Scientific education and popularization of Science: investigation teaching as a educational approach

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Abstract:

Knowledge was always a powerful strategy, orienting the development of societies, economies, cultures and individuals. The analysis of the science history reveals its most relevant tonic: the logical-experimental posture, responsible for all the most recent and important technologies for the eurocentric history. However, undeniable authority of scientific knowledge betrays its own origins when it kills the self-criticism, a heritage that comes from universal science, absolute and unchangeable. In this scenario, the teach of Science, carries the aspects that surrounds its own scientific history. The complaints of Basic Education students, that learning Science means "memorize dificult words", are not rare. On that manner, this research has as an objective the proposal of an investigative activity, by the interchange between academy and school, aiming for science popularization. The methodological path occurred in a qualitative research, based on an exploratory studying, with the proposition of pedagogical intervention. It was developed a sequence of investigation study (SEI) with 70 students of a public High School. The SEI used was oriented by three key-steps predicted by Carvalho (2013): questioning; systematic and contextualization of knowledge. Through the proposed study, it was imposed that the investigative teaching, as a pedagogical approach, amplified the scientific repertoire of the participating students and of its method, through which they could test and found out the negative influence of saline environment on the development of vegetables. In this sense, we advocated a proposal of trialetical teaching, based on the mixed between: investigating, litiracy and scientific education, essential conditions to the popularization of science and entering in the intensive knowledge society.

Keywords: Scientific literacy; popularization; SEI.

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Introduction

The history of Science reveals a stricting quality of its identity: the logical-experimental perspective, that instigate a diffusion of existing technologies inherited from the Eurocentric history.

However, the supremacy of the scientific knowledge challenges its own origins when invalidates the self-criticism. The idea of a universal, absolute and unchangeable science, still resounds around contexts and individuals. For that matter, knowledge becomes a trick of power practice, conducting the development of human communities in their cultural and economic aspects. Knowledge is replaced sometimes as a strategy of the power owners to maintenance of their subordinates, sometimes as a retaliation of those who decide to emancipate from their rulers.

It is almost usual that the teaching of Science and Biology carries the aspects that reverberate their own scientific historicity. It is known the complaints of Basic Education students that learning Science is only "memorizing hard words".

The inclusion of the CTS Education (Science, Technology and Society), in the curriculum of Science, by the end of the 1970's, in Brazil, represents an attempt of giving a new meaning to the "stained image" of a Science purely positivist, closed, of prompt and finished contents, to reach their social affirmation and their formative character (CARVALHO et al., 2012).

Globalization itself has brought to education its own effects, characterized by the inversion of the information flow: if before, from school to society, now the outside world enters into the school (CHASSOT, 2006). Even by a non-intentional way, students are exposed, on a daily basis, to different other forms of scientific information in the universe outside the school walls – there are multiple inputs from the exterior world into the classroom - (ALBAGLI, 1996; CHASSOT, 2006).

Therefore, a monopolistic Science, restrict to a selected group of almost initiated ones, does not legitimate more its sociocultural paper in front of human groups and communities. The socialization of knowledge by the academy has become a sine qua non condition to the citizenship of scientific information.

Following the demands of this new informative era, the scientific education presents itself as one of the pillars to the amplification of the practice of citizenship, according to the suppositions of the so-desired scientific literacy. The educational reorganization becomes, in this context, an urgent and necessary reality, and the

investigation teaching merge to this new scientific view socially relevant and intelligible to a number of educational contexts.

The reality of many Brazilian public schools reflect to a considerable number of students originated from economically underprivileged classes, that in their own circumstances of their social contexts, underappreciate studies as a toll for better future perspectives. In that sense, this research aimed the proposition of investigated activity, by the interchange between academy and school, visualizing the popularization of science. The objectives expand themselves to specific aspects, such as: conduct an inquisitive study with students about the sprouting of species grown under environmental harsh conditions; reflect about the influence of environmental impacts on the plants developments, and the consequential risks to humans' health and subsistence; develop an interdisciplinary paper about the presented theme aiming to comprehend scientific phenomenons and methods by a contextualized reading of the sociocultural dimensions of human communities.

It's common sense that many students do not "see" themselves or do not know what is "produced" at the university, justifying the credit to that scientific researches amplify their benefits claimed beyond the academic buildings. Of knowing: in the scene of the current education, until what point scientific knowledge has fulfilled its educational exercise? In what way the scientific diffusion happens in the school contexts of Basic Education? The propagation of scientific information has been a powerful tool that uses and helps the individuals in development? Has it helped the individuals to realize a critical and creative reading about technological development of human society?

In a nutshell, the movement showed here, for beyond a simple (des) adjective of science – even if one cannot ignore its superb and filled with conveniences character – seeks to combine the canonic relevance of its method with the collaborative citizenship that must be its intrinsic property.

Scientific literacy and teaching through investigation: possible weavings to educate scientifically

About the main debates that concern the teaching of Science in the context of Basic Education, maybe there are the challenges of educating scientifically or, in other words, how can we educate researching?

The propositions of scientific literacy are intrinsically related with the curriculum of Science that have been following the interdisciplinary approach inter-related with technology and society. The scientific illiteracy is formed in a continuum process, enabling the individuals in formation to realize a world reading. Far from requiring the authority argument, it allows the individuals the perception of transformation of reality to better. Therefore, the demand of its authoring refers to the capacity (re)constructive of knowledge, shielded by the authority of argument and not the opposite (CHASSOT, 2006; DEMO, 2013; SASSERON, 2015).

> [...] The scientific formation cannot be visualized as an eventual external interference; it must be faced as intrinsic dynamic of the formative process itself. Another way of saying it would be accentuating formative aspects of the well-made exercise of 'argumentative authority', motivating the construction of authoring and autonomy (DEMO, 2013, p. 54).

Without falling into reductionism, the proposition of educating to research, consists in providing investigative environments in the classrooms, through simplified representation of the scientific work, so that the individuals in formation can amplify progressively their scientific culture, scientifically educating themselves (SASSERON; CARVALHO, 2008).

According to surveys from the Functional Illiteracy Indicator (INAF, 2018), the reality of Brazilian schools portrays, on a critical way, a delay in the quality of learning from the population in what refers to the mastering of literacy and counting skills (Table 1).

Table 1: Population distribution by levels of Illiteracy and Scholarship (% in scholarship)

	Total	None	Elementary School	Junior High	High School	College Education
Basis	**2002**	**116**	**297**	**451**	**796**	**342**
Illiterate	8%	82%	16%	1%	1%	0%
Rudimentary	22%	17%	54%	32%	12%	4%
Elementary	34%	0%	21%	45%	42%	25%
Intermediate	25%	1%	7%	17%	33%	37%
Proficient	12%	0%	1%	4%	12%	34%
TOTAL	100%	100%	100%	100%	100%	100%
Functional illiterate	**29%**	**99%**	**70%**	**34%**	**13%**	**4%**
Illiterate literate	**71%**	**1%**	**29%**	**66%**	**87%**	**96%**

Source: (Adapted from INAF, 2018, p. 8).

Table 1 reinforces the lack existing in the mastering of reading and writing codes that still persists in individuals already enrolled in High School level. It is observed that only 12% of the population in this school level are considered proficient and, still, 13% are considered functional illiterated (categories illiterate and rudimental). Those data take us to a discussion that a priori appears to be very "utopic", because, if it still persists the problems of scholar and functional illiteracy, how to argument about scientific literacy?

However, if one problem made us abandon the other, then que would surrender to being victims of a heritage predominately white and eurocentric from the years 1500. As it is said by Prensky (2010), knowledge is a disruptive and rebel dynamic, in constant evolution, and, thus, on that we should center our efforts.

Sharpening the optimistic perspectives of teaching by investigating to scientific literacy, Sasseron (2015) purpose the idea of hybridism between the scientific culture and the school culture, by the incorporation of elements from the scientific making to teaching elements from the classroom. The teaching by investigation, stimulating the argumentative exercise that it is intrinsic to it, allows a reflection around a problem, investigating the active participation of students in the search for solutions for the conflicts.

The practice of investigative teaching becomes relevant as far as it is noticeable in the educational context a school science that courts the scientists' science (from the Academy), even if the concepts that it needs to transmit are not comprehensible (CHASSOT, 2006). The school, under this judgment, has its own sentence amplified, when unauthorized the early knowledge (the ones students bring with themselves, from their own contexts of their sociocultural relations), that are not validated by the Academy (University) stamp.

Therefore, it still seems to be appropriate to discuss that the proposal of scientific literacy in the perspective of investigation teaching does not occasion the formation of scientists by the simple reproduction of apprentices from researchers in basic school. It is about the practice of argumentation, associated to scientific work, that embodies in the classrooms of Natural Science and can engage the students' development, capacitating them to perform in society, in a conscious way facing the problems that upset them and with disposition to overcome them.

Methodological course

The paper brought to discussion is from qualitative foundation, based on an exploratory study, with a research position of pedagogical intervention type. The qualitative approach prioritizes the process ad its meaning as objects of analyses and converge to necessary clashes around the supremacy of analytical science and supposedly empiric.

> The movements around the qualitative research seek comfort with the formalization excess, showing us that quality is less a question of extension than of intensity. Leave it left out would be a distortion of reality. If science has difficulty to deal with it, that is a science's problem, not a reality problem (DEMO, 2000, p. 29).

The exploratory studies presume, according to Lakatos and Marconi (2010, p. 188), "the formulation of questions or of a problem, with triple purposes: develop hypothesis, increase the researcher's familiarity with an environment, fact or phenomenon, for the realization of a future research more accurate or modify and clarify concepts.

The pedagogical intervention research is characterized by planning and execution of interferences that aspire upgrades and advances on the learning processes of the students participating. One of its main aspects is the posterior evaluation

of effects from the interferences that were implemented (COSTA; LORENZETTI, 2020; DAMIANI et al., 2013). Thus, it is not limited to mere activism, but aspire to increase the knowledge of researchers and the knowledge or 'consciousness level' of the people and groups considered – the research subjects (THIOLLENT, 1998).

The choice for intervention happened from the research realized during the Doctorate trainee stage of one of the authors, that pursued to comprehend the recovery and protective effect of nitric oxide on lettuce seeds exposed to drought and salinity. The formative route of the researches responsible for the theses authorship (student and supervisor) itself was marked by the dialogical interactive between teaching and researching, making the compromise of a return to society of all things produced by the scientific field public. As it has already been emphasized, the pedagogical intervention research is a reciprocal way: it must amplify the research subjects 'consciousness level', as well as from the one that searches – the investigator.

The research subjects include 70 students, regularly enrolled on 3rd year of regular High School, located in two classes in the afternoon shift; and teachers from Biology, Math and Chemistry. The investigation was conducted at a State Public High School located in Serra – ES, Brazil.

Investigation teaching as a didactic approach: application of an Investigation Teaching Sequence (SEI)

Structural criteria are constituted from "fundamental ideas that organize models and concepts that reflect in the epistemological status of a knowledge field and in their relations with other subjects and in the classroom teaching practice itself" (CARVALHO et al., 2012, p. 02). About those criteria, are included: subject, methodology and the teacher role.

The didactic modalities and resources that will value to fill one stage of high importance of the curriculum planning and are related with one of the criteria that structure the teaching of science: the methodology.

Inside the theoretical context and considering the discussions mentioned on the preview topic, this study proposed a sequence of investigative study, which didactic planning and interactions, that resonate from their application, will be listed here to occasion to the reader a better participation on narrating.

According to Carvalho (2013), the development of sequence of investigative teaching runs through key-steps that include three activities: the proposition of a problem; built knowledge systematization activity and knowledge contextualization, specially by the social importance of its applicability. Some SEIs more complex demand many application cycles of the three activities mentioned before, or even the accession of new proposals.

About the SEI that will be reported here, its planning happened through the steps previewed by Carvalho (2013), structured according to Board 1, and described as following:

Board 1: Structure of a sequence of investigative teaching

SEI STEPS	DURATION	CONTENTS WORKED
Questioning	1 55 minutes class Place: classroom 1 55 minutes class Local: UFES Lab	Vegetal species growth salinization impacts. Environmental sustainability and human communities' subsistence. Angiosperms germination. Vegetal physiology. Vegetables productivity and development.
Investigation	2 55 minutes class Place: UFES Lab 2 55 minutes class Place: School Lab	Seeds germination in vitro. Seeds analyses technics. Graphs construction and interpretation. Arithmetic average calculus. Length measure units. Math formulas resolutions.
Knowledge Systematization	4 55 minutes class Place: classroom	Tolerance and defense of vegetables against salinity stress. Nitric oxide effects over vegetal physiology. Scientific texts interpretation. Scientific method steps. Nitric oxide molecule reactivity Inorganic functions: salts. Oxireduction and NOX (oxidation number) variation.
Knowledge contextualization	1 55 minutes class	Science and society. Science popularization and scientific dissemination. Anthropic actions and ecosystemic disasters. Scientific culture, school Science and popular Science.

Step: Questioning

The questioning step of the SEI was conducted in two physical spaces: School and University. The dynamics of this initial step happened from a News taken from G1 website (globo.com) according the headline shown below:


Edição do dia 06/07/2013
06/07/2013 21h06 - Atualizado em 06/07/2013 21h06

Salinização de áreas irrigadas degrada terras do Nordeste

A longa estiagem está produzindo um efeito devastador no solo de áreas irrigadas do Nordeste, a salinização: 30% dessas áreas já foram atingidas.

Picture 1: News headline about the problem of salinization on irrigated areas of Northeast of Brazil. Source: "Portal G1". Available in: < http://g1.globo.com/jornal-nacional/noticia/2013/07/salinizacao-de-areas-irrigadas-degrada-terras-do-nordeste.html>. Accessed in: Dec. 2019.

(*In English, it says: "July 6th 2013 Edition: News title: "Salinization of irrigated areas damages lands in Brazil's Northeast" – The long drought is producing a devastating effect on the soil of irrigated areas of Northeast, the salinization: 30% of these areas were already affected.)

The news link was provided to the students to access from their own cell phones. Some copies from the news were provided for those students who demonstrated interest for reading the printed text.

After the time of silent reading, there were proposed to the students some catalyst questions that introduced all the other steps of the applied SEI: Are all plant species tolerant to salinity? On what ways can the salinity problem affect the economic and sociocultural dimensions of human communities? What are the practicable measures for the salinization problem under the sustainable aspect?

After reflecting about such environmental issues, the students could realize the damages that reach the agricultures of that region, that lose productivity and income, and that on the other hand is triggered by the negative impact on the plants' growth and development. Consequently, the problem to be investigated: Why does the soil salinization harms the plants development? How can we help the plants to stand this issue?

The hypotheses elaborated by the students, that serve to the core of the questioning indicated, emerged mainly during the step of building and following the experiments, and will be exposed on the next topic.

Step: Investigation

For encouragement of the questioning exposed in the introductory moment of the SEI, it was proposed an experimental activity developed in two distinguished environments: a priori in a lab in the Federal University of Espirito Santo – UFES and, afterwards, on the own schools' lab.

It was brought about a visit to the Seeds and Forest Ecophysiology Lab (LASEF) at UFES, where the students, by the researcher's orientation, had access to the infrastructure, to the researches being developed, as well as the opportunity to listen to reports of the experience from academics connected to LASEF.

On site, the students got familiarized with the equipment and the laboratorial routine of the researchers that develop researches with seeds germination. The students were oriented about the steps that comprehend the germination process on Petri dish and performed an experimental practice (Picture 2), with the objective of evaluating the germination of seeds submitted to different environmental conditions. On this phase, the most relevant thing was not the scientific concepts themselves, but the manipulative actions that awaken the lifting of hypotheses and the possibility of testing them. Advancing on the catalytic questions on the introductory moment, the practice in the University attempt to wave close relation to the dramatic situation lived by the agricultures from the Brazilian Northeast region, where the salinization has jeopardized the productive potential of various vegetal species.

Picture 2: Student preparing a germinate trial. Step developed at LASEF – UFES.
Source: Researcher register (2019)

Back to the school environment, the same trial design was replicated and followed by the students during 7 days (Picture 3). The students were organized into 8 groups (4 for each class) and divided between trials of germination with lettuce and beans. The germinate treatments were built under three conditions (control ([11]); saline solution at -0,6 Mpa ([22]) and saline solution with sodium nitroprussiate at 100 µM ([3])). 10 seeds of every dish were sowed, and the experiments maintained under the temperature of 25±1 ºC, in the presence of constant lightening (so that those conditions were attended, the school science lab remained during a week with the air conditioning supplies and lights turned on) (Picture 4).

On this phase was identified the elaboration of hypotheses by the students. A lot of them anticipated the germination developments, presuming what would happen with the seeds under each treatment condition. It was noticeable that the hypotheses were built by the analogy with the salinization problem on the soils from Brazilian's northeast region: in the dish with the NaCl solution, the students assured that the seeds "would not grow".

Script of practice class about germination

GERMINATION TEST PRACTICE

Objective

To determine the germination maximum potential of a seeds pack, which can be used to compare the quality of different packs.

Material

- filter paper; - Petri dish; - beckers; - pipette; - tweezers; - distilated water; - scissors; - beans and lettuce seeds; - NaCl solution on -0,6 Mpa; - SNP solution on 100 µM.

NOTE: Depending on the size of the seed and its demanding related to water quantity, it is possible to build germination tests in boxes like "Gerbox", which can be made with filter paper or other substrate such as sand or vermiculite.

Procedures

The germination will be conduct in Petri dishes forged with filter paper like *germitest*, moistened with 2mL (lettuce) and 4mL (beans) of the correspondent solutions for each treatment. There will be sown 10 seeds and the dishes will be kept under the temperature of 20±1 ºC, in the presence of constant lighting.

PARAMETERS TO BE EVALUATED AND WRITEN IN THE REPORTS:

1)Germination percentage (G)

To determine the germination percentage (G) was adopted the following formula:

$$G = (N/A) \times 100$$

Being: N = total number of germinated seeds; A = total number of seeds placed to germinate. (LABOURIAU; VALADARES, 1976).

2)Germination velocity index (GVI)

The GVI parameter will be determine by the number of germinated seeds related to the experiment time (MAGUIRE, 1962; KRZYZANOWSKI et al, 1999). For its evaluation will be adopted the formula:

$$GVI = G1/N1 + G2/N2 + Gn/Nn$$

Where: G1 = number of germinated seeds in the first counting; N1 = number of days passed until the first counting; G2 = number of germinated seeds in the second counting; N2 = number of days passed until the second counting; Gn = number of germinated seeds on the final counting and Nn = number of days passed until the final counting.

REPORT:

After the data collection the groups will have to present a report with the germination treatments, exposed with graphics. The report must have the following parts: Introduction; Material and Methods; Results and Discussion; Conclusion. The paper must be delivered printed.

Date for delivering: 22/08

References:

KRZYZANOWSKI FC; VIEIRA RD e FRANÇA NETO JB. 1999. **Vigor de sementes**: conceitos e testes. Londrina: ABRATES. 218p.

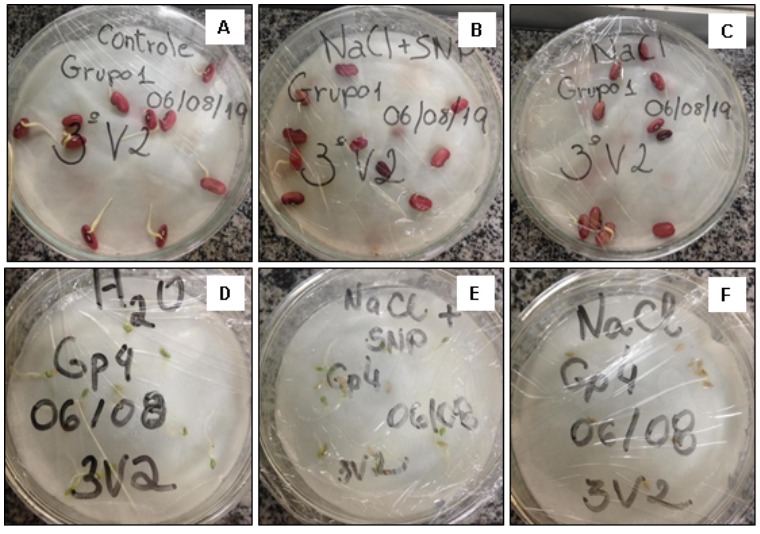
LABOURIAU LG e VALADARES MEB. 1976. On the germination of seeds Calotropis procera (Ait.) Ait.f. **An. Acad. Bras. Ciênc.**, Rio de Janeiro. v.48, n.2, p.263-284.

MAGUIRE JD. 1962. Speed of germination-aid in selection and evaluation for seedlig emergence and vigor. **Crop Science**, Madison, v.2, n.1, p.176-177.

Plant:	Saline stress Period: 7 days		Temperature: 20ºC
DIAS	Control	NaCl	NaCl + SNP
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			

	Roots			Aerial part		
	Control Treatment	NaCl Treatment	NaCl + SNP Treatment	Control Treatment	NaCl Treatment	NaCl + SNP Treatment
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Picture 3: Script for the practice class "Germination test" delivered to the students.



Picture 4: Experiments built by the students at the school lab. A, B, C – Germinate treatments with beans. D, E, F – Germinate treatments with lettuce. Source: Register made by the students during the making of the steps.

By the ending of the experiment, the students assessed measurements of the radicle length and of the area part of the seedlings, with the objective of realizing a comparative between the treatments (Picture 5). The students learned to calculate the parameters of germination percentage (%G) and the germination velocity rate (IVG), through formulas described by the scientific literature of the area.

Picture 5: Measurement of radicle and area part of the lettuce seedling.
Source: Register made by the researcher (2019).

It seems to be appropriated to highlight the interaction between knowledge areas in the school environment, by the promotion of interdisciplinary investigative paper. On that sense, it showed to be important the participation of the Math teacher that oriented the students to develop the statics part: calculus of the attributes of G (%) and IVG, confection of graphics, calculus of radicle and area part average, application of formulas for the verification of variables and interpretation of results. The climax of the project happened with the production of experimental report, from the description of the results observed by the students.

Step: Knowledge systematization

On this step, it was pursued to analyze the relevant variables about the announced problematic, facing the divulged knowledge systematization. For this phase analyses, were adopted the following resources: appreciation of the reports produced

by the groups; application of activity to verify the upper bound[44] level of scientific illiterate (Activity 1); application of activity to verify the capacity of interpretation of scientific texts (Activity 2).

On a class before the application of "Activity 1", the students were oriented to realize an ou-of-class research about the role of nitric oxide on the vegetables growth and development. When the moment to execute the activity arrived, it was allowed to the students to consult the researched material, if it was available printed. The groups were oriented to use the interpretations of the results obtained from their experiments, in the elaboration of a viable resolution to the proposed exercise (Picture 6).

Subject: Biology – 2nd Trimester		Date: ___/___/____
Teacher:		Value: 5 points
Grade: 3rd (Junior)	Class: ____	Grade: _____
Student:		

Orientation for the activity: It is forbidden to use the cellphone during the activity. It can only be used the printed or written researches brought by the group.

Components:

ACTIVITY 1 – GERMINATION PRACTICE

Through the observed results and knowing the SNP (sodium nitroprusside) is a nitrate oxide (NO) donner substance, create a hypothesis to explain in acting in the improvement of tolerance of plants exposed to saline stress.

Picture 6: Heading of the activity 1 applied to the students.

The "Activity 2" was previously organized by the distribution of 4 different scientific paper, one for each group of students. The articles chosen cover a proximal theme to the experimental study conducted by the students. In the occasion of the application, the students were oriented to identify in the scientific text the

[4] Paraphrasing Piaget, it was adopted the use of the expression "upper bound" that, according to the author, express a better and bigger balance than the previous, when the individual is submitted to new situations and/or challenges that destabilizes it. Here, the term is used to express the student's capacity on developing his/her process of scientific literacy, by the acquisition of new concepts and capacities

following topics: problem, hypotheses, methodology, main results and conclusion (Pictures 7, 8, 9, 10 and 11).

Subject: Biology – 2nd Trimester | Date: ___/___/____

Teacher: | Value: 5 points

Grade: 3rd (Junior) | Class: ____ | Grade: _____

Student:

Orientation for the activity: It is forbidden to use the cellphone during the activity. It can only be used the printed or written researches brought by the group.

Components:

ACTIVITY 2 – LEARNING TO INTERPRET A SCIENTIFIC PAPER

Summarize in the next lines the following topics referring to the article:

-What is the research problem? (What take the researchers to choose of the theme?)

-What are the researchers' hypothesis? (What the researchers hope that happens by the end of the experiments?)

-Methodology (How did they do it?)

-What are the main results?

-The realized research conclusion.

Picture 7: Heading of the activity 2 applied to the students.

APLICAÇÃO DE NANOPARTÍCULAS CONTENDO DOADOR DE ÓXIDO NÍTRICO NA PROTEÇÃO CONTRA OS EFEITOS DO ESTRESSE SALINO EM PLANTAS DE MILHO.

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Área e subárea do conhecimento: Botânica/Fisiologia Vegetal.

Palavras-chave: nanotecnologia, salinidade, *Zea mays* L.

Picture 8: “Paper 1” selected in the conduction of the step of knowledge systematization for the applied SEI”.

(In English, it says – Title: Nanoparticles application contemning oxide nitrate donner in protection against the effects of saline stress in corn plants/ Authors names/ Universities they are from/

Areas and subareas of knowledge: Botanic/Vegetal Physiology

Key-words: nanotechnology, salinity, Zea mays L.)

EFEITO PROTETOR DO ÓXIDO NÍTRICO SOBRE A SALINIDADE EM PLANTAS DE *Crambeabyssinica*Hochst (Brassicaceae)

Nathália Ferreira Flausino[1]
Rodrigo Miranda Moraes[2]
Jade Del Nero Oliveira[3]
Sandro Barbosa[4]

Picture 9: “Paper 2” selected in the conduction of the step of knowledge systematization for the applied SEI.

(In English, it says – Title: Protector effect of nitrate oxide over the salinity on plants of Crambeabyssinica Hochst (Brassicaceae) / Authors names)

Anais da Semana de Ciências Agrárias e Jornada da Pós-Graduação em Produção Vegetal
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Efeito do estresse salino na germinação e no vigor de sementes de repolho

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Picture 10: "Paper 3" selected in the conduction of the step of knowledge systematization for the applied SEI.

(In English, it says – Title: Effect of saline stress on germination and vigor of cabbage seeds/ Authors names/ Universities they are from)

EFEITO DA GERMINAÇÃO DE SEMENTES DE ALFACE (*Lactuca sativa* L.) EM DIFERENTES NIVEIS DE SALINIDADE

EFFECT OF DIFFERENT SALINITY LEVELS ON GERMINATION OF LETTUCE (*Lactuca sativa* L.) SEED

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Picture 11: "Paper 4" selected in the conduction of the step of knowledge systematization for the applied SEI.

(In English, it says – Title: Effect of different salinity levels on germination of lettuce seed/ Authors names/ Universities they are from)

Step: Knowledge contextualization

On this final step, in possession of the reports and Activities (1 and 2) evaluated, it was conducted a conversation circle with the students. With the researcher's mediation, it was pursed to detect in the students the positive and negative points, the potentialities and learnings of the applied learning sequence. There were punctuated

during the dialog relevant aspects about the importance of the scientific researches to the progress of human communities and animals and vegetables beings. It was also pursued to investigate in the students their own vision about the role of the scientist and the scientific researches and the perception of potential changes in the previews judgments of the students after the experimental work was conduct.

This phase of the SEI was concluded with the free production of texts by the students, with "insights" and "impressions" of the experience.

Investigative teaching sequence and pedagogical intervention research: convergences for scientific disclosure

On this topic, will be addressed the unfolding of the pedagogical intervention research developed in two High School classes of a regular public school. It will be pursued for beyond the steps interpretation of the SEI developed, its applicability about the assumptions of science popularization.

The plot of relations woven between the investigation teaching and the Science popularization it is not constructed devoid a more complex and consistent version of scientifically literate.

The scientific literacy suggests a certain care by guiding axes that transit between canonic points of science teaching and aspects that derivate of appropriation of these knowledge for actions in out-of-school contexts. According enunciates Sasseron (2015), there are three structure lines on scientific literacy: "basic comprehension of scientific terms and concepts; comprehension of science nature and of factors that influence its practice; understanding of the relations between science, technology, society and environment" (p.57).

For a better contextualization of the reader at this moment of discussion, the section will be divided according the steps of the SEI announced by Carvalho (2013), and previously characterized.

Step: Questioning

Having the proper decorum covered toward the substantial character of scientific literacy, the initial step of the SEI highlight aspects of two out of three structure lines mentioned above: **comprehension of the science nature and of factors**

that influence its practice and understanding the relations between science, technology, society and environment.

About the **comprehension of the Science nature,** it is imperative to treat its own historicity. Here, it is assumed a reading of an interdisciplinary and historically constructed science. After all, the study of the history of science does not occur on a disconnected way, at least on the "utopic" side of what we have idealized for teaching practices.

During the visit to the University research lab, the speech of the academics about the challenges and journey of the realized researches awakened a certain "surprise" on the High School students about the "human" nature of the researcher. The Eurocentric heritage itself that impose us, contribute to the idealization of a scientist model that embodies the figure, sometimes emblematic, sometimes odd, of a being with a bright mind and free of its own historicity and imperfections.

For sounding appropriated, it is stressed the conception of science as a human activity and the temporary character of scientific knowledge. Better scrutinizing these aspects, it is read pieces of two texts about the history of science, taken from the book *Source book on physics* (MAGGIE, 1935):

> Being recently in charge of the superintendence of cannon drilling, in a workshop of military arsenal in Munique, I was impressed with the significant heat degree that a metallic piece acquires, in a short amount of time, being drilled; and with the heat even more intense (bigger than the heat of boiling water as I have proven by experience) of metallic chips originated by drilling (p. 151-152).

> The more I thought about these phenomena more they seemed to be to me curious and interesting. A complete investigation of them seemed, at the same time, offer a satisfactory interpretation to the occult nature of heat and make us capable of weaving some reasonable conjectures related to the existence or not of an igneous fluid: a subject that for a long time has divided the opinion of philosophers (p. 160-161).

The segments describe the impressions that Benjamin Thompson (physicist and inventor) on the work with cannon drilling. The contributions of the scientist to the modern Kinetic Molecular Theory do not emerge from isolated moments, circumscribed within the four walls of an equipped lab, but from his own participative sociocultural context: in the practice of his working activity. On the same way, his experience with heat coming from metals chips takes him to question the scientific theory current at the time, the one that validated the existence of an igneous

fluid [5] [5](caloric) included on material bodies (solid, liquid and gases). Benjamin Thompson suspects regarding the caloric theory send us back to the provisory character of scientific concepts, for this propose, just look the ideas broadly widespread and accepted on that context for a long time has become obsolete.

On a similar way, the contact of the students with researchers during the visit provide interesting speeches about science's social dimension. Many did not consider listening from the scientists present that their papers had moments of frustration, perception of execution mistakes on some steps, or even of the difficulties faced due to lack of resources for costing the research. Now, if for those beings with "privileged minds" there are difficulties, it can, at least, disprove the supernatural and ridiculous character assigned to the scientist figure.

Here it fit us a reflection regarding the importance of assigning the teaching of Science to a character less a-historic (CHASSOT, 2006). That suggests the perception that the history is not ready and how are we transformation agents (we can change the world and change it to better). The other perspective is that there is not an unchangeable truth. And, in conclusion, that the scientists are social subjects, located on time and space, inserted in a personal history and written in cultural environments that molded them. With that, the students could realize that the difficulties faced by them during the learning of scientific concepts, can moreover had been the same faced by the scientists of the history of science.

About the axis **understanding the relations between science, technology, society and environment**, it is highlighted the article proposed at the beginning of questioning, with which was revealed the impact of science over human communities and the relevance of scientific research that reverberate upon the environmental problems, such as, for example, the situation of salinization of soils at the Brazilian Northeast.

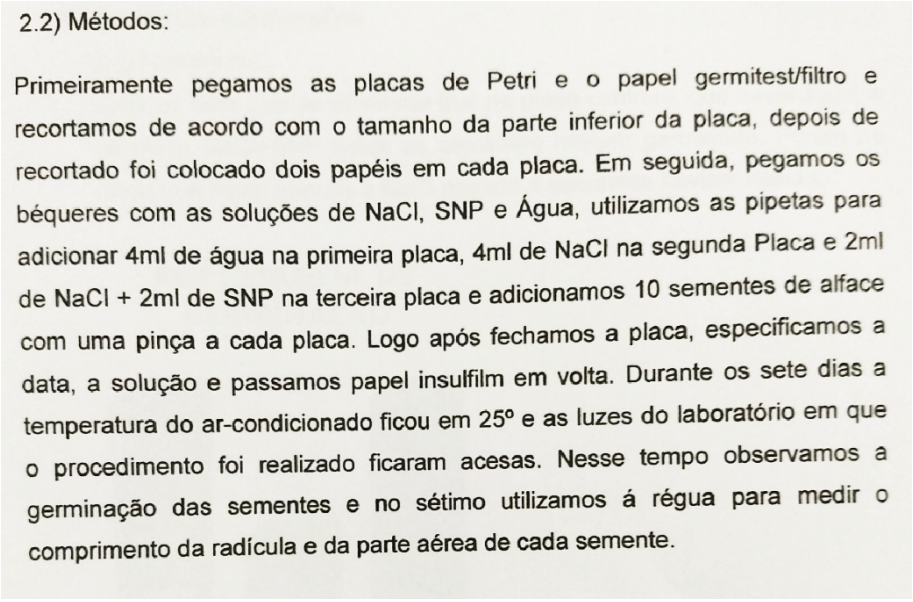
Step: Knowledge systematization

In the continuous and necessary practice of return to the structural axis proposed by Sasseron (2015), the phase of knowledge systematization of the SEI applied is aligned to the presumptions of the first axis: **the basic comprehension of scientific terms and concepts**.

[5] Invisible and odorless fluid, called caloric, that all bodies would have in determine quantities in their composition, that was nominated as the causer of temperature alterations.

The reports created by the students give relevant clues about the appropriation of concepts and the amplification of a scientific cultural repertoire, as it was observed in the domain of specific technical aspects.

In cutouts from "Material and Methods" described in the presented reports (Picture 12), the students demonstrate to distinguish activities that comprehend the "experimental methodology". It is noticeable the domain over the "tools" (Petri dish, germitest paper, pipette, tweezers, ruler) used during the built of the experiments (as much on what it is referred to identification as to manipulation of instruments). Not diminishing the essentiality of the formal quality of the research, the analysis of the reports denotes abilities connected to the precision of the scientific method, validity so pleading throughout science's own history – students describe the "ideal" conditions for the germination to happen, such as temperature and lighting.



2.2) Métodos:

Primeiramente pegamos as placas de Petri e o papel germitest/filtro e recortamos de acordo com o tamanho da parte inferior da placa, depois de recortado foi colocado dois papéis em cada placa. Em seguida, pegamos os béqueres com as soluções de NaCl, SNP e Água, utilizamos as pipetas para adicionar 4ml de água na primeira placa, 4ml de NaCl na segunda Placa e 2ml de NaCl + 2ml de SNP na terceira placa e adicionamos 10 sementes de alface com uma pinça a cada placa. Logo após fechamos a placa, especificamos a data, a solução e passamos papel insulfilm em volta. Durante os sete dias a temperatura do ar-condicionado ficou em 25º e as luzes do laboratório em que o procedimento foi realizado ficaram acesas. Nesse tempo observamos a germinação das sementes e no sétimo utilizamos á régua para medir o comprimento da radícula e da parte aérea de cada semente.

Picture 12: Cutout about "Material and Methods". Fragment extracted from the reports presented by the students.

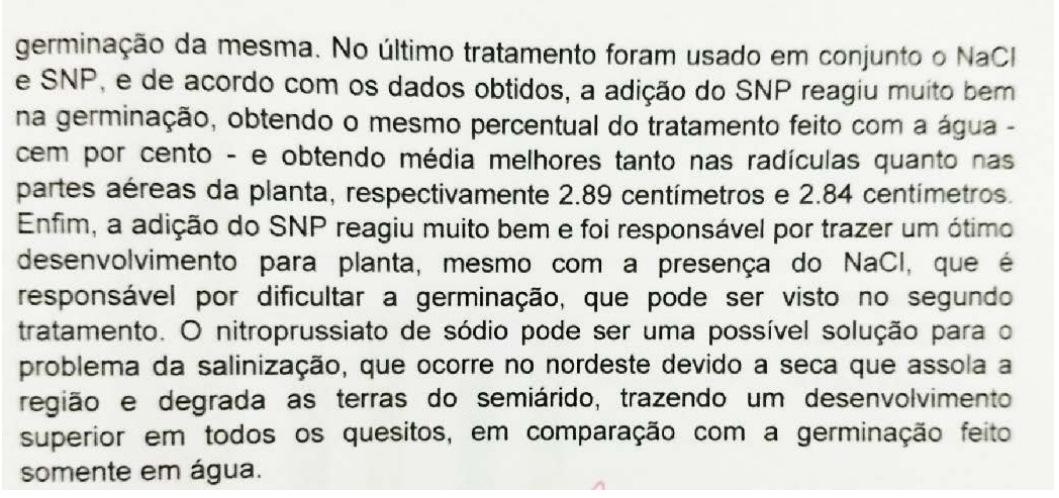
(In English, it says: "First we took the Petri dish and the germitest paper/filter and cut it according to the size of the bottom of the dish, after cutting they were placed two papers in each dish. Following, we took the beakers with the solutions of NaCl, SNP and water, we used pipettes to add 4ml of water in the first dish, 4ml of NaCl on the second dish and 2ml of NaCl + 2ml of SNP on the third dish and added 10 lettuce seeds with tweezers in each dish. After that we closed the dish, specified the date, the solution and covered with insulfilm paper around it. During the seven days the air conditioning temperature was kept at 25oC and the lights of the lab were the procedure was made were on. During this period, we observed

> the seeds germination and on the seventh day we used a ruler to measure the length of the radicle and the areal part of each seed".)

The qualitative evaluation of scientific literacy, beyond the axis that structure its organization, suggests a prescription of indicators of its effectiveness, as proposed by Sasseron (2015). The indicators are abilities bound to the comprehension of science themes and that deflagrate upon the active role of the apprentice in search for the understanding of these thematic.

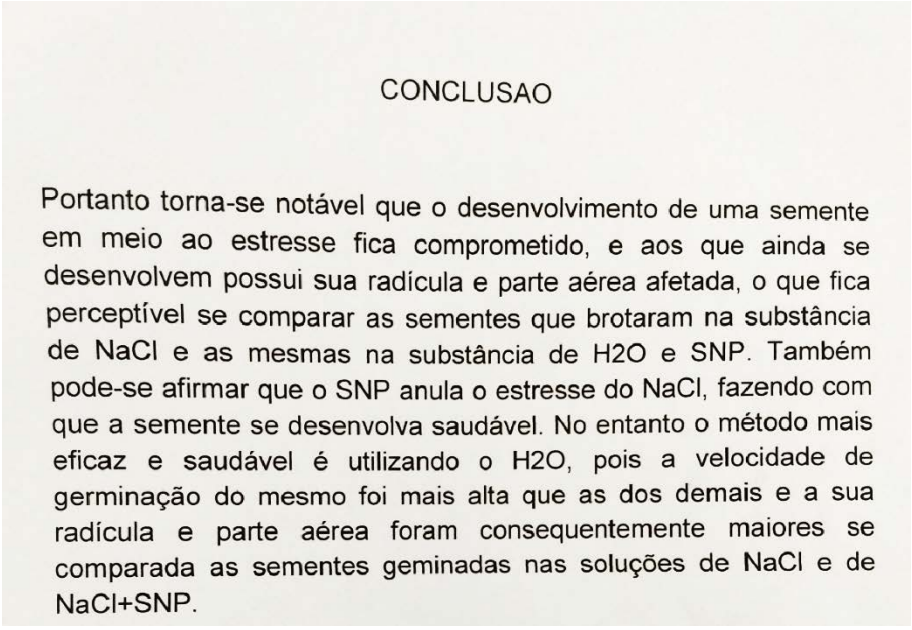
The fragments extracted from the reports and exhibit below, signalize these essential indicators such as: the treating of available information and data; the hypotheses survey and tests by the students; the proposition of explanations for the phenomenon observed, seeking justifications to rate them and establishing previsions arising from those explanations; the use of logical thinking during the investigation and the communication of ideas in situations of learning teaching (SASSERON, 2015).

There are evidences that students contextualize the collected data: first, by the description of visual attributes, relating them to morphological aspects of the tested species ("it has its radicle and areal part affected"; "obtaining better averages as much on the radicles as in the areal parts of the plant"); second, for the capacity of previewing "benefits" and applicability of the experiment (*"the nitroprusside of sodium may be a possible solution for the salinization problem, that occurs on the Northeast because of the drought that desolates the region and denigrate the semiarid lands"; … because they help the plants develop"*) (Pictures 13, 14 and 15).


germinação da mesma. No último tratamento foram usado em conjunto o NaCl e SNP, e de acordo com os dados obtidos, a adição do SNP reagiu muito bem na germinação, obtendo o mesmo percentual do tratamento feito com a água - cem por cento - e obtendo média melhores tanto nas radículas quanto nas partes aéreas da planta, respectivamente 2.89 centímetros e 2.84 centímetros. Enfim, a adição do SNP reagiu muito bem e foi responsável por trazer um ótimo desenvolvimento para planta, mesmo com a presença do NaCl, que é responsável por dificultar a germinação, que pode ser visto no segundo tratamento. O nitroprussiato de sódio pode ser uma possível solução para o problema da salinização, que ocorre no nordeste devido a seca que assola a região e degrada as terras do semiárido, trazendo um desenvolvimento superior em todos os quesitos, em comparação com a germinação feito somente em água.

Picture 13: Cutout about “Results and Conclusion”. Fragment extracted from the reports presented by the students.

(In English, it says: “…germination of itself. On the last treatment were used together the NaCl and SNP, and according to the obtained data, the addition of SNP reacted very well on germination, obtaining better average as much in the radicles as in the areal parts of the plant, respectively 2.89 centimeters and 2.84 centimeters. At last, the addition of SNP reacts very well and was responsible for bringing a great development for the plant even with the presence of NaCl, that is responsible for making the germination difficult, that can be seen on the second treatment. The sodium nitroprussiate can be a possible solution for the problem of salinization, that happens on the Northeast because of the drought that desolates the region and denigrates the semiarid lands, bringing a higher development in all concerns, in comparison with the germination done only with water”.)

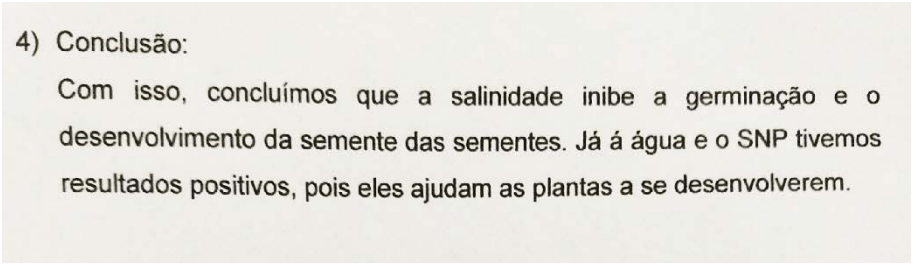


CONCLUSAO

Portanto torna-se notável que o desenvolvimento de uma semente em meio ao estresse fica comprometido, e aos que ainda se desenvolvem possui sua radícula e parte aérea afetada, o que fica perceptível se comparar as sementes que brotaram na substância de NaCl e as mesmas na substância de H2O e SNP. Também pode-se afirmar que o SNP anula o estresse do NaCl, fazendo com que a semente se desenvolva saudável. No entanto o método mais eficaz e saudável é utilizando o H2O, pois a velocidade de germinação do mesmo foi mais alta que as dos demais e a sua radícula e parte aérea foram consequentemente maiores se comparada as sementes geminadas nas soluções de NaCl e de NaCl+SNP.

Picture 14: Cutout about “Conclusion”. Fragment extracted from the reports presented by the students.

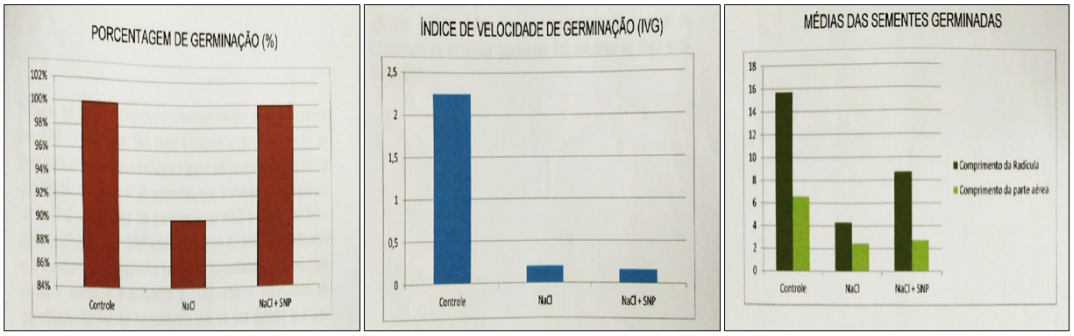
(In English, it says: “Therefore it becomes noticeable that the development of a seed in the middle of stress gets compromised, and to the ones that still develop have their radicle and areal part affected, that gets perceptive if comparing the seeds that grew in the NaCl substance and the same in the H2O and SNP substance. We can also affirm that the SNP deletes the NaCl stress, making the seed to develop health. However, the most effective and healthy method is using the H2O, because its speed of germination was higher than the others and its radicle and areal part were consequently bigger if compared to germinated seeds in the solutions of NaCl and NaCl+SNP”.)


4) Conclusão:

Com isso, concluímos que a salinidade inibe a germinação e o desenvolvimento da semente das sementes. Já á água e o SNP tivemos resultados positivos, pois eles ajudam as plantas a se desenvolverem.

Picture 15: Cutout about "Conclusion". Fragment extracted from the reports presented by the students. (In English, it says: "With that, we conclude that the salinity suppresses the germination and the development of the seeds' seed. Whereas the water and the SNP we had positive results, because they help the plants to develop".)

The graphics built exhibit the interpretative capacity of the students before the collected variables (G, IVG, radicle length, areal part length), as well as the aptitude on adequately discriminating the measures units for each kind of evaluated parameter. It was observed the students' ability on the calculus of attributes as, also, in the systematization of data by the statistics slant (Picture 16).



Picture 16: Graphics of G (%), GVI and averages of radicle and areal part length. Fragment extracted from the reports presented by the students.

The students' answers obtained with the application of *Activity 1* filled one of the main requisites claimed by the scientific education: the reconstruction of knowledge. The process of self-educating scientifically finds its fundament in the expectative of society intensive of knowledge. It is not enough a simple passive "assimilation" of subjects, but also an investment for originality during the process. The scientific literacy only translates its efficacy in environments of textual production and not of the ones reproduced passively (DEMO, 2013).

Going against the pessimistic expectations about the inefficacy of investing on scientific education, the students demonstrared not only having "assimilated" the scientific concepts, as well as the capacity of a resignification of them with an own, personal and contextualized meaning, that was noticed on the answers of several groups of students[6] (G1, G4 and G6) to the Activity 1.

As follows, as an income of exemplification of what was exposed, the texts produced by the students does not exhibit any authorship, but denote one own science language, attacking their methodologic cares, just as required in a scientific essay.

> G1: In conditions of stress, the nitrate oxide acts as seed protector, and its answer against the stress is given upon diverse mechanisms, such as the induction of defense genes expression, through protector enzymes and the development of their own chloroplasts. Generally, it is used as a way of minimizing the saline and hydric stress on seeds, and, consequently, favoring its own development.

> G4: Being a specie reactive to oxygen (ROS) the nitrate oxide neutralizes the effect of numbness on the seeds, an effect that prevents them from germinate. Comparing with our research, we agree with that, because, amidst NaCl + SNP, being the SNP a donner of nitrate oxide, even being on a stressful situation the plant could germinate.

> G6: Bottom line, it signalizes all the systems of the seed/plant making them "work" to survive in such stressful situation. This part of signalization can also be related to the protection, because as the nitrate oxide signalize all, these mechanisms that it signalizes will be protecting the seed/plant.

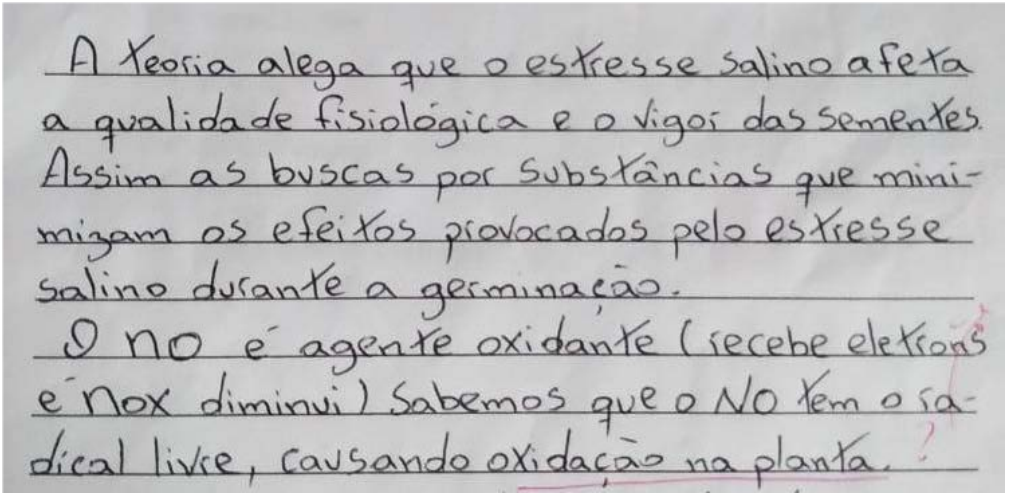
It is undeniable the importance given to the popularization of Science, that amplified roughly in the past years. The arguments around this expansion put in check the motivations that occasioned the initiatives of the big centers of knowledge production: university, organs of research promotion and institutes of technologic stamp.

The changeable character of the scientific disclosure activities is linked to the capacity that those actions can bring, even to the scientifically "initiated" citizen; the insight about the scientific information that is transmitted to him (ALBAGLI, 1996; GERMANO 2007; OLIVEIRA, 2013).

Still during this step, it was observed a students' enganging to obtain the answers to a positive action of sodium nitroprusside (SNP) upon the vegetables. The

6 On the purpose of salving the privacy of the research participants, the groups of students will be represented by the letter "G" followed by a number, characterizing the eight groups of students formed during the execution of the steps of the SEI.

students pursued assistance from the Chemistry teacher for a better comprehension about the chemical structure of the NO molecule and about its interaction mechanisms, reactivity and its relation on the elimination of toxicity produced on stress situations (Picture 17).



Picture 17: Answer elaborated by a group of students about the "chemical" action of the nitrite oxide molecule (Activity 1).

(In English, it says: "The theory plead that the saline stress affects the physiologic quality and the seeds vigor. That way the searches for the substances that minimize the effects provoked by the saline stress during the germination. The NO is a oxidant agent (receives electrons and NOx reduces) we know that the NO has a free radical, causing the plants oxidation".)

The nitride oxide acts as a signalized substance on vegetables and represents the capacity of reducing the oxidative damage, directly neutralizing the reactive species of oxygen (EROs) and eliminating them from the cell. Its action derives to the presence of mismatched electron that gives high reactivity to the molecule, considered to be an antioxidant. The NO has a tendency of attacking other molecules, stealing electrons, and making it to be oxidized (lose electrons), while the radical is reduced. On clear terms, the interaction mostly known on plants it is of the anion superoxide (a free radical dangerous for the cell) with NO to form peroxinitride (ONOO-), molecule that is quickly decomposed onto stable products, reduced to cellular toxicity (GROß et al., 2013; SHEOKAND; KUMARI, 2015).

Even if it does not present a formal and complete structure (Picture 17), the answer of the students demonstrates comprehension of biochemical processes that

the nitrite oxide molecule unleashes, extrapolating even the most common and superficial notion of that the "oxidation", by itself, always characterize a harmful effect.

The proposition of *Activity 2*, as long as an immersion strategy and "belonging" to the "scientific universe", fulfil the requirements for this purpose, when it is observed the students' ability on the interpretation of scientific researches realized. Well, the idea of the nature being frequently ambiguous for the scientific knowledge does not allow the common citizen to distinguish its accomplishments, fortunately does not represent a unanimous.

> 1- The general problem of the research is based on the substrate salinity that is one of the main factors of the lettuce low productivity. This theme was chosen with the order to find out the influence of salinity on the lettuce seeds.
>
> 2- The main hypotheses raised by the researchers is that the sowing under stress conditions on the soil may result in a low percentage of development and lower emergency velocity.
>
> 3- Lettuce seed were used and were submitted to 6 different doses of NaCl that were equivalent to their respective osmotic potentials, under a determine temperature evaluating the germination after 96 hours from the application of NaCl.
>
> 4- The main results of the research conducted were the decline of germination, length and seeds dry matter mass percentage according to the increase of NaCl concentration and of osmotic potential.
>
> 5- It is concluded that the bigger the salinity and the osmotic potential of the middle of the germination, smaller the development will be
>
> (Answer created by group of students for the *Activity 2*. The interpretative activity refers to the "Article 4" – See Picture 11).

Step: Knowledge contextualization

The step of contextualization of a SEI is a type of "public sphere" of the scientific method, turned to the service of reality and to a collaborative citizenship that knows how to think. Dara to consider this step as an opportune moment of those who desire to "turn the table"[7] .

[7] Allow us an addendum about the meaning of the expression. Paraphrasing Lobo (2008), we speak about "to the minority […] to the singular variations transmitted by a web of marginalized through their fights, their resistances, their conformism, their joy and bitters" (p.58). We invite to a reflexive exercise about the "minority processes that go through society and that most afect those whose difference is always reduced to inequality and to a consequent subjugation" (p.58). About "those" bolded, we give the desire of "turn the table".

Science popularization, literacy or scientific education seem that can coexist when they acquire the educative practice of its formative appealing. Scientific research is a project typically Eurocentric, in general strongly patriarchist, Nordic, politic and colonizer (DEMO, 2013). The change will come just by the democracy of the method, by the rebellion of the reach of all to the scientific language and artifacts – a political right of collectivity.

In the final step of the SEI route, it was opportunized to the students the report of their experiences/impressions with the achieving of the investigative experiments, reports and activities. The registers also happened in the form of texts[8], delivered after the "conversation circle" conducted by the researcher:

> A1: Well, I found relevant to learn and see how the food develops in various types of situations, I say food because we worked with beans and lettuce I think how would it be the same development of the experience with flowers or other kinds of vegetables mixing other substances, it was a different and at the same time interesting experience.
>
> A2: In the experience I found interesting the fact of participating of a hole process, that is, being active in the experience. I liked the performance related to the development of plants, interesting to see the solutions interfere in the productivity.
>
> A3: Positive aspects – the knowledge about how to germinate beans in another way without using "cotton" as we do in our childhood, it was extremely impressive the ways that the products put on the beans react making it reproduce in 1 week.
>
> A4: Just think of how much we enjoy with all of this, because disasters as the ones in Mariana and Brumadinho happen and if we are ready we can avoid terrible things for the soil.

The contextualization of scientific knowledge is perceptive when it hits the transversality of socialized knowledge. Clarifying these affirmative, when it is realized the applicability or implantation of knowledge acquired in other contexts that the individual in formation is the participant partner agent. The students mention other ecosystem disasters (A4), whose socio-environmental sequels are still felt by the local population and in national scale ("*Just think of how much we enjoy with all of this, because disasters as the ones in Mariana and Brumadinho happen and if we are ready we can avoid terrible things for the soil.*"). Here science seems to recover certain "breath" when advocates its fruitful nature to the social responsibility.

[8] Fragments of texts elaborated by students with impressions and insights around the experience proportioned by the SEI. The students were identified as A1, A2, A3 and A4.

The students' reports denote, still, a progress on the practice of "scientific making". Research is a permanent and continuous practice. The researcher researches, reconstruct the knowledge, creates hypotheses, experiment, build, learn how to learn. On a text fragment produced by student (A1), she points out that the germination experience was relevant and provided the desire of learning about how "food" develops. Still, it is explicit on the report the curiosity of how it would be the development of "similar" experience with other vegetal organs, other species, or using other substances. Student as scientist may seem anecdote, but means potential formation, capable of propelling people on the intensive society of knowledge (DEMO, 2013).

The contextualization practice, as proposed on this step, faces perhaps the biggest "brio" of science as a unique, universal and undisputed supremacy. Historically, the practice of science power happened by the acceptance of its imposing authority. Conversely, in the post-modern times, the diffusing of scientific education emphasizes the expansion of the students previews knowledge, in order to make the scientific information more significant ("*the knowledge about how to germinate beans in another way without using "cotton" as we do in our childhood…*" – A3).

Finally, the argumentation and investigation compose the culture of scientific making, that, on the other hand, corroborate to the claimed indicators on the literacy process. This logic only processes when the student transits from the sphere of "plagiarism"[9] – characteristic of traditional methodologies essentially "instructionalists" – to a new level of authorship, active and participant ("*I found interesting the fact of participating of a hole process, that is, being active in the experience*" – A2).

Final Considerations

It must be considered that power is not an illegitimate reference of scientific knowledge, only when assume the abuse of its politics. About science and its achievements, it is not questionable its political practice, because it views the promotion of citizenship, and the formation of more critical beings, cultivating environments favorable to the scientific literacy (CHASSOT, 2006; DEMO, 2013).

Considering the contemporary challenges of Science teaching and the growing demands by the diffusion of scientific knowledge, this paper pursued the proposition

[9] Here, understands plagiarism not as bad intention appropriation of the belongings of others, but as a logical passive reproduction on what it is transmitted.

of investigative and interdisciplinary activity, by the interchange between Academy and school, viewing the popularization of what is produced by science.

Through the proposed study, it is postulated that the investigative teaching, as a didactic approach, amplified the scientific repertory of the participant students and its method, by which they could test and find out the negative influence of saline environments on the vegetables development. It is worth to highlight that the SEI promoted the interaction between different knowledge areas (biology, math and chemistry) by the students' initiative, as a way of visualizing their investigations. On this process, it was observed significant progress on the participants learning, who demonstrated to comprehend and discuss on an integrated form, concepts of biochemistry and plants metabolism, considered of grand difficulty by teachers and students. The activities conducted during the SEI corroborate to reflections about the impacts that anthropic actions have been occasioning to the ecosystems and in what scale these practices threaten the human subsistence itself.

With the advent of the technical-scientific community, especially in the end of the 19th century, the Science starts to relegate the artificial intentionalities of social technocratic and hegemonic trading models, to engender its social affirmation, seeking to legitimate itself to human communities (ALBAGLI, 1996; GERMANO 2007; OLIVEIRA, 2013).

In the meantime, so that Science can acquire the proper structural impact, it is necessary scientific education. A bridge that opens up to new horizons, many times unknown by the students. That implies a hybridism between the school culture and the scientific culture that, in the case here described, it is about a hybridization also of the physical space where the school culture and scientific culture blends in by the interchange and knowledge socialization.

Society is naturally a power and counter power web, and produce knowledge is possibly an essential ability required by those that desire to "turn the table". That implies a permanent dialogue that reduce obscurities, invalidate the domain relations and benefits a less apolitical teaching, less a-historical, building the citizenship that knows how to think (CHASSOT, 2006; DEMO, 2013).

Therefore, we advocate a proposition of a teaching by trialetic dimension, guided in the fusion between: investigation, literacy and scientific education. Only by these conditions it can aim a popularization of science and enter in the intensive knowledge society.

Educação científica e popularização da ciência: o ensino de investigação como abordagem educacional

Resumo:

Conhecimento sempre foi estratégia de poder, orientando o desenvolvimento das sociedades, economias, culturas e indivíduos. A análise da historicidade da ciência revela uma de suas tônicas mais relevantes: a postura lógico-experimental, responsável pelas tecnologias mais recentes e marcantes da história eurocêntrica. Entretanto, a autoridade indiscutível do conhecimento científico trai sua própria origem quando aniquila a autocrítica, uma herança que ressoa da ciência universal, absoluta e imutável. Nesse ínterim, o ensino de Ciências carrega os aspectos que reverberam a própria historicidade científica. Não são raras as queixas de estudantes da Educação Básica de que aprender Ciências significa "decorar palavras difíceis". À vista disso, esta pesquisa objetivou a proposição de atividade investigativa, por meio do intercâmbio entre academia e escola, visando a popularização da ciência. O percurso metodológico incorreu em pesquisa qualitativa, calcada em estudo exploratório, com proposição de intervenção pedagógica. Foi desenvolvida uma sequência de ensino investigativa (SEI) com 70 alunos no Ensino Médio de uma escola pública. A SEI aplicada foi orientada pelas três etapas-chave previstas por Carvalho (2013): problematização; sistematização e contextualização do conhecimento. Por intermédio do estudo proposto, postula-se que o ensino investigativo, enquanto abordagem didática, ampliou o repertório científico dos estudantes participantes e de seu método, por meio do qual puderam testar e descobrir a influência negativa de ambientes salinos no desenvolvimento dos vegetais. Nesse sentido, advogamos uma proposta de ensino trialética, pautada na fusão entre: investigação, alfabetização e educação científica, condições indispensáveis à popularização da ciência e ingresso na sociedade intensiva do conhecimento.

Palavras-Chave: Alfabetização científica; popularização; SEI.

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