Mathematics, i.e., breaking with the paradigm that the contents are far from reality, ready, and finished, with a single form of resolution that the teacher must present and the students must just reproduce.

The teacher, in turn, when implementing classes based on active methodologies, must be willing to listen more and seek to learn about different subjects that can be linked to the theme, since there are ways and possibilities for broader questioning. Thus, it is important to invest in teacher education and openness to inquiry and debate in the classroom in an ethical and reflective way. Such changes also imply teachers' additional expenditure of energy, especially those rooted in traditional methodologies.

We must remark that the methodological changes led to a transformation in the dynamics of the classes: there was a decrease in the number of activities based on the resolution of routine exercises and in mechanical and automated execution, i.e., the students were led to reflect and build meanings (POSSAMAI, CARDOZO, and

MENEGHELLI, 2018; SILVA, 2016). We also noticed that the students engaged more when we proposed situations that required an investigative posture, considering the students' previous knowledge and accepting as correct different ways of solving the same problem (LEAL JÚNIOR and ONUCHIC, 2015; ALLEVATO, 2005).

The search for the origin of a formula, the meaning of its name, the establishment of relationships between the times in which it emerged and today, based on research techniques that involve the selection, organization, evaluation, and discussion of facts, enable students to see the concept in a clearer and more meaningful way, attribute more meanings, and understand its application possibilities. Here, we observe the Information Literacy, which involves "locating, selecting, organizing, using information, and generating knowledge, aiming at decision-making and Problem-Solving" (GASQUE, 2010, p. 83), at the service of Mathematical Literacy, by the development of skills related to competent reading of numerical data, the establishment of conclusions and a critical stance towards the data read, and the use of technology in an ethical and evaluative way, i.e., following the *trivium: literacy, matheracy and technoracy* (D'AMBROSIO, 1999).

It was evident that the detachment of the copied class, encouraging students to understand the different senses and meanings inherent in a content (DEMO, 2015) contributed to building up skills related to the development of reasoning and knowing how to think and act in different situations and contexts, something necessary for the advancement of Mathematical Literacy. During the observations, we came across the false socio-digital inclusion mentioned by Neves (2011), as few students used the computer or *notebook*, both at home and at school, to access the internet for research. Therefore, they did not present a well-structured and advanced information behavior.

Therefore, one of the challenges to be overcome is that students see their cell phones as mere tools for accessing social networks, with sharing of photos, videos, and messages, which may impair them from building up skills related to Information Literacy. Moreover, students find it difficult to understand the language of the articles and choosing adequate and safe information sources.

The application format of the didactic sequences, in which students should be researchers, solve problems, and establish correlations between mathematical concepts from the etymology of the word, the origin of the content, its relationship with everyday life, having the teacher as a mediator, favored the learning process and contributed to

more active and motivated students. In the proposed model, students were perceived in their uniqueness and were motivated to be active agents (ALLEVATO, 2005). Thus, group work, followed by sharing and discussing the information found and construction of concepts, as suggested by Allevato (2005), proved to be promising for Mathematics classes, which began to have a new meaning, both for the teacher and the students.

In this way, the inclusion of research in Mathematics classes, using the internet as a resource, through pedagogical intervention actions based on the mediation of knowledge, promoted a paradigm shift from the traditional classroom, corroborating Diedrich (2009), who suggests that the internet does not guarantee this shift, but the teacher's action. We also understand that the teacher's presence as a mediator is important because, according to Davenport (1998) and Froehlich (1998), the internet is a chaotic environment, as it does not have a regulatory body relation to checking disclosed data. Therefore, people are still the best way to select relevant and reliable information.

We must remark that implementing the proposition discussed here may be difficult. The difficulties are connected to changes in pedagogical practices, revision of curricula, need for reformulation, and elaboration of new problems (ALLEVATO, 2005). But, given the possibilities of positive results, it is important to promote its application in the classroom. Not as an exclusive or unique methodology, but in accordance with the proposed content and learning objectives.

One of the difficulties identified during the research is the informational behavior of students, who will not always be included in digital culture, in which information and technology are used reflectively and ethically in favor of personal and educational development. Many still do not realize the importance of seeking information and discussing it, of having it as a means of forming arguments and seeking answers to doubts in reliable and secure sources.

Another difficulty is, as mentioned by Demo (2015), that many teachers are not trained or encouraged to promote activities that foster debate and construction of arguments in Mathematics classes. The above owes to the few actions to promote research in the classes in this subject matter, with few investments for the construction of new concepts and abstractions when dealing with the implementation of research in the classroom and with the Problem-Solving methodology.

The discussion presented so far, and the observations made, demonstrate that it is necessary to expand the reach of Information Literacy in the context of Mathematics classes. This can be done by more frequently including research in the classroom and implementing teaching methodologies in Mathematics through Problem-Solving.

8 Final Considerations

From the results, we noticed that Information Literacy, instrumentalized by classroom research, can give students subsidies to understand some mathematical concepts related to the area and volume of geometric solids and matrices in the modern world, beyond giving them only a set of rules and norms. In this way, they can reach Mathematical Literacy.

We also observed that the research in the school context served to construct concepts from the reconstructive inquiry. Students felt more empowered to intervene, propose, test, and validate hypotheses and arguments, being active and protagonists in the learning process. As a mediator, the teacher was essential for the implementation of the methodological proposal suggested in this research, as he acted by guiding the students in the process and not only transmitting knowledge.

Thus, the reference to the methodology based on the proposition of a problem for research, identifying relationships between Mathematics and everyday life, and having the teacher as a mediator, proved to be a methodological possibility for the teaching of Mathematics in high school from the triad between Information Literacy, Mathematical Literacy, and Problem-Solving.

The study was validated with a small group of students and can be adapted for other grades. Therefore, it is crucial that the teacher listens, understands the reality, and establishes problems from the context and content, which remains a suggestion for future studies.

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