

STSE Approach in High School Chemistry: A Brief Review in National Literature

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ABSTRACT

Today we live in an increasingly scientific and technologically developed society that has promoted transformations in the social, political and economic environment. This development brought with it the illusion that all social and cultural problems would be solved, creating a traditional image of this science, in which its development would be free of particular interests. In order for the community to be able to understand the relations between science and the collective, it is necessary to have debates about the subject, and thinking about it, the movement called Science, Technology, Society and Environment (STSE) was created, representing a critical study group about the traditionalist and essentialist view of science and technology. The STSE studies seek to understand their social dimensions and even their consequences. Thus, this study has as main objective to review the Brazilian literature in search of articles that work the STSE approach in the teaching of Chemistry in the context of the high school classroom, with the intention of training citizens critical about the most diverse subjects of this. This research has a qualitative character, as it allows the researcher a better approximation and understanding of the facts studied. The articles were searched in national journals that allow free access and with Qualis A1, A2 and B1 Qualis according to the CAPES Qualis-Periodical system. In all, 24 journals were found, but only 8 articles were found with the theme under study, being found 14 in total. The selected papers cover the topics of Acids and Bases (1), Physical-Chemistry (1), Environmental Chemistry (3), Organic Chemistry (8) and Radioactivity (1), in which teaching was conceived in the STSE precepts to promote greater contextualization and the formation of the critical citizen. All the creators of the researches sought through the STSE to make the classes more attractive and dynamic, centring the construction of the knowledge in the student through the stimulation of the research.

Keywords: STSE Approach; Teaching Chemistry; National Periodicals; Bibliographical Study.

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Abordagem CTSA na Química do Ensino Médio: Breve Revisão na Literatura Nacional

RESUMO

Hoje vivemos em uma sociedade cada vez mais desenvolvida científica e tecnologicamente, que promoveu transformações no meio social, político e econômico. Esse desenvolvimento trouxe consigo a ilusão de que todos os problemas sociais e culturais seriam resolvidos, criando uma imagem tradicionalista dessa ciência, em que seu desenvolvimento estaria livre dos interesses particulares. Para que a comunidade possa entender as relações da ciência com o coletivo é preciso que haja debates acerca do assunto. Pensando nisso, foi criado o movimento chamado de Ciência, Tecnologia, Sociedade e Ambiente (CTSA), que representa um grupo de estudo crítico acerca da visão de natureza tradicionalista e essencialista da ciência e tecnologia. Os estudos em CTSA buscam compreender suas dimensões sociais e até mesmo suas consequências. Com isso, este estudo tem como objetivo principal analisar por meio de uma revisão na literatura brasileira os artigos que trabalhem a abordagem CTSA no ensino de Química no contexto da sala de aula do Ensino Médio, com o intuito de formar cidadãos críticos acerca dos mais diversos assuntos dessa ciência. Esta pesquisa tem caráter qualitativo, pois permite ao pesquisador uma melhor aproximação e compreensão dos fatos estudados. Os artigos foram pesquisados em periódicos nacionais que permitem o acesso integral gratuito e com classificação Qualis A1, A2 e B1 de acordo com o sistema Qualis-Periódico da CAPES. Ao todo foram encontrados 24 periódicos, mas somente em 8 foram achados artigos com a temática em estudo, sendo encontrados 14 no total. Os trabalhos selecionados abordam as temáticas de Ácidos e Bases (1), Físico-Química (1), Química Ambiental (3), Química Orgânica (8) e Radioatividade (1), em que o ensino foi pensado nos preceitos do CTSA para promover uma maior contextualização e a formação do cidadão crítico. Todos os idealizadores das pesquisas buscaram, através do CTSA, tornar as aulas mais atrativas e dinâmicas, centrando a construção do conhecimento no aluno através da estimulação da pesquisa.

Palavras-chaves: Abordagem CTSA. Ensino de Química. Periódicos Nacionais. Estudo Bibliográfico.

INTRODUCTION

Today we live in an increasingly technological and scientific world where there have been changes in the ways of getting around, studying, communicating, etc., in which such transformations have influenced social, political and economic development (Pinheiro, Silveira & Bazzo, 2009). This immersion of society in a highly technological and scientific world brought with it the false idea that all social and cultural problems would be solved with access to these tools, as Santos and Mortimer (2002, p.111) point out “Modern societies have passed to rely on science and technology as one trusts in a deity”.

There is a traditional image of science and technology in which the conception of the relation between technology, science and society is given by the essentialist and apothetic aspect where Palacios et al. (2001, p.120) summarize in a simple equation that they themselves call a *modelo lineal de desarrollo* (linear model of development): + science = + technology = + wealth = + social welfare. According to the authors, this conception is very present in the academic world.

Society is aware of this technological and scientific development through the media. But despite the many reports on the risks of installing nuclear power plants, the uncertainties about the use of transgenic foods, the disasters caused by the oil industries, the recycling of rubbish that is still minimal in several places, people are still not aware of the problems that such issues can generate in the short and long term (Pinheiro, Silveira & Bazzo, 2009). These authors still highlight the lack of knowledge that the population has about the interests of large corporations to profit, disguised as technological development and improvements for the people.

Palacios et al. (2001, p.120, our translation) highlight in their studies a brief summary of the myths of the so-called Research and Development system, or R & D system, being

- Myth of Infinite Benefit: More science and more technology will inexorably lead to more social benefits.
- Myth of unimpeded research: any reasonable line of research on fundamental natural processes is just as likely to produce a social benefit.
- Myth of responsibility: peer arbitration, reproducibility of results, and other quality controls of scientific research sufficiently account for moral and intellectual responsibilities in the R & D system.
- Myth of authority: scientific research provides an objective basis for resolving political disputes.
- Myth of the endless frontier: the new scientific knowledge generated at the frontier of science is autonomous in relation to its practical consequences in nature and society.

Therefore, science in the classical view could only develop independently pursuing only its objectives, which would be to discover truths about nature, thus remaining free of the influences caused by the social. In the same way, technology also needs the independence of social interference, to be able to develop autonomously. With this, science and technology are presented as a form of culture and activities of neutral values.

Studies in sociology and the philosophy of science have shown that it is erroneous to think of science as superior to other forms of knowledge, and that the idea of a “science for science” is being tested inconceivably by the various debates generated by the consequences that science and technology have generated to the environment (Santos & Mortimer, 2002, p.111).

Proposals from the scientific-technological context should be effective and active, and may actually influence the subject under debate, allowing the public to become involved in the problems and not only in the final decision, which could already be planned. (Pinheiro, Silveira, & Bazzo, 2009, p.2)

But for this to happen, it is necessary for society to get involved in the debates on the subjects that involve the common good, and to discover that it is possible to resolve conflicts through the basis of discussions. We must emphasize that for this to happen, it is necessary to have a technological-scientific formation, so with this assumption, a movement has been developed in several sectors of society called Science, Technology, Society and Environment, more known by the acronym STSE (Pinheiro, 2005).

The STSE movement represents a critical study group about the vision of a traditionalist nature, in which science is seen in isolation without taking into account the implications for society, and essentialist, in which it is believed that more scientific and technological development necessarily means more social well-being. The studies in STSE seek to understand their social dimensions and even their social and environmental consequences, regarding “both the social and political factors that modulate the scientific and technological change, regarding the ethical repercussions, environmental or cultural changes “(Palacios et al., 2001, p.125, our translation).

This article aims to analyze, through a review in the Brazilian literature, the articles that work the STSE approach in the teaching of Chemistry in the context of the High School classroom, with the intention of forming critical citizens about the most diverse subjects of this science.

ORIGINS OF THE MOVEMENT SCIENCE, TECHNOLOGY, SOCIETY AND ENVIRONMENT (STSE)

To open this discussion, we will clarify the use of the acronym STSE (Science, Technology, Society and Environment). Some authors began to add the “E” of “Environment” to the acronym, not because they thought this theme would not be addressed in the discussion of the movement, but because they believed that with the addition of the letter, more attention would be given (Santos & Auler, 2001, pp.179-180, as cited in Vacheski, 2016). In order to adapt to the “modernization” of the acronym, if we can say so, we decided to use the acronym STSE.

The STSE movement took on importance from the mid-1960s to the early 1970s, highlighting as one of its themes “the need for citizens to know their rights and obligations, to think for themselves and to have a critical view of society where lives, and especially to have the disposition to transform reality for the better” (Pinheiro, 2005, p.2). This movement emerged as a response to the growing feeling that the development of science and technology did not have a one-dimensional relationship with common welfare, as has been believed since the nineteenth century and with renewal after World War II (Linsingen, 2007).

Even before the beginning of this movement, people were already discussing the role of science and technology in society. However, the major focus was given to the meaning of what was scientific activity itself, so that the scientific method and to distinguish what was and what was not considered science (Pinheiro, 2005). The author also emphasizes

that “this understanding does not take into account the historical questions or the relations between the scientific activity and the social contexts in which it develops, supposing that science is neutral in relation to the historical-social context” (Pinheiro, 2005, p.29).

Palacios et al. (2001) emphasize that

The most innovative aspect of this new approach is found in the social characterization of the factors responsible for scientific change. Generally it is proposed to understand science-technology, not as an autonomous process or activity that follows an internal logic of development in its optimal functioning (resulting from the application of a cognitive method and a code of conduct), but as a process or product inherently social, where non-epistemic or technical elements (for example moral values, religious convictions, professional interests, economic pressures, etc.) play a decisive role in the genesis and consolidation of scientific ideas and technological artifacts. (p.125-126, our translation)

The movement also has as one of its assumptions, to emphasize that science and technology have a social role of importance, in which it is necessary to develop critical evaluations and analyzes in an impartial and reflexive way about the scientific-technological link and the community (Pinheiro, Silveira, & Bazzo, 2007).

This criticality is necessary, since society in general still believes that the greater the production of scientific knowledge, the greater the technological production, which, supposedly, will increase the development of the nation, and as a consequence, the common welfare. This type of thinking that was described above is called by Palacios et al. (2001) of linear development. This idea is reinforced by Bazzo (1998), p.145 apud Pinheiro (2005, p.29), stating that there is a “belief that science translates into technology, technology modifies industry, and industry regulates the market to produce social benefit.”

This conception of a linear model of development gained momentum after World War II, since after that period there were many technological developments, serving the common interests to promote the quality of life of the people, in which we can mention as example: the development of the first computer, transplants of organs, use of nuclear energy for transportation, invention of the contraceptive pill, among others (Palacios et al., 2003).

In its beginning, as pointed out by Palacios et al. (2001), the STSE movement has developed in three main directions: research, public policy and education.

- In the field of research, STS studies were raised as an alternative to traditional academic reflection on science and technology, promoting a new non-essentialist and socially contextualized view of scientific activity.

- In the field of public policy, STS studies have advocated social regulation of science and technology, promoting the creation of a number of democratic mechanisms that facilitate the opening of decision-making processes on issues related to science and technology policies.
- In the field of education, this new image of science and technology in society has crystallized the emergence of STS programs and subjects in secondary and university education in many countries. (p.127, our translation)

With the purpose of knowing and analyzing the extension of science and technology from social and historical points of view, and also to evaluate the linear model of development that had been established so far, STSE in Europe and the United States (Pinheiro, 2005). In the European origin, the study was carried out in the character of the social changes of the binomial science-technology, while the tradition of North American origin was centered in the environmental and social consequences with scientific-technological field and its ethical problems (Palacios et al., 2003). Below we can see in Table 1 the summary comparing the two traditions of the STSE adapted from Palacios et al. (2003, p.128, our translation).

Table 1
Difference between European and American STSE traditions.

European tradition	North American tradition
Academic Institutionalization in Europe (in its origins)	Administrative and academic institutionalization in the United States (in its origins)
Emphasis on social background factors	Emphasis on social consequences
Attention greater to science, and secondary to technology	More attention to technology with a secondary look at science
It has a theoretical and reflective character	Practical and evaluative character
Explanatory table: social sciences (sociology, psychology, anthropology, etc.)	Evaluative structure: ethics, theory of education, etc.

Source: Adapted from Palacios et al. (2003, p.128, our translation).

STSE APPROACH TO EDUCATION

It is the citizen's duty to have decision-making power and know how to make choices without relying solely on its political representatives, having the ability to express opinions and have the power to make informed decisions. Thus, one of the objectives of the teaching based on the principles of the STSE is to provide education geared to social formation geared towards science and technology taking into account its social context. (Palacios et al., 2003; Pinheiro, Silveira & Bazzo, 2009).

The STSE curricula in education have a relational character, in which the knowledge studied is viewed from different perspectives, emphasizing the relations between society,

science and technology (Santos & Mortimer, 2002). These authors present a summary table with these illustrated relationships, which can be observed in Table 2.

Table 2
Clarifications of the CTSA approach in education.

Aspects STSE	Clarifications
1. Effect of Science on Technology	The production of new knowledge has stimulated technological change.
2. Effect of Technology on Society	The technology available to a human group greatly influences the lifestyle of this group.
3. Effect of Society on Science	Through investments and other pressures, society influences the direction of scientific research.
4. Effect of Science on Society	The development of scientific theories can influence the way people think about themselves and about problems and solutions.
5. Effect of Society on Technology	Public and private pressures can influence the direction in which problems are resolved and, as a consequence, promote technological change.
6. Effect of Technology on Science	The availability of technological resources will limit or enhance scientific progress.

Source: McKavanagh and Maher, (1982, p.72) as cited in Santos and Mortimer, (2002, p.121).

As pointed out by Pinheiro, Silveira and Bazzo (2009), since the beginning of the follow-up of studies based on the STSE, about 30 years ago, education with this approach has been one of the main fields of research. The authors emphasize that

[...] the importance of discussing with students the advances of science and technology, their causes, consequences, economic and political interests, in a contextualized way, lies in the fact that we must conceive science as the fruit of human creation. Therefore, it is closely linked to the evolution of the human being, developing itself permeated by the reflexive action of those who undergo / acts the various crises inherent in this development process. (Pinheiro, Silveira, & Bazzo, 2009, p.10)

Therefore, we can return to the discussion of the question proposed above on the linear conception of development. It is imperative that students understand that science is not neutral, and that often represents the interest of those who finance it (big companies, industries, government), hence the importance of knowing and discussing their advances in a contextualized way.

STSE APPROACH IN HIGH SCHOOL

The STSE approach has been growing with regard to secondary education (middle level), since several countries are developing teaching programs to insert this subject at this level of education (Palacios et al., 2003). These authors also point out that STSE-based education programs can be classified into three groups, in which we have: Introduction of the STSE in science content (STSE Graft); the science content seen through the STSE approach; STSE pure.

- STSE graft: in this approach the insertion of the STSE theme in science teaching is done, in which it aims to develop the critical formation of the student, in which he becomes aware of the implications of the development of science and technology and its relationship with society.
- Science content as seen through the STSE approach: in this modality, the content of the curricular component is structured through the precepts of the STSE approach, which can be done in individual chairs or through disciplinary programs for restructuring the curriculum.
- Pure STSE: from this perspective, it is taught purely STSE, where the scientific content is in the background. It may even address diverse scientific content, but only as a way of illustrating the subjects worked on in STSE.

Thus, the teaching based on the principles of the STSE does not only seek to promote a new organization of school curricula. It is important to emphasize that the objective is to promote in the student a creative and critical posture of the scientific and technological aspects of society. This construction goes beyond simple information management, seeking above all the articulation of knowledge, arguments and counterarguments, based on problems common to students, related to the implications of scientific and technological advances. (Palacios et al., 2003).

METHODOLOGICAL PATH

In order to reach the objective proposed here, this research has a qualitative character, which, according to Godoy (1995), allows the researcher a better approximation and comprehension of the facts studied, allowing the integral analysis, in which several types of data are collected about the phenomenon under study. Still according to the author, the qualitative study can follow several paths of investigation, in which he cites three with being the most known: documentary research, case study and ethnography. Considering that the data collected here come from articles published in journals, this research is characterized as bibliographical.

The articles were researched in national journals of the area of Education relevant to Chemistry or Sciences, and that allow access to their productions in an integral and free form, with *qualis* A1, A2 and B1 *qualis* according to the Qualis-Periodicals system

provided by the Coordination of Improvement of Higher-Level Personnel – CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*), database of the quadrennium 2013-2016. The cut-off period from 2007 to 2017 was defined for research. For the identification of the articles in the periodicals, the title, abstract and key words were included that covered the following terms: CTSA; CTS; Have been associated with the teaching of Chemistry.

In total, 24 journals dealing with the Teaching of Science / Chemistry were found, of which only 8 articles were found in the subject. We selected articles that deal with the use of the STSE approach in High School Chemistry, in the modalities presented here as STSE graft and science seen through the STSE precepts. In Table 3 it is possible to see the journals where articles were found that fit the one specified heretofore. They are organized by the *qualis* classification, periodical and number of articles found. In the graph of Figure 1 we can see the distribution of the years of publication of the articles found.

Table 3
Selected journals and number of articles found.

Qualis	Journals	No. of articles
A1	Ensaio. Pesquisa em Educação em Ciências	1
A2	Acta Scientiae: Revista de Ensino de Ciências e Matemática	1
A2	Investigações em Ensino de Ciências	1
A2	Rencima – Revista de Ensino de Ciências e Matemática	2
A2	Revista Brasileira de Ensino de Ciência e Tecnologia	3
B1	Ciência & Ensino	1
B1	Ensino de Ciências e Tecnologia em Revista	1
B1	Experiências em Ensino de Ciências	4
Total		14

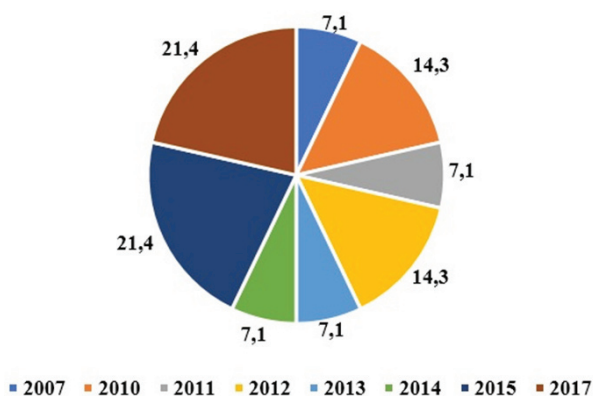


Figure 1. Distribution of articles by year of publication in percentage (%).

The 14 articles found address five subjects studied in Chemistry: Acids and Bases, Physical-Chemistry, Environmental Chemistry, Organic Chemistry and Radioactivity, which were organized in Table 4 below.

Table 4
Articles separated by content addressed.

Subject addressed	No. of articles
Acids and Bases	1
Physical-Chemistry	1
Environmental Chemistry	3
Organic Chemistry	8
Radioactivity	1
Total	14

The area of Chemistry most contemplated by the studies was organic, found in 8 papers. This subject is usually addressed in the last year of high school, and enables the teacher to perform a number of contextualized practical classes, which may explain the greater number of studies directed to it. Another fact to be highlighted is that two of the content contemplated are not much worked in high school, they are: Radioactivity and Environmental Chemistry. This shows that the STSE approach can provide a new vision about these contents, and can be contextualized with the daily life of the student.

RESULTS AND DISCUSSION

The results of the research were constructed from the analysis of the data highlighted in Table 4, where they are organized by content addressed. In each session, the subject and its analysis of the selected articles will be presented.

Acids and Bases

It was only found 1 article dealing with the subject of acids and bases (Niezer & Silveira, 2014). In it, students are motivated by the problem of correcting acid pH of the soil through the use of eggshells from the school where they study. The research was carried out in the Educational Center of Professional Education, located in the city of Rio Negro, state of Paraná, with 10 students of the technical course in Agropecuária.

The practice was elaborated with the principles of the STSE, to which we can fit in the modality of science content seen through the STSE approach. The work was developed with the support of teachers in the areas of mathematics, geography, agriculture,

biology, vegetable garden, plant production, sociology and soil, which promotes the interdisciplinarity of the project in question.

After the application of the project the students concluded that the egg shells have the potential to use soil acidity correction, since this material is rich in CaCO_3 (calcium carbonate), and was favorable to its use because it is a natural product which was usually dumped to the school trash.

This article elaborated through the principles of the STSE was able to promote in the students a greater learning of the Chemistry, besides assigning greater meaning to them. With this theme, it was possible to work on some of the objectives of the STSE, which would be the use of scientific knowledge for decision making and social responsibility.

Physical-Chemistry

For the content of Physical-Chemistry we also find only one article (Oliveira, Guimarães & Lorenzetti, 2015). The proposal that he presents is the use of the STSE approach in the elaboration of classes with the theme of indoor air quality, working the concepts of Gas Study and Chemical Kinetics. The research was developed in a state high school located in the metropolitan area of Curitiba, Paraná, with a class of 20 students from the 2nd Year. The authors sought with this teaching proposal to intensify the scientific and technological literacy of students through the teaching of chemistry science seen by this approach.

It was elaborated a pedagogical insertion composed of 14 classes, in which the authors of the study sought to follow three stages (initial problematization, organization of knowledge and application of knowledge) researched in the literature. The researchers prioritized the use of materials that would encourage critical thinking by students, such as experimentation, videos, and group discussions. It was also proposed that each student, at the end of each class, produce a narrative text about that day. This proposal fits into the second modality of STSE teaching, in which researchers worked on the science content based on the precepts of this theory.

The authors of the study concluded that through the STSE approach it is possible in the school context to contextualize scientific and technological knowledge, as well as to reflect on the social consequences of this knowledge. They also reported that a broader use of this approach requires guidance that provides information for its broad implementation in the context of basic education.

Environmental Chemistry

On the theme of Environmental Chemistry, 3 articles were found, in which the topics of pesticides (Buffolo & Rodrigues, 2015), environmental pollution (Flor, 2007)

and atmospheric pollutants (Regis & Bello, 2011) are discussed. Two of the articles use the science seen through the STSE approach, and one uses the graft. What can be noticed with the reading of the research is that in both cases the teacher uses this approach as a way to escape from the traditional way of teaching, in which the teacher acts as a transmitter of knowledge.

The work on the subject of pesticides is part of a larger study of a master's thesis developed at a public-school system in the northwestern region of the state of Paraná (Buffolo & Rodrigues, 2015). The data for the study were collected from the development of a didactic sequence, covering 13 classes of 50 minutes each. It is reported in the study that the application of this didactic sequence based on the precepts of the STSE allowed the development in students of the understanding of the chemical concepts addressed, besides extending the knowledge to social, technological and environmental issues, which allows the construction of a sense critical of reality with a view to citizen training.

The second article (Flor, 2007) area of Environmental Chemistry, deals with the issue of environmental pollution, having as a guiding question the installation of a garbage incinerator in the municipality where the research took place. The work is characterized as a STSE graft. It was applied in the period of four weeks, with a total of 8 classes, in a public school in the state of Santa Catarina. The study promoted debates among students about the subject studied, and it is possible to see in their speeches the awakening of interest in research, and the development of the questioning sense about the role of science in society and the consequences that it can cause. The study produced reflections that were incorporated by the students in their inquiries about science and, in particular, pollution, the guiding theme of the research. The work besides providing the approximation of the contents of Chemistry with the everyday of the student allows the student to have an increase in self-esteem, because their comments are valued, allows participation in decision making and allows the teacher to become a mediator of knowledge.

The third article (Regis & Bello, 2011) on environmental issues deals with air pollutants. The research aims above all to involve the scientific and popular knowledge, with which the student has contact, so that there can be the contextualization of the study carried out in the classroom and the daily experience, besides developing critical thinking, decision making and awareness of environmental problems, especially those related to the central theme of the study. Through pre-test, post-test and workshop questionnaires applied to the students, it was possible to observe an evolution in the internalization of the concepts approached. The study pointed out that the approach employed can be considered as a good option to develop students' abilities and awaken environmental awareness, and as a consequence, to facilitate the learning of Chemistry.

Organic Chemistry

Organic Chemistry was the area contemplated with the greatest number of articles, totaling 8. Firstly, we will discuss the four articles that belong to the same group of authors

(Santos, Amaral, & Maciel, 2012a, 2012b, 2010a, 2010b), later, we will discuss on the remaining four articles.

The four studies presented here refer to a case study developed in the third year of the technical course in Integrated Chemistry of CEFET-MG, in which socio-scientific topics were adopted using the STSE approach. The themes adopted in the articles were: Cachaça; Cachaça and Beer; Milk; Soap and Detergent. Were used as instruments of data collection: observations, records, recordings, filming and questionnaires. With the application of these studies it was evident that the insertion of socio-scientific themes in the curricular of Chemistry is a fundamental condition to develop a more humanistic STSE education with training for citizenship, objectives proposed by this approach.

The fifth paper analyzes the theme Biodiesel (Azevedo et al., 2013), a subject working within Organic Chemistry. The study was based on an activity developed at the Laboratory of Oil and Biodiesel of the Chemistry Department of UFRPE. Through a partnership of the university with the Education Department of Pernambuco, the project was reached by the schools through the students belonging to the Institutional Program of Initiation to Teaching – PIBID (*Programa Institucional de Bolsa de Iniciação à Docência*). The pibidians recruited a group of 20 volunteer students belonging to the public network of the second year of high school, along with the collaboration of the professor of Chemistry. Data collection instruments involved pre and post-test questionnaires, didactic intervention with videos, etc. What was noticed at the end of the study was that there was a conceptual evolution in relation to the social issues discussed on the subject of biodiesel together with the chemical concepts exposed and the development of attitudes in the students as the collection of fry oil from their houses.

The sixth work (Kuchla & Souza, 2017) analyzed has the main objective of the study to develop and put into practice a methodology for the teaching of Organic Chemistry, having as its generator theme the dyes, in which it used a simulated case elaborated in the precepts of the STSE, besides having the intention to awaken in students the interest in research and Chemistry. The research was developed in a school of the state network of Paraná, and had the participation of 28 students of the third year of high school, in the school located in the city of Guaramiranga. Among the instruments of data collection, are notes in field diary, photography, questionnaires and videos. The results show that the methodology used made a great contribution to the critical formation of the students, since it provided an ample discussion and for being directly associated with the reality of the students.

In the seventh analyzed article we find the soap production issue (Machado et al., 2015). In order to reduce the fragmentation of the traditional teaching offered by the school, this project motivates to associate the content studied in Organic Chemistry with the student's everyday life, making the learning process more appreciable by the students, participation in their social environment. The subjects that participated in the research were 20 students from second year group of the integrated technical course of Agropecuária of a federal institution located in the city of Alegrete-RS. Through the analyzes made in the documents written by the students, it was noticed that there was an

increase of interest in the scientific concepts, mainly about the resolution of social and environmental problems, and it was verified that the STSE approach is a good strategy for the teaching of Chemistry.

Finally, the eighth and last work (Silva, Souza & Pires, 2017) analyzed in the field of Organic Chemistry brings the use of 3D molecular representations as didactic material for the teaching of Chemistry. With this, the main goal of this work is to use software as a didactic alternative for the representation and study of three-dimensional molecular structures, promoting the interdisciplinarity between Organic Chemistry and Biology. The research was developed with 10 volunteer students from a state public school located in the city of Luziânia in Goiás. Through the feedback from the students, it was possible to verify that the software can help in the better understanding of the geometric representations of some organic molecules, since the visualization only in two dimensions hinders this understanding.

Radioactivity

This was the only article working on the topic of radioactivity (Cortez, Prado & Rosa, 2017). It focuses on the teaching of physics; however its choice to be part of this study is justified by the fact of working a subject relevant to chemistry, and talk about the life of a leading scientist linked to these two sciences: Marie Curie.

This study uses as a proposal the science seen through the precepts of the STSE to work on the subject of radioactivity with a group of 15 students of the 3rd Year of High School of a public school located in the city of Sertão, in the interior of Rio Grande do Sul. To create an alternative for the teaching of radioactivity that allows the insertion in the context of the student, here focused on the teaching of Physics, but which can easily be worked in Chemistry.

The proposal was distributed in 18 classes, 10 in the curricular component of Physics and 8 in extracurricular classes. Seven stages were organized for the development of classes, covering the most diverse study materials: consultations, magazines, books, videos, films, etc. It was also worked with the use of active methodologies, using conceptual maps and the student protagonist, who seeks the construction of their own knowledge.

After the study, despite the difficulties imposed in evaluating the efficacy of new alternatives in teaching, the authors believe that this approach has produced good results. It was possible to bring the subject of radioactivity to the reality of the students, where they knew aspects of the daily life in which this theme has connection.

CONCLUSION

The present paper aimed to present how the STSE approach is being used in the teaching of Chemistry in High School, establishing a cut between the years 2007 to 2017 (10 years), and the journals classified with *qualis* A1, A2 and B1, according to the CAPES portal. All articles reported here are fruits of experiences lived in the classroom, which served as a subsidy for the analysis of the use of this approach as a teaching approach.

An aspect observed in the analysis of all the articles is that the idealizers of the studies looked for in the approach of teaching STSE a means to make the classes more attractive and dynamic, centering the construction of the knowledge in the student through the stimulation of the research. The fourteen (14) studies analyzed here obtained positive results in relation to the students' reports, which shows good acceptance of the use of this teaching methodology.

AUTHORS CONTRIBUTIONS STATEMENTS

E.S.F. conceived the presented idea. C.G.S. oversaw the project. C.G.S. and A.K.P.V. presented the theory and, together with E.S.F., adapted it to that context, creating the models to carry out the activities. E.S.F. collected the data and, together with A.C.B.N., G.C.B.S., M.H.F.S.G. and M.C.S.B., analyzed the data collected. All authors contributed to the discussion of the results and the final version of the manuscript. M.C.S.B. has made one last review.

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