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Modeling in science and scientific literacy in the early years: a review study

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ABSTRACT

This work aims to recognize the research done about the theme Modeling in Science - SC and Scientific Literacy - SC in the early years, as well as to understand how practices of Modeling in Science contribute to the development of SC in the early years of Basic Education. To contribute to our study, we conducted a qualitative bibliographic research and searched the Brazilian Digital Library of Theses and Dissertations made available by the Brazilian Institute of Information in Science and Technology (IBICT) for research in the form of theses and dissertations. We selected 13 studies for analysis in the period from 2010 to 2020. The researches are analyzed through the procedures of Content Analysis, which allowed to highlight the word "model" linked to the notion of representation and "modeling" as a means to qualify the processes of teaching and learning. In relation to CA, this is understood as a process by which we use scientific information to read, understand, and transform the environment in which we are inserted. In addition, the modeling process allows for the development of skills that carry with them indicators of CA, namely: problem formulation; information search; interpretation of graphs, tables, and illustrations; communication of results; and construction of arguments to solve the problem. However, for the interweaving of MC and CA to be present in the classroom, it is necessary to promote the experience of both processes in teacher education.

KEYWORDS: Pedagogical Practices. Science and Mathematics Teaching. Teacher education.

INTRODUCTION

Pedagogical practices of Modeling in Science - MC1 have been carried out with students of all educational levels and according to Biembengut (2016, p. 175) aims to "promote knowledge to the student in any period of schooling and teach him to do research in this school structure, that is: in the physical space and in the period concerned to this purpose", this because the steps of the modeling process resemble the steps of scientific research, since the choice of theme, formulation of the problem and communication of the result.

According to Biembengut (2016), pedagogical modeling practices enhance the realization of investigative activities from a theme of interest to students to solve a problem that can be proposed by the teacher or by the students themselves. The experience of the modeling process allows the articulation of knowledge and the development of reading skills and understanding of the world, which are marked by Chassot (2003) as characteristics of Scientific Literacy - CA. For the author, "[...] to be scientifically literate is to know how to read the language in which nature is written. A scientific illiterate is one who is incapable of a reading of the universe" (CHASSOT, 2003, p. 91). Still, it is made AC when the teaching of science contributes to the understanding of knowledge, procedures and values that allow students to make decisions and realize the utilities of science and its applications, both for the improvement of the quality of life, as well as the limitations and consequences of its development. In this perspective, Araújo and Leite (2019) textualize that CA involves understandings of social, political, and historical nature in the individual's action in their daily lives, from knowledge about Science.

When considering the specificities of school education, particularly in the early years, it must be clear that at this stage learning goes beyond reading and writing. Students need to read and understand the world in which they live and learn to make conscious choices and interventions. According to the Common National Curriculum Base - BNCC, a normative document that organizes the essential learning during Basic Education, in the early years of elementary school:

> It is necessary to provide opportunities for them to actually engage in learning processes in which they can experience moments of investigation that enable them to exercise and expand their curiosity, improve their capacity for observation, logical reasoning, and creation, develop more collaborative attitudes, and systematize their first explanations about the natural and technological world (BRASIL, 2018, p. 329).

In this sense, we believe that pedagogical practices based on the foundations of MC can contribute to the development of these capabilities. We consider that models and the process of creating models (modeling) play an important role in Science Teaching, since they predispose the student to the condition of learning Science, learning about Science and learning to do Science (HODSON, 1992; JUSTI, 2006).

> The process of model building is central to the construction of science itself and, consequently, inserting students into activities analogous to the scientific modeling process has the potential to develop knowledge about this process and skills associated with it - which implies learning about both scientific content and the nature of science and scientific practices (MAIA, JUSTI, 2017, p. 2749-2750).

For Ferreira and Ferracioli (2008), modeling is defined as a continuous reconstruction of reality in an artificial manner, which is directly related to the skill of the modeler, that is, his or her experience, knowledge, judgment, intuition, perception, and imagination when producing models.

Regarding the word model, we understand that it has different meanings depending on the context in which it is inserted. However, in this study we understand it as allied to the sense of representation of something that is intended to realize, understand, explain, infer. For Biembengut (2016, p.86) the "model is understood, in general, as a means to represent something, make decisions, or be used heuristically to learn more about the problem situation. In addition, models aim to provide an approximate knowledge of reality, as already pointed out by Bunge (1974) when he stated that models are mediators between theory and reality.

Modeling is the process used in the preparation of a model of any area of knowledge"; it is, par excellence, a research process (BIEMBENGUT, 2014, p.21). According to this author, the modeling process goes through three stages called: a) perception and apprehension in which happens the motivation to students by choosing a topic that is of interest to them and familiarization with this theme; b) understanding and explicitness, step in which there is the formulation of the problem, the model and its resolution and contains the sub-steps "raise hypotheses or assumptions, express the data, develop the content, exemplify and formulate the question"; and c) meaning and expression where the interpretation of the solution and validation of the model. (BIEMBENGUT, 2016, p. 198).

The use of modeling in teaching favors the study and discussion, not only of content, but also of interdisciplinary ideas. Thus, it provides the student with "[...] cultural values and some general principles concerning his role as a person responsible for the reality that surrounds him" (BIEMBENGUT, 2012, p. 37).

We understand that modeling as a research process, provides a teaching that articulates knowledge, experimentation, reading, observation, organization and classification of information, hypothesis raising, justification and communication of results, actions that favor learning, help to understand the world and are some skills pointed out by Sasseron (2008) to be worked in order to develop CA in students.

When referring to the initial years of elementary education, Lorenzetti and Delizoicov (2001) point out:

> The definition of scientific literacy as the ability of the individual to read, understand and express opinion on issues involving science, assumes that the individual has already interacted with formal education, dominating, thus, the written code. However, complementary to this definition, and in a sense opposing it, we start from the premise that it is possible to develop scientific literacy in the early grades of elementary school, even before the student masters the written code (LORENZETTI; DELIZOICOV, 2001, p.47).

Thus, according to the aforementioned authors, even before children master the written code in the early years, it is possible to involve them in activities in which opportunities are provided for the development of CA, engaging them in processes of investigation and problem solving that make sense to them. In addition, children live with the advancement of science, technology, and their artifacts, i.e., the expansion of the universe of scientific knowledge is a cultural necessity. Thus, starting from the early years and gradually expanding and rebuilding this literacy is of fundamental importance to form conscious and responsible citizens.

Also, according to Palmieri and Silva (2017), from the early years, scientifically literate students will be

> [...] able to combine scientific knowledge with the ability to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes brought about by human activity (PALMIERI; SILVA 2017, p. 22).

Given the above, the objective of this work is to recognize the research done on the theme “Modeling in Science and Scientific Literacy in the early years”, as well as to understand the meaning attributed to the words model and modeling. In addition, we seek to understand how modeling practices contribute to the development of CA in the early years of Basic Education.

METHODOLOGICAL APPROACH

Considering the objective of this research, we classified it as qualitative of the bibliographic type (LÜDKE; ANDRÉ, 2013). Qualitative research is characterized by having an interpretive and naturalistic approach, involving the obtaining of descriptive data. In this sense, for Lüdke and André (2013, p. 45) "to analyze qualitative data means "working" all the material obtained during the research, that is, the reports of observations, the transcripts of interviews, the analysis of documents and other available information".

The constitution of the data occurred in the Database of Theses and Dissertations (BDTD), through the portal of the Brazilian Institute of Information in Science and Technology - IBICT, which enabled the identification of dissertations and theses. For this, we used the option "advanced search" and "all fields" with the expressions "Modeling in Science", "Modeling in Science and Mathematics", "Scientific Literacy" and "Early Years".

Initially, when we searched for the expression "Modeling in the Sciences", we found 6661 papers. When we intertwined the terms "Modeling in Science" and "Early Years", this number was reduced to 81 (eighty-one) papers, from which, by reading the title, keywords, and abstract, we selected four for analysis. The others were not included because they were not related to our research interest.

Using the terms "Modeling in Science and Mathematics" and "Early Years", we found 15 (fifteen) papers, seven of which were selected. With the terms "Modeling in Science" and "Scientific Literacy" we found 9 (nine) papers, of which we selected one. When we used the terms "Scientific Literacy" and "Early Years" we found 92 (ninety-two) papers, from which we selected 7. However, when we intertwined the terms "Modeling in Science", "Scientific Literacy" and "Early Years", we found only one paper, which was repeated in the previous searches.

Thus, our corpus of analysis consists of 13 (thirteen) studies, which are identified in Chart 1 below.

Chart 1 - Academic papers selected for analysis

Research	Author	Title	T²	Year
P1	Marinês Avila de Chaves Kaviatkovski	Mathematical Modeling as a Methodology for Teaching and Learning in the Early Years of Elementary School	D	2012
P2	Simone Raquel Casarin Machado	Perceptions of mathematical modeling in the early years	D	2012
P3	Emerson Tortola	The uses of language in mathematical modeling activities in the early years of elementary school	D	2012
P4	Tatiana Schneider Vieira de Moraes	The development of scientific investigation processes for the 1st year of elementary school	T	2015
P5	Igor Daniel Martins Pereira	Science teaching from a scientific literacy perspective: pedagogical practice in the literacy cycle	D	2015
P6	Emerson Tortola	Mathematical modeling configurations in the early years of elementary school	T	2016
P7	Míriam Navarro de Castro Nunes	Memorize-imagine-create: investigations on memory and science teaching in the early grades	D	2016
P8	Flávia Rossi Maciel	A didactic proposal on medicinal plants in the early years of elementary school from a science-technology-society perspective	D	2016
P9	Maria Alina Oliveira Alencar de Araújo	Scientific literacy in the early years of elementary school: the official documents and the teacher's view of their practice	D	2017
P10	Elise Cândida Dente	Mathematical Modeling and its implications for the teaching and learning of mathematics in 5th grade in two public schools in Vale do Taquari	D	2017
P11	Mateus Lorenzon	The investigative spiral as a strategy for developing Scientific Literacy in the Early Years of Elementary School	D	2018
P12	Ronalti Walaci Santiago Martin	Mathematical modeling and autonomy: a look at elementary school activities	D	2019
P13	Emiliana Silva de Lima	Galperin's stage theory of mental action formation: a proposal for science teaching articulated with literacy and literacy	D	2019

Source: Own authors (2020).

The analysis of the dissertations and theses followed the Thematic Content Analysis procedures of Lüdke and André (2013), following three basic steps: the first, pre-analysis; the second, exploration of the material and the third, treatment of results and interpretation.

The pre-analysis involved the reading of the abstract and keywords and the selection of the 13 researches. The material exploration involved the analysis of the frequency of the words "model", "modeling", and "CA" from the introduction to the final considerations, as well as the context in which they were mentioned in the research texts. We emphasize that Thematic Content Analysis is a way to interpret the message, breaking down the content of the document into simpler parts, which reveal senses and meanings contained in the text. This process involved numerous readings and re-readings in order to detect more frequent themes and topics: "this procedure, essentially inductive, will culminate in the construction of categories or typologies" (LUDKE; ANDRÉ, 2013, p. 50).

In this study, we defined, a priori, three categories that deal with: i) Model, ii) Modeling and iii) Scientific Literacy, for which we seek to recognize the understanding of the authors of the research. This understanding is contemplated in the subcategories that emerged from the analysis process and are explained in the next section.

DISCUSSION AND RESULTS

From the identification of the 13 selected papers we initially sought to understand the authors' understanding of the words "model", "modeling" and the expression "Scientific Literacy" and which theoretical references are used to anchor such understandings. In addition, we seek to understand how MC practices contribute to the development of CA in the early years of Basic Education.

We present in Table 2, the frequency related to the words: "model", "modeling" and "Scientific Literacy" which were quantified from the introduction to the final considerations in the analyzed researches.

Table 2 - Quantification of the thematic units

Code	Type	Modeling	Scientific Literacy - AC
P1	90	402	0
P2	24	262	0
P3	188	177	0
P4	13	0	15
P5	2	0	72
P6	314	616	0
P7	27	3	19
P8	10	0	36
P9	5	0	98
P10	60	132	0
P11	81	1	44
P12	19	252	0
P13	13	0	3
Total	846	1845	287

Source: Own authorship (2020).

Chart 3 - Participants and research themes

Thematic	Students in the early years	Teachers of the early years
Modeling	P3, P6, P10, P12	P1, P2
Scientific Literacy	P4, P7, P8, P11, P13	P5, P9

Source: Own authorship (2020).

The research involving students from the early years aim, from the development of modeling practices, to understand: the use of language in modeling activities (P3); the implications of the development of pedagogical practices based on modeling (P10); the settings of modeling activities (P6); and the autonomy actions of the students involved (P12).

The research involving early years' teachers and modeling practices aimed to understand: the contributions of modeling insertion in the early years (P1) and the perceptions of early years' teachers about modeling (P2). In both cases, the teachers had the experience of the modeling process in continuing education courses.

The researches dealing with Scientific Literacy in the early years developed with students are about the engagement of children in investigation processes and the development of CA (P4, P11 and P13); the understanding of mnemonic processes in science teaching activities (P7) and the potential and limitations of the study of themes with a Science, Technology and Society (STS) character (P8).

The involvement of early grade teachers in research on CA is through the understanding of their pedagogical practices and whether they promote CA (P5 and P9).

From the above, we highlight that the analyzed researches, besides the understanding of the modeling process and the development of CA, seek the insertion of its assumptions in the classroom through the development of pedagogical practices in teacher training courses or the development of didactic sequences based on modeling or on the development of CA with students of the early years.

Having recognized the purpose and participants of the research, we present, next, the understanding of the authors about the meaning attributed to the words model and modeling and the term Scientific Literacy. Table 4, below, presents a synthesis of the unfolding of the analysis performed.

Table 4 - Summary of the analysis process

A priori categories	Emerging subcategories	Survey code
Model	Model with the sense of representation.	P1, P2, P3, P4, P6, P7, P10, P11, P12
	Model to refer to ways of teaching.	P4, P5, P7, P8, P9, P11, P12, P13
Modeling	Modeling as a teaching and learning methodology	P1, P10
	Modeling as a conception of Mathematics Education	P2
	Modeling as a pedagogical alternative	P3, P6, P12
	Modeling presupposes interdisciplinarity	P1, P3, P6, P10, P12
	Modeling as a process of making a model.	P1, P2, P3, P6, P10, P12
	Modeling is a means to question reality	P1, P2, P7, P13

A priori categories	Emerging subcategories	Survey code
Scientific Literacy - AC	CA allows the reading and understanding of the world and its transformations.	P4, P5, P7, P8, P9, P11, P13
	CA favors interdisciplinary contexts and stances.	P4, P5, P7, P8, P9, P11, P13

Source: Own authorship (2020).

Considering the polysemy of the word model, we resort to the notion explained by Biembengut (2016) and by Gilbert and Boulter (1998), for whom the meaning is linked to the sense of representation of something, an idea, object, event, process or system, being created for a specific purpose.

This notion of model as representation is present in (10:13)3 of the analyzed researches P1, P2, P3, P4, P6, P7, P8, P10, P11 and P12, as passages presented, below:

> [...] the concept of model is extended to understand it as a representation, and it can make use of several types of representations, such as: formulas, price tables, equations already known, graphs, floor plans of a house, among others. (P1, p. 94).
>
> It is evident that the need for representation of a real situation comes from provocations, questionings, and doubts raised, which are then problematized, thus aiming at the learning of knowledge that is actually meaningful to the student. (P2. p. 28).
>
> [...] mathematical models are conceptual and representational tools that allow us to learn, develop and apply relevant mathematical concepts, as well as to understand how this understanding occurs. (P3, p. 30).
>
> [...] the models in three dimensions, in high relief and well colored are facilitators of learning. (P7, p. 37).
>
> [...] the children explored a planetarium model that existed in the school. (P12, p. 142).
>
> [...] the representations of teeth and diseases through a resin model. (P14, p. 63).

In relation to the last three passages presented above, we notice the use of physical models used in teaching and learning processes. Such models, according to Biembengut (2016, p. 79), "are scaled representations and/or analogues of something to be highlighted, evidenced". Still, in relation to the use of such models, we dialogue with the study of Silva and Catelli (2019, p.1), which points out that "although the models are present in teaching materials, in forms of three-dimensional objects, didactically transposed, they can provide distortions on the reality they try to represent" and, in this sense, it is up to the teacher to perform the mediation so that students realize that the models are approximations of reality and represent the entity studied under some aspect or point of view.

We also recognize in (8:13) that the word model is used to refer to ways of teaching or training teachers: teaching models, educational model, pedagogical model, school model, curriculum model: P4, P5, P7, P8, P9, P11, P12, P13.

In this perspective, the study by Krapas et al (1997) presents an overview of the uses and meanings of models in the international science education literature and highlights 5 categories, among which the category "pedagogical model" to refer to the "model constructed for the purpose of promoting education. In the broad sense, a pedagogical model includes the processes of didactic mediation, that is, the processes of transformation of scientific knowledge into school knowledge" (KRAPAS, QUEIROZ, COLINVAUX, 1997, p. 192). This model typology was identified in the researches analyzed, as passages, below:

> [...] Part of these problems, related to the educational reality, deals with a vision of teaching proposed by pedagogical models linked only to memorization and repetition. (P2, p. 81).

> [...] it is necessary to completely overcome the traditional model of Science Teaching. (P4, p. 20).

> [...] the model contemplates different pedagogical approaches as to methods and strategies; however, although it has methodological similarities among several approaches, it is distinct from other models because it relates scientific knowledge and social reality in a critical and reflective way. (P8, p. 14).

> [...] the pedagogical model refers to the simplified representation of an idea, object, event, process or system that constitutes an object of study, with the aim of facilitating a meaningful understanding by the students. (P12, p. 142).

The passages presented are also linked to what Zabala (1998) presents about pedagogical models. For this author, such models make explicit the time/space variables in pedagogical interaction. In this context, they are explored in pedagogical practices with the purpose of reconstructing knowledge and developing skills, abilities, and competencies in students. In this way, we understand as pedagogical models the different possibilities of representation of the teaching and learning processes, specifically, the classroom and school practices.

Regarding the word modeling, in the 13 researches analyzed, it appears 1845 times in 8 researches (P1, P2, P3, P6, P7, P10, P11, P12) and is assumed as a teaching and learning methodology in P1 and P10, following Burak's (2004) conception; as a conception of Mathematics Education, in the sense of conceiving or creating a new way to educate mathematically in P2 according to Caldeira's (2009) understanding; as a pedagogical alternative in P3, P6 and P12 referring to Almeida, Silva and Vertuan's (2012) conception; with educational purpose in P11 based on Krapas et al's (1998) study. In P7 the notion of modeling is used in the sense of being a varied didactic strategy that caters to different learning styles. The passages, below, denote the different understandings.

> [...] the present work stems from six distinct but interconnected moments of study, seeking to contribute to the insertion of Modeling as a teaching and learning methodology in the early years. (P1, p. 14).

> Thus, modeling is seen in this work as a conception of Mathematics Education, in the sense of conceiving or creating a new way to educate mathematics. (P2, p. 36).

> In this scenario, we take Mathematical Modeling as a pedagogical alternative for teaching and learning Mathematics [...]. (P12, p. 18).

> [...] in which they highlight consensus models, pedagogical models, mental models, meta-models, and modeling as an educational goal. (P11, p. 141).

From the above, we distinguish in the research different understandings which mark groups of researchers who take modeling as a research object in Mathematics Education and Science teaching in the Brazilian scenario and, from this, different possibilities of insertion of its assumptions in the classroom arise, as well as variations of the attributions of students and teachers. Such variations culminate with the development of the student's protagonism and the teacher's guiding and mediating role. We emphasize that although there are different understandings about modeling, the authors agree that the beginning of the modeling process should take into account the students' interest and start from the context in which they are inserted.

Regarding the notion of modeling, we recognize in (6: 13) modeling as a process of elaboration or construction of a model: P1, P2, P3, P6, P10, P12, as passages presented, below:

> [...] the close relationship that exists between model making and modeling. (P1, p. 51).

> [...] the work with modeling requires the construction of a mathematical model representative of reality. (P2, p. 32).

> [...] in the production of mathematical models in the Modeling activities developed. (P3, p. 68).

> [...] for the development of mathematical modeling activities: the principle of generalization of the model. (P6, p. 248).

> In the development of a Mathematical Modeling activity we usually associate the investigated situation with a mathematical representation. This representation is called, in the literature, a mathematical model. (P12, p. 23).

In this context, modeling allows the elaboration of models, from a problem that one is interested in investigating. In this process, the student develops skills in interpreting the situation, obtaining and organizing data, communicating the results and argumentation that are essential to understand and interpret the world (natural, social and technological) and also transform it (BRASIL, 2018).

We emphasize, however, that there are understandings about the insertion of modeling in the classroom, in which obtaining the model is not the final purpose of the process and there is the emphasis on the discussion of problems, selection and organization of information which are intended to achieve reflective knowledge (BARBOSA, 2004). In this understanding, modeling and scientific knowledge are means to understand and question the social, political, economic, and cultural context.

We also recognize in the researches P1, P3, P7, P11, P13 the notion that working with models and modeling by allowing the approach of themes and problems from different areas of knowledge, favors the realization of interdisciplinary work, as already pointed out by Burak (2017, p. 23) the modeling "by having as a starting point a theme is interdisciplinary". The following passages denote the above.

> Modeling favors a more dynamic teaching, consequently, more meaningful to students, the establishment of relationships between the content covered and enables interdisciplinarity. (P1, p. 101).

> [...] the production of mathematical models can prepare students to deal with different problem situations in their lives, in which mathematical language does not appear in isolation, but is rooted in many other languages. (P3, p. 31).

> [...] the insertion of modeling in the early years can favor the creation of dialogical and interdisciplinary spaces. (P7, p. 25).

> Mathematical Modeling as a process that has in everyday life or in other areas of knowledge its beginning, and in the mathematical model of the situation, described by means of symbols or mathematical relationships, the way to interpret the situation, answer the problem, organize the data, aiming at its understanding and solution. (P13, p. 20).

We understand that there is interdisciplinarity when we insert modeling in the classroom, because we resort to knowledge from different areas of knowledge to solve a problem that is established. In this sense, we agree with Tomaz and Davi (2008) when they present that interdisciplinarity presupposes integration between disciplines and this is achieved when knowledge from "several disciplines is used to solve a problem or understand a given phenomenon from different points of view" (TOMAZ; DAVID, 2008, p. 16).

The insertion of modeling in the classroom allows students, since the early years, to build models, structure, validate and/or modify solutions to problems at all levels of education. According to Barbosa (2001, p. 4), "neither mathematics nor Modeling are 'ends', but 'means' to question the reality lived".

> Modeling in the early years enables [...] the student to realize that he is inserted in a world [...]. (P1, p. 63).

> [...] teach Mathematics that contributes to the students of the early years to achieve a greater mastery and representation of reality, not just reducing Mathematics to "doing mathematics". (P2, p. 52).

> [...] students in the initial years are indeed capable of doing mathematical modeling in the initial years, they can direct a solution to problems mediated by modeling, according to their knowledge. (P7, p. 56).

> [...] the development of autonomy occurs through constant experiences centered on the action of the subject that needs to make decisions in learning situations. This perspective raises the importance of the teacher in creating learning environments that are diverse and open enough to allow students to experience autonomy: moments when they have the possibility to act with freedom, to solve a problem and perform an activity independently. We consider, in this sense, that Mathematical Modeling can promote these experiences. (P13, p. 38).

From the above, we understand that modeling practices are possible to be performed in the early years and contribute to the understanding of the reality in which we are inserted.

Regarding the expression "Scientific Literacy", it appears 287 times in (7:13) (P4, P5, P7, P8, P9, P10, P13) and we identified different unfoldings of its use: Scientific Literacy - SC, Scientific Literacy - SC and Scientific Enculturation - SC (P4, p. 20; P5, p. 26; P7, p. 29; P8, p. 20; P9, p. 51, P11, p. 42). We also identified that the researches that present and discuss the terminological variations choose to use Scientific Literacy, rather than LC or CE (P4, p. 21; P5, p 26; P7, p. 29; P8, p. 19; P9, p. 53; P11, p 53).

P5, P7, and P11 justify their choice of CA terminology by tying the notion of literacy to Freirean postulates

> Understanding and realizing that there are difficulties in translating terms from one language to another [...] intends to follow with the term Scientific Literacy. Freire's words [...], are, for me, significant and translate my way of understanding the meaning of Science teaching practices in the early years. (P5, p. 28).

> The present work [...] opts for the term "Scientific Literacy", which [...] has its origin in Paulo Freire's postulates. (P7, p. 29).

> Besides the sense that literacy is a continuous process, another justification for my choice of this term is the possibility of thinking of it from Freire's point of view. (P11, p. 43).

According to Sasseron and Carvalho (2011, p.60), despite the use of different terminologies, which we do not intend to discuss in this text, both LC, CA and CE are related to science teaching that "aims at the citizen formation of students to master and use scientific knowledge and its unfoldings in the most different spheres of their lives".

In the early years, for Lorenzetti and Delizoicov (2001, p. 52), CA is understood as "the process by which the language of Natural Sciences acquires meanings, constituting a means for the individual to expand his universe of knowledge, his culture, as a citizen inserted into society" that is, for the authors, scientific knowledge is an ally for the student to read, understand and transform the world in which he lives; it is "the set of knowledge that would facilitate men and women to make a reading of the world where they live" (CHASSOT, 2014, p. 62).

The above is a convergent aspect in all the researches that address the AC theme: P4, P5, P7, P8, P9, P11, and P13, according to the following passages

> Scientific literacy comprises knowing the concepts involved in the area of Science, understanding about the use of this knowledge in everyday life, operating with scientific knowledge to understand the world and the technologies built. (P5, p. 31).

> [...] CA becomes indispensable, especially in the early grades [...] in order to develop their reading of the world. (P7, p. 30).

> The term Scientific Literacy (CA) is related to the acquisition of the individual's ability to read the world and transform it for the better. (P8, p. 19).

> [...]as a consequence of contact with other sciences and that Scientific Literacy will provide unique situations of social experience and citizen formation. (P9, p. 19).

> Scientific Literacy can be thought of as a process in which conditions are created for children to develop a more critical and rational understanding of their environment. (P11, p. 43).

To this end, the teaching and learning processes must be organized considering: the students' context and the issues pertinent to their reality and interest; the use of different languages, codes, and technologies; the development of the students' protagonism; and the carrying out of investigative activities, according to the passages presented below.

> [...] existing relations between the knowledge systematized by the school and the issues that students face in their daily lives. (P4, p. 40).

> [...] science teaching needs to be rethought in order to highlight the possible relationships of scientific content with students' lives. (P5 p. 149).

> [...] students are (or should be) stimulated to appropriate different languages, codes, and technologies in order to develop their reading of the world. (P7, p. 36).

> ...] stimulate the students' protagonism before the reality in which they are inserted, in a dialogical environment, in which teachers and students become partners in the search for scientific knowledge and in the resolution of socially relevant problems. (P7, p. 37).

> [...] children can adopt an investigative and exploratory posture in relation to their environment, how they employ arguments, communicate the findings of their investigations, and dialogue with their peers. (P11, p. 48).

Furthermore, we have already pointed out that MC practices favor interdisciplinarity and we also recognize that practices based on the development of CA favor interdisciplinary pedagogical contexts and stances, whereby relationships across areas allow "students to make decisions and realize both the many uses of science and its implications for improving the quality of life, and the limitations and negative consequences of its development" (CHASSOT, 2007, p. 46). The following excerpts evaluate the authors' perspectives on CA,

> CA including in the curriculum [...] production and application of scientific and technological knowledge, advocating an interdisciplinary teaching. (P7, p. 27).

> [...] Scientific Literacy in a CTS perspective the possibility of integrating different areas of knowledge. (P8, p. 11).

> [...] relates the work of Scientific Literacy with reading and writing of the mother tongue as an interdisciplinary work. (P9, p. 104).

> Thus, the themes of the investigation projects developed by the children took on an interdisciplinary character. (P11, p. 28).

Furthermore, we would like to highlight that the study by Sasseron (2008) presents some skills, which are grouped into what she calls the Structuring Axes of CA and that should be considered when planning a lesson that prioritizes the development of students' CA: basic understanding of fundamental scientific terms, knowledge and concepts; understanding of the nature of science and the ethical and political factors surrounding its practice; understanding of the relationships between science, technology, society and the environment.

In this sense, the author presents CA indicators, which aim to identify whether the skills presented in the three structuring axes are being worked and developed. The indicators involve: information serialization, information organization, information classification, logical reasoning, proportional reasoning, hypothesis raising, hypothesis testing, justification, prediction, and explanation.

We observed that the ideas of raising, testing, justifying hypotheses, making predictions, and explaining are intrinsically covered in the steps of the modeling process. In addition, when performing modeling activities, the student develops skills such as: searching for information, interpreting graphs, tables, and illustrations, communicating results, formulating and solving problems, constructing arguments, thinking critically, working in groups, which allow scientific understanding and world reading. The following passages denote these aspects

> [...] it was found that the insertion of Mathematical Modeling in the early years is possible and should be considered by those who are part of this context, because through it is possible to understand and interpret the different situations present in everyday life. (P2, p. 100).

> Modeling favors the interaction between mathematical language and different languages used in everyday practices, contributing for students to become critical citizens, able to actively participate in decision making for society. (P3, p. 9).

> The actions of problematization and investigation, characteristic of Mathematical Modeling [...] can lead students to develop the ability to deal critically with problem situations. (P3, p. 27).

> Mathematical Modeling is proposed as an alternative to pedagogical practices associated with the classroom, practices that aim to promote [...] an education in which students are prepared to act critically and autonomously in society. (P6, p. 43).

> Undertaking Modeling activities in the classroom, therefore, means providing investigation activities that start from a problem, go through the development of hypotheses and action plans, different resolution routes, and culminate in interpretations of the initial situation in terms of the results obtained. (P12, p. 23).

Hence, anchored on the empirical data from the analyzed researches, we confirm our hypothesis and recognize that the MC pedagogical practices can contribute to the development of CA. However, for this intertwining to be possible, there is a need to enable teachers in (continuing) education to experience both processes and overcome some obstacles or resistance, as denoted in the following passages:

> [...] The vision of having to perform a work with mathematics, obeying the linearity in which the contents are arranged in the school curriculum [...] thus reinforcing the need for research work involving Modeling, more focused on this scope of education, as well as reflections involving the in-service training of teachers who already work with these students. (P1, p. 101).

> ...] from the workshops, we identified feelings of resistance, discomfort with the new and insecurity - especially in relation to the mastery of mathematical content. To overcome these feelings, continuing education courses and the

> possibility of working with new proposals and themes that promote the development of Mathematical Modeling in the early years are pointed out. (P2, p. 101).
>
> [...] even advocating the inclusion of mathematical modeling in the training of future teachers for this level of schooling. (P6, p. 25).
>
> Thus, for scientific literacy to actually occur in school, it is necessary to go beyond the textbook, oral presentations, decontextualized exercises, and memorization (mechanical repetition) of scientific concepts. (P7, p. 37).

The obstacles to be overcome require transformations in the formative processes and in the practice of teachers and a more dialogic, investigative, guiding, and mediating posture in the teaching and learning processes.

CONSIDERATIONS

This review study aimed to recognize the research conducted on the theme "Modeling in Science and Scientific Literacy in the early years" as well as to understand how modeling practices favor the development of CA. In addition, we sought to highlight the understanding of the authors in relation to the words model, modeling and CA.

In relation to the word model, we showed that it is associated with the idea of representation of something (concrete or abstract) and linked to pedagogical processes with the sense of pedagogical model. As for modeling, we point out that it is associated with the notion of elaboration of a model and as a means that qualifies the teaching and learning processes, enables interdisciplinary relationships and the questioning of the reality experienced. In relation to CA we recognize it as a process that allows the use of scientific knowledge to read, understand and transform the environment in which we are inserted.

The recognition of the elements that provide evidence of CA allowed us to show that the pedagogical practices of MC favor the development of CA, as they involve students in problems arising from their social context, thus stimulating their interest and scientific curiosity in an integrated way with other areas of knowledge.

Moreover, in the early years of elementary education, students need to elaborate new explanations, make appropriate choices at each moment of the learning process to understand and interpret their daily lives in the context of the world in which they live and make responsible decisions. Thus, through MC practices, we can favor the development of other reading and writing skills. In addition, the modeling process, in its different stages, as marked in this text, carries with it the development of skills recognized as indicators of CA and, therefore, practices based on the assumptions of MC constitute a favorable environment for the development of CA.

Finally, for the interweaving of modeling practices and the development of CA to be present in the school context, we believe in the need for discussions and experience of both processes in teacher education.

Modelagem nas ciências e a alfabetização científica nos anos iniciais: um estudo de revisão

RESUMO

Este trabalho tem como objetivo reconhecer as pesquisas realizadas acerca da temática Modelagem nas Ciências-MC e Alfabetização Científica-AC nos anos iniciais, bem como, compreender como práticas de Modelagem nas Ciências contribuem para o desenvolvimento da AC nos anos iniciais da Educação Básica. Para fins de contribuir com nosso estudo realizamos uma pesquisa qualitativa do tipo bibliográfica e buscamos na Biblioteca Digital Brasileira de Teses e Dissertações disponibilizada pelo Instituto Brasileiro de Informação em Ciência e Tecnologia (IBICT) pesquisas na forma de teses e dissertações. Selecionamos 13 estudos para análise no período de 2010 a 2020. As pesquisas são analisadas mediante os procedimentos da Análise de Conteúdo, a qual permitiu evidenciar a palavra “modelo” atrelada a noção de representação e “modelagem” como um meio para qualificar os processos de ensino e aprendizagem. Em relação à AC, esta é compreendida como um processo pelo qual utilizamos informações de cunho científico para ler, compreender e transformar o meio no qual estamos inseridos. Além disso, o processo de modelagem permite o desenvolvimento de habilidades que carregam consigo indicadores de AC, a saber: formulação de problemas; busca de informações; interpretação de gráficos, tabelas e ilustrações; comunicação de resultados e construção de argumentos para a resolução do problema. Entretanto, para que o entrelaçamento de MC e AC se faça presente na sala de aula há necessidade de favorecer a vivência de ambos os processos na formação de professores.

PALAVRAS-CHAVE: Práticas Pedagógicas. Ensino de Ciências e Matemática. Formação de professores.

NOTES

1. We sometimes use the word modeling to denote Modeling in the Sciences in order to avoid repetition.

2. T - Type of academic work: D - Dissertation, T - Thesis.

3. Frequency of papers - "10 out of 13 papers analyzed".

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