

Forays into the Field of Science, Technology and Society in Northeastern Brazil through Systematic Mapping

Evaldo Raymundo Dias da Silva¹, Ricardo José Rocha Amorim²

¹Attending Master's Degree in Human Ecology and Socio-Environmental Management

State University of Bahia(UNEB)

evaldodias62@gmail.com

²Doctor in Electronics and Programming by the University of Santiago de Compostela, Spain

Professor at the Post-Graduation Program of Human Ecology and Socio-Environmental Management

State University of Bahia(UNEB)

amorim.ricardo@gmail.com

Abstract— *This scientific work investigates the referrals in educational practices Science-Technology-Society in the context of northeastern Brazil, contemplates the presence of values of interests in the direction given to scientific-technological development and socio-environmental issues. Science has supported the scientific investigation in the field of Education in many countries and Technology Management Systems, an area of lower visibility, usually referred to the domain of Social Sciences and Humanities. In the specific case of Science Education, this discussion also exists, with some authors choosing the term Science Education and other Science Education. It is a position of epistemological nature that has a lot to do with the objects of study, the scientific Education of the non-specialist citizen or, in the second case, the scientific Education in curricular context. In the case of one or the other, they take as crucial the development of scientific culture as an integral part of democratic citizenship. It is the perspective of the present work, intending to reflect aspects and guidelines for the teaching of Science in an orientation of scientific culture, a concept of polysemy that always includes knowledge of content, development of critical awareness about the potential and limitations of Science and adoption of attitudes and behaviors according to the social role of each one. Thus, we signal the need to assume a new objective in educational processes, besides empowering the participation in decision-making processes involving the formulation of public policies for Science-Technology.*

Keywords— *Science. Technology. Society. Scientific and Socio-environmental Education.*

I. INTRODUCTION

This paper aims to analyze the works published in peer-reviewed journals, and the purpose of characterizing environmental education within the perspective of Science, technology and Society, from the point of view of national researchers, from research available at CAPES journals and the SUCUPIRA platform and/or in the repository of dissertations and theses of the analyzed institutions. Accordingly, this objective is guided by the following questions: what are the approaches employed in education in Science, Technology, Society and Environment (CTSA), and how is being addressed the training of teachers for primary education in scientific production in Northeast Brazil.

Therefore, it is necessary to adopt inclusion criteria, viz. availability of consultation through the web, highlighting only articles published between the years

2007 and 2017; complete articles written in Portuguese, Spanish or English; and research available in the portals hereinabove cited.

II. SYSTEMATIC MAPPING METHODOLOGY

The present research of descriptive nature entails systematic mapping that aims to “(...) provide an overview of a research area, to establish if there is evidence on a topic and provide an indication of the amount of evidence” (KITCHENHAM; CHARTERS, 2007, p. 44).

The results of an investigation of this nature can contribute to the identification of fields of study that deserve more detailed attention through a systematic review. (KITCHENHAM; BRERETON; BUDGEN, 2012)

Thus, both methods support the development of an investigation regarding the search and extraction of evidence-based data, while remaining distinct to the scope

and procedures of analysis. According to Felizardo *et al.* (2017), systematic mapping is characterized by

(...) provide a broad view of a research topic, generic research questions, search process defined by the research topic, full scope, more generic search string, and quality assessment is not mandatory, categorization of primary studies according to classification schemes (FELIZARDO *et al.*, 2017, p. 96).

Therefore, for the systematic mapping that identifies evidence in the literature, we go through a formal process defined through a research protocol, which consists of 1) survey of research questions, 2) conduct the search, 3) analysis of articles, 4) classification of articles, and 5) data extraction and mapping.

This way, we begin by formulating the research question that refers to what are the approaches employed in education in Science, Technology, Society and Environment (CTSA), and how is being approached the training of teachers for primary education in scientific production in Northeast Brazil? For this, we aim to verify how is inserted the socio-environmental education focused on education within the theme Science-Technology-Society; identify which are the teaching modalities, and the themes concentrate on scientific education and investigate which are the educational objectives inherent to socio-environmental education in the school environment.

From this stage on, the search terms for the search string were gathered, meaning the gathering of descriptors that constitute a standard. The search string forms “(...)a set of syntactic characteristics that should be found in a text segment. Those segments that meet the standard specifications are said to ‘match’ the standard” (YATES; RIBEIRO NETO, 2013, p. 254). Thus, the defined string was:

- *String 1* = (“Science” OR “Technology” OR “Society”) AND (“Science Education”) OR (“Environmental Education”).
- *String 2* = (“Teacher Training” OR “Professor Training”) AND (“Scientific Training” OR “Technological Education”).

The search for articles was based on the string formulated and applied in the search engines, being the bases: CAPES journal portal, and the SUCUPIRA platform and the repository of dissertations and theses of educational institutions.

This way, we have identified the quantity of thirty-five academic productions on Education in Science-Technology-Society (CTS) found in the Postgraduate Programs (PPG) present in the Northeast region, between 2007 and 2017. We emphasize that in the column on production on Science, Technology, and Society, the

highlighted numbers account for the two doctoral theses defended, with the others referring to dissertations.

Chart 1: Amount of researches developed about CTS in Northeast Brazil

State	IES	Program	CTS
Pernambuco	UFPE	PPGE	1
Paraíba	UEPB	PPGECM	5
Sergipe	UFS	PPGECIMA	7
Bahia	UESB	PPGECFP	6
Rio Grande	UFRN	PPGECNM	11
			TOTAL: 35

In this case, we use the search string constructed from keywords derived from the main question and the terms “CTS, CTS, C/T/S, and CT-S, CTSA¹” abbreviated or in full in the titles, abstracts, and keywords of the works.

After the identification of these studies, it was necessary to select the primary studies potentially relevant to this study. Thus, the productions were evaluated, and for this, we indicated some inclusion and exclusion criteria. According to Kitchenham and Charters (2007), these criteria are intended to identify the primary studies that provide direct evidence on the research question.

Accordingly, we have analyzed titles and abstracts and listed as inclusion criteria: studies that consider characteristics and theories of learning in socio-environmental education; studies that report and describe the development of environmental education in educational environments. Moreover, original articles in the English, Portuguese and Spanish languages; complete articles available for download in full; and primary articles, mapping and/or systematic reviews and theoretical articles.

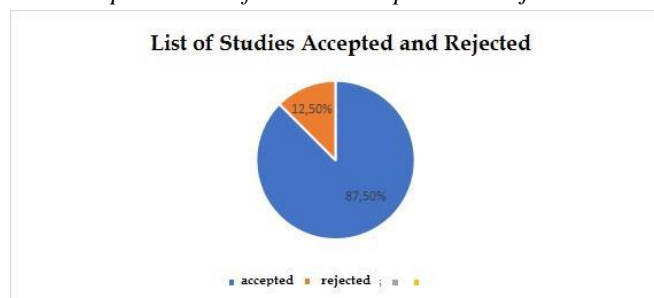
As exclusion criteria, we have established that duplicate studies; secondary and tertiary studies; and research that does not raise the problems related to environmental education within the context of Science-Technology-Society should be excluded from our selection. After this, we have captured only the most relevant works for this study.

After performing the search, forty articles have been pre-selected according to the criteria presented. Henceforth, the exclusion criteria were applied,

¹ CTSA stands for Science, Technology, Society and Environment in Portuguese.

eliminating five studies that represent 12.5% of the pre-selected articles, as shown in Graph 1.

Graph 1 – List of Studies Accepted and Rejected



In the Brazilian context and especially in the Teaching of Sciences, these discussions started only in the 1990s. In 1992, the first academic research on CTS took place in the field of Chemistry teaching and was developed by Wildson Santos, who began his studies in the area with his master's dissertation, followed by the doctoral thesis of Silvia Trivelato (1993) and the treatise of Antônio Carlos Amorim (1995).

Already in the 2000s, two essential and referenced pieces of research in the first years were published: the scientific paper by Santos and Mortimer (2001) on the theoretical assumptions of the CTS approach in the context of Brazilian education and the doctoral thesis by Auler (2002) on CTS in teacher education. From this period on, several researchers started to understand the assumptions of CTS education as guidelines for a critical and autonomous education, capable of contributing to the process of reflection and development of an integrating consciousness that would enable the unveiling of the world.

We have found the works available on the sites of graduate programs in the SUCUPIRA platform or the repository of dissertations and theses of the educational institutions. We consider ten years (2007-2017) because the first research completed in the Northeast occurred in 2007.

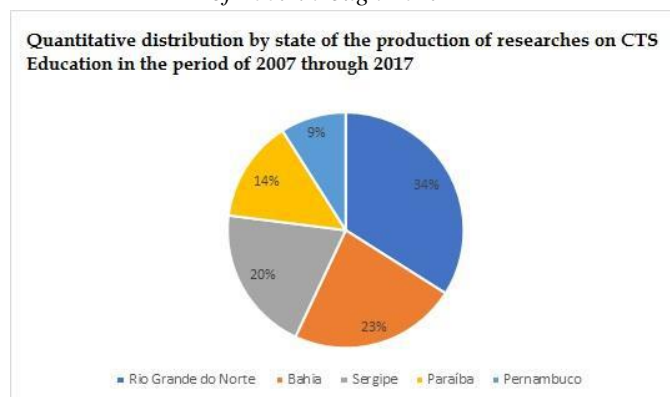
In this sense, we were able to analyze the entire regional panorama of the area. We selected thirty-five defended pieces of research, being thirty-three from master's courses and two from doctorate courses. The master's works were written by Firm (2007), Nunes (2010), Oliveira (2010), Souza (2010), Dantas (2011), Lima Neto (2012), Oliveira (2012), Silva (2012), Bitencourt (2013), Oliveira (2013), Sousa (2013), Andrade (2016), Bezerra (2014), Macedo (2014), Marques (2014), Porto (2014), Rosa (2014), Santana (2014), Silva (2014), Binatto (2015), Costa (2015), Andrade Júnior (2015), Santos, A. (2015), Santos, E. (2015), Almeida (2016),

Gomes (2016), Santana (2016), Santiago (2016), Silva, D. (2016), Silva, M. (2016), Jesus (2017), Santos, M. (2017) and Santos, R. (2017).

On the other hand, the research at the doctoral level was carried out by Firme (2012) and Nunes (2010). Although the second thesis was developed in a PPG that does not belong to the axis of Education and Teaching (the PPG in Chemistry of the Federal University of Rio Grande do Norte), we counted it for the research because it is focused on the theme of Science Teaching and dealing with the CTS education, constituting the second thesis of the Northeast. We have listed five categories of analysis that emerged from our research questions and used the reading of abstracts to categorize each work.

Thus, we located thirty-five pieces of research on the CTS theme in the Northeast PPG. This distribution by state quantifies eight productions in Bahia, five in Paraíba, three in Pernambuco, 12 in Rio Grande do Norte and seven in Sergipe. Graph 2 shows the distribution in percentage (%).

Graph 2 – Quantitative distribution by state of the production of researches on CTS Education in the period of 2007 through 2017



Characterizing trends and perspectives in dissertations and theses

The Northeast region has seventeen PPGs in Education (fifteen entitled for education, one entitled for Professional Education and the other for Education and Teaching) and thirteeprograms for Teaching Science and Mathematics (some of them only for Science, but with evaluation area in Teaching Science and Mathematics in CAPES). We have listed five categories of analysis to describe the trends and perspectives of CTS production in this region. The types include: a) CTS production by state, b) production by the graduate program, c) curriculum perspective addressed, d) context in which the researches are inserted, and e) knowledge area of research in Scientific Education.

In the context that they are inserted the researches on CTS show the trends of this perspective as to its

“implementation” in the different levels of education. We analyzed from the summaries, and sometimes in the methodology, the contexts in which the researches were found. Bringing a quantitative panorama of these characteristics leads us to understand what the regional needs are in the view of northeastern researchers. Table 1 shows the distribution of the specific areas of the research context.

Chart 2 – Context of development and/or discussion of researches

CONTEXT	QUANTITY	%
Primary school	2	6%
Primary and secondary school	1	3%
Secondary school	11	31%
Continuing formation of	7	20%
Continuing formation of teachers and secondary school	2	6%
Initial formation of teachers, technologists and bachelors	12	34%

We have found that the research is divided into two broad lines, i.e. teaching and learning and teacher training. Two surveys included in this last line discuss teacher training and include other subjects in their research, such as bachelor's degree students and technologists. CTS education is also related to discussions on the Science curriculum and provides for its (re)organization. From this table, we note that the highest production rates correspond to initial and continuing teacher education (54%) and secondary education (31%). The training processes focused on CTS Education are also targets of investigations throughout Brazil (PRUDÊNCIO, 2013; SILVA, 2014; MÜNCHEN, 2016; ROSA; ARAÚJO, 2017).

These surveys indicate the need to work on proposals for the training of teachers that aggregate critical references, in the context of CTS education, since there is a lack of discussion on the assumptions of this perspective in teacher training. Many pieces of research still related to teacher education are focused on conversations on the conceptions of Science, Technology, and Society.

Studying the area of knowledge that the CTS perspective is linked is necessary to delimit the spaces in which it gains repercussion. It is evident that many of these

results are related to the area of its origin in the Brazilian context and we know that studies on CTS in Brazil began in the Teaching of Chemistry, followed by the Teaching of Biology and then by the Teaching of Physics. However, researchers in the Teaching of Chemistry and Physics followed the line of research even more intensely at the end of the 1990s and have become references in the area to this day. This process of arrival of the CTS perspective in the Brazilian context and its consequent repercussion in the Teaching of Chemistry generated countless researches in this area.

Today, Chemical Education is the area of knowledge in Sciences that has more materials in the CTS perspective. Wildson Santos, in co-authorship with other researchers, articulated projects that originated chemistry textbooks² based on socio-scientific aspects that enhance dialogical interactions in the classroom, facilitating the emergence of students' experiential situations and the development of attitudes and values in a humanistic perspective (SANTOS; MORTIMER, 2009). With this material, Wildson Santos and Gerson Mortimer, still in the 1990s, sought through the thematic contextualization, to introduce texts that problematize the reality of subjects and contribute to the formation of citizenship (SANTOS, 2007).

III. RESULTS AND DISCUSSIONS

Concerning research approaches, in general, we identified that the works sought, above all, to propose and undertake formative experiences in the field of primary education or teacher training aligned with themes that arise from the reality of the subjects of each investigation.

Besides, despite adopting diverse transversal themes or more specific contents, all with potential for the development of interdisciplinary proposals, the selected researches stopped to present the issues with greater emphasis on the perspective of a single subject.

Based on what was analyzed, it becomes necessary a greater diffusion of the CTS approach in the scope of the Postgraduation Programs in the Northeast due to the low scientific production, a fact observed in the number of productions in this region when compared to other areas of the country, expanding the debate about the need for a scientific and technological development aligned with the desires and the well-being of humanity and the environment.

Analyzing some dissertations published in Graduate Programs in the area of Teaching of Natural Sciences in the Northeast region, based on the areas of knowledge that

²Chemistry on Society (1998), Chemistry and Society (2003), and Chemistry Citizen Science (2010, 2013, 2016).

each research took as focus, we achieved the following results: the investigations that opted for various themes, had as focus the treatment of cross-cutting issues, addressing the theme water for elaboration and application of didactic sequences. The dissertations focused on discussing problems emerging from the context of the research participants, such as: the process of degradation of the river Apodi-RN (NUNES, 2010), the quality of water supplied in the municipality of Cuité-PB (MARQUES, 2014), and the relationships between the theme evaporation and the constant scarcity of water in the city of Santa Cruz-RN (BEZERRA, 2014).

Dantas Filho, Silva e Silva (2015) point out that the theme water can be well explored and contextualized in the Teaching of Chemistry, because it is possible to work with conceptual and socio-scientific aspects, through contents such as the law of conservation of masses, chemical bonds, physical states of matter, energy involved in the relationships, solutions, chemical reactions, speed of responses, concentration, etc.. In addition, the approach to this topic in the classroom universe, and in particular in the Teaching of Sciences, is related to the fact of making approximations between the chemical concepts and the situations of the student's daily life.

The dissertations that developed proposals focusing on several simultaneous contents used Information and Communication Technologies (ICT) as educational resources. Developing activities focused on content: hydrostatic and gravitation, like Dantas (2015) who used films as a strategy for the teaching of physics. Concerning the CTS subcategory in education, the classified works aimed to provide experiences in the area of teacher training as a contribution of Science, Technology and Society and their relations with the Teaching of Natural Sciences and Mathematics. In Firme's research (2007), the focus was to analyze the conceptions of teachers about CTS and the use of this perspective by teachers during their classes.

In this sense, Santos et al. (2015) state that it is essential to develop teaching proposals that can work on themes that generate from scientific concepts, seeking to bring problematizing situations that are within the context of students' lives so that scientific literacy occurs of these subjects.

In Silva (2012), the idea was to analyze the contributions of a formative proposal on the CTS approach in the training of teachers of mathematics. In this context, Silva et al. (2014) state that teacher training should offer an education for the exercise of citizenship and is a primary function of public educational policies, as established by the Brazilian constitution and the teaching legislation.

This function has been defended by several teachers researchers of primary education, attributing to the disciplines of Science of Nature the role of providing a critical, participatory, reflective and human education (SANTIAGO, 2016). The only research that opted to work with a specific content was that of Lima Neto (2012) which aimed to develop an educational experience about the concept of energy, taking as thematic axis the sustainable theme development. According to the author (2012), the didactic sections developed sought to work beyond the concept of energy, "(...) understand its transformations and conservation law, as well as its production, distribution and consumption processes in the context of the laws of physics in which it is involved" (LIMA NETO, 2012, p. 6).

IV. FINAL CONSIDERATIONS AND SUGGESTIONS FOR FUTURE WORK

We understand that analyzing the conceptions of teachers in practice is the starting point to discuss CTS Education in teacher training, but we know that research needs to advance in order to promote training processes or moments of dialogue for greater engagement of teachers with this perspective of making available working conditions to teachers that enable a broad discussion on social and environmental education within a theme that favors Science, technology and social aspects.

The concerns for the discussion of a work like this will always be expanding our readings. This is because we understand that, although there is still much to be defined in CTS education, it is necessary to advance in the discussion so that the interrelationships in CTS are introduced in research not only as a field of study but as an essential and emerging field for human formation from the attendance of our regional needs. This survey also brings us apprehension about the states of the Northeast region that do not debate widely on the CTS perspective. Simultaneously, we are disturbed by the fact that in the countries where studies on this topic are found, most of them, even though finalized, have not yet been published in journals in the area of Science Education.

The weaknesses on the publications scenario evidenced in this systematic mapping may subsidize future investigations that broaden the scope of the search and address other issues that permeate the knowledge on teacher training for education in Science, Technology, and Society.

REFERENCES

- [1] AMORIM, A. C. R. **O ensino de biologia e as relações entre ciência/tecnologia/sociedade: o que dizem os professores e o currículo do ensino médio?**

- Dissertação (mestrado) – State University of Campinas, School of Education, Campinas – SP, 1995. Available at <<http://www.repositorio.unicamp.br/handle/REPOSIP/253841>>. Accessed on 20th July, 2018.
- [2] ANDRADE JÚNIOR, J. A. **Episódios históricos no contexto do ensino de ciências: a energia nuclear e sua utilização**. Dissertação – State University of Paraíba, Campina Grande, 2015.
- [3] AULER, D. **Interações entre ciência-tecnologia-sociedade no contexto da formação de professores de ciências**. Tese de Doutorado em Educação – Federal University of Santa Catarina, Florianópolis: CED/UFSC, 2002.
- [4] BEZERRA, M. E. B. **Um estudo sobre o ensino de evaporação no contexto ciência, tecnologia e sociedade**. Dissertação (mestrado) – Federal University of Rio Grande do Norte, 2014. Available at <https://repositorio.ufrn.br/jspui/handle/123456789/19488>. Accessed on 20th September, 2018.
- [5] BINATTO, P. F. **Enfoque Ciência, Tecnologia e Sociedade na Formação Reflexiva de Futuros Professores de Biologia**: Possibilidades, Desafios e Contribuições. Dissertação – State University of Southwest Bahia, Jéquié, 2015.
- [6] DANTAS FILHO, F. F.; SILVA G. N. AND SILVA, H. C. **Entendimento da abordagem CTSA no ensino de química e as dificuldades apontadas por professores de escolas da cidade de Campina Grande – PB** em séries e nos seus ensinos. In: Revista Scientia Amazonia, v.4, 2015. Available at <http://scientia-amazonia.org/wp-content/uploads/2016/06/v4-n2-100-106-2015.pdf>. Accessed on 14th June, 2018.
- [7] FELIZARDO, K. R. *et al.* **Systematic Mapping On The Use Of Visual Data Mining To Support The Conduct Of Systematic Literature Reviews**. Journal of Software, 2017, p. 450-461.
- [8] FIRME, R. N. **A abordagem ciência-tecnologia-sociedade (CTS) no ensino da termoquímica: análise da construção discursiva de uma professora sobre conceitos científicos**. Tese (doutorado) – Federal University of Pernambuco, 2012. Available at <https://repositorio.ufpe.br/handle/123456789/13025>. Accessed on 20th July, 2018.
- [9] FIRME, R. N. **A implementação de uma abordagem CTS (Ciência-Tecnologia-Sociedade) no ensino da química: um olhar sobre a prática pedagógica**. Dissertação (mestrado) – Federal Rural University of Pernambuco, Recife, 2007.
- [10] KITCHENHAM, B.; CHARTERS, S. **Guidelines for performing Systematic Literature Reviews in Software Engineering**. 2.3 ed. Durham, 2007.
- [11] KITCHENHAM, B; BRERETON, P; BUDGEN, D. **Mapping study completeness and reliability – a case study**, IET, 2012.
- [12] LIMA NETO, J. A. **O uso da abordagem CTSA no ensino de energia tendo o desenvolvimento sustentável como eixo temático**. Dissertação (mestrado) – Federal University of Rio Grande do Norte, Natal, 2012.
- [13] MARQUES, A. M. **Açude do Cais: uma proposta de aplicação de uma sequência de atividades didáticas em um contexto real**. Dissertação – Mestrado em Ensino de Ciências Naturais e Matemática – Federal University of Rio Grande do Norte, Natal, 2014.
- [14] MÜNCHEN, S. **A inserção da perspectiva Ciência-Tecnologia-Sociedade na formação inicial de professores de Química**. Tese (Doutorado em Educação) – Federal University of Santa Maria, Rio Grande do Sul, 2016.
- [15] MÜNCHEN, S. **As pesquisas sobre Ciência, Tecnologia e Sociedade no Nordeste: um retrato das dissertações na área de ensino de ciências naturais e matemática**. Conexões: Ciência e Tecnologia, v. 10, n. 4, 2016, p. 42 – 50.
- [16] NUNES, A. O. **Abordando as relações CTSA no ensino da química a partir das crenças e atitudes de licenciandos: uma experiência formativa no Sertão Nordestino**. Dissertação – Federal University of Rio Grande do Norte, Natal, 2010.
- [17] OLIVEIRA, T. B. **Ensino de ciências na perspectiva CTS: concepções e práticas escolares**. Dissertação – Federal University of Sergipe, 2013.
- [18] PRUDENCIO, C. A. V. **Perspectiva CTS em estágios curriculares e em espaços de divulgação científica: contributos para a formação inicial de professores de Ciências e Biologia**. Tese (doutorado) – Federal University of São Carlos, São Carlos, 2013.
- [19] ROSA, S. E.; ARAÚJO, W. S. **Processos Formativos no Contexto Brasileiro: uma articulação dos pressupostos de Freire e a Educação CTS**. In: XI Encontro Nacional de Pesquisa em Educação em Ciências. Anais... Atas do XI ENPEC, 2017. Available at <http://www.abrapecnet.org.br/enpec/xi-enpec/anais/resumos/R1454-1.pdf>. Accessed on 6th August, 2018.
- [20] SANTIAGO, J. F. A. **O uso de textos de divulgação científica com o recurso didático em aulas de biologia: concepções e relações com a abordagem CTS de ensino**. Dissertação (mestrado) – Federal University of Rio Grande do Norte, Natal, 2016.
- [21] SANTOS, D. G.; *et al.* **A Química do Lixo: utilizando a contextualização no ensino de conceitos químicos**. In: Revista Brasileira de Pós-graduação, 2012. Available at <http://ojs.rbpg.capes.gov.br/index.php/rbpg/article/view/241/233>. Accessed on 15th July, 2018.
- [22] SANTOS, W. L. P. **Educação científica humanística em uma perspectiva freireana: resgatando a função do ensino de CTS**. In: Alexandria: Revista de Educação em Ciência e Tecnologia, 2007. Available at <https://periodicos.ufsc.br/index.php/alexandria/article/view/37426>. Accessed on 10th September, 2018.
- [23] SANTOS, W. L. P.; MORTIMER, E. F. **Tomada de decisão para ação social responsável no ensino de ciências**. In: Ciência & Educação, Bauru, 2001. Available

at http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-73132001000100007. Accessed on 10th July, 2018.

- [24] SILVA, D. J. R. **Abordagem CTS e ensino de matemática crítica: um olhar sobre a formação inicial dos futuros docentes.** Dissertação (mestrado) – Federal University of Paraíba, Campina Grande, 2012.
- [25] SILVA, *et al.* **Práticas avaliativas e aprendizagem significativas em diferentes áreas do currículo.** Editora Mediação, 2014.
- [26] TRIVELATO, S.L.F. **Ciência, Tecnologia e Sociedade: mudanças curriculares e formação de professores.** Tese (doutorado) – School of Education, University of São Paulo, 1993.
- [27] YATES, R. B; RIBEIRO NETO, B. **Recuperação de Informação: Conceitos e Tecnologia das Máquinas de Busca,** Ed. Bookman, 2013.