

The Role of Chemistry in Environmental Education: Learning and Constructing Knowledge Through Research in High School

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Abstrak

Pelestarian, konservasi, pembangunan berkelanjutan, kualitas hidup, adalah konsep yang harus menjadi bagian dari kehidupan sehari-hari bagi orang-orang di seluruh dunia. Guru kimia harus mendiskusikan masalah lingkungan dengan siswa secara langsung dan mengambil kesempatan untuk mempromosikan Pendidikan Lingkungan emansipatoris, memungkinkan siswa untuk hidup selaras dengan lingkungan. Tujuan pertama dari penelitian ini adalah untuk menyelidiki bagaimana Pendidikan Lingkungan, dalam pengajaran kimia, dapat membentuk warga negara yang kritis dalam kaitannya dengan masalah lingkungan. Jenis penelitian ini yaitu kualitatif dengan menggunakan pendekatan penelitian tindakan partisipatif untuk menggambarkan realitas dan lebih mementingkan proses daripada produk. Metode yang digunakan dalam mengumpulkan data yaitu observasi, dokumentasi, dan kuesioner. Instrumen yang digunakan dalam mengumpulkan data yaitu kuesioner. Teknik yang digunakan untuk menganalisis data yaitu analisis deskriptif kualitatif. Hasil penelitian yaitu para siswa mengungkapkan persepsi mereka tentang Lingkungan dan bagaimana tindakan manusia mengganggu alam di tingkat global. Akuntabilitas individu menjadi tujuan penting untuk mempromosikan model pembangunan baru, yang disebut oleh banyak orang sebagai pembangunan berkelanjutan. Singkatnya, juga dibuktikan bahwa penyisipan Pendidikan Lingkungan di kelas Kimia sangat penting untuk pendidikan, serta untuk lingkungan sosial. Hal ini disebabkan karena pendidikan lingkungan memberikan pelatihan pada siswa, serta seluruh komunitas sekolah tentang pentingnya mengetahui mekanisme pelestarian lingkungan.

Kata kunci: Pembangunan Berkelanjutan, Pengajaran Kimia, SMA, Lingkungan

Abstract

Preservation, conservation, sustainable development, and quality of life should become part of everyday life for people worldwide. Chemistry teachers should discuss environmental issues with students directly and take the opportunity to promote emancipatory Environmental Education, enabling students to live in harmony with the environment. The first aim of this research is to investigate how Environmental Education in teaching chemistry can shape citizens who are critical of environmental issues. This type of qualitative research uses a participatory action research approach to describe reality and is more concerned with the process than the product. The methods used in collecting data are observation, documentation, and questionnaires. The instrument used in collecting data is a questionnaire. The technique used to analyze the information is descriptive qualitative analysis. The result of the research is that the students express their perceptions about the environment and how human actions disturb nature globally. Individual accountability is becoming an essential objective for promoting a new model of development, which many refer to as sustainable development. In short, it is also proved that the insertion of Environmental Education in Chemistry class is essential for education and the social environment. It is because environmental education provides training to students and the entire school community on the importance of knowing environmental preservation mechanisms.

Keywords: Sustainable Development, Chemistry Teaching, High School, Environment

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1. INTRODUCTION

Contents of Chemistry may be found in several activities in society, such as production and consumption of chemical products, residue generation and environmental impact, which directly and indirectly affect the environment, quality of life of living beings and citizens' decision-making processes; thus, they are fundamental to develop citizenship (Junior & Fernandez, 2016; Muntholib et al., 2020; Santos & Royer, 2020). Chemistry exerts a very relevant role in children's, adolescents' and adults' development not only by teaching systematized knowledge, but also by contributing to develop critical citizens throughout a

responsible, sensitive, contextualized and critical process which prepares individuals to learn, develop their skills and live in society (Nugraha et al., 2020; Soeharto et al., 2019).

Since the scientific, cultural and political debate about the environment has got more space in the Brazilian society lately due to several problems it has caused and poor management of natural resources. Intertwining this theme with Chemistry teaching has become a new challenge and a new possibility of developing critical and reflexive individuals who are capable of seeing themselves as part of the environment and of interacting with all kinds of knowledge, such as the scientific one (Ewais & Troyer, 2019; Santoso et al., 2018; Yerimadesi et al., 2019). According to previous study even though interlocution between Chemistry teaching and Environmental Education (EE) has been strongly recommended, basic education institutions have carried out specific activities that are disconnected from students' realities besides using some curriculum organization that leads to knowledge fragmentation (Wuillda et al., 2017). Teachers have highlighted their difficulties to overcome such issues in their practices (di Fuccia et al., 2012; King-Sears et al., 2015; Sutiani et al., 2021).

Environmental protection as a life option by means of a healthy and balanced relation with the social context, which depends on the development of ecological awareness (Bilgin, 2009; Ewais & Troyer, 2019). It should be emphasized that EE enables solidarity, equality and respect for human rights to be encouraged. In this line of analysis, themes related to environmental issues and chemistry teaching must be articulated in order to promote environmental and scientific education which aims at developing critical and aware citizens (Ewais & Troyer, 2019; Miranda et al., 2018).

In line with previous study that determine relationship between the infusion of environmental education (EE) in chemistry teaching and awareness and students' attitudes toward environment (Ismail, 2011). The result show descriptive statistics revealed knowledge, attitudes and practice of EE infusion among chemistry teachers were high (above 4.0). The obstacles in infusing EE faced by teachers were moderate. Students' awareness and attitudes toward environment were high. Other study determine level of pre-service chemistry teachers' environmental literacy and their perceptions on environmental education (Teksoz et al., 2010). The result show pre-service chemistry teachers did not have a sound understanding of environmental issues. Although the participants were lack of necessary subject matter knowledge, they were willing to integrate environmental issues into their teaching practice.

Base on those problems the researcher interesting in conducting this study. This study aimed at showing how contributions of a didactic sequence which involves themes of Chemistry and EE may favour students' learning processes. It also investigated how EE may develop critical citizens towards local and global environmental issues. In sum, this study showed how students who attend High School in south-eastern Brazil see and practice concepts of EE.

2. METHODS

This qualitative study uses the approach of participatory action research to describe reality and concerns more for the process than the product (Bedin et al., 2020). It is a qualitative and descriptive study because it aims at describing phenomena and understanding them in different ways. Participatory action research, one of the most common techniques used by researchers who conduct qualitative studies, consists in inserting the researcher into the group under observation so that s/he may interact with the subjects for long periods and share their everyday lives to feel what it means to be in that situation (Clark et al., 2020; Manfra, 2019). This technique enabled information to be collected and photographs to be taken so that researchers could conduct better reflection and analysis.

This study was carried out at the Instituto Federal do Triângulo Mineiro - Uberlândia Campus in Uberlândia, Minas Gerais (MG), Brazil, with 60 High School sophomores who attended morning classes in two groups. The following criteria were used for selecting students to participate in the study: **I** - students had to be enrolled in the institution; **II** - students had to attend Chemistry classes and take part in activities and discussions; and **III** - after having answered the questionnaires, students had to participate in debates about the answers given by all interviewees. The questionnaire comprised eight questions as show in Table 1.

Table 1. Questionnaire Comprised Eight Questions

No	Questions
1	In your opinion, is Environmental Education (EE) an interesting and important subject?
2	How do you evaluate your knowledge about the subject?
3	In your opinion, should the community know about it?
4	Is the theme “environment” well addressed in school?
5	How do you see Brazil in the area of EE?
6	Regarding issues related to the environment, which is a serious environmental problem nowadays, in your opinion?
7	Considering that the world has so many environmental problems, propose an action that could help to preserve nature.
8	How can Chemistry help to improve EE?

3. RESULTS AND DISCUSSION

Results

Respondents which consisting of 60 students filled out a questionnaire consisting of 8 questions. The results of the responses from the questionnaires distributed by students are shown in Table 2.

Table 2. The Results of Questionnaire

Question No.	Percentage of Yes Answer	Reasons by Respondent
1.	100%	Respondents said that EE is an interesting subject that should be addressed in all teaching levels, from early childhood education to college.
2.	55.6%	Respondents answered that they feel it is insufficient when the topic is addressed both inside and outside the classroom. Students feel that they are capable of debating any theme related to EE.
3.	88.7%	Students stated that the population cares and tries to find ways to preserve the place where people live.
4.	41.7%	Respondent state that the school addresses the topic EE well
5.	-	Students answered that Brazil cares for the environment and its biomes. However, deforestation in the Amazon region, deforestation in areas which are used for animal husbandry and gas emission have been considered negative in this field. On the other hand, students highlighted a positive aspect that has made

Question No.	Percentage of Yes Answer	Reasons by Respondent
6.	-	Brazil produce clean energy (Green Hydrogen). Students pointed out several issues such as 1.) Deforestation. 2.) Forest fire which in Amazon region. 3.) Large cattle farmers' lack of responsibility for environmental preservation, 4.) Excessive use of agrochemicals in agribusinesses, 5.) Amount of garbage spread in large cities and sea pollution. 6.) Global warming and consequent climate changes on the planet. 7.) Decrease in biodiversity. 8.) Lack of fauna and flora preservation. 9.) Inadequate waste disposal, loss of natural resources (water, wood), industrial pollution (toxic gases, river pollution). 10.) Uncontrolled consumerism. 11.) Water deficit, i. e., potable water has been diminishing worldwide. 12.) Lack of investment in recycling.
7.	-	Students have opportunity to reflect on environmental issues and propose solutions that aim at nature preservation. Students emphasized the following solutions and suggestions: 1.) To avoid gas emission to the atmosphere and waste disposal in inadequate places. 2.) Environmental authorities should better control places in critical situation. 3.) To implement volunteer actions in society to rebuild what has already been harmed. For instance, events which encourage people to plant trees and to take care of abandoned animals and awareness-raising projects that can really be carried out. 4.) To make heavy consumers invest in sustainable products that use biodegradable packaging. 5.) To reinforce appropriate disposal of all kinds of waste.
8.	-	Respondent state that chemistry is a field of study and dialogue that is appropriate to EE since it enables different perceptions of reality, thus, broadening our conceptions of world and nature. Chemistry, as a science of nature, must be a tool to make the awareness-raising process easier so that a better relation may be established between society and environment. Chemistry is not only the ideal course to conduct complex perceptions of our actions with nature but also a mediator to unite scientific knowledge and environmental relations.

This study was based on the principle presented by who have stated that the main point of any problem. It is to make students feel the need to learn new knowledge, i. e., a situation is discussed as a problem that must be observed and faced. Therefore, students were encouraged to search for environmental issues that devastate the world in Internet and discuss solutions in groups to improve EE in groups as show in [Figure 3](#).



Figure 3. Group Discussion about the Theme Environmental Education (EE)

Discussion

Discussion session in the Chemistry class was also fundamental to enable students to debate and analyze answers given to the eight questions in the questionnaire. Through this activity students be able to carry representations of reality that are experienced and constructed throughout their lives to academic spaces (school, college) (Castro et al., 2019; Giacomini & Muenchen, 2015).

Teaching is socialized when it focuses on students' intellectual work on the object of learning by means of cooperation among study groups under the teacher's guidance not only to promote learning but also to trigger more critical (explanation of contradictions) and creative (elaborated expression) teaching (Cardoso & Miguel, 2020; Danczak et al., 2020; Martínez Torregrosa et al., 2012). It enables knowledge to be exchanged and encourages development of respect, critical thinking, questioning and solutions, thus, favoring exchange of experiences, information, cooperation and mutual respect among students to make learning significant.

EE is understood as an educational process of construction of full and planetary citizenship that aims at quality of life and at consolidation of ecological ethics (Miranda et al., 2018; Susilawati et al., 2019; Wajdi et al., 2022). In this respect, EE is very important because it contributes to develop citizens who are aware of their roles in environment preservation and improves relations between individuals and the environment so that they may be able to take decisions about environmental issues to create a sustainable society, raise awareness and improve quality of life (Ramadhan et al., 2019; Susilawati et al., 2019; Wajdi et al., 2022).

The literature also mentions that discussion of social themes articulated with Chemistry teaching plays a fundamental role in developing citizens since it helps them to learn basic skills and to acquire capacity to take decisions. When some social issue – that requires either a solution or a critical position – is discussed in class, students have the opportunity to develop their critical sense to participate democratically in their society (Hong & Talib, 2018; Mutakinati et al., 2018; Santos, A. T., Tamiasso-Martinhon, P., Sousa, C., & Rocha, 2021). When the authors of this study proposed questioning activities in class, they

helped students to learn new knowledge and form opinions and values to feel more responsible for the environment. In both formal schools and community organizations, EE aims at triggering processes of social and cultural changes not only to make the society become sensitive to the environmental crisis and to the need to change patterns of use of environmental assets, but also to acknowledge this situation and take decisions (De Oliveira et al., 2016; Sutiani et al., 2021). Thus, carrying out EE practices by means of awareness-raising pedagogical activities enables students to develop skills to solve everyday problems in their communities, a fact that results in critical, aware and committed citizens in their society.

When teachers address themes that interest students, Chemistry classes become more attractive, a fact that leads to more possibilities of interaction among the teacher, students and the concepts under analysis (Chen & Liu, 2020; Mutakinati et al., 2018). Therefore, Chemistry teaching should aim at contributing to a broad view of knowledge that enables better understanding of the physical world and to construction of citizenship by addressing, in class, socially relevant knowledge which makes sense and integrates with students' lives (Ismail, 2011; Miranda et al., 2018).

Chemistry enables to study phenomena that take place in the environment and their chemical processes. It is a transversal field of knowledge which is adequate to address EE in an interdisciplinary process and expand views of the world and nature (Arrigo et al., 2018; Junior & Fernandez, 2016). Chemistry teaching has become necessary to humankind because it is relevant that citizens learn chemical knowledge and understand what takes place around them as the result of chemical transformations that take place in nature. Living with the environment is a daily reality. Different discussions must happen and comprehension must be satisfactory so that actions may be taken (Barke et al., 2008; Ismail, 2011).

The implications of this study provide an overview that confirms intertwining between scientific knowledge and students' common sense knowledge contributes to make them take part in the processes of learning and teaching and in active concept elaboration. This research still has many limitations. One of the limitations of this research lies in the method of data collection which is limited to interviews only. Therefore, it is hoped that future research will be able to deepen and broaden the scope of research related to chemistry in environmental education.

4. CONCLUSION

This study shows that insertion of environmental themes into Chemistry classes enables students to better develop sensitivity to local environmental issues and become critical and aware citizens who may intervene in their communities by proposing innovative, transforming and sustainable socio-environmental practices. In addition, this study highlights that schools have planned to insert EE into Chemistry classes but very few schools have actually carried it out. Even though teachers have been encouraged and convinced that it is important in Education, they may face much difficulty to work on it. In sum, since Chemistry is an essential and constituent part of nature, the course must deeply interact with issues related to EE.

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