ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 09, Issue, 08, pp.29148-29152, August, 2019

RESEARCH ARTICLE OPEN ACCESS

TEACHING SCIENCE DOING SCIENCE: ANALYSIS OF SECONDARY STUDENTS' PERCEPTION OF SCIENCE TEACHING

***[1,2]Jackson Rubem Rosendo Silva and [3,4]Antônio Carlos Pavão**

[1]Professor at the Federal University of São Francisco Valley, Petrolina, Pernambuco (PE), state (UNIVASF), Petrolina, PE
[2]Doctoral Student in the Graduate Science Education Program: Chemistry of Life and Health – Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Rio Grande do Sul (RS) state
[3] Professor at the Federal University of Pernambuco (UFPE), Recife, Pernambuco (PE) state
[4] Professor, PhD, Graduate Science Education Program: Chemistry of Life and Health – UFRGS, Porto Alegre, RS

ARTICLE INFO

Article History:
Received 16th May, 2019
Received in revised form
03rd June, 2019
Accepted 11th July, 2019
Published online 28th August, 2019

Key Words:
Science Teaching,
Student Perception,
Investigative Methodology.

ABSTRACT

Objective: investigate students' perception of science teaching in public schools in two cities: Petrolina, Pernambuco (PE) state and Senhor do Bonfim, Bahia (BA) state, Brazil. **Materials and Methods:** This study used quantitative-qualitative, observational, exploratory methodology.Forty students of both sexes, aged between 12 and 19 years, participated in the research. **Results:** The results showed that 97.5% of the students reported enjoying science classes, but there were inconsistencies in the answers related to the concept of sciences.However, the students' perception of the investigative methodology applied in activities and its contribution to scientific development was positive and necessary. **Conclusion:** The study demonstrated the need and importance of implementing the investigative methodology in secondary school science classes. However, it is suggested that more studies on the topic be conducted to better clarify educational, cultural and contextual aspects related to science teaching using the investigative methodology.

Citation: Jackson Rubem Rosendo Silva and Antônio Carlos Pavão. 2019. "Teaching Science Doing Science: Analysis Of Secondary Students' Perception of Science Teaching", *International Journal of Development Research*, 09, (08), 29148-29152.

INTRODUCTION

The interaction between science and education is at the core of the scientific revolution, whose primary concepts are production, dissemination and teaching, demonstrating that scientists, teachers and disseminators are one and the same. This perspective promotes the idea of combining scientific practice with the teaching and learning process to bring academic and scientific knowledge together (TROPIA, 2009).
In Brazil, the Teaching Science By Doing Science initiative, developed in partnership with the Department of Technology (Science Space of Pernambuco), Federal University of Pernambuco (UFPE) and Federal Rural University of Pernambuco (UFRPE), promotes a number of educational projects involving 1,447 teachers and 4,048 students from public schools in Pernambuco and other states (FERRAS, 2016), (FERRAS, 2016).

***Corresponding author: [1,2]Jackson Rubem Rosendo Silva,**
1Professor at the Federal University of São Francisco Valley, Petrolina, Pernambuco (PE), state (UNIVASF), Petrolina, PE
2Doctoral student in the Graduate Science Education Program: Chemistry of Life and Health – Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Rio Grande do Sul (RS) state

In this respect, experimental activities have been used in science teaching since the early 20th century, with different approaches emerging, such as the "la main a la pâte" (hands-on) technique introduced in France in 1995. This method consists mainly of students discovering objects and phenomena in nature, thereby stimulating their imagination and mastering scientific language. According to Pavão (2005), science must be demystified, and it must be taught and disseminated by doing, making it more accessible, which could also helpindividuals become fully functioning citizensin their communities.Hodson (1982) believed that teaching young people to think scientifically is important because it helps them better understand how scientists work and how scientific knowledge is produced. Morreira (1999) stated that for significant learning to occur, new information based on relevant concepts or propositions that already exist in the cognitive structure of students is needed.Thus, teachers should focus on student learning and use content that favors the construction of important scientific tenets. According to Araújo (2017, p. 7): "knowledge is socially referenced and immersed in a cultural melting pot".Silva (1999) wrote that schools are not the only "place of knowledge" and

transformation of subjectivity. In this respect, Araújo (2016, p. 2) stated that since "education is a complex multi-faceted permanent social practice, it does not occur only in schools but also in various cultural settings". Education is a tool in the teaching-learning process thatequips individuals to develop their activities throughout their lifetime and, according to the literature, can be divided into three types: formal, non-formal and informal (SEBASTIANY *et al*., 2012). Cazelli and Vergara (2007) explained that the use of the terms non-formal and informal education by English and Portuguese-speaking authors requires specific definitions.The former use these terms for science teaching without distinguishing what generally occurs outside the school setting.However, Portuguese-speaking authors subdivide science education outside the school setting into two groups, with the difference between non-formal and informal education being "institutional intentionality" such as museums, science facilities and educational/cultural activities, while knowledge acquired through experience in a range of different environments without the need for institutional intentionality to generate knowledge is characterized as informal.The concept adopted by Portuguese-speaking authors is used in this article. According to Sebastiany *et al*., (2012), there is a consensus among English and Portuguese-speaking authors that formal education is linked to schools and represents a systematic and organized teaching model, structured into levels, grades, programs, curricula and diplomasaccording to certain laws and guidelines. Academic institutions continue to be a privileged systematized knowledge environment for the training of individuals. However, it is undeniable that human beings can learn in other settings, often more efficiently and enjoyably without systematization (ARAÚJO, 2016).

Although formal education occurs at school, considered a privileged space, the quality of education in Brazil was classified as poor by the Programme for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD), a major international framework for identifying student performance in reading, mathematics and sciences.According to PISA data (OCDE, 2017), in 2015 Brazil ranked between 59th and 66th, depending on the subject, out of 73 regions and countries assessed by the program.The average scores of 407 in reading, 401 in mathematics and 377 in science are below OCDE student averages of 493, 493 and 490, respectively. As such, this study contributes to popularizing science and building a culture of scientific literacy via teaching, research and extension courses aimed at teaching science by doing science. This is achieved by reflection-action and research-actionprocesses involving the entire academic community. The purpose of this study was to analyze students' perception of investigative science teaching in public schools in two cities (Petrolina, PE and Senhor do Bonfim, BA).This methodology emphasizes the use of scientific methods to develop skills, such as describing an object, recording activities, as well as applying scientific methods to help students understand how science functions.

MATERIALS AND METHODS

The study was conducted at two secondary schools in the cities of Petrolina, PE and Senhor do Bonfim, BA, with 440 and 680 students, respectively, 23 and 17 of whom took part. Both were selected because they participated in science popularization projects (edict PIBEX 2013-2014) executed until 2016. This exploratory study used a quantitative-qualitative observational methodology. Forty students of both sexes, aged between 12 and 19 years, participated in the research on August 25 and 28, 2018.All the students were volunteers and the school administration gave its written informed consent. The study consisted of science workshops on knowledge of biological sciences, held within and outside a school setting.The workshops were based on the constructivist theory of Piaget (1976), Dewey (1985) and Vygotsky (1989), which discusses knowledge construction in culturally structured natural environments of social interaction. The students' skills were assessed using questionnaires and presentations explaining their activities at the end of each workshop. The first step of this study was to visit the school administrators, informing them about the objectives of the research, whereupon authorization to collect data was granted. Next, the research project, including detailed information on the study aims, methodology, treatment and analysis, was submitted to the school administrators with a view to obtaining the collaboration of professors as monitors. The monitors were trained at technical meetings held to discuss the development of and adjustments to the methodology, with a group of 5 undergraduate students from the Science Methodology discipline who belonged to the Center for Research in Science Studies (NPEC) at the Federal University of São Francisco Valley (UNIVASF) and the researcher in charge of the study, in order to standardize the workshops and apply the research instrument.It is important to underscore that three monitors were teachers at one of the participating schools, which contributed significantly to implementing the workshops. The didactic sequence consisted of several activities that were applied in six classes.

The thematic workshopswere planned and executed in five stages:

1. The first stage involved a previous study, where participating schools were asked to provide the biology course content being taught in order to determine the level of the students' science knowledge.
2. In the second stage, the teachers and monitors of the UNIVASF natural sciences course were invited to prepare the workshops.
3. In the third stage, the material to be used in the experiments was compiled, considering the lack of science teaching equipment and accessories in the public schools.
4. The fourth stage consisted of writing the scripts for the presentations.A group of students participated in each workshop, and at the end of the activities, these groups presented what they had learned viaplays, music and seminars, among others.
5. Finally, in the fifth stage, workshop assessments were planned. These involved questionnaires and student presentations on what was proposed in the activities.

The methodology applied in the workshopsat the two schools aimed at comparing the results obtained.To that end, the workshops discussed day-to-day problems.
Planning and execution of the workshops

Workshop planning consisted of the following phases:

1. Informing the teachers and inviting them to take part;

2. Revising the topics and methodologies in collaboration with the pedagogic coordinators and teachers and adapting them to the reality of the schools
3. Scheduling workshop activities with the pedagogic team
4. Disseminating the topics of the workshops
5. Collective planning of workshop activities between the teachers and students of each discipline
6. Assigning teams and tasks
7. Creating posters for the study topics
8. Lectures, videos, films, and documentaries about the topics of each workshop.
9. Displaying workshop projects in the schoolyard of the institutions.
10. Applying assessment questionnaires after the schoolyard presentations; interviews took place during the workshops and at the end of the presentations.

Before the workshops, the monitors and students visited a science facility in Olinda, PE. During this activity, monitors and students were asked to observe the entire facility in order to be able to answer a case/problem spontaneously. Next, the students were assigned to groups of 2 or 3 and questioned about the visit and daily problems.The students were presented with an investigative case to solve. They were divided into subgroups and suggested hypotheses that could solve the case.

project and lesson plans), students' field diaries as well as the recorded interviews and their transcripts. A semistructured interview was created to determine what students liked about science classes. The pedagogic project and biology lesson plan were used to organize the sequence of workshops that discussed issues students were already familiar with. Students collected data using field diaries to record everything they deemed important, with no interference from the teacher or monitors. Audio recordings were made at the workshops in order to obtain an accurate picture of the students' perceptions of the event. Finally, the audio recordings were transcribed, based on Bardin's (2011) approach (categorization analysis by response similarity).

Data Analysis

Values less than or equal to 0.05 ($p < 0.05$) were statistically significant. Textual analysis was carried out to construct the response categories, based on Bardin (2011), who proposed language analysis by relatingthe semantic (significant) structures of the statements to sociological structures (meanings), considering the conceptual issues and proposals in a constructivist context, namely,

1. Investigative activities as teaching-learning strategies
2. Contribution of thematic workshops to scientific, cultural and social development.

Audio recordings were transcribed and the students identified by letters of the alphabet.

Tabela 1. I like the science teaching of students from two public high schools in the cities: Petrolina / PE and Senhor do Bonfim / BA – 2016

Nº	Questions	Answers (%)	
		YES	NOT
1	Do you like thesciencestudy classes?	97,5(39)	2,5(01)
4	Do youknowanyscientists?	17,5(07)	82,5(33)
6	Do youthinkyouonly do science in big labs?	10,0(04)	90,0(36)
7	Does theschoolyoustudy do anywork / activitythatarousesthedesire for youtobe a researcher / scientist?	7,5(03)	92,5(37)
8	Do youthinkscience classes are good as they are beingtaughtorwouldyou like themtobedifferent?	57,5(23)	42,5(17)

Tabela 2. Understandingoftheconceptandvisionofscience in the classes oftwo high schools in thecities: Petrolina / PE and Senhor do Bonfim / BA – 2016

2	Whatisscience?	(%)
	Studiesof living beingsandtheplanet	22,5 (09)
	Knowledge	40,0 (16)
	Discovery	37,5 (15)
3	How do youviewscience classes atyourschool?	(%)
	Studiesof living beingsandtheplanet	2,5 (01)
	Knowledge	80,0 (32)
	Discovery	17,5 (7)

Tabela 3. Perspectives ofscienceeducationofstudentsfromtwo high schools in thecities: Petrolina / PE and Senhor do Bonfim / BA – 2016

5	Do youthinkthereisanydifferencebetweenscienceandtechnology?		
		45,0(18)	55,0(22)
10	Wouldyou like tobe a scientist?	20,0(08)	80,0(32)
12	Haveyoueverattended a science fair?	32,5(13)	67,5(27)
13	Wouldyou like toattend a Science Fair?	85,0(34)	15,0(06)

Instrument

The instrument used to collect information was created based on a compilation of validated instruments or those used in other school-based studies, exhibiting the following aspects: semistructured interviews, school documents (pedagogical

RESULTS AND DISCUSSION

Although quantitative data analysis (Table 1) showed that 97.5% enjoyedtheir science classes, 82.5% could not name a single scientist.This is likely due to the fact that 92.5% of the

students reported that their school did not promote projects/activities that stimulated them to become researchers or scientists. According to Santos *et al*., (2011), this preference for science classes can be explained by a number of factors, such as classes that resulted in significant learning and inspirational teachers, among others. Table 2 shows the results of students' understanding and assessment of science classes at the schools under study.The findings demonstrate that there was no consensus between what science actually is and their assessment of the classes.For most students (40%) the concept of science is "knowledge", but 37.5% view it as "discovery". This may corroborate their responses in the previous table, namely, that their schools did not promote science-related activities.The answers in table 2 show that80% of students use the word "knowledge" to describe their science classes. The results of Table 3 reinforce the coherence of the answers regarding the students' perception of science classes, since 55% found no difference between science and technology; 80% reported not wanting to be a scientist and 67.5% of never having participated in science fairs. Although the results showed that most of the students enjoyed science, 90% did not have laboratory classes.There wereinconsistencies in the answers regarding the concept of science and the lack of interest in becoming a scientist.

Nevertheless, 57.5% of the students reported enjoyed the way their science classes were taught. In the first categorization of responses, the primary findings reveal that investigative activities were seen as tools to help assimilate knowledge and that these activities gave rise to problem situations, organization of thoughts, and making and sharing arguments (communication), as expressed by student A regarding the importance of the investigative methodology to consolidate knowledge: "Perfect and always useful, helps to consolidate teaching.It's a way of sharing knowledge". However, for knowledge to be consolidated, teachers must stimulate their students to explore and express their opinions.In doing so, teachers stimulate them to want knowledge and pursueit. According to Moreira (1999), with this teaching attitude students assume the role of receivers of knowledge, that is, agents of their own learning, thereby developing autonomy. This learning autonomy was observed in student B's statement: "Very interesting, students feel responsible and important as they conduct research and discover the world around them". This shows that the teaching methodology means more than changing one set of theories for another; first and foremost, it means clearly determining what the theories consist of. In this respect, Driver *et al*., (1999) stated the following: Teaching science involves introducing children and adolescents to a different way of thinking about the natural world and explaining it; it means becomingfamiliar to a greater or lesser extent with the practices of the scientific community, its specific goals, way of seeing the world and how it supports the assertions of knowledge.Before this can occur, however, they must be engaged in a personal process of construction and attribution of meanings.Thus, learning science involves both personal and social processes. In the social context, it consists of being introduced to the concepts, symbols and conventions of the scientific community (DRIVER, 1999, p. 36).

According to Freire (1999), understanding the world means codifying the meanings that permeate social life.Thus, for students to acquire scientific knowledge, teachers must value previous concepts. Carvalho *et al*., (2011) underscored that the cognitive process always evolves via reorganization of knowledge and that students do not directly acquire correct knowledge, making itvital to consider the knowledge that students gained previously. Some of the students' statements valued this learning methodology, as described by student C: "It facilitatespedagogic practice". However, despite the positive results described here, these investigative activities should not be seen merely as a way to memorizecontent and/or limit access to handling objects or observing phenomena. Azevedo (2004) states that it is important for students to develop a critical and reflexive character.According to Furman and Podestá (2008), concrete experience is essential to understanding the world and interacting with situations that expand our universe. Moraes and Lima (2004) and Lima (2004) agree that the investigation process results in significant knowledge and is not limited to knowing how to engage in the practice, but also reflecting on it. In this knowledge building methodology, it is important to highlight the involvement of students in all the phases of scientific investigation, using problem situations.

Thus, making students reflect on experimental problems and their ability to solve them teaches them how to think about the world scientifically and build their own viewpoint (CARVALHO and GIL-PEREZ, 2011). In the results of the second categorization regarding the contribution of thematic workshops to cultural and social scientific development, seven statements illustrate the essence of their contribution, as follows: Students D, E and J stated that "it is important because we learn about the work of other young people, who discuss different approaches from ours"."It was useful and very organized, a large event where we learn from people and they learn from us"."It is important because we learn about the work of other young people from other classes and grades.It broadens our knowledge … andencourages students to research more and raise awareness". These three statements demonstrate the importance of cultural activities conducted by students, to provide a sample of their work and knowledgevia demonstrations they plan and execute.This result was similar to that found by CECIRS (1970), confirming that these reports are the best way a school can act in the community, since they generate cultural development. According to student F, "Consolidatingscience as a tool originating in social construction results in the dissemination of a series of scientific facts and relations to the community". Borba (1996) states that workshops and science fairs can stimulate students to develop collective participation and exchange ideas, allowing them to think critically and communicate effectively. As such, students that participate in workshop activities will likely return to the classroom better able to deal with daily problems, as demonstrated in the following statements: Students G, H and I reported that "There are workshop projects that can really help the country in a number of areas". "Contributing to the evolution of every person"."Developing research techniques, demonstrating knowledge about products and incentives for environmental conservation".

These accounts were confirmed by Moraes and Lima (2004), who reported that science and research are closely related concepts that cannot be separated.The relation between knowledge produced by experience and historically accumulated by the studentsassumes many forms. It is important to underscore that activities such as non-formal education enabled greater interaction betweenthe school and the community.Thus, coexistence between the range of learning levels and comprehensive development of students

favors a less stagnated and fragmented view of the world that is more in line with processes involving the individual as a participant in a constantly changing society.

Conclusion

During the course of this study and based on the proposed objective, although the results demonstrated that the students reported enjoying science classes, their perception of the topic was incipient, revealing inconsistent answers regarding the concept of science and that their schools preserved a traditional science teaching methodology.However, the initiatives and workshops carried out using investigative methodology produced positive results that students easily understood and could be readily implemented in lesson planning and execution. This study demonstrates the need and importance of implementing the investigative methodology in secondary school science classes. However, further research is suggested to provide more information on the educational, cultural and contextual aspects of science teaching using the aforementioned technology.

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