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Computational thinking and problem-solving methodology: Possible approaches in the context of mathematics teaching and learning

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ABSTRACT
Despite being lacking in number of articles, dissertations and theses produced, research relating Computational Thinking and Mathematics are standing out in the country and studies on this relationship are gaining more and more space. In this direction, this work aims to discuss about some theoretical approximations between computational thinking and the methodology of problem solving focused on the process of teaching and learning mathematics. To this end, following a qualitative research approach, at first, theoretical aspects of Computational Thinking and Problem Solving methodology will be presented. Subsequently, it will be discussed about some possible relationships between Computational Thinking and the methodology of Problem Solving, with regard to the process of teaching and learning Mathematics. As a result, it was possible to observe that Computational Thinking and Problem Solving Methodology have their pillars in the constructivist trend of education and conceive the problem as a starting point and essential for the teaching and learning process, in addition to valuing creativity, problem decomposition, abstraction and pattern recognition, important characteristics to improve the learning of Mathematics.

Keywords: Computational Thinking, Problem Solving, Mathematics Teaching, Mathematics Education.

1 INTRODUCTION

Computational Thinking (PC), Problem Solving and Mathematics teaching are very simple terms for subjects with such importance and complexity that they must be treated. Problem solving here will be addressed as a teaching methodology (which will be explained in more detail later).

The objective of this article[1] is to make a discussion about a possible connection between Computational Thinking (PC) and the Methodology of Problem Solving (MRP) in the process of teaching and learning Mathematics. Technology is occupying more and more space in the educational environment, and it is necessary to accompany it and use it efficiently. Santos and Souza Mafra (2020),

[1] An earlier and partial version of this work was presented and published in the annals of the International Congress of Teaching Movements, held on October 14 and 15, 2022, virtually.

highlight the frequent use of new technologies in various sectors of society, including the educational environment. These authors point out that CP has emerged as a necessity of today's society. The PC goes far beyond technology as there is an important cognitive approach involved. Despite being lacking in number of articles, dissertations and theses produced, research relating PC and Mathematics are gaining prominence in the country and studies on this relationship are gaining more and more space. Silva and Meneghetti (2019, p.13), after analyzing recent proceedings of the 25th Brazilian Symposium on Informatics in Education (SBIE), I Teaching Workshop on Computational Thinking, Algorithms and Programming (WalgProg) and XX Workshop on Informatics in Education (WIE), important scientific events in the area of computing, found few studies establishing a relationship between Mathematics and the PC and the authors also highlighted that "(...) there is still much to be researched to implement activities with computational thinking in mathematics in Brazil, but it is a promising path that has been growing over the years."

The present work begins with a presentation of the CP aiming to understand the main characteristics of it from its conception to the present day. The same path is made in relation to the Methodology of Problem Solving. Finally, some possible relationships between CP and MRP will be traced, taking into account the process of teaching and learning of Mathematics and aiming at some approximations between these areas.

2 COMPUTATIONAL THINKING

PC is a term that has been used and widely explored today, not only by computer scientists, but also by educators from various areas of knowledge, but also seeks a better understanding of its scope, meanings and everything that involves it, even if there is still no consensus on its definition. Initially, the term PC was developed by Seymour Papert (1928-2016), mathematician and pioneer of Artificial Intelligence and the use of computers for the development of learning and father of the programming language LOGO, supported by constructivism. Papert (1980) believed in the insertion and use of programming in Education, developing learning and other ways of thinking. For him, computers had great potential, they were not just tools for working in homes or offices.

> In 1967, he created the programming language LOGO, together with Wally Feurzeig, an important educational tool for understanding the learning processes of children in interaction with computers. His contributions were important in recognising the potential of computers in learning. Papert was considered the world's foremost expert on how technology can provide new methods of learning and teaching mathematics, thinking and learning in general. He recognized that computers could be used not only to provide information and instruction, but also to empower children to experiment, explore, and express themselves. (SOUSA, J. et al., 2021)

In 2006, with the article *Computational Thinking*, Jannette Wing, computer scientist rescued and popularized the term PC. Wing (2006) defines some elements that correspond to the PC as a fundamental skill to all, not being exclusive to computer scientists and such skill is as important as learning to read, write and perform Mathematical operations and should be taught to children and, according to this author, the PC is related to the ability to solve problems. After the repercussion of this article, Wing (2011) perfects the term, this time, pointing out that "Computational thinking is the thought process involved in the formulation of problems and their solutions so that the solutions are represented in a way that can be effectively performed by an information processing agent." (WING, 2011, p.1). And yet, it complements that problem and solution are seen in a general way, in a broad way, without specifying specific problems related to an area of knowledge. The author lists some elements present, and necessary, in the PC, such as abstraction, decomposition, recursive thinking, pattern recognition and parallelism.

Other researchers and computer scientists share the same ideas as Wing, among them, we cite Valerie Barr and Chris Stephenson (2011), who believe that the PC is a way of solving problems that can be elaborated and developed using the computer, leading students to develop their own tools. According to these last authors, there are nine fundamental skills for PC development: 1. Data collection, 2. Data analysis, 3. Data representation, 4. Decomposition of the problem, 5. Abstraction, 6. Algorithms and procedures, 7. Automation, 8. Parallelization and 9. Simulation.

According to Yadav, Stephenson and Hong (2017) developing the PC in students would enable them to create, design and develop technologies, tools and systems with possibilities of evolution in any area of knowledge. According to Silva and Meneghetti (2019, p.1), "Computational thinking encompasses the competencies and skills that are explored through this computational logic and can be developed in several areas of knowledge, including Mathematics." In this same direction, Azevedo and Maltempi (2020) present the importance and meaning of thinking computationally.

> Thinking computationally does not mean programming a computer, it is a way to encourage new ways of thinking and new paths of knowledge production from active learning methodologies that stimulate the autonomy and creativity of the student beyond the curricular guidelines and the walls of the school. (JACKSON; MALTEMPI, 2020, p.3)

Although it is not a consensus among researchers, in general, we can say that the PC represents a way of thinking to solve problems, supported by some elements, such as abstraction, decomposition, simulation, parallelism, algorithms and pattern recognition.

Even though it may seem distant, distant from our context or the reality of our students, the PC is present in our lives, in various activities that We do, however, we don't pay attention to that. When a teacher goes to prepare a class, or a doctor will do a surgery, or a driver is on his way to a customer and is faced with a traffic jam, when we are in line at the restaurant choosing what we are going to eat, or even, when we are going to put the bibliographic references of an article in alphabetical order, illustrate situations in which we use the PC. When faced with a problem, we need to understand it, divide it into smaller parts to get its solution, recognize patterns, that is, remember if we have already faced a problem similar to this and then draw a strategy to, in fact, solve the problem.

The PC theme has gained a lot of prominence in recent years and has been the focus of many works, such as dissertations and theses, both in computer science and in the educational area, as shown by the work developed by Berssanette and Francisco (2021), in which they present a systematic review of literature that sought dissertations or theses of graduate programs in Brazil, related to the PC, between 2010 and 2019. In all, 71 studies were selected, among 147 found in the search carried out by the authors, and throughout the text, they present various forms of classification of these works, such as number of researches produced per year, federation units with more works produced, study approaches, resources and/or tools used, levels of education (elementary, secondary and higher) where the research was applied, among others. According to these authors, as of 2015 there is a trend of growth in the number of papers presented in graduate programs in Brazil, related to the development of CP, indicating a greater interest of researchers in the subject.

In summary, CP is a very extensive, complex and current topic, with adherence to all areas of knowledge and consequently, most researchers believe that it should be part of school curricula, from the initial grades to undergraduate courses. The goal is to train people capable of solving problems, facing and solving everyday situations, in any area of activity.

3 THE PROBLEM-SOLVING METHODOLOGY

Problem Solving, as an active methodology for teaching and learning Mathematics, represents one of many Trends that Mathematics Education has brought as a tool to assist and enhance student learning. The authors Onuchic and Allevato (2011) point out that in the History of Mathematics, there are records of the use of problem solving in the ancient Chinese, Greek and Egyptian civilizations, for example, and some of these problems have similarities with problems published throughout the twentieth and twenty-first centuries.

For João Pitombeira de Carvalho (1994), during the 70s and 80s some of these Trends in Mathematics Education were consolidating, and problem solving, according to Carvalho (1994) is an activity that requires active participation, there are no ready answers, "it is not sport for spectators". It is worth mentioning the origin of MRP through the works of George Polya and Paul Halmos, as highlighted by this author.

> (...) They have always called attention to the fact that to do Mathematics is to solve problems. The first of them, creator of the Polya heuristic, tried to guide the activity of solving problems at the various levels of mathematical learning in remarkable books, which to this day deserve to be read and meditated on. The second has always encouraged, in his courses, conferences and writings the habit of solving problems. He was the writer of collections of books dedicated to problems of mathematics, at various levels. More specifically in the area of Mathematics Education, studies on problem solving are oriented in two directions that cannot be dissociated: one tries to understand how children and adolescents solve problems, what are the

> characteristics of a good problem solver, etc.; the other tries to elaborate didactic sequences based on problem solving, as opposed to classical expository teaching. (CARVALHO, 1994, p.78).

Highlights include the pioneering work of the Hungarian mathematician George Polya (1887-1985), who in his famous book "The Art of Problem Solving" (translation of "*How to solve it* " written by Polya in 1945) features a problem-solving heuristic specific to mathematics, which remains very current and serves as a starting point for many works in this line of research. In general, Polya (1995) divided the process of solving a problem into four stages: 1. Understanding the problem; 2. Establishment of a plan (construction of a resolution strategy); 3. Implementation of the plan and 4. Retrospect (verification of the result). In addition to these four steps, this author suggests numerous questions pertaining to each step, which can be asked by the teacher to his students, as a form of mediation, throughout the process of solving a problem, aiming at the development of the ability to solve problems in his students.

Like Polya, the works of Paul Richard Halmos (1916-2006), a Hungarian-American mathematician who believed that the problems and their solutions represented the main character of mathematics teaching and complemented

> (...) Problems are the heart of mathematics, and I hope that we teachers, in our classes, seminars, and in the books and articles we write, will emphasize this more and prepare our students to be better troublemakers and problem solvers than ourselves. (HALMOS, 1980, p.524).

At this point, we ask: what is the importance of using Problem Solving in Mathematics? D'Ambrosio (1989) emphasized that, after some changes, Problem Solving is a teaching methodology that the teacher proposes to students problem-situations to be explored and investigated, obtaining new concepts. Onuchic and Allevato (2011) state that problem solving, whose ideas are based on the foundations of constructivism and Vygotsky's sociocultural theory, is considered as a teaching methodology, bringing the problem as a generator of new contents and mathematical concepts, contributing to the construction of mathematical knowledge.

According to Pirola (2000, p. 32), "It is of fundamental importance for the teaching of school mathematics that students understand the concepts and principles involved in the problems, as well as the algorithms used in their solution.". According to Boavida (1992), MRP goes beyond the direct application of formulas or algorithms, it should be challenging for students and aims at them to build their knowledge.

After all, what is the problem? What is the definition for the problem? There is no definition of what a problem is, but some authors, such as Boavida (1992), explain about the difficulties in defining, in a coherent way, the concept of problem, because it is characterized by subjectivity, temporality and the context in which it is inserted. Chi and Glaser (1992), argue that a problem can be obtained in an attempt to solve a puzzle, a question of Differential Calculus, everyday situations, such as saving money on the water bill, not being restricted only to mathematical problems. For Onuchic and Allevato (2011, p.81) a problem "is everything that one does not know how to do, but that one is interested in doing." It should be noted, because of its specificities, that a problem for one student may not represent a problem for another student, due to their personal characteristics, social context, previous knowledge, among other factors.

According to Onuchic and Allevato (2011, p. 80) in MRP "(...) the problem is seen as a starting point for the construction of new concepts and new contents; the students being co-builders of their own knowledge, and the teachers being responsible for driving this process."

In this methodological approach, the construction and learning of new concepts will be established during the process of solving the problem proposed by the teacher. It is the role of the teacher to encourage and motivate students to participate in the problem-solving process to understand the concepts in them and those that will be presented.

The problems are proposed to provoke curiosity in students, who do not know the concept (the subject) that will be addressed (that content that the teacher intends to teach) and the beginning of the subject to be taught will take place through a problem and will consist of its solution. Onuchic and Leal Junior (2015) present a roadmap for solving a problem using a sequence of ten steps, namely: 1. Proposition of the problem, 2. Individual reading, 3. Reading together, 4. Problem solving, 5. Observe and encourage, 6. Recording of resolutions on the blackboard, 7. Plenary, 8. Seeking consensus, 9. Formalization of the content, 10. Proposing and solving new problems. The authors make it clear that this is a proposal for problem solving and, because of this, teachers can adapt it in the way they deem necessary, taking into account the particularities of their classrooms and their students. The methodology of teaching Mathematics through Problem Solving has the necessary tools to enable students to be the main character in their search for knowledge.

In what follows we present, finally, some approximations which are evidenced when we compare some of the principles of CP and MRP in the light of the process of teaching and learning Mathematics.

4 COMPUTATIONAL THINKING AND PROBLEM-SOLVING METHODOLOGY IN THE CONTEXT OF THE MATHEMATICS TEACHING AND LEARNING PROCESS

This work aimed to discuss about some theoretical approximations between the CP and the MRP focused on the process of teaching and learning of Mathematics.

Analyzing the elements presented up to this point, we can perceive some approximations between the CP and the MRP. Initially we can observe that for CP and MRP the problem has a fundamental role in the teaching and learning process; it is considered the starting point of educational action. The PC as we have seen, represents a way of thinking to solve problems, supported by some elements, such as abstraction, decomposition, simulation, parallelism, algorithms and pattern recognition. Problem Solving, as a teaching methodology, indicates that the teaching and learning process should start with a problem or a set of problems, motivating and generating discussions, to build new mathematical knowledge.

We can also infer that they are constructivist approaches in which the learner is conceived as the subject of his knowledge, the latter should be constructed by the student playing, therefore, an active role in this process, and, it is also worth noting, that it is very important the interest of the learner in wanting to exercise this active role. It is necessary a change of posture of the teacher and the student when adopting this teaching methodology.

We can still observe that some of the steps presented by Barr and Stephenson (2011) resemble those brought by Polya (1995), as well as Onuchic and Leal Junior (2015). The first step of problem solving presented by Polya (1995), called problem comprehension, is identical to the steps called individual reading and reading together, by Onuchic and Leal Junior (2015), which in turn, are similar to the steps that Barr and Stephenson (2011) present as data collection and data analysis, due to the fact that these steps suggest that the student understands the problem, Recognize the situation that has been put to you and realize which way to go and what tools you should/can use.

Continuing this analysis, the second step of Polya (1995), called the establishment of a plan, is coincident with the stages data representation, problem decomposition and abstraction of Barr and Stephenson (2011), configuring the stage of elaboration of the strategies necessary to solve the problem. Onuchic and Leal Junior (2015) do not highlight a step in their resolution roadmap, referring to the elaboration of a plan to solve the problem. However, as has been pointed out previously, these authors have already indicated that this script is a proposal for problem solving. We can suggest the inclusion of an intermediate step, situated after reading together and prior to the resolution of the problem, aimed at the elaboration of a plan to solve the problem, if it is necessary to the reality of the class in which the teacher is working.

The execution of the plan, Polya's third step (1995), is consistent with the item solving the problem of Onuchic and Leal Junior (2015), and the steps algorithms and procedures, automation and parallelization of Barr and Stephenson (2011), indicating, in fact, the moment to put into practice the strategy elaborated and use it to solve the problem.

At the end of the resolution of a problem, Polya (1995) suggests as a fourth step the retrospect, which we approximate with the items record of the resolutions on the blackboard, plenary and search for consensus, by Onuchic and Leal Junior (2015), and the stage of entitled as simulation brought by Barr and Stephenson (2011) to PC. At this point in the process of solving a problem it is necessary to present, verify and analyze the result obtained after the solution of the problem and make the discussion of the solution obtained. Table 1 below summarizes the comparisons made previously, indicating the corresponding authors, and similar steps of their proposals for problem solving.

Table 1: Comparison between the Troubleshooting steps of Polya, Onuchic and Leal Junior and Barr and Stephenson

Troubleshooting steps according to each author		
George Polya	**Onuchic and Leal Junior**	**Barr and Stephenson**
1. Understanding the problem	2. Individual reading 3. Reading together	1. Data collection 2. Data analysis
2. Establishment of a plan	There is no	3.Data representation 4.Decomposition of the problem 5.abstraction
3. Implementation of the plan	4. Problem Resolution	6.Algorithms and procedures 7.Automation 8.parallelization
4. Retrospect	6. Recording of resolutions on the blackboard 7. Plenary 8. Seeking consensus	9.Simulation.

Source: Prepared by the authors

As seen, after the presentation of this comparative analysis, correlations were found between the resolution steps that these authors enumerate in their previously cited works. In this direction, Silva (2020) highlights that:

> (...) the competencies of Computational Thinking are directly related to solving Mathematics problems. In fact, they emphasize the ability to read and interpret texts, as well as to understand the real situations proposed in the problems and transpose the information extracted from these situations into mathematical models. This correlation has been the object of study of many recent researches, whose main objective is to collaborate with the discussions about the integration of the teaching of Computing to the school curriculum. Such research suggests that the discipline of Mathematics is used so that students can have contact with programming tools. In parallel, there is another line of work whose proposals converge with the objectives of this dissertation, that is, which seek to develop the competencies of Computational Thinking, using concepts and / or computational tools for the resolution of Mathematics problems. (SILVA, 2020, p. 24).

Thus, it is understood that the process of teaching and learning Mathematics could be improved through the use of CP and MRP. In addition, it is present in Mathematics the representation by codes and algorithms, skills such as abstraction, pattern recognition, generalizations, decomposition and creativity, elements that appear in the definitions of PC and MRP, discussed earlier.

Mathematics offers many possibilities for implementing activities related to PC and MRP, from the initial grades to undergraduate courses, because of the diversity of subjects and themes that can be addressed, including "unplugged" activities, that is, those activities that do not need the use of the computer to be applied. We can cite as an example a teacher who selects and proposes a problem to his students in the Mathematics class and to solve it, it is necessary that the students follow the steps of the MRP in conjunction with the elements of the PC, that is, it is necessary that the students understand the problem, decompose the problem into smaller parts, use abstractions and generalizations and use their creativity to, anyway, solve the problem. Once the problem is solved, one should check, analyze and discuss its solution and, simulate whether such a strategy can be adopted to solve problems similar to the one that was initially proposed.

According to Barbosa (2019, p. 54), there are numerous activities that can be planned and developed, according to the students' school level. This author also adds that its insertion in schools requires many efforts, especially with regard to teacher training, since it is up to the teacher to analyze which problems are best suited to their class and the objectives of the content that will be taught, according to the reality of their school environment.

The teacher needs to find challenging and thought-provoking problems for his students to solve and actively participate in during the lessons. An interesting possibility would be to present problems consistent with the reality of the students, making the learning process more meaningful.

We emphasize that there should be a change of attitude in the performance of the teacher and the students, since it is an active teaching methodology. Students will be responsible for building and obtaining their knowledge and the teacher will act as a mediator in the teaching and learning process. We believe that this path is promising for improving the quality of mathematics education.

5 FINAL CONSIDERATIONS

This work aimed to discuss about some theoretical approximations between the CP and the MRP focused on the process of teaching and learning of Mathematics.

Through the course traced we could observe that CP and MRP although they have their own characteristics, with regard to the process of teaching and learning Mathematics it is possible to perceive a rich intersection between them.

Relying on constructivism, the CP and MRP identify the student as the main character in their search for knowledge, conceiving him as an active subject in the construction of new concepts, motivated from the problems proposed. Both CP and MRP carry similar competencies that are important for students' cognitive development at all grade levels. Also in both CP and MRP the problem has a fundamental role for the teaching and learning process, representing the starting point of this process.

However, it is worth mentioning that they refer to relatively current themes within the educational context and, because of this, still there is much to be done, to be researched, to be developed so that the PC and MRP are implemented correctly and fruitfully in the process of teaching and learning Mathematics, aiming at improving the educational framework in the country. As Ubiratan D'Ambrosio said, "Education is preparing for the future." Are we heading toward the future?

REFERENCES

AZEVEDO, G. T.; MALTEMPI, M. V. Processo de Aprendizagem de Matemática à luz das Metodologias Ativas e do Pensamento Computacional. Ciência & Educação, Bauru, v. 26, 2020. Disponível em: https://doi.org/10.1590/1516-731320200061 . Acesso em: 29 de maio de 2022.

BARBOSA, Lara Martins. Aspectos do Pensamento Computacional na Construção de Fractais com o software GeoGebra. Dissertação (Mestrado em Educação Matemática) - Universidade Estadual Paulista (Unesp), 2019. Rio Claro, 2019, 168 f. Disponível em: https://repositorio.unesp.br/handle/11449/180523 . Acesso em: 10 de jun. de 2022.

BARR, V.; STEPHENSON, C. Bringing Computational Thinking to K-12: What is Involved and What is the Role of the Computer Science Education Community? ACM Inroads.v.2, n.1, p. 48-54, 2011. Disponível em: https://dl.acm.org/doi/10.1145/1929887.1929905 Acesso em: 10 de maio de 2022.

BERSSANETTE, J. H. ; FRANCISCO, A. C. de. (2021). Um panorama das pesquisas sobre pensamento computacional em programas de pós-graduação no Brasil. Revista Contexto &Amp; Educação,36(114), p. 31–53. Disponível em: https://doi.org/10.21527/2179-1309.2021.114.31-53 Acesso em: 15 de maio de 2022.

BOAVIDA, A. M. Resolução de problemas: que rumos para a Educação Matemática?
In Brown, M., FERNANDES, D., MATOS, J. F. E PONTE, J. P. (Eds.), Educação Matemática. (p. 105-114). (1992). Coleção temas de Investigação. Lisboa.

CARVALHO, J. P. de. Avaliação e Perspectivas da área de ensino de Matemática no Brasil. Em Aberto, Brasília, Vol. 14, no. 62, jul/set/1994-Tendências na Educação Matemática. Disponível em: http://webcache.googleusercontent.com/search?q=cache:PYsyTShIivAJ:www.emaberto.inep.gov.br/ojs3/index.php/emaberto/article/download/2273/2012+&cd=1&hl=pt-BR&ct=clnk&gl=br Acessado em: 30 de junho de 2021.

CHI, M. T. H.; GLASER, R. (1992). A capacidade para a solução de problemas. In STERNBERG, R. As capacidades intelectuais humanas. Uma abordagem em processamento de informação (Tradução de Batista, D.). (pp. 250- 275).Porto Alegre: Artes Médicas.

D'AMBROSIO, B.S. (1989). Como ensinar matemática Hoje? Temas e Debates v.2 (2), 15-19 Diponível em: http://sbemrevista.kinghost.net/revista/index.php/td/article/view/2651 Acessado em: 10 de jun. de 2022.

HALMOS, Paul Richard. The heart of Mathematics.The American Mathematical Monthly, v. 87, n. 7, p. 519-524, 1980. Disponível em: https://doi.org/10.2307/2321415 Acesso em: 05 de maio de 2022.

ONUCHIC, L. De La R.; ALLEVATO, N. S. G. Pesquisa em Resolução de Problemas: caminhos, avanços e novas perspectivas. Bolema - Mathematics Education Bulletin, v. 25, n. 41, p. 73-98, 2011. Disponível em: http://hdl.handle.net/11449/72994 Acesso em: 15 de jul. de 2022.

ONUCHIC, L. De La R.; LEAL JUNIOR, L. C. Ensino e Aprendizagem de Matemática Através da Resolução de Problemas Como Prática Sociointeracionista. Bolema - Mathematics Education Bulletin, v. 29, n. 53, p. 955-978, 2015. Disponível em: https://www.scielo.br/j/bolema/a/nLsFMY58vc7767N6RV9rGcb/?lang=pt&format=pdf Acesso em: 15 de jun. de 2022

PAPERT, S. Mindstorms: Children, computers, and powerful ideas. New York: Basic Books, 1980. 238 p.

PIROLA, N. A. Solução de problemas geométricos: dificuldades e perspectivas. 2000. 218p. Tese. Universidade Estadual de Campinas, Faculdade de Educação, Campinas, 2000. Disponível em: http://www.repositorio.unicamp.br/handle/REPOSIP/251070 Acesso em: 30 de maio de 2022.

POLYA, G.;A Arte de Resolver Problemas: Um novo aspecto do método matemático. Rio de Janeiro-RJ: Interciência, 1995.

ROBERTSON, E.; O'CONNOR, J. MacTutor: History of Mathematics Archive. GEORGE POLYA. Mactutor. Disponível em: https://mathshistory.st-andrews.ac.uk/Biographies/Polya/ Acesso em: 20 de jun. de 2022.

ROBERTSON, E.; O'CONNOR, J. MacTutor: History of Mathematics Archive Paul Halmos. Mactutor. Disponível em: https://mathshistory.st-andrews.ac.uk/Biographies/Halmos/ Acesso em: 20 de jun. de 2022.

SANTOS, G. P.; SOUZA MAFRA, J. R. O ensino de matemática por atividades: uma interface entre recursos tecnológicos e o pensamento computacional. REMATEC, v. 15, n. 35, p. 79-99, 4 dez. 2020. Disponível em: http://www.rematec.net.br/index.php/rematec/article/view/287 Acessado em: 10 de jun. de 2022.

SILVA, F. M. da; MENEGHETTI, R. C. G. Matemática e o pensamento computacional: uma análise na pesquisa brasileira. Anais. Cuiabá: SBEM, 2019. Disponível em: https://repositorio.usp.br/directbitstream/68a87351-7fdb-443b-906b-56d6baf59152 /2981768.pdf Acesso em: 25 de jun. de 2022.

SILVA, T. V. O pensamento computacional como ferramenta de resolução de problemas de Matemática. Universidade Federal de Campina Grande, Paraíba. Centro de Ciências e Tecnologia. Unidade Acadêmica de Matemática. Mestrado Profissional em Matemática em Rede Nacional (PROFMAT), 2020. Disponível em: http://mat.ufcg.edu.br/profmat/wp-content/uploads/sites/5/2020/10/DissertacaoPROFMAT_Teofilo.pdf Acesso em: 15 de jun. de 2022.

SOUSA, J. S.; MEIRINHOS, M.; PATRÍCIO, M. R. e GONÇALVES, V. Instituto Politécnico de Bragança (IPB). Educação: Pensadores ao longo da história. Seymour Papert. Colaboração: Departamento de Tecnologia Educativa e Gestão da Informação. Disponível em: https://bibliotecadigital.ipb.pt/bitstream/10198/13622/3/Seymour_Papert_TEGI_BD.pdf Acesso em: 16 de jun. de 2022.

WING, J. M. Computational thinking. Communications of the ACM, New York, v. 49, n. 3, p. 33-35, mar. 2006. Disponível em: https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf Acesso em: 18 de jun. de 2022.

WING, J. M. Computational Thinking: what and why?. 2011. The Magazine of Carnegie Mellon Universitys School of Computer Science, March 2011. LINK, Research Notebook. Disponível em: https://www.cs.cmu.edu/link/ research-notebook-computational-thinking-what-and-why. Acesso em: 18 de jun. de 2022.

YADAV, A.; STEPHENSON, C.; HONG, H. Computational Thinking for Teacher Education. Communications of the ACM, v. 60, n. 4, p. 55-62, 2017. Disponível em: https://doi.org/10.1145/2994591 Acesso em: 24 de jun. de 2022.