LUMEN ET VIRTUS

UESC Knowledge Park: 21 years promoting the popularization of science and physics teaching

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ABSTRACT

The UESC Knowledge Park is an extension action with 21 years of history promoting the popularization of science, teacher training and physics teaching in the southern region of Bahia. Historical facts are reported, obtained through documentary research, of the trajectory of the extension actions promoted, partnerships formed and transformations of extension practices over time. The objective of this article is to show the adaptation of the project's activities to the reality of the schools served, from scientific exhibitions to workshops, mini-courses for the teaching of experimental Physics through Information and Communication Technologies (ICT) and Internet of Things (IOT) at times opposite to classes.

Keywords: Popularization of Science, Physics Teaching, Teacher Training.

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INTRODUCTION

Historical research was carried out in personal documents, such as records of submitted projects, photos and articles for a survey of the initial trajectory of the extension action Knowledge Park of the State University of Santa Cruz (UESC), which has been registered in the Dean of Extension as a permanent extension action since May 2003.

Originally, the UESC Knowledge Park (PARCON) was submitted to a meeting of the then Department of Exact and Technological Sciences (DCET) as a temporary extension action of two years on March 13, 2003. We shared the authorship with Professor Nestor Correia, now retired.

We had a great collaboration with Professor Herlon Silva Brandão, also retired. Herlon, who at the time was director of DCET, bridged the gap with the entire structure of UESC, since both Nestor and I were beginning professors at the time.

Other collaborators were Professor Sérgio Xavier da Silva, who was a recent graduate student of the Physics Degree course and Professor Lívia Rocha from UESC, who at the time coordinated the first activities of the Pedagogical Museum of this institution.

We also received a lot of support from the then Rector of UESC, Professor Reneè Albagli Nogueira, Professor Maridalva de Souza Penteado, Pro-Rector of Extension and the Department of Education of the municipality of Ilhéus, which was the responsibility of Professor Dinalva Melo.

The first experiments that were part of this project were carried out with low-cost material and with materials from the UESC Physics teaching laboratory that were not in use. At the time, the project did not bring any cost to the University and old kits of materials that had existed in the University were used. Examples of these materials were kits from the former Funbec (Brazilian Foundation for the Development of Science Teaching), extinct in 1990, and from Bender, a São Paulo industry that produces material for physics experiments, also extinct.

The first exhibition was held on the premises of the municipal library of Ilhéus (former general Osório college) (Photo 1). The inauguration took place on September 29, 2003. Present, from left to right in Photo 2, were Professor Herlon, Nestor, Adriano, Reneé, Dinalva and Maria Luiza Heine, who was president of the Cultural Foundation of Ilhéus. To Herlon's right was Professor Maridalva.

Photo 1: Municipal Library of Ilhéus. Source: Author's collection.

Photo 2: Inauguration of the first exhibition of PARCON. Source: Author's collection.

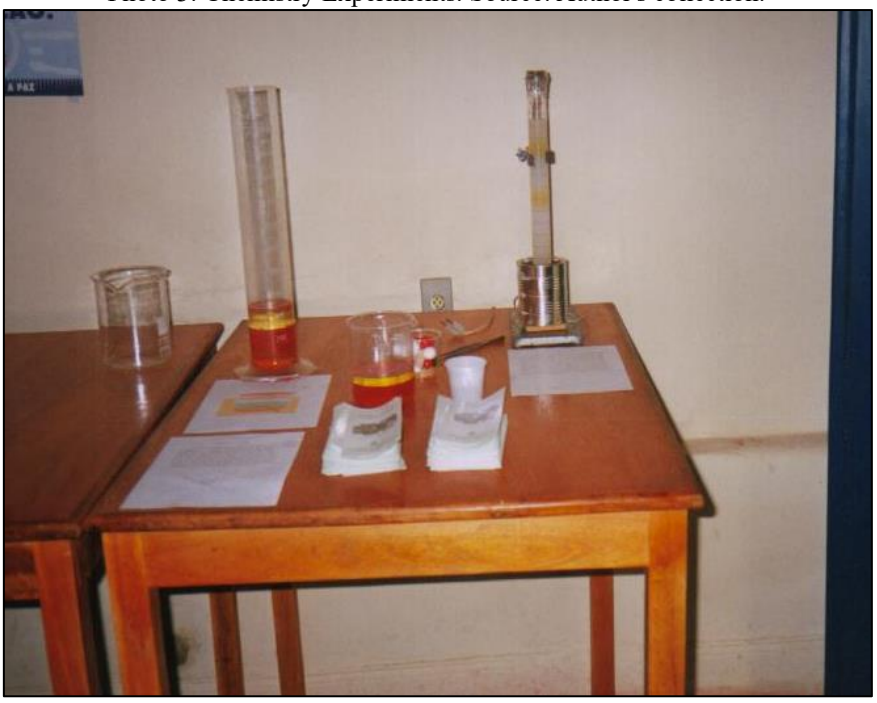
At the time, we had two extension scholarship holders who received visitors and scheduled schools throughout the day. In the first days of the exhibition, we also had the Chemistry exhibition, coordinated by Professor Neurivaldo José de Guzzi Filho (Photo 3). The exhibition was completed on December 15, 2003 and had 923 visitors, including free public and scheduled schools.

The physics experiments that were part of the first exhibition were: s'Gravezande's ring, Galileo's thermoscope, the Duke de' Medici's thermoscope, kinetic model of gases, liquid convection, thermoelectric, air dilation, nail bed, pulley system, vortex, propagation of mechanical waves, resonance, bicycle wheel (conservation of angular momentum), current balance, elementary motor,

transformer, jumping ring, induction furnace, electromagnetic induction, magnetic field visualization of magnets, electronic circuit, polarization of light, light and colors (STUCHI, CORREIA, 2005).

At the beginning of the 2004 school year, PARCON exhibited at the Rotary College of Itabuna for a period of approximately 60 days. In addition to the experiments, a website was initially set up, where explanatory scripts of all the experiments and computer simulations of some of them were hosted, carried out. with the help of extension scholarship holders from the Computer Science course at UESC.

Photo 3: Chemistry Experiments. Source: Author's collection.



PARCON also offered physics experiments to be taken by teachers as loans. The experiment library had experiments in Mechanics and Electromagnetism made with low-cost material. The teachers also had support at UESC and on the website to carry out activities in the classroom.

The initial objectives of the project were to create a science museum in the region where UESC operates, to enable the development of research and science teaching and scientific dissemination, to promote initial and continuing training actions for teachers and to create a center for the development of new technologies and science teaching.

Another goal of the project was to make room for other areas of knowledge. This was accomplished shortly afterwards with the participation in a CNPQ public notice in 2003 in which we could count on the area of Paleontology, in addition to Physics and Chemistry. The project, called EXPOENERGIA, was contemplated and more physics experiments were acquired, along with chemistry materials, models and fossils that illustrated the generation, transformation and use of

energy from various sources. The exhibition initially took place in the space of the Adonias Filho Cultural Center in Itabuna in the second half of 2004.

In 2005, many other UESC professors, mainly from the area of Biological Sciences, Astronomy and Mathematics, in addition to those already mentioned from Physics, Chemistry and Paleontology, joined to carry out a broader project, called Truck with Science. The project was contemplated with the purchase of a truck, so that the dreamed science museum could at that moment gain wheels and become a traveling exhibition.

In 2006, work began, basically with the same team for the elaboration, of the UESC science center, called Cais Consciência (Consciousness Pier). The project was also contemplated by CNPQ and started its activities partially in 2007. Even today, it is waiting for infrastructure resources to continue its activities fully.

Currently, the Knowledge Park is responsible for coordinating the area of Physics in the Truck with Science, but it has greatly diversified its activities, also working in schools with Experimental Physics workshops and actions for the continuing education of Physics teachers. Next, we address these actions and show how the ideas evolved according to the experiences acquired.

THE TRAVELING SCIENTIFIC EXHIBITIONS OF THE KNOWLEDGE PARK AND THE TEACHING OF PHYSICS

The traveling exhibitions for the popularization of Science adopted by PARCON had the same molds and aspects as the exhibitions held in Museums and Science Centers at the time. From the works of Alberto Gaspar (Gaspar, 1993), the references of the original project were built (UESC, 2003). The studies were elaborated for a better understanding of the role of Museums and Science Centers in the educational scenario of the time. The conceptualization of the teaching-learning process was based on Vygotsky's socio-interactionist theory.

According to this work, Museums and Science Centers can be understood as institutions of informal education. This is because, unlike formal and non-formal education, "informal education does not obey curricula, does not offer degrees or diplomas, is not mandatory of any nature and is not intended only for students, but for the general public. These are basically the characteristics of museums or science centers. Therefore, museums and science centers are institutions of informal education" (GASPAR, 1993)

According to Gaspar (1993), Vygotsky's socio-interactionist theory brings instruments and subsidies for the understanding and analysis of the teaching-learning process that develops in museums and science centers. In this theory, social interactions are emphasized in relation to the occurrence of the teaching-learning process and a Science Museum has these interactions as its main

characteristic. This can be seen when the monitors talk about a certain experiment with the visitors, a teacher explains a phenomenon to his student or the father exchanges knowledge with the child.

According to the work of Gaspar (1993), another condition for learning in a Science Museum, according to Vygotsky's theory, is that the thematic content of the exhibitions can reach the cognitive level of the visitors. One can add to this concept notions incorporated into Vygotsky's theory by some of his followers, such as the definition of situation and semiotic mediation.

Different definitions of the situation in relation to a visit can be observed by the different ways in which visitors experience the objects on display, and interact with the monitor during an explanation. Semiotic mediation is related to the way a monitor, teacher, and visitor interact verbally during the presentation of an experiment or discussion of a phenomenon. It is the way in which the monitor, the teacher, the father of a family or a schoolmate can make sure that a certain thematic content of an exhibition can be understood by visitors to the Museum. In the process of semiotic mediation, language is the vehicle that brings knowledge to people. The language is structured on the resources that the monitor uses for an explanation.

Another indication of Vygotsky's theory of how cognitive development occurs refers to the way in which spontaneous or scientific concepts are developed in the child. In his theory, Vygotsky states that these concepts develop in opposite directions, from the levels of greater complexity to those of less complexity and vice versa. (GASPAR, 1993).

Regarding the acquisition of erroneous conceptions in museum visits, possible concerns regarding the damage that a playful, uniform learning may cause, according to Vygotsky's model of cognitive development, in relation to the development of concepts in the child, are irrelevant. (GASPAR, 1993).

This does not mean, in any way, that one should have a comfortable position in relation to the informal teaching of science, assuming that any activity is valid. The monitor, as the most capable partner, guides the demonstrations according to the objectives of the task and concepts to be addressed. Since the situation, the starting point for interaction, is created from the representation that each one makes of the object, it is important that its definition is approximately the same for everyone. In this way, interaction becomes viable and productive (GASPAR, 1993).

Monitors or teachers have a fundamental role in a scientific exhibition. The speech of a monitor or teacher and their language must be consonant with the material of the exhibition, that is, with what visitors are observing. The language of explanations has the visual component of the experiments as an ally for the exposition to be intelligible (UESC, 2003).

THE KNOWLEDGE PARK IN MEDIUM AND LONG-TERM ACTIONS IN SCHOOLS

There was already concern about the role of schools in the wake of the exhibitions. In general, the permanence of the Truck with Science, and consequently of the Knowledge Park, in schools is brief. The exhibitions are made in a single day and the visitors, mostly students from the schools themselves, show a lot of interest in the experiments, but without time to interact more or delve deeper into the observations.

The contents of the exhibitions are very little used by Physics or Science teachers in the classroom, despite the great interest shown by students. At most, unfortunately, they ask students to make reports of the experiments, in which they literally copy the monitors' speeches during the explanations in a mechanical way, if any relationship with a didactic approach that could offer an opportunity to deepen the concepts seen.

Another concern in the traveling exhibitions of Physics that we participate in the Truck with Science is the progressive loss of space of the conceptual approaches of experiments to play. We do not mean that the monitors do not make an effort, or that a certain practice should be abolished, but we would like to be closer to the students for a time that goes beyond the exhibitions, since most of them are held on Saturdays at times that Elementary and High School students usually dedicate to leisure.

Thus, visits to traveling exhibitions, in the same format as Science Museums, could be part of the school curriculum as a complement to formal education, since scientific exhibitions are taken to schools. Science museums are environments of cultural enrichment with great potential to be taken advantage of by teachers.

An article by Janette Griffin and David Symington (1997) cited discusses the importance of linking visits to science museums to school programs. This work shows that little is done in this sense, and that this is directly related to the students' learning and interest in the content of the exhibitions. The authors of another work along these lines go further, saying that the learning of the concepts addressed by the exhibitions is only consolidated outside museums (ANDERSON, LUCAS, GINNS and DIERKING, 2000).

For Carvalho (2010), teachers are often not used to using experimental practices in the classroom and, when they do, they are often unfamiliar with these activities. The author presents possibilities of working with experiments when reporting a research of laboratory manuals that showed that students, depending on the methodology used, could have more and more freedom of action. In this case, the students, according to the author, could be characterized as young scientists.

In order for the work with experiments to develop this skill in students, in a process that the author calls scientific enculturation, teachers must provide experimental activities that provide the

opportunity to solve questions by raising hypotheses based on their previous knowledge. Afterwards, these hypotheses must be submitted to tests through the data obtained (CARVALHO, 2010).

Another important point raised by the author would be the promotion of students' argumentation, which is characteristic of scientific language when transforming facts into evidence. The goal of teaching through experimental activities would be to create a learning environment to stimulate argumentation based on the data obtained, building justifications that lead to conclusions or further deepening (CARVALHO, 2010).

In this context, the use of mathematical tools would be essential for the development of scientific enculturation, as the teacher would lead students to work with data not only qualitatively, but also quantitatively, using the reasoning of proportionalities, that is, the translation of conceptual language into mathematical language (CARVALHO, 2010).

The teacher would play the role of promoting the scientific enculturation of students by proposing an experimental problem, helping to solve this problem not by giving ready-made answers, but by conducting investigations and helping them to understand error as natural and important in the construction of knowledge. In addition, the teacher must also be encouraged to write, which can be elaborated from data obtained in groups, where they seek to transpose oral discourse to a more convergent and focused form of expression, with greater cognitive effort (CARVALHO, 2010).

Gil-Pérez and Vilches (2005) draw attention to the relationship between scientific education and exclusively conceptual aspects in basic education, converging to a conscious purpose that can be equated to the preparation of future scientists.

> "(...) What research is showing is that the meaningful understanding of concepts requires overcoming conceptual reductionism and presenting science teaching as an activity, close to scientific research, that integrates conceptual, procedural and axiological aspects." (GIL-PÉREZ and VILCHES 2005, p.32)

There is a need for education focused on the personal and social development of human beings. The improvement in the quality of current science education is related to the change in the image that educators have of Science, which has repercussions on the way they transmit it. One of the consequences of this teaching is the failure of the student's scientific training, often generating an aversion to Science and its teaching. (GIL-PÉREZ, et. al., 2005).

In addition to experiments and writing, activities such as group debates, reading, among others, should be the vehicle for interactions between students in search of answers to questions for a greater understanding of the topic studied and a source of creativity for the approach and solution of real situations, which can also be experienced outside school. In this sense, for the teaching of

Physics by investigation, the participation of students in the construction of their own knowledge is fundamental (CARVALHO, 2013).

Based on the teaching of Physics by investigation, the Knowledge Park has been working in public schools in the region promoting mini-courses and workshops. The workshops will be organized respecting a periodicity of 7 to 14 days, in a period opposite to classes, as previously agreed with the school board. These moments are preceded by planning, construction and testing of the experiments and other materials to be used. Science teachers are invited to participate in the planning and execution of the activities.

The work methodology applied with the students will be organized according to the Freirean thematic approach presented by Demétrio Delizoicov, Antonio Angotti and Martha Pernambuco (2002) through the three pedagogical moments, combined with the teaching of Physics by investigation with the objectives of expanding scientific culture and promoting scientific and technological literacy with the purpose of exercising citizenship (Solino and Gehlen, 2015).

For Delizoicov, Angotti and Pernambuco (2002), when interacting subjects, they appropriate knowledge in a "non-neutral" way, that is, one that respects their essence and common characteristics. Hence the need to plan the "appropriate interactions", so that scientific knowledge is inserted in "a certain context of relations that gives it meaning". (DELIZOICOV, ANGOTTI and PERNAMBUCO, 2002, p.184)

Based on the works of Paulo Freire and George Snyders, Delizoivoc, Angotti and Pernambuco (2002) propose a teaching:

> "(...) that allows the occurrence of ruptures during the training of students." (DELIZOICOV, ANGOTTI and PERNAMBUCO, 2002, p.189). The ruptures refer to the transition between the knowledge of the students and the scientific knowledge taught by the teachers. This transition can be structured by the dynamics of "codification – problematization – decoding" proposed by Paulo Freire, so that the teacher can access the "first culture" of the students and can promote the "confrontation and overcoming of this level of consciousness." (DELIZOICOV, ANGOTTI and PERNAMBUCO, 2002, p 194-195)

Thus, Delizoicov, Angotti and Pernambuco (2002) developed a strategy for teaching performance called "Pedagogical Moments". The Pedagogical Moments are structured in three specific and differentiated phases, which represent a strategic sequence to be adopted in the classroom: the "initial problematization"; the "organization of knowledge" and the "application of knowledge". (DELIZOICOV, ANGOTTI and PERNAMBUCO, 2002, p.200)

In the initial problematization, the information that students bring about topics previously chosen dialogically from the possibilities of working with the materials available by PARCON at the time are investigated, organizing work and discussion groups. The information brought by the students should indicate how the subjects related to general themes appear, so that concepts of Physics in initial training can be selected. Professors who want to participate and extension

scholarship monitors, who may be linked to the work proposal, will play a fundamental role in this phase, managing student activities and archiving information.

Solino and Gehlen (2015) present the role of the problem in science teaching from two perspectives: the conceptual approach and the thematic approach. In the Freirean thematic approach, as we have seen in the work of Delizoicov, Angotti and Pernambuco (2002), which are also mentioned by Solino and Gehlen (2015, p.912), "the problematization of real situations is explored, based on what emerges from social contradictions experienced by the students".

The information obtained in the previous stage will be studied in the Knowledge organization phase. The data will be selected according to their relevance to science teaching and to the scientific and technical understanding of general topics. In this stage, investigations will take place on how the knowledge generated in the initial problematization can be understood from concepts of Physics.

Here strategies for teaching science according to need, whether they are experiments, documentaries, computer simulations, texts or field classes, in addition to traditional classes using only the blackboard and the textbook.

Solino and Gehlen (2015) bring the perspective of choosing and approaching problems in the teaching of Science by investigation as conceptual, in which scientific themes are worked didactically from natural phenomena, by the elaboration of hypotheses, assembly of experiments, discussion around observations and presentation of results as conclusions. All of this is aimed at the scientific enculturation of students for decision-making involving aspects of Science, Technology, Society and Environment (CTSA) in everyday life.

All the students' production in the development of the two stages already mentioned is systematized in the application of knowledge. The information gathered will be transformed into materials for an exhibition in partnership with the Truck with Science Project, such as banners, models and experiments built with low-cost material prepared by the students. In this opportunity, students will be able to use the Truck experiments, the demonstrations carried out in the classroom, videos and computer simulations.

THE ACTIONS PROMOTED BY THE KNOWLEDGE PARK IN SCHOOLS BEYOND THE EXHIBITIONS

Retrieving the initial objectives of PARCON, teacher training actions and workshops were carried out from 2017 onwards at the Salobernho State College. (UESC, 2017). It was with great joy and enthusiasm that we started working with *smartphones* in schools, adopting the approach to teaching Science from the Freirean perspective, promoting investigations of physical quantities in low-cost experiments and in everyday situations of students. In a survey carried out at the time, more

than 50% of high school students in Salobrinho had smartphones connected to the Internet and took them to school.

The project provided for stargazing actions with applications and subsequent interpretation of the results from a historical and cultural perspective; measurements of sound intensity in various situations of daily life, with special attention to health risks; Study of light intensity in different environments to promote visual comfort. The activities lasted 24 months with extension scholarships and continuing education activities for teachers.

In this matter, another approach that can be taken is precisely to bring technologies to the exhibitions. Today, with the use of smartphones and tablets and with the vast majority of schools having internet via Wi-Fi, the exhibitions can be accompanied by information sought on the networks to contemplate precisely those students who are interested in conceptual explanations and want sources to learn more, spontaneously.

Other PARCON experiments, under the coordination of Prof. George Kouzo Shinomiya, have also held workshops in schools with traditional physics experiments, such as rockets[2] and electric motors.

In February 2023, we started work to disseminate the book "Iron Train and Almada Plant: the Physics of the History of the Cocoa Region" (Stuchi; Moura, 2021), with the Department of Education of Ilhéus. The work deals with the history of the Almada hydroelectric power plant and the Ilhéus Railroad from the perspective of Physics for the understanding of the functioning of the machinery. The objective is to arouse the interest of schools and teachers to read topics related to Physics in the classroom.

The material was used by a Portuguese Language teacher and another 9th grade Science teacher at the Professora Horizontina Conceição Municipal School, in Ilhéus. Books were lent for reading and text interpretation activities, according to the methodology chosen by the teachers. As students become interested in the subjects covered by the book, our participation is done through demonstrative experimental activities, in which the concepts are deepened and debated.

In addition to promoting scientific reading in the classroom, the proposal aimed to encourage teachers to create interdisciplinary projects contextualized in schools. To the extent that they are interested in the work, they can contribute to the understanding of the history of Ilhéus and the cocoa region, for example, with the knowledge of each discipline, enriching the dialogues on the subject. As they gain experience with interdisciplinary projects, more specific themes naturally arise in the debates that better contemplate the interests of the school community.

The students promoted at the Professora Horizontina Municipal School an exhibition of their work on the book, taking advantage of the talents of each student in art, writing, construction of

[2] https://pt.wikiversity.org/wiki/Parque_do_Conhecimento

models and preparation of reports for the school newspaper. At the end, we were invited by the students to a moment of dialogue in which we were interviewed about the historical and technological issues involving the railroad.

At the moment, the UESC Knowledge Park is working at the São Pedro Municipal School in the Salobrinho neighborhood in Ilhéus, in a proposal approved in the UESC Communities 2023-2024 Integrated Innovative Extension and Research Program (PIEP), promoted and funded by the Dean of Extension (UESC, 2023).

In the project, entitled "Information and Communication Technologies, Internet of Things and Physics Teaching for the exercise of citizenship in Salobrinho", students are invited, after attending scientific exhibitions, to participate in actions to problematize their own reality and build devices using smartphones and microcontrollers for investigations.

CONCLUSIONS

In our reflections presented here, we show a tendency to improve the original objectives of PARCON for the insertion of technologies to assist in the development and monitoring of exhibitions, as well as for the realization of workshops in schools and continuing education activities for teachers, not only addressing experimental Physics.

Technologies are extremely widespread in our society, but they are very little used in schools as a source of physics teaching activities. The current smartphones, which most students take to school, and which are often prohibited by administrators because they are sources of distraction, to say the least, have various sensors and free applications available that transform them into true compact physics laboratories.

A recent survey carried out in a public school in the region considered a reference, 90% of the students who participated were completely unaware of any use of smartphones related to the teaching of Physics. It is not conclusive at all, but it is undoubtedly a trend that becomes evident by the continuous observation of the behavior of students and teachers. If cell phones are now part of popular culture, the teaching of Physics from these devices could gain a lot in motivational character.

Reading is also a very important aspect to be inserted as one of the goals of extension work in the area of popularization of Science. Reading that fosters curiosity can increase the desire to learn through other means, such as experimentation, for example. The culture of reading directly influences people's ability to understand the world and make better-founded decisions, which permeates all areas of knowledge that, ironically, seem to be unable to dialogue precisely in our schools.

Therefore, reading activities and experimentation with didactic approaches that can be developed in collaboration with teachers, respecting school planning, curriculum and work dynamics in classrooms, is essential for academic knowledge to reach schools.

Allied to research that enables the broadening of the horizons of action, PARCON will thus be able to continue contributing to social transformations inside and outside the University, as recommended by FORPROEX (2012).

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