CONTEMPORARY SCIENCE EDUCATION AND CHALLENGES IN THE PRESENT SOCIETY: PERSPECTIVES IN PHYSICS TEACHING AND LEARNING

Editors Maurício Pietrocola,
Ivã Gurgel & Cristina Leite

Assistant Editor Antonio Carlos Mometti

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PREFACE

The conference was initiated by the Groupe International de Recherche sur l'Enseignement de la Physique (GIREP) and the International Commission on Physics Education (ICPE) – Commission 14 of the International Union for Pure and Applied Physics (IUPAP). It is being sponsored by GIREP, ICPE and the Multimedia in Physics Teaching and Learning (MPTL) group and endorsed by American Association of Physics Teachers (AAPT), Latin American Physics Education Network (LAPEN) and the Asian Physics Education Network (AsPEN). The vision for 2016 World Conference on Physics Education is to follow a global participative process before, during and after the conference. The Conference will be structured to help foster collaborations on physics education research and development which can transcend national boundaries. The goal will be reached through working sessions which will develop actions plans that strengthen the teaching and learning of physics at all levels and in many countries.

The 2016 World Conference on Physics Education was a concrete step forward in global cooperation. Envisaged as a series of conferences with a four-year periodicity, it was a working conference with follow-up actions that presumably would carry over to the following conference.

ICT AND MULTI-MEDIA IN PHYSICS EDUCATION

1

COMPARATIVE STUDY OF THE VIRTUAL LAB: PENDULUM OSCILLATIONS

Miguel A. Ré, Mariano Magran

| INTRODUCTION

The inclusion of Information and Communications Technology (ICT) in teaching and learning processes opens up new prospects and at the same time poses new challenges. In this way it is necessary to rethink teaching methods and practices taking advantage of the greater participation of students that ICT afford. Even though technology has dramatically invaded many areas of human work there has been a lag in including new technologies in education.

Some authors consider that in part this is due to a tendency to look the technological aspect in isolation dissociated from the field of knowledge or pedagogical considerations.

> In our working group we are interested in ICT incorporation to physics teaching and learning. We aim to frame our project in the Technological Pedagogical Content Knowledge schema (TPCK – Mishra & Koehler 2006), proposing integration of the three aspects. In a historical perspective we recognize that to the original idea of content knowledge as a teaching base it was subsequently added pedagogical aspects even though separately of the content field, assuming that the same considerations could be adapted to every knowledge field. Shulman (1986) introduced the idea of Pedagogical Content Knowledge: content and pedagogical knowledge should join to understand how particular aspects of subject matter are organized, adapted and represented for instruction. Meanwhile technological aspects, even present as books, projectors, periodic tables, etc., were not considered as such. But the appearance of digital technologies made clear the necessity of its integration into the schema, emerging TPCK.

Our proposal for ICT inclusion in our physics lectures is based on Simulation Based Virtual Laboratories (SBVL). The introductory physics lab goals are summarized by the AAPT (1998) in five points:

> to engage students in significant experience. to help students to develop basic skills. to help students to master basic physics concepts. to understand the role of direct observation.

to develop collaborative learning skills.

We maintain that SBVL contribute to the achievement of these objectives and at the same time they help to overcome the difficulties that arise due to shortage of time, budget restrictions or lack of teachers. All the mentioned facts limit the number of experimental practices that are carried out and as a result of this students see the laboratory practice as a pitfall to overcome with little contribution to their learning object (*González et al.* 2002).

We present in this communication a comparative study between SBVL and traditional practice based on a classical experience in a first physics course: the study of the ideal pendulum oscillations and the measurement of the oscillation period.

Comparative study of the virtual lab

Simulation based virtual labs

We define a Simulation Based Virtual Lab (SBVL) as a simulation program that enables the essential functions of a laboratory experiment to be carried out on a computer (Cramer and De Meyer 1997, *Ré et al*. 2012). We do not require that the results of SBVL be indistinguishable of real data. We do expect that programs can be run remotely or that programs may be downloaded for local execution. We find JAVA programs are quite adequate for this requirement.

Through the SBVL we intend to pose problems to the students which solution will be obtained from measurements made on the simulation program.

The simulations experiments are available at any time for the students. The programs may be run from outside of the institution so that students may go over the experience after the class and they can take new measurements if necessary.

The SBVL are implemented following a pattern design of a learning object schema. In this way the practical activities show a common environment to the student (Jones & Boyle 2007).

The problem: the oscillations of an ideal pendulum

The measurement of the period of pendulum oscillations is a typical practice in a first physics course. Ideal pendulum is a classical example of an oscillating system and for small amplitude oscillations it may be considered a harmonic oscillator. In this approximation restitutive force and oscillation amplitude are proportional, a property from which isochronism derives. Also measuring the period of oscillation for a given pendulum length, gravity acceleration can be calculated. With this activity, we intend to foreground the variables on which the oscillation period depends on: the string length and gravity acceleration. The oscillation period does not depend on the oscillation amplitude (for small amplitudes). We propose the students to analyse what the small amplitude approximation means and how it is related to the precision with which the period is measured.

Experimental dessign / results

We have assayed this practice in the first physics course at our university FRC-UTN. Eighty four students took part in the experience organized in two groups: one of the groups (50 students) worked in the computers lab with the SBVL and the other (34 students) in the physics lab carrying out the traditional practice. In each major group students worked in small groups made of two or three people. Students were asked not to work alone to promote peer discussion during the practice.

The practice was completed in two hours in both modalities. During virtual practice students were enthusiastic and in some cases they considered alternatives not included in the activity guide.

For the virtual practice a simulation program from the phet project was selected.

This choice complies with the requirements we ask to simulation programs.

Sometimes the setting of the browser should be adjusted to allow JAVA programs execution.

Students answered two inquiries: one just before and another just after finishing the practice. The questions focused on the dependencies of the oscillations period. The main difficulty arouse in the recognition of the dependence on the length of the string.

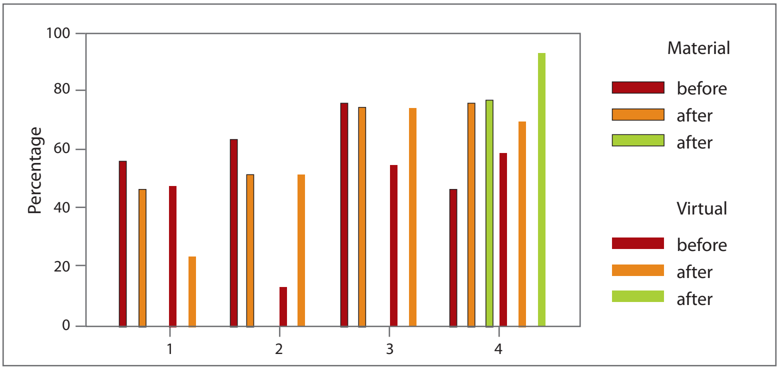

Figure 1: results of inquiries

We find that students in the virtual lab did better in the last two questions after the practice. One of these questions refers to the dependence on the point mass suspended. The other question asks about the dependence on the gravity acceleration, but in an indirect way.

We show the results of the inquiries in figure 1. It is shown there the percentage of right answers before and after the experience in both cases: traditional lab and SBVL.

Conclusions

A SBVL was designed and assayed in a first physics course for the measurement of the oscillation period of a pendulum under the ideal approach (point mass and small amplitude oscillations). The isochronism property was highlighted as a consequence of the approximation.

The virtual practice was evaluated through two inquiries made to the students, one before and one after the activity and the results were compared with those obtained from similar inquiries presented to students carrying out the traditional practice in the usual conditions at our university. From the comparison we obtain similar or even better results from the virtual practice. For the virtual activity there is no extra cost.

We consider the results satisfactory from the comparisson of the right answers to the inquiries. Besides this, the reports that students had to present a week after the practice were also satisfactory, particularly data analysis.

Comparative study of the virtual lab

Students that made the virtual practice alse expressed a positive assesment of the activity in a separate inquiry. They say that virtual practice helped them to understand some theoretical aspects by experiencing with the simulation.

The authors aknowledge UTN for its support through grant UTI 3833 TC

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ICT, OPEN EDUCATIONAL RESOURCES AND THE TEACHING OF PHYSICS

Appropriations and Group Contributions

José André Peres Angotti

| INTRODUCTION

The approach and conscious appropriation of Open Educational Resources (OER) by teachers from all areas and levels in general and physics in particular, is imperative. In resonance with this commitment to initial and continuing education, we consider the virtually inexhaustible set of free and open instructional materials, projects and proposals, classes, courses, speeches and activities of the most diverse. This repository involving the accumulated knowledge in physics in extension and depth, it looks so rich and diverse, although sometimes overused. Today we are close to an asymptotic limit, marked in recent years with the MOOC phenomenon, and transition to web 3.0 semantic. In our assessment, data and interpretations about the avalanche of Information and Communication Technologies (ICT) in Education, point to a decision made in favor of the priority of teaching ownership, focus activities anchored in a group of traditional sources and recognized by many colleagues. The chances of training and strengthening of "virtual communities of practice" may actually be larger, for the benefit of processes and related products. Our goal has been linked to the ownership of ICT by undergraduate students (classroom and blended), Master's and Doctorate in Science and Technology Education with emphasis in Physics. The primary theoretical platform originates from Freirean´s design, considering the scope the natural sciences/physics. Original categories of this brazilian consecrated educator as Generator Theme, Thematic Research and Thematic Reduction, are guiding for contributions from a working group since the 80s, which added methodological and epistemological categories, like Generating Question, Generator Equipment, Pedagogical Moments and Unifying Concepts. In a recent leave at Autonomous University of Barcelona - Centre ss recent relevant sources of ICT, OER and MOOC or similar. As a product of this recent activity, we publish a digital book dedicated to Teachers of Physics. Our presentation in WCPE was guided by this ebook script synthesis, especially for theoretical and methodological references and related sources guided by ICT and OER (Angotti, 2015).

A teacher training programn

Our program is compatible with demands and current requirements, and keep the following commitments: **a)** initial and ongoing, assumed as data, not as issues; with ICT - synchronous and asynchronous models, traditional present class, distance and blended; **b)** we consider the collaboration between individuals and groups in Practice Virtual Communities as fundamental to face and overcome this challenge;

c) classical and contemporary knowledges for selection of what and how to teach and learn relevant content and methods; **d)** disciplinary and interdisciplinary, using unifying concepts to guide curricular programs for print and digital educational materials, **e**) dialogic and ludic, in order to promote teaching mediation guided by questioning Science and Technology-S&T and about S&T. (Delizoicov, Angotti & Pernambuco, 2011; Angotti, 2015).

Such platform have been continuously reflected and put into practice since the early 80s, in various scenarios of formal education, always focused on the teaching of natural sciences (Teacher Project in Guine-Bissau - 1979/81 and several states in Brazil - 1990/today). At the beginning we used the printed versions and video, then we create a "Multimedia Pedagogical Office" some years before the prevalence of personal computer and cell phones.

Themes, unifying concepts and science programs

There are four unifying concepts presented and characterized below in its broadest aspects: transformation, regularities, scale and energy. These epistemological categories have been exercised explicitly and implicitly, in essays, proposals and elaborations of learning programs (Delizoicov, Angotti & Pernambuco, 2011; José, Angotti & de Bastos, 2016).

16 Transformations: many kinds of changes of matter in all dimensions of space and time.

17 Regularities: categorize and group transformations by rules, similarities, open and closed cycles and conservations in space and time. Regularities in this sense are understood as "regularities of transformation". They are the counterpart of the changes in knowledge, especially scientific knowledge. In a nutshell, we can say that science works dynamically couple Transformations and regularities (T & R).

18 Energy: a concept that incorporates the previous two, with the advantage of achieving greater abstraction accompanied by mathematical language plus analysis and synthesis, and still be associated with degradation in statistical perspective, besides change and permanence.

19 Scales: any kind of events studied in different dimensions, macro or microscopic in spatial level; normal, instant and remote durations in temporal levels or with the aid of the previous three concepts: transformation and regularities analised by "powers of ten jumps" or energy scales (Boecke, 1959).

Added to these concepts we may use Generating Questions (Pernambuco, 1993), conveniently formulated, that help the teachers to identify which of their knowledge students need to appropriate to understand the phenomena, situations and themes through scientific knowledge. It also records the potential systematic approach anchored in processes and C & T products via the concept of Generator Equipment (De Bastos & Angotti, 2001).

Thematic reduction (see fig. 1 P. 5)

There are three major benchmarks that structure the teaching work in this educational perspective: the knowledge that we want to make available, the significant issues involved with their relationship to the immediate and remote student´s reality, and the factors directly linked to learning. Use of Generator Theme or situation is one way to articulate these three dimensions. First, the choice of subject is linked to an understanding, an effective study of the local reality in the experiential sense, shared by students and social groups, in relations that allows establishing with current social structure. Also, connected to the generator theme, but strongly present in the thematic reduction and drawing up the program itself, is the reinterpretation of the knowledge produced in the field of natural sciences. The creation of new instruments and the search of reasoning are an ongoing part of both educator's activity and the researchers which is being developed at school plus the other researchers who can advise it. Within a framework and alternative teaching materials with ICT, it is for teachers, also producers of references and materials, to make decisions and organize the activities of their classes. Among other possibilities of establishing a dynamic of teacher performance in the classroom covering the aspects presented here, we use the called three Pedagogical Moments.

1. Problematization: the students are called to present questions about what they know and are witness involved in the issues, but also require, to interpret them, the introduction of the knowledge contained in scientific theories. At this time, we problematize is the knowledge that the students will expose, generally from a few questions posed about the topic and significant situations, initially discussed in a small group. After that, each group shares and discusses their positions with other colleagues in the large group. The culmination of this questioning is to make the students feel the need to acquire other knowledge that does not already own, or are looking to set the situation under discussion as a problem that must be faced.

2. Knowledge Organization, selected as necessary for an understanding of the issues of the first moment, are systematically studied in this time under the guidance of the teacher. Several activities are employed so that the teacher can develop the concept identified as key to a scientific understanding of the situation.

3. Knowledge Application: the intended primarily to systematically address knowledge that has been built by the student to analyse and interpret both the initial situations that determined their study as others that, although not directly linked to the initial reason can be understood by the same knowledge. The activities must be open, seeking the generalization of the concept that has already been addressed, and potentials for formulating the so-called open problems.

The digital book structure, mooc and similars

Our publication is split in two parts: Theoretical-methodological foundations, summarized before in this paper (30 pages, 02 sections, 12 items) and Descriptors (88 pages, 11 sections, 114 items – each one with its link). Among these many suggestions for teacher in the second section, were we consider the impact of free massive online courses and large portals that accumulate accesses of the order of millions, a contingent which great majority is made of teachers in service and in initial formation.

Around the world, from the Google Scholar database, a survey of articles and other intellectual works on MOOC as keyword, indicates the following data: since 2011 approximately 17,000 contributions, as of 2014 are 15,600 records, data denoting one Exponential growth, and since 2015 are 5,600, indicating deceleration. In Brazil, we have been watching academic intellectual production on these courses since 2011, with indicators that attune and parallel the offer of MOOC courses. Survey of articles on the same platform at the end of September 2015 indicates 326 texts since 2011, 126 productions in 2014 and 119 in 9 months of the last year, evidence of strong growth in this biennium. For the MOOC categorization there are two styles: c-MOOC, associated with the connectivism of the pioneering Canadian school, where there is a prevalence of pedagogical field and the desirable constructions of students in networks without attachment to content formats, and x-MOOC, "MIT style ", that is, those most related to the knowledge of areas historically linked to the specific contents. Also, worth mentioning are the sites with relevant menus of options for training and teaching activities, such as Teachers´s Portal in Brazil and Open Culture worldwide. Theoretical-practical contributions to Teaching/Learning with ICT on Science and Technology highlighted in the descriptors of the book can foster the understanding and follow-up of MOOC in this field. Other important areas of interest for interdisciplinary studies aimed at teachers in exercise in Basic or Higher Education may be also founded in this section.

We conclude with questions that merit reflection on the potential of massive free courses and the whole universe of online options for improving teacher training and work, which are discussed in the book: Why can this mutation scenario improve teacher training in Physics and related sciences? Why can MOOC and similar ICT products disrupt the tradition, curricula and courses in Basic Education and Graduation around the world? Which option will be most profitable: Content or Context or Content and Context?

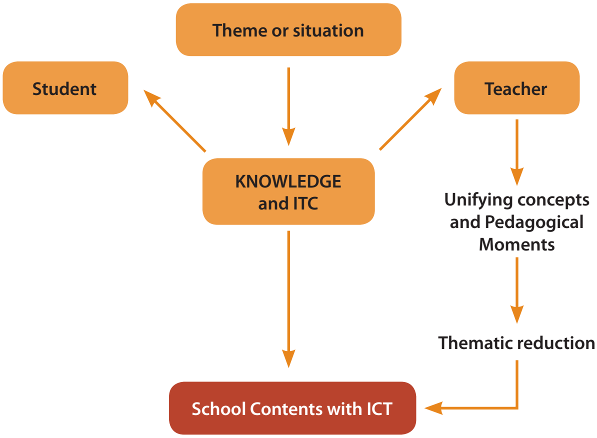

Figure 1: Freirean´s conception, Physics/ Science Teaching and ICT

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TEACHING PHYSICS CONCEPTS | 2

UNIFORM MOTION AND THE BIG BANG THEORY

J. A. M. Pereira

| INTRODUCTION

Although the Big Bang theory is widely reported in the media, being a subject of great interest by the general public, it is usually absent in Physics classes, even in its rudiments. This absence leaves a latent curiosity that could be exploited to develop activities for introductory classes on the Physics of uniform motion. For example, it is frequently acknowledged in the media that the age of the universe, a major characteristic of the Big Bang theory, is approximately 13 billion years. It turns out that the Physical concepts used for this estimation are actually quite easy to be understood. The meaning of Hubble's law, which resumes into a proportionality relationship, the knowledge of the law of rectilinear uniform motion and simple mathematical operations, such as unit conversion and manipulation of powers of ten, is all that is needed to justify the above age estimation.

A didactic sequence containing such characteristics was prepared aiming to present the Hubble's law in simple terms and use it to show students how the age of 13 billion years is computed. The sequence is designed so it becomes clear that this result is just an order of magnitude estimation and does not include the effects of gravity for instance.

Few Historical Remarks

The idea of the expanding universe is quite recent. Newton defined the absolute space with respect to the fixed stars and even at the time of Einstein, the universe was believed to be static. It was only at the end of the 1920´s that the scientific community came to a dynamic model of the universe (Singh, 2005). In 1929, E. Hubble presented experimental observation leading to the Hubble´s law stating that the galaxies are moving away from us (Hubble, 1929). Figure 1 present schematically the so called Hubble plot where the velocity of a moving galaxy, usually given in km/s, is show as a function of the distance, commonly appearing in megaparsecs, that galaxy is from us. This plot suggests an empirical law since the velocity of a given galaxy, υ, is proportional to the distance, d, to the observation point. Mathematically one has that $v = Hd$ where H is the Hubble parameter, having the value of 70.4 km/s Mparsec^{-1} (Wendy, 2001). Because it is the ratio between a speed for a distance, H has dimensions of frequency. Its numerical value is currently accepted (see figure 1) can be converted in Hertz providing $H = 2.35 \times 10^{-18}\ s^{-1}$ where the factor 1 parsec $= 3.08 \times 10^{15}$ m was used.

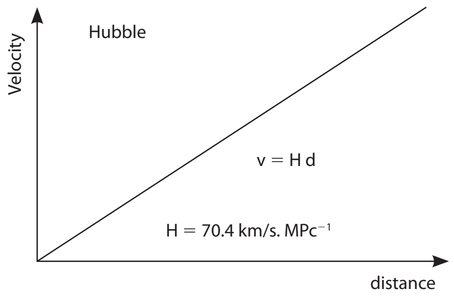

Figure 1: An schematic Hubble plot. The reader is referred to (Wendy, 2001) for more profound discussion on the value of H and realistic Hubble plots.

Discussion

The details on how to obtain the data represented in figure 1 are outside the conceptual field of the students, but the information contained in it can be discussed in simple terms. What the Hubble's law says, basically, is that the farther a Galaxy is the more quickly it moves away as represented in figure 2

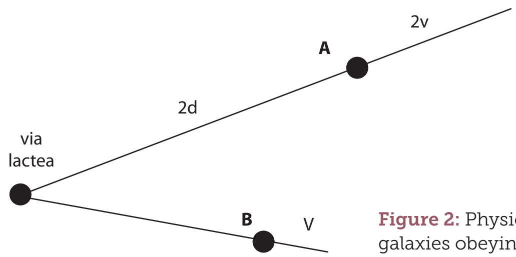

Figure 2: Physical situation of two galaxies obeying Hubble´s law.

The assumption that the velocity the galaxies have today have been the same for all times, that is, if we think that they have been in uniform rectilinear movement throughout time, it is possible to determine how long since the movement started. Simply use the expression of the position as a function of time for the rectilinear uniform motion and apply Hubble´s law:

$D = vt$ **(1)**

One has for Galaxy A:

$D_A = d = v_A t_A = H d t_A$ **(2)**

since $D_A = d$ and $v_A = H d$. As Galaxy B is concerned:

$D_B = 2d = 2v t_B = H 2d t_B$ **(3)**

since $D_B = 2d$ and $v_B = H 2d$. One has immediately that:

$t_A = t_B = 1/H$ **(4)**

The fact that these times are equal requires a common beginning so the galaxies have originated at the same time. That suggests that matter today scattered in space originated from a single point in space which corresponds to the idea of the Big Bang. Admitting that the movement of galaxies were uniform from the time of their creation, the age of the universe corresponds numerically to the inverse of the value of the Hubble constant. Performing the calculation one has:

Age of the Universe $= 1/H = 4{,}26 \times 10^{17}$ s **(5)**

that is converted to the 13,5 billions of years ending the sequence. This is the number that is commonly reported in the media and is known in the field of cosmology as the Hubble age.

It is important to mention that the above calculation disregard the role of gravity. One can make a qualitative improvement of this discussion by arguing that gravity tends to reduce speed since it is an attractive force. That means Galaxies have been faster in the past and therefore the time elapsed since the beginning of the movement is less than that calculated on the assumption of uniform motion. Another improvement of the sequence concerns the more recent finding that Universe expansion is accelerated. That means there is another mechanism playing a role in the history of the Universe. To date Dark Energy would provide such mechanism that has been associated to the Cosmological constant introduced by A. Einstein in the beginning of the last century (Pereira, 2016).

Conclusion

In this work, a didactic sequence, aiming the calculation of the age of the universe, was proposed. The outcome is a simple exercise concerning an application of the rectilinear uniform motion to the relative motion between galaxies. Finally, the treatment of a modern physics issue fulfills the students' curiosity about a topic that is usually presented in the media as being a subject surrounded by mystery and out of the reach of the general public.

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POSET STRUCTURE IN PHYSICS TEXTBOOKS AND LESSON PLANS

Eizo Ohno

| INTRODUCTION

Recently, there has been a focus on examine the more nuanced aspects of teaching and learning physics. As such, the approach with which textbooks are analyzed has transitioned from a quantitative to a qualitative and hermeneutic approach. A quantitative approach, for example, statistically measures the frequency of a particular word or phrase in a textbook. However, in a qualitative approach, textbooks are analyzed based on semantics and pragmatics to reveal the fine structure of the descriptions they contain (Khine, 2013). There is a similar trend in research focused on the analysis of lessons. A quantitative approach statistically analyzes the interactions between students and their teacher. Conversely, when using a qualitative approach, we would use discourse analysis, conversation analysis, and narrative approaches (Mortimer & Scott, 2003; Erduran et al., 2008; Rutten et al., 2015). Despite all the progress, conducting more studies focusing on the nuanced impact that learning activities have during class is necessary.

Descriptions in physics textbooks can be interpreted as being "physics knowledge to be taught." By analyzing the descriptions in a physics textbook, we therefore obtained the structure of the physics knowledge that is to be taught. Meanwhile, an analysis of a teacher's lesson plan provides us with the structure of the learning activities. Understanding both is important because they are interrelated. In this qualitative study, we present a mathematically formalized method for representing the structure of the physics knowledge to be taught using partially ordered set (poset) theory. Next, we connect the structure of the physics knowledge to be taught with the learning activities obtained from a teacher's lesson plan. This connection clarifies the structure of the learning activities. We expect that this qualitative study will leads to a deeper understanding of both teaching and learning physics.

Mathematical formalization of textbook analysis

Methods

In this study, we utilized poset theory (Roman, 2008). Ordered set and lattice theories have been applied to areas such as concept analysis, knowledge representations, and mental modeling (Ganter & Wille, 1999; Watanabe, 1969; Moray, 1990). For our analysis, we segmented explanatory descriptions in a physics textbook into a set of passages S = {s1, s2, …, sn}.

Table 1: Textbook descriptions about adding and resolving forces segmented into passages

PASSAGES	CONTENT
a_1, a_2	Adding two force vectors
a_3, a_4, a_5	Resolving a force into two forces x and y components of a force vector
a_6	Adding and resolving are represented by components
a_7, a_8	Two force vectors in equilibrium
a_9	Three forces in equilibrium
a_{10}	Multiple forces in equilibrium
a_{11}	Multiple forces in equilibrium represented by components
$\varnothing_A$	Ideas and knowledge students have already learned

The expectation function $E(s_i)$ was defined as follows. Its value lies between 0 and 1 and expresses the expectation of how well a group of students understands the passage si. The value 1 means full understanding of the passage. The value of $E(s_i)$ is a subjective estimate. We have not yet obtained adequate information about the function $E(s)$. For a given understanding si, the conditional expectation of understanding sj is denoted as $E(s_j|s_i)$. $E(s_js_i) = E(s_j|s_i)\,E(s_i)$, where $E(s_js_i)$ is the degree of expectation of how well a group of students understands si and sj if they have first learned si.

Among some pairs of S, there exists the one-way relation "s_i partakes of s_j" if the following three conditions are satisfied:

d) s_i is not skipped. $E(s_j|s_i) > E(s_j)$

e) s_i is read before s_j. $E(s_js_i) > E(s_is_j)$.

f) s_i is a necessary part of the explanatory description of s_j.

The symbol "‹" is used to indicate the partake relation. We express "s_i partakes of s_j," as $s_i \lessdot s_j$.[1]

Results

We analyzed a physics textbook written in Japanese, which is used for high school level basic physics courses. Textbook descriptions about adding and resolving of forces were segmented into eleven passages, a1 to a11 as detailed in Table 1.

Let $A = \{\varnothing_A, a_1, ..., a_{11}\}$ be a set of the passages. Here, $\varnothing_A$ denotes the ideas and knowledge the students have already possess. As such, $\varnothing_A$ is not detailed explicitly in this textbook. Set ***A*** and the partaking relation "‹" thus make a poset $\boldsymbol{A} = [A|\lessdot]$. Passage a_{11} is the unique maximal element of ***A*** and $\varnothing_A$ is the unique minimal element of ***A***.

In the same way, we obtained the poset $\boldsymbol{B} = [B = \{b_1, \ldots, b_6, \square_B\}|\lessdot]$ by analyzing textbook descriptions on arrow representations of forces. $\square_B$ is the unique maximal element of ***B*** and summarizes $\{b_1, \ldots, b_6\}$. $\square_B$ is not detailed explicitly in this physics textbook; however, it is a necessary summary for constructing ***B*** and understanding ***A***. Figure 1 diagrammatically explains the relation between poset ***A*** and ***B*** as well as detailing the relations between the individual passages. The partake relation "$a_i \lessdot a_j$" is represented by an arrow from a_i to a_j. $\square_B$ partakes of $\varnothing_A$. The group of students is supposed to use $\square_B$ while they read the passages a_1 to a_{11}. The two posets ***A*** and ***B*** together form the larger poset $\boldsymbol{A} + \boldsymbol{B}$. The passage a_{11} is the unique maximal element of the larger poset and b_1 is the unique minimal element of $\boldsymbol{A} + \boldsymbol{B}$.

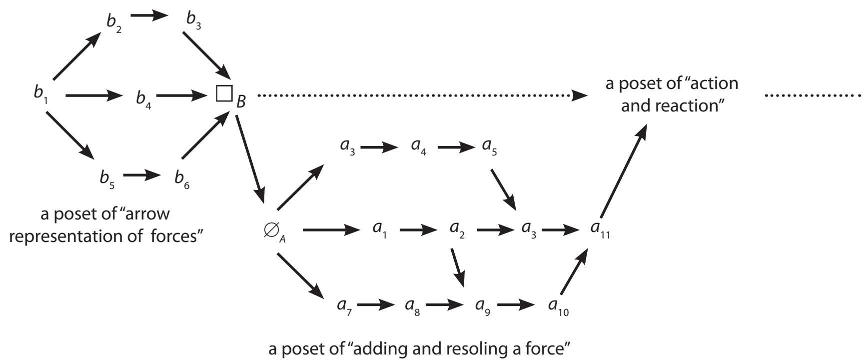

Figure 1: Diagram of the poset structure of A and B.

Connection between textbooks and lesson plans

Reading Sequences and Learning Activities

The set of passages A can be divided into four subsets, as shown in Figure 2(a):

[1] Let a subset of passages be $\{s_i, s_j, s_k\}$. If $s_i \lessdot s_j$ and $s_j \lessdot s_k$, then $s_i \lessdot s_k$. However, we do not explicitly consider si ‹ sk.

$A_1 = \{\varnothing_A, a_1, a_2\}$, $A_2 = \{a_3, a_4, a_5, a_6\}$, $A_3 = \{a_7, a_8, a_9\}$, and $A_4 = \{a_{10}, a_{11}\}$. Reading passages a_1 to a_{11} in sequence can thus be expressed as $(A_1A_2A_3A_4)$. Japanese teachers usually make their lesson plans by designing and developing a series of lessons. We analyzed a teacher's lesson plan based on the same textbook from which we took the passages. Learning activities described on the lesson plan were segmented. Set $L = \{L_1, L_2, L_3, L_4\}$ is composed of the segmented learning activities.

A map φ from A to L was defined. For $i = 1, \ldots, 4$, each element of a subset A_i is mapped to L_i by φ. For example, $\varphi(a_1) = L_1$. Another map ψ from L to A was defined. For i = 1,..., 4, L_i is mapped to the maximal element of a subset A_i by ψ. For example, $\psi(L_1) = a_2$. The maximal element of A_i is considered an important point in the structure of the physics knowledge to be taught. ψ makes the connection between each learning activity and the key points of the physics knowledge.

relation "$\angle$" on L was defined as follows: $L_i \angle L_j$ if

1) Each element of a subset A_i is mapped to L_1 by φ.

2) $\psi(L_1)$ is the maximal element ofA_i.

3) $\psi(L_1) \lessdot a_j$ and $\varphi(a_j) = L_j$.

$L_1 \angle L_2$, $L_1 \angle L_3$, $L_2 \angle L_4$, and $L_3 \angle L_4$ are satisfied on L. Set $\boldsymbol{L}$ and the relation "$\angle$" thus make a poset $\boldsymbol{L} = [L|\angle]$. L_1 is the minimal element of $\boldsymbol{L}$, and L_4 is the maximal element of $\boldsymbol{L}$. The pair of maps (φ: $\boldsymbol{A} \rightarrow \boldsymbol{L}$, ψ: $\boldsymbol{L} \rightarrow \boldsymbol{A}$) connect the two posets $\boldsymbol{A}$ and $\boldsymbol{L}$ with each other[2].

The passages in $\boldsymbol{A}$ can be read in the sequence $(A_1A_3A_2A_4)$. The sequence $(A_1A_3A_2A_4)$ suggests a new sequence of learning activities $(L_1L_3L_2L_4)$. The posets $\boldsymbol{A}$ and $\boldsymbol{L}$ remain unchanged. A lesson plan consisting with $(L_1L_3L_2L_4)$ should thus be feasible.

Other sequences and activities

It is possible to divide the set of passages A into four subsets: $A_1' = \{\varnothing_A, a_7, a_8\}$, $A_2' = \{a_1, a_2, a_9\}$, $A_3' = \{a_3, a_4, a_5, a_6\}$, $A_4' = \{a_{10}, a_{11}\}$ as shown in Figure 2(b). It is possible to write a textbook in the sequence $(A_1' A_2' A_3' A_4')$. A lesson plan based on this sequence requires suitable learning activities.

Let a set of learning activities be $L' = \{L_1', L_2', L_3', L_4'\}$. A pair of maps ($\varphi$: $A \rightarrow L'$, ψ: $L' \rightarrow A$) is defined in the same way as described above. $\psi(L_1') = a_8$, $\psi(L_1') \lessdot a_9$. and $\varphi(a_9) = L_2'$. Therefore, $L_1' \angle L_2'$. However, $\psi(L_1')$ and $\psi(L_1')$ do not partake a_6, and $\varphi(a_6) = L_3'$. L_1' and L_2' do not have the relation ($\angle$) with L_3'. The set of learning activities L' does not have a unique minimal element. It is not clear within this study whether the value of the expectation function $E(A_1' A_2' A_3' A_4')$ is larger than that of $E(A_1A_2A_3A_4)$.

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2 The pair of maps (φ: $\boldsymbol{A} \rightarrow \boldsymbol{L}$, ψ: $\boldsymbol{L} \rightarrow \boldsymbol{A}$) has the following properties:
1) For a_j and $a_j \in \boldsymbol{A}$ and L_i, $L_j \in \boldsymbol{L}$, $a_j \lessdot a_j \Rightarrow \varphi(a_i) \angle \varphi(a_j)$ or $\varphi(ai) = \varphi(a_j)$, and Li $\angle$ Lj $\Rightarrow \psi(L_i) \lessdot \psi(L_j)$.
2) For $a_j \in \boldsymbol{A}$ and $L_i \in \boldsymbol{L}$, $a_i \lessdot$ (or =) $\psi(\varphi(a_i))$, and $\varphi(\psi\ \psi(L_i)) = L_i$.
The pair (φ, ψ) is a Galois connection on $\boldsymbol{A}$ and $\boldsymbol{L}$.

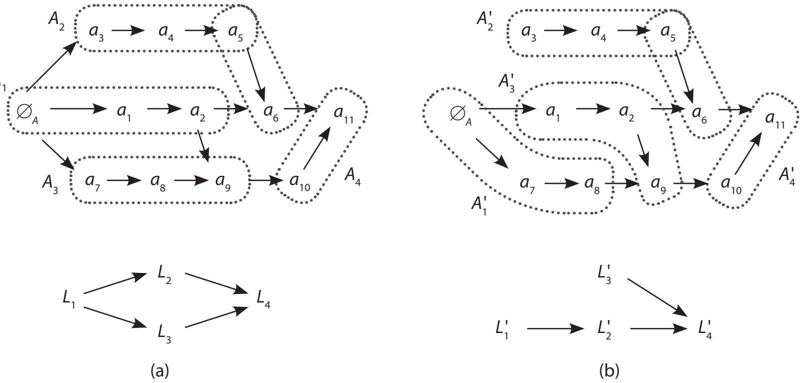

Figure 2: Sequences of passages and the corresponding learning activities

Discussion and conclusion

Explanatory descriptions in a high school physics textbook were segmented into a set of passages. We provided a method for representing the structure of the set of passages based on the mathematical theory of partially ordered sets. The partak ingrelation between the passages was defined. The set of passages was considered to be a poset using the partake relation. We also analyzed a teacher's lesson plan and made a set of learning activities. The pair of maps was defined to make a connection between the sets of textbook passages and learning activities.

Analyzing the descriptions in physics textbooks indirectly reveals the underlying structure of the physics knowledge they contained. We have proposed a mathematical model of the data structure for representing the "physics knowledge to be taught" and the corresponding learning activities. We will be able to create a database on physics knowledge to be taught and lesson plans. Such a database would be a helpful in handling a large amount of diverse data and visualizing its relational structure.

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DEVELOPING THE CONCEPT OF NANOSCIENCE THROUGH A PLAYFUL ACTIVITY IN PHYSICS CLASS TO HIGH SCHOOL

Dante Ghirardello, Luís Carlos Versa Amarante, Rascachi Caretta Martins, Selma Aparecida Romano Costa, Allan Victor Ribeiro

| INTRODUCTION

Recent studies indicate a growing number of scholarly papers on the insertion of modern and contemporary physics topics in basic education (LAHERTO, 2011). With regard to the securities aimed at teaching physics approved in the National Program of Textbook for high school (PNLEM) there is a main concern of the authors to facilitate the teaching-learning process Modern Physics (SOUZA FILHO, 2015).

But when evaluating the content related to the theme of nanoscience and nanotechnology (N&N) in recent editions of textbooks in high school physics, noted the absence of systematic approaches on the subject (ERNEST, 2009).

In this panorama address topics of contemporary science in basic education requires a new way to look at the pedagogical practice. The purpose of this work is to approach the concepts of N&N using active methodologies as didactic resource and assess their contributions in the context of the Brazilian public school (NICOL, 2003). In the activities was developed a didactic sequence guided by the junction of two active methodologies, Problem Based Learning (PBL) and Peer Instruction.

Active methods are based on different strategies that teachers may use in order to develop in their students a critical, participatory and autonomous training (BORGES, 2014).

METHODOLOGY

The activities were promoted by scholarship students of the Institutional Scholarship Program Introduction to Teaching (PIBID) of the degree course in physics who developed a didactic sequence guided by the junction of two active methodologies, Problem Based Learning (PBL) and Peer Instruction. The didactic sequence was conducted in classes the first year of public high school, was composed of three structured activities at different moments, like shown in the figure 1.

The first moment aimed to contextualize the students and provide a quantity perspective of the universe through the student / teacher. The other two moments were used the active methodologies, which one structured in a problem situation;

g) through a game, it was proposed that in groups the students discovery keywords related to N&N, with an encrypted alphabet in the form of scientific notation;

21 making the honeycomb structure of graphene using an assembly kit of molecular modelling representing the nanostructures made with the hexagonal connecting carbon atoms.

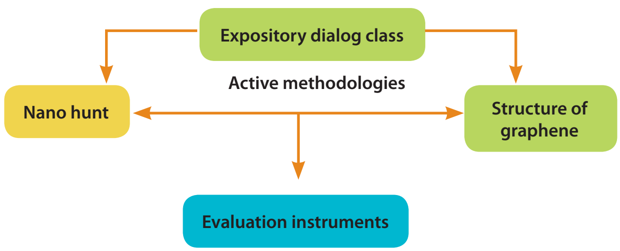

Figure 1: Class structure developed

At the end of the activities two students from each group prepared a presentation of the results, debating among them the diagnosis of the problem and presenting to the teacher, based on the peer instruction. Through the analysis of the results of evaluation instruments which was composed by the resolution of the second stage quantity of processed and three essay questions about the motivation, interest, comprehension and logical reasoning of the concepts discussed.

Analysis and results

The analysis was divided in motivation, facilitated, no answers and absents, the obtaining data was composed by the resolution of the second stage quantity of processed and three essay questions about the motivation, interest, comprehension and logical reasoning of the concepts discussed, after the conclusion of the activities the groups had an average of 76.3% positives answers, like in Figure 2. It highlights the need to adapt these active methods at school context publishes.

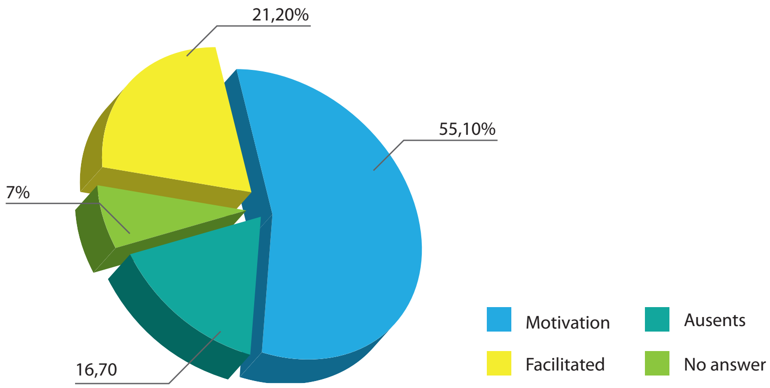

Figure 2: Opinion of the students about the class after completed all the activities.

Conclusion

From the analysis presented we verified the efficiency and success of the methodologies used, where after the conclusion of the activities the groups had an average of 76.3% correct answers. It highlights the need to adapt these active methods at school context publishes.

The results were satisfactory considering that issues related to N&N commonly are not addressed in the public network of basic education. It was assessed that the articulation of active methodologies with activities that have a recreational component was successful, where in addition to fostering teamwork, solving mathematical and conceptual problems, also reflected on the motivation in learning about topics related to N&N.

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LEARNING PHYSICS CONCEPTS | 3

ON THE UNDERSTANDING OF ASTRONOMICAL DISTANCES

Tero Sahla

| INTRODUCTION

The accuracy of astronomical conceptions of upper comprehensive school students (ages 13-16, N=162) in South-Western Finland was studied. The interest in space related issues and science in general was also surveyed, and their connection to i.e. gender and grades was studied.

Method

This study was inspired by the work done by Brewer and Miller (2010), who did a similar free scale survey study about the astronomical distances. In this work we are asking the same question from Finnish students of several levels and backgrounds, as well as from Physics teachers and teacher trainees.

The question

A baseball was placed on the teacher's desk in a classroom, and the students were asked, that if the ball was the Earth, in that scale, where would

h) the Moon

i) the Sun

j) the closest other Star

k) the closest other galaxy be located. The answers were requested to be given either in units or length (i.e.cm, m or km), or in terms of a location (i.e. Turku Market Square).

Results And Discussion

Astronomical distances were grossly underestimated. The median of the distance estimates for the Moon was about one sixth, and that of the Sun one hundredth of the correct value. The approximated stellar and galactic distances were in the range of one millionth and one billionth. Gender differences in favor of the males were detected in both interest on space issues and in comprehension of astronomical distances. The school grades would correlate with the level of comprehension only for those students that had the highest possible marks (10/10), others showed no correlation. As a conclusion it is noted, that teachers should use the travel time of light to describe distances, emphasize the multi-level hierarchy of cosmological structures, and underline the difference between a star and a planet.

Worldview

We studied, whether the worldview of the student was realistic in the sense, that they had understood the order of the distances of the objects. That is, the worldview was considered to be correct, if the Moon was closer than the Sun, which again was closer than the nearest other star, and that the nearest other galaxy was the farthest object of the four. More than half of the seventh-graders, and a third of the ninth-graders could not arrange the objects in the right order. For the older people (high-school students and teachers, N=18), the male answers were all in the correct order, whereas 20 % of the females in both categories had a less than correct worldview.

Effects of gender

The effect of the gender on space interest is studied. Only one out of the 87 females

22 a seventh-grade girl - had evaluated her interest to space related things as a 10. Of the males, 22 % had rated their interest with this highest possible grade. The male grade average was 2/3 units higher (on the scale 4-10) than that of the females.

Results of gender differences are in conflict with the observation of Lavonen (2005, 80), according to which boys and girls were equally interested in astronomical issues. On the other hand, our results support Hoffman's (2002) finding, that boys are more interested in the subjects taught in Physics classes. This can probably be explained by the space lego theorem: Because space toys are mainly profiled for toys, has a male been subjected to positive images about space since childhood, and is thus more likely to attain space related concepts.

On the conceptions of gifted students

The fact, that only the upper comprehensive school students with a perfect grade

4. had better conceptions of the distances, is sad in the sense, that these are said to be the ones who thrive regardless of the teacher's teaching. Like Dunn (1984, 16) and others

(Stewart 1981; Dunn & Prince 1980; Prince, Dunn, Dunn & Griggs 1981) have stated, the interest span of the talented students is not enough to cope with the slowness of teacher-led studying, and thus easily tend to self-studies. Thus the gifted ones have knowledge, which is not even taught to ordinary students. According to my understanding, in Finland regretfully often space content is overlooked in the curriculum, and they are taught mainly as extra material. Thus the observation of perfect 10 - students' better understanding of the distances may likely be due to this kind of 'off-classroom-learning'.

Misconceptions

In case an upper comprehensive school student gave the distance as a geographical location, it was more commonly closer to the truth than a numeric answer. Perhaps students have trouble quantifying even the terrestrial distances.

The most common worldview-error was, that the closest star would be closer than the Sun. This is most likely due to a misconception in the concept of a star - these students might also classify planets as stars. This may have something to do with linguistics; at least in Finnish some of the expressions describing a planet contain the word 'star'. The difference between a planet and a star could - and should - be underlined even in the non-space-courses, for example when discussing the difference of light sources and reflecting objects in optics.

Miller and Brewer (2010) suggest that instead of emphasizing the vastness of space, one should use a different approach, as the misconceptions are of a complex nature. In my opinion, the best way to get the students to remember magnitudes of interplanetary and interstellar distances is, if you can help them construct a model of cosmology, where smaller bodies are always a part of a bigger system, where everything orbits one another, and the size ratio of the bigger and the smaller entity is of the same order of magnitude in each step. As a scale to this, one can use the memory rule of the travel times of light from the Moon, the Sun and the stars. Most results given by the teachers were based on these numbers.

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TEACHING BASIC SPECIAL RELATIVITY IN HIGH SCHOOL: THE ROLE OF CLASSICAL KINEMATICS

María Rita Otero[1], Marcelo Arlego[2]

| INTRODUCTION

In this work, we present a possible didactic sequence for the study of basic aspects of special relativity (SR) in high school. The sequence re-signifies the role of classical kinematics and Galileo´s relativity principle (Otero, M. R, Arlego, M., Prodanoff, F., 2014). It has been implemented in four courses of two secondary schools in Argentina in 2014-2015 (Otero, M. R, Arlego, M., Prodanoff, F., 2015) and in Colombia in 2016, with students aged 15-16, during 20 school hours, being the teacher a member of our research team.

The conceptualization is analyzed within the Theory of Conceptual Fields (TCF) framework (Vergnaud, G., 1990), in a classroom context, where the selected situations are essential to promote the emergence of the relevant concepts. According to the (TCF), a concept C is defined by a set of three interrelated elements: C=(S,I,R), where S represents the set of situations that make the concept useful and meaningful, I the set of operational invariants used "in situation" by individuals, and R the set of symbolic representations, linguistic and graphical that can be used to represent invariants, situations and procedures.

Structure Of The Sequence

The sequence is structured in three phases. The first phase is in turn divided in two parts (1a and 1b).

Phase 1a - Description of motion and relative velocity: This part refers to the classical (pre-relativistic) kinematics and the Galileo's relativity principle. Here the motion analysis from different reference systems is proposed, allowing introducing the relativity from the beginning, and avoid the concept of a privileged reference frame, deeply rooted in the students. After that, the relative velocity topic is addressed, based on daily life student's experience. This type of situations aims the emergency of the Galileo's law of velocities addition.

Phase 1b - Inertia and Galilean Relativity: Here situations that allow considering the inertia principle and Galilean relativity are presented. To this end, it is proposed to personally perform different actions like stay at rest, at uniform motion (respect to the floor), as well as braking, accelerating or moving in a circle, with a pendulum hanging from the hand. With that it is intended that students "experience" the inertia and approach the idea of indistinguishability between rest and uniform translation. In the last situation of this phase, it is proposed to infer the state of motion of a wagon (ideally isolated) only with the help of a pendulum hanging from the ceiling.

Phase 2 - Transition from Galileo´s to Einstein´s relativity: The second part of the sequence consists in a transition to SR, which generalizes the relativity principle, introduces the c-invariance and the issue of the simultaneity.

Here the aim is to analyse the absolute character of the simultaneity, in a Galilean context, by means of situations involving different events with low-speed rubber bullets, which are requested to be analysed from different reference systems. This requires applying the concepts of Galilean relative motion and the relativity principle discussed in the first part, to solve kinematic meeting problems which are treated progressively from a numerical up to a symbolic and graphical level.

In the last part of the second phase similar situations but with light beams (instead of bullets) are presented. The corresponding meeting problem equations are solved by using the technique developed in the first part and the c-invariance. In this way, the relativity of the simultaneity phenomenon emerges in a context involving light, bringing the entrance to the SR.

Note that this phase represents a transition because although the analysis with rubber bullets is incorrect in a fully relativistic framework (simultaneity is always a relative concept), it enables introducing the issue of simultaneity in a familiar context for students, as well as developing the technique to address the meeting problem for light.

Phase 3 - Basic aspects of Einstein´s relativity: This phase considers basic kinematical concepts of the SR. By using the relativity principle and the c-invariance, the time dilation, the length contraction and the relativistic addition of velocities are considered. The latter allows revisit the issue of bullets in a relativistic context, giving to the phenomenon of non-simultaneity a general character.

Implementation And Results Analysis

In this work, we focus on the first two phases of 2016 implementation (Colombia). We employ a qualitative methodology based on students' productions when they are faced with the situations. Thus, we analyze the conceptualization process from the point of view of the (TCF), by analyzing operational invariants (I) as theorems in action (TA), and the representation systems (R).

In the following we present selected results of the different stages of the parts 1 and 2, showing emergent TA from student´s productions.

Phase 1a results - Here we analyse one (S2) of the three situations presented in this phase, which corresponds to relative motion and Galileo´s speed addition.

The situation S2 is: "I am traveling by car on a straight road behind a car which is always at the same distance. I see the car of a friend of mine coming from the front. My travel partner says that this car is approaching us at 150 km/h, and since the speed limit on this road is 80 km/h, he says that my friend will be fined. I say no, because we are traveling at the speed limit. To find out for sure we send a message to our friend in the other car, asking for his speed. Which is his response?"

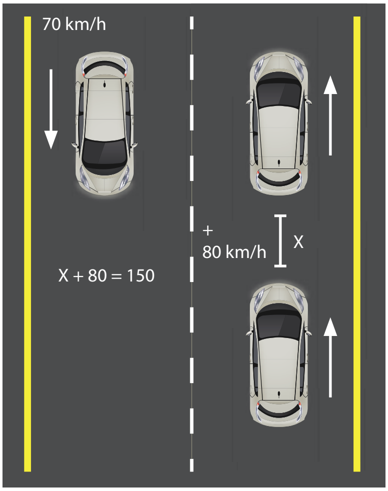

Figure 1: Drawing of a student representing the situation S2

In Figure 1 we show a typical drawing made by students about to S2. Relevant TA that we infer from student´s productions here are listed below. The relative frequencies are indicated between brackets.

"The car coming to me seems to have more speed than mine. The speed of the car that passes me is smaller than mine" (28/65).

"The approaching velocity is the sum of their velocities" (47/65).

"If the cars are in the same direction, the approaching velocity is the subtraction of their velocities". (36/65).

Phase 1b results- In this case we analyze one (S5) of the two situations presented in this part.

The situation S5 is: "Suppose we were locked in a train wagon or in a car and cannot see out, or take any external reference, we only have a pendulum. Can it help us to find out if we are moving?"

Here students make many drawings from inside the train, as it is illustrated in Figure 2. This suggests a conception of motion as relative and not absolute. Also, the principle of relativity emerges, as the following TA suggests:

"We cannot differentiate rest from uniform motion" (49/59).

"The pendulum moves in the opposite direction to the wagon when the speed changes" (44/59).

"A pendulum helps to know how the car moves" (28/59).

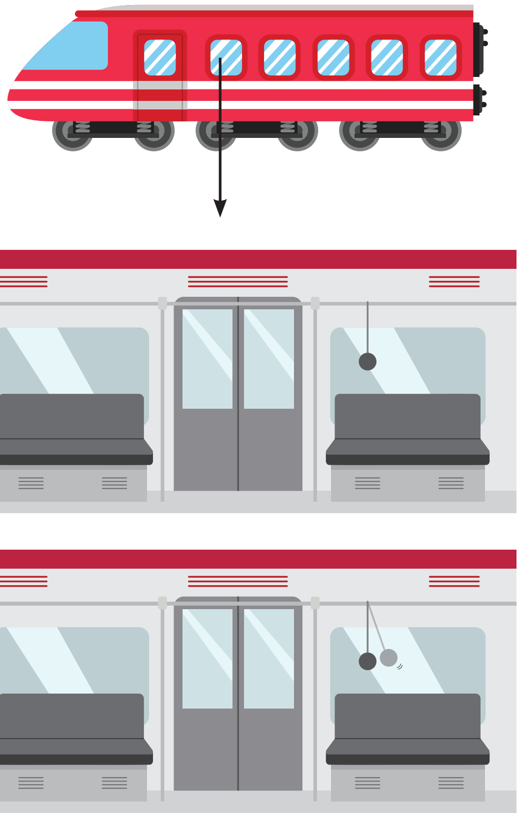

Figure 2: Representative drawing of a student about situation S5. Note that the point of view is from "inside", suggesting that this student considers the motion respect to the wagon. Text translation: "The pendulum could help us only if the wagon brakes or turns, but with uniform motion it is at rest".

Therefore, from the TA and R in these situations we could conclude that there is a good approximation to the concept of equivalence between rest and uniform motion.

Phase 2 results – Here we analyze the situations S6 and S7 which comprise this phase. The first one is the following:

S6: An observer sits in the middle of an empty wagon. Another observer standing on the side of the road, determines that the car moves at a constant speed. The observer who is in the wagon has a device that can shoot rubber balls forward and backward at the same instant.

a) First analyze for each observer, without doing calculations, if the projectiles arrive at the same time at each side of the vehicle.

b) Complete a table for each observer and propose different speeds for the wagon and projectiles.

c) After that calculate the meeting point (position and time) between bullets and walls of the wagon, for each observer, considering the different speed values proposed.

In the anticipation of part a) the relevant TA are:

"To the observer inside the car, bullets come at the same time" (56/59).

"To the observer outside the car bullets arrive at different times" (52/59).

The second theorem might be related with the common idea that the time to the left is smaller than to the right, because the projectile to the left goes to the wall of the wagon, while the projectile to the right follows the other wall. This theorem in action is so powerful that it completely masks the loss of simultaneity prediction, implicit in the anticipation. However, the subsequent use of tables and graphics software to analyze the meeting problem, facilitates the conceptualization of the Galilean addition of velocities, which in turn contribute to make explicit the absolute character of the simultaneity phenomenon, in a Galilean context. This is evident from the emergence of the following TA after calculations:

"To outside observers, left bullet speed is smaller than the right one" (58/58).

"The observer on the route measures the same to both sides because the speeds and distances are compensated" (51/58).

Regarding S7, which is equivalent to S6 but replacing bullets by a light beam, in the anticipation, the opinions are divided, despite c-invariance is introduced by the teacher as an experimental fact. As before, the work with the tables and the analytical treatment of the meeting problem, facilitates in this case the introduction of the lack of simultaneity phenomenon, i.e. opposite to the purpose of S6. This is illustrated in student protocols of Fig. 3 and the following emergent TA, after calculations:

"Light speed is the same for both observers" (55/55).

"Calculations show that light comes at different times for outside observer" (48/55).

Observador em el Camión			Observador em la Ruta		
V'_v (m/s)	V'_{Ld} (m/s)	V'_u (m/s)	V'_v (m/s)	V'_{Ld} (m/s)	V'_u (m/s)
0	C	−C	30	C	−C
0	C	−C	25	C	−C
0	C	−C	20	C	−C
0	C	−C	15	C	−C
0	C	−C	10	C	−C

2. Dentro del vagón:

$XPd = 10$

$XPi = -10$

$XLd = ct$

$XLi = ct$

$XPd = XLd$ $XPi = XLi$

$10 = ct$ $-10 = -ct$

$t = \dfrac{10}{c}$ $t = \dfrac{10}{c}$

Fuera del vagón:

$XLd = ct$ $XLi = ct$

$XPd = 10 + 25L$ $XPi = -10 + 25L$

$XLd = XPd$ $XLi = XPi$

$ct = 10 + 25t$ $-ct = -10 + 25t$

$10 = (c - 25t)$ $-10 = (-ct + 25t)$

$t = \dfrac{10}{(c - 25)}$ $t = \dfrac{10}{(c + 25)}$

Figure 3: Left panel: Table elaborated by a student proposing different velocities for the wagon and light beams to the right and to the left, respectively, from inside the wagon (first three columns) and the same from outside (last three columns). Right panel: student protocol showing the meeting point time calculation for both light beams, from inside and outside the wagon, respectively.

Conclusions

To summarize, in this work, we have presented a possible didactic sequence for the study of the basic aspects of special relativity (SR) in high school. The sequence gives a central role to classical Galileo´s relativity principle as a natural starting point to Einstein´s relativity. Preliminary results based on the analysis of "in situation" student´s productions, suggest that a progressive transition to Einstein relativity could facilitate the conceptualization of very counterintuitive phenomena like lack of simultaneity.

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THE DEVELOPMENT OF SCIENTIFIC COMPETENCIES IN THE PERSPECTIVES OF INQUIRY BASED SCIENCE EDUCATION AND PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT: THE SEARCH FOR POSSIBLE POINTS OF CONVERGENCE AND OF TENSION

Leonésia Leandro, Viviane Briccia, Luciana Sedano

| INTRODUCTION

In the last decades, science education researchers and educators have signaled the need for an education capable of preparing citizens to pursue - or not - scientific careers and to take informed decisions on various issues related to Science, Technology and Society (Auler & Delizoicov, 2001; Cachapuz, Gil-Perez, Carvalho, Praia, & Vilches, 2005; Fourez, 2003; Sasseron & Carvalho, 2011, 2008; Teixeira, 2013).

Many of the authors mentioned above point out that their intentions refer to the need for, in addition to having scientific knowledge, students use to act in society, which is demonstrated by the competence in Scientific Literature (LC), which is the focus of evaluation in the Program for International Student Assessment (PISA).

PISA is an international scope assessment that evaluates three areas of knowledge, including Sciences, and adopts a LC concept that dialogues with the intentions of the authors highlighted above. This program emerges in the educational context, with one of its objectives aimed at evaluating science education in several countries, assessing students' performance in areas of knowledge and competencies.

Assuming that the educational perspectives which involve the active participation of the students in the construction of their knowledge, that promote the problematization of the knowledge, fomenting the dialogue and the research, could help to develop competencies and not only concepts, we have adopted Inquiry Based Science Education (IBSE) as a didactic approach that promotes the development of scientific competencies in the classroom, in order to relate them to LC ideas presented in PISA 2006.

The teaching of science, in this context, becomes an important space for the development of the necessary competencies and knowledge to the LC. This leads us to inquire whether the way in which the curricular component of science is taught would lead to the development of scientific competencies.

Objectives of the Search

This article is part of a research that had as objective to analyze what the specialized literature of the IBSE area presents as points of convergence and tension in relation to the development of competencies evaluated and required by PISA 2006. In view of the following specific objectives: explain the scientific competencies promoted by the IBSE, as well as its historical characteristics, analyze criteria and parameters present in the matrix of evaluation in sciences, of PISA 2006, with emphasis on the scientific competencies, to discuss the possible points of convergence and tension found between the IBSE and PISA.

Research Methodology

In order to reach the objectives of the research, we carried out a bibliographical survey in order to identify authors who discuss about competence, especially about the notion of scientific competence. Through the analysis of the work of several authors, we identify scientific competencies that are developed by the IBSE, however, we support with greater emphasis the works of Furman & Podestá (2009) e Furman (2009). In the sense to reach the following categories of competencies provided by IBSE: **observation**, **description**, **formation of investigative questions, formulation of hypotheses** and **predictions**, **planning and conducting experiments, formulation of theoretical explanations, understanding of scientific text and information search, argumentation, comparison and classification, with own criteria or data, analysis of results and text writing in the context of the sciences**.

From this set of competencies, we investigated articles related to the IBSE approach, published in national journals[1], from the first publication number of each journal to the year 2015, which the authors discussed about each scientific competence in its essence. In addition, we systematized guidelines provided by Furman & Podestá (2009) for working with scientific competencies in the classroom.

The articles found in the periodicals also served as indicative of the works of the main authors that discuss the perspective of the IBSE. The citations and references contributed both to the construction of the discussion and to the explanation of the historical characteristics and development stages of this teaching approach.

Regarding the scientific competencies assessed in PISA 2006, we analyzed official program documents and reports, as well as the ideas and contributions of correlated studies. In short, we observed that the competencies *identifying scientific issues, explaining phenomena scientifically and using scientific evidence*, integrate the evaluation structure of PISA 2006 (OECD, 2007).

These three competencies are represented individually by six LC levels, each level expressing the set of competencies and knowledge required to reach a given level. Levels range from level 1 considered the lowest of LC up to level 6 designated as the highest of LC (OECD, 2007).

With the data obtained, we identified the competencies required in the LC levels of each competency of PISA 2006 and the scientific competencies of the IBSE that converged. We tried to verify the steps of the IBSE in which the scientific competencies could be developed and the possible points of tension between the discussions/evidences present in the studies on the IBSE and the PISA.

Results and Discussions

Analysis of Possible Convergence and Tension Points Between IBSE and PISA

We present below the synthesis of the analysis and discussion of the data obtained in this research and our findings. We emphasize that, next, call by category(s) of IBSE, the scientific competencies favored in the IBSE and by category(s) of PISA, the competencies assessed in PISA 2006.

Possible Convergence Points

The first point of convergence focuses on the categories of IBSE **understanding of scientific texts and information search**, which we consider a demand for all LC levels of the three categories of PISA, judging by the student's interaction with the evaluative instrument. We understand that for the student to select information, from a command expressed in an evaluation instrument, it should also be able to locate and understand the information contained in it.

We identify that there is a strict relationship between the category of the IBSE **formulation of investigative questions** and the category of the PISA **identifying scientific issues**, we believe that as students have the opportunity to learn how to formulate research questions, they will have the opportunity to learn to identify questions, which can be investigated or not.

At the levels of LC 1, 2, 3 and 4 of PISA category **identifying scientific issues**, students are required to identify and/or recognize variables and their changes related to a given phenomenon (OECD, 2007). These actions refer to the category of IBSE **comparison and classification, with own criteria or data**, since the student is required not only to recognize and compare the analyzed variables. Levels 5 and 6 require the ability to analyze a given experiment, an explanation of the relationship between methodology and the question (OECD, 2007), and the understanding of research, we understand that these actions are explicitly related to the following categories of IBSE: **formulation of theoretical explanations and analysis of results**.

The six levels of LC in the category of the PISA **explaining phenomena scientifically**, relate to the category of the IBSE **formulation of theoretical explanations**, we consider that at all levels the elaboration of explanation, by the student, is a fundamental requirement. In our view, what differentiates in terms of requirement by level is the complexity of the explanations to be elaborated, that is, if the students demonstrate to be able to add more elements and knowledge to their explanations. In addition, we identify that to perform tasks required at these levels, the student should also be able to formulate the categories of the IBSE **hypotheses** and **predictions**, since they are competencies that precede the formulation of an explanation.

At all levels of LC in the PISA category **using scientific evidence**, the student is required to categorize the IBSE to **argumentation, comparison and classification, with own criteria or data**, since information must be organized so that relationships are established between them. The student should interact with data provided, seeking evidence to construct ideas, arguments that support statements. The establishment of relationships and the construction of arguments between available information, involves the work with the categories of the IBSE hypotheses and predictions, aiming to sustain a conclusion /affirmation, in the attempt to expose a certain opinion/explanation - stands out the presence of another categories of the IBSE: **theoretical explanations**.

The convergent categories can be developed in the IBSE in the stages of: **problematization, research planning, data acquisition and analysis, and the stages of the conclusions**, as they complement and overlap, in which students construct new knowledge and expose them, as a result of an investigative teaching process.

Possible Tension Points

The IBSE approach is a didactic approach to the everyday classroom, which is **intention** to teach and develop through proposals for research activities, knowledge and competencies characteristic of the scientific work, that is, the procedures adopted by the students. Scientists-researchers in their investigations. PISA is a large-scale international evaluation that intention to evaluate the teaching developed by the schools in the various countries participating in the program through a test of student performance from a LC perspective.

Besides intention, another point of tension identified refers to time, this understood in the sense of the student, we call it **temporality**. At all stages of the IBSE, students have the opportunity to gradually develop both the knowledge, competencies and attitudes provided through this teaching approach. In this process, the student's learning times are considered in interaction with the science teacher in the classroom. The PISA as a punctual exam that is, disregards the teaching and learning process, focusing attention and interest only on the results obtained through the tests of answers to the items. In examining student performance, PISA intends to measure in its test what it considers to be the result of the entire period of compulsory basic training.

The third explicit point of tension brings the relation of the **curricular adequacy**, we have observed that the activities that are proposed based on the IBSE, in general, are always oriented by a demand of the school curriculum. There is a concern about the teaching proposal inserted in a curriculum perspective, which, in turn, belongs to a certain society and school community. PISA, on the other hand, when applying a test in a timely manner for some students, seeks to standardize the curriculum for all schools in the various countries participating in this program. While IBSE considers the curricular approach with its multiple consequences, PISA focuses on the result, without considering the different curricular realities of the many countries participating in its tests.

Conclusion

This research aimed to analyze what literature in the area of IBSE presents as points of convergence and tension in relation to the development of competencies assessed and required by PISA 2006, in the curricular component Sciences. We find that few authors discuss in their studies what competencies need to be worked out by the teacher and developed by the students in the school context.

In analyzing the concepts of scientific competencies offered by IBSE and evaluated in PISA, we identified as points of convergence: **understanding of scientific texts and information search, formulation of investigative questions, formulation of theoretical explanations, analysis of results, formulation of hypotheses and predictions, argumentation and comparison and classification, with own criteria or data**. The results show that these IBSE categories potentiate the development of the three PISA categories to designate an individual as scientifically literate. As points of tension, we obtained the **intention, temporality and curricular adequacy**.

We conclude that the results obtained are interesting for the research community on science teaching, because it helps us to think deeper about the relation between these apparently different universes, in a more critical way, indicating that the IBSE can be a good instrument for the development of competencies required in PISA.

We conjecture that specific actions developed in the long term, focusing on the development of scientific competencies, can contribute both to the formation of the citizen student and for the student's education as a researcher. This conclusion takes into account that PISA is present in the school context, and even if it is an instrument that does not consider the teaching process, it is understood that the competencies presented can be developed in the classroom, not in the sense of preparing the student for an external evaluation, but rather as another opportunity for the development of scientific competencies.

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LABORATORY ACTIVITIES 4

AN INQUIRING LOOK INTO PLANE MIRRORS

Dorothy Langley & Rami Arieli

| INTRODUCTION

There is widespread consensus concerning the importance and value of integrating inquiry into physics education at all levels of the education system (e.g. Baybee & Goodram, 1999; Blumenfeld, Kempler & Krajcik, 2006)). This longstanding trend, which has known periodic waves of enthusiasm and decline, is rooted in two main beliefs: 1. Physics is an investigative science and learning physics should involve authentic experience of physics "as inquiry" and "by inquiry" (McDermott, 1991).

I) The particular knowledge, skills, habits of mind and attitudes that are involved in physics inquiry, are generic traits that will serve learners in many diverse fields. Considerable financial and academic resources have been invested in attempting to realize this goal, and inquiry is formally mandated in education standards world-wide (e.g. Loucks-Horsley & Olson, 2000).

In reality, implementing authentic physics inquiry in school settings entails facing many challenges such as administrative and logistic constraints, teacher knowledge and beliefs and student and parent attitudes (e.g. Crawford, 2000). There seems to be a mis-match between the teaching-learning-culture of the "tightly scheduled, content intensive, matriculation exam targeted" high school physics class and cultivating inquiry practices, skills and habits of mind (Zhu & Gilan, 2013).

The recently launched 3 year, elective, "Inquiry Physics" matriculation unit for high school physics majors in Israel, is an attempt to address this conflict, with special emphasis on learners in outlying areas with limited access to relevant teaching resources. One of the ways the program has been implemented is the Inquiry Physics regional class, which meets on a weekly basis, for 3 hours after school, in the teaching labs of a prestigious academic scientific institute. The instructor (co-author of this paper) is an expert physicist and an experienced physics project mentor, who has been involved in high school student inquiry and design projects for many years (Langley, Arieli & Eylon, 2010).

Proposed Physics Inquiry Skills for Novices

A 10^{th} grade novice physics learner lacks the wide repository of knowledge and practice, as well as the access to expert and technical resources, which are available to professional scientists. A wide gap exists between junior-high classroom culture and student beliefs about science and learning science and the culture, practices and beliefs compatible with engaging in meaningful inquiry. How should "Inquiry Physics" be introduced to novices? Should one adopt a "serious", rigorous introduction into the language and protocols of inquiry, in theoretically complex scenes, or should one allow a period of gradual accommodation into this new setting, involving students in activities that are readily accessible, relate to commonly experienced phenomena and include elements of "serious fun"?

We propose a set of Basic Physics Inquiry Skills (Table 1) for novices that should be cultivated in a stimulating environment, in an instructional climate encouraging inquisitiveness and providing some support. We will demonstrate how these skills were cultivated in an instructional sequence for inquiry novices.

Table 1: Basic Physics Inquiry Skills

Re-visit commonly experienced phenomena.
Describe and Explicate sensory experiences.
Develop awareness; Notice sources of bias.
Formulate expectations; Notice the unexpected.
Identify a physical attribute and manipulate it.
Document; Capture sensory experiences.
Use tools.
Ask questions.
Seek and Share information.
Be a "Maker".
Communicate; Present.

The study

This study describes the initial instructional inquiry sequence employed in the regional class, and presents results of pre-instruction questionnaires and sample evidence of student response and activity products. Plane mirrors serve as a context for experiencing and exploring in a familiar, yet puzzling environment. Puzzlement is considered a valuable starting point for inquiry (Chaippetta, 1997). The daily experience of seeing one's image in a mirror seems unrelated to the ray diagram representations of formal optics (e.g. Goldberg & McDermott, 1986).

Study Issues

23 To what extent did the instructional sequence provide an environment for developing basic inquiry skills for novices?

24 To what extent did the instructional sequence foster the development of a physics inquiry disposition?

Student Inquiry Background

The study deals with 20, 10th grade students from 4 schools, recruited into the regional Inquiry Physics class, in January 2016. The Inquiry background questionnaire was administered in a printed format during the opening session. All the students were studying physics as their high school major, and took math at an advanced level. Some of them also studied chemistry, computer science or biology at an advanced level. The students' previous physics background, depended on their schools, and included optics (13), kinematics / mechanics (14), and even some atomic physics (3).

Most of the students lacked inquiry experience. Seven students (35%) had previous inquiry experience in various sciences (4 of them in physics), mainly in the school laboratory. Responding to items related to inquiry experience and skills (ordinal scale 0-4), students reported some experience (average >3) in "Observing teacher demonstrations", "Presentation in front of class"; "Seeking information on the internet"; "Presenting questions"; "Participating in science field trips". Low average values (< 2) were found for most advanced practical inquiry skills, such as using spreadsheets or programming mathematical models, using sensors, video analysis, open inquiry, inquiry in simulation environment.

The main factors motivating students to join the regional class were: Increase physics knowledge; Work with professional scientists; Seek variety; Interest in pure science; Belonging to an excellence program; A prestigious institute and Gaining an additional major. The average scores for these factors were above 3.5 (1-4 Likert scale). Parent recommendation ranked very low among motivating factors, while teacher recommendation was considerably more important. Factors considered important for successful inquiry were Gaining wide physics knowledge; Mental fortitude; Creative and critical thinking and Team work. Measurement technologies and advanced math techniques were considered less important.

Plane Mirrors - Initial Knowledge

Students responded to a pre-instruction "Plane Mirror Image" questionnaire. Analysis of student responses showed that 10 students had studied the topic previously, but only 5 remembered it. Six of the students had substantial relevant previous lab experience. Students described things they could do with plane mirrors: Create and see object images; Re-direct light; Dazzle; Focus light; See behind you. Many asserted that images were created by reflection of light from the mirror surface, but opinions about the location of the image were varied - 41% claimed the image was on the mirror surface. Inquiry issues of interest included the mechanism of creating images, attributes of mirror images, properties of mirrors and practical applications. Almost all the students expressed interest in learning about and inquiring into plane mirrors.

The Instructional Sequence

The study spans four, 3 hour sessions, during which students investigated various aspects of plane mirror images. Following is a short description of the activity and student products and the Basic Inquiry Skills that were activated in the first session.

Session 1: Image Orientation in Plane Mirrors

Figure 1: Image reversal

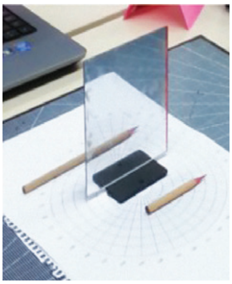

Figure 2: Image orientation

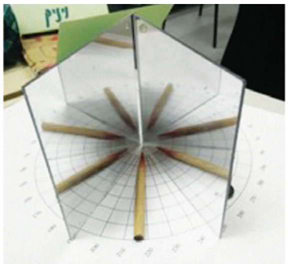

Figure 3: Kaleidoscope

Part 1: Image reversal puzzlement

The teacher placed a large mirror in front of students, asked them to raise their right hand and asked which hand was raised in the mirror (Figure 1). There was a general consensus that the image had raised its left hand, and apparently the mirror reversed "right to left", echoing student response on the questionnaire. Following a demonstration-discussion with sticks with coloured ends, the teacher demonstrated that the mirror only reversed the axis perpendicular to its surface. The trick was to take oneself out of the picture, and gain objectivity. The idea that the image was not real, yet was perceived as being in a particular location behind the mirror, was reinforced by the teacher demonstration of a candle flame image in a glass plate.

Basic inquiry skills

- Re-visit commonly experienced phenomena
- Explicate sensory experiences
- Formulate expectations

Part 2: Object and image orientation

The students were given a plane mirror attached magnetically to a metal surface, a protractor and ruler, and short and long red-tipped pencils to be used as an object and an aid to locate the image (Figure 2). The students changed the angle between the short pencil and the mirror and placed the long pencil to coincide with the apparent image location. They documented their observations photographically and recorded the angles in a table.

Part 3: Kaleidoscope

Students investigated the number and orientation of images created by two plane mirrors placed at an angle. They changed the angle between the mirrors and recorded the number of images and their relative orientation. They were also challenged to discover a quantitative relationship between the angle and the number of images. Students photographed different situations, showing the object and the mirror images (Figure 3).

Basic inquiry skills (parts 2 & 3)

- Identify a physical attribute and manipulate it
- Document: Capture sensory experiences

Discussion

To What Extent Did the Instructional Sequence Provide an Environment for Developing Basic Inquiry Skills for Novices?

The instructional environment provided progressive complexity and gradually reduced guidance. Students repeatedly activated the basic inquiry skills. The investigations were not straight-forward. The instructions were not detailed, and students had to spend time designing, and re-designing their experiment. They needed to decide how many measurements to take, and how to document their work. They had to coordinate their team work. Although the instructor responded to some of their questions, they had to deal with frustration and uncertainty as is reflected in their reports:

At first the two experiments were a little strange. Like all the others I started working without planning. The experiment took much longer than if I had planned ahead. I have understood that planning has great effect on the quality and time required for the assignment.

To What Extent Did the Instructional Sequence Foster the Development of a Physics Inquiry Disposition?

Evidence from student comments

We gained insight into optics. We experienced phenomena that were new to us. We enjoyed the independent learning experience. We feel that we have understood what we did, even though we had no prior knowledge.

Work on the project gave us great pleasure. We had an opportunity to express our creativity. We learnt a lot and experienced solving a realistic practical problem. This encouraged us to care more about the problem and motivated us to solve it.

Evidence from student products: The open inquiry students conducted in session 4 required them to observe and explain selected reflection phenomena, in previously unrehearsed contexts such as curved mirrors. The students produced presentations summarizing their investigation. Following are some of the inquiry issues from the presentation prepared by two girls and photographs they presented as evidence (Figures 4a 4b):

Q1: How does the curvature of the mirror affect the observer's field of view?

3 The more curved the mirror surface, the more the field of view increases.

Q2: Does the distortion depend on the curvature?

A: Yes. The more curved the mirror, the greater the distortion.

Q3: Is the orientation of the image affected by the curved mirror?

A: The curved mirror affects the image orientation the same way a plane mirror does.

Figure 4a: Curvature and field of view

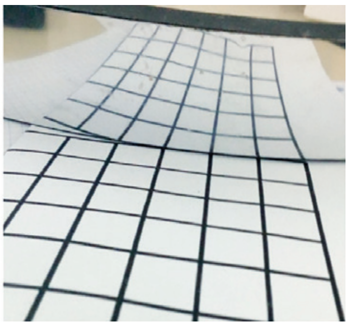

Figure 4b: Curvature and distortion

This example demonstrates that the students were able to generalize from their previous inquiry activities into a new context, using concepts such as "orientation". They identified the "curvature" concept, manipulated it systematically using available objects, documented their sensory experiences in an original fashion (including their own images as evidence of ownership), formulated relevant inquiry questions, "made" a presentation and communicated their inquiry in a coherent and aesthetic manner.

This preliminary study indicates that students were able to activate the basic inquiry skills with increasing confidence, in a manner that gave them satisfaction and minimal frustration. The instructional environment resonated with student initial ideas of factors that could expedite inquiry such as team work, gathering information from many sources, asking novel and critical questions. This method can be further implemented in other areas of physics such as electrical circuits, magnetism and lens systems.

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TEAM INTERACTIONS AND DEVICES DEVELOPMENT FAVORING THE UNDERSTANDING OF NONTRIVIAL SUBJECTS: FLUID MECHANICS AS A CASE STUDY

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| INTRODUCTION

In a technological society, interdisciplinary must be pursuit by researchers and teachers daily. Furthermore, in order to actuate in a global and complex world, STEM (Science, Technology, Engineering and Mathematics) contents are mandatory in any curriculum, from the school beginner to the graduate student. Teamwork persons are expected on the majority of enterprises at the beginning of this century. This scenario favors high stress on the teacher-student and student-student relationship; thus any attempt to facilitate these interactions is usually celebrate. A possible strategy is the use of specified equipment to teach these complex new concepts; nonetheless this usually also means expensive equipment and/or the use of research ones. Therefore, this works aims the development of new ways to improve interactions on heterogeneous work teams, such as undergraduate and graduate students, but with low cost equipment, mainly formerly developed by the same group. Fluid mechanics was chose as the subject matter because it is usually considered a highly demanding school subject.

Theoretical Framework

This work is based in object manipulation, tool production and self learning; therefore, it is linked to the object learning theory that has long been established (KOHRMAN, 2012). One variant on this approach of object manipulation for acquiring knowledge is the use of teaching kits on classroom. This use can comprise from k5 (RICHARDS & DONOHUE, 2008) and freshmen students to graduate personnel (SINGER, 2015). Moreover, it can provide insights in complex engineering problems whereas deal with simple physics concepts (BOESING, 2008). There are also concrete evidences of improvement in important intrapersonal and interpersonal skills such as teamwork, interdisciplinary learning and transfer of knowledge, i.e., these tools promote active learning (SINGER, 2015). Thus, for decades these kits have been used to teach several distinct contents – physics, math, biology, etc., but there still is room for some adjustment. For instance, the commonest kits, used mainly for engineering teaching, normally are pre-formed for achievement of some results, i.e., despite modular are not extremely versatile, which difficult customization. Some of them are expensive, considering the reality of public high schools, or only present web virtual environments, or eventually mobile based experiences, which does not favor manipulation of real devices (PHANG et al, 2012). This scenario is also encountered in Brazil, what led us to developed modular, easily customizable devices and kits, in pursuit of the motto "anyplace, anytime, anyone".

Fluid mechanics, according to Dreyfus et al (2015), is a multidisciplinary subject, linked to physics, chemistry and biology areas. Therefore, it is ideal subject to test the versatility of didactic tools and also to improve knowledge in STEM area. More important, due to the complexity of some aspects of this subject, it can create a situation without an existing correct or wrong answer, where teamwork discussion is expanded, i.e. without "the single answer paradigm" (WEI & FORD, 2015).

Methodology

The methodological approach makes use of small devices and kits previously developed (PICHI et al, 2016) as the central piece for team aggregation. The important feature regarding these kits is the dimensions since all parts and pieces were miniaturized in order to diminish environmental impact due to extensive use, which also assures the low cost of devices production. Moreover, the small size favors quick response on any experiment, which means different hypotheses can be tested in a small period of time, and also provides good mobility (PICHI et al, 2015). Figure 1 shows a general view of the whole kit (setups and devices) in a layout that allows eight students be attended simultaneously. In summary, the kit, in the figure showed on a table 180 cm long, is composed by small setups, the black or grey pads. The pads function is to support the miniaturized devices and this whole setup acts like a manufactured cell. The devices are easily exchanged since they are fixed on the pads using small clamps; thus, different situations, such as mixture of reactants or heating, can be tested sequentially. The main operations provided by the kit are: a) continuous flow injection and admission system, which allows inserting small amount of reactants, b) recipients to manipulate fluids, m) flow meter and d) detection system with array of electronic sensors adequate for determination of volatile organic compounds. Data acquisition requires a computer.

During all the steps for kit development, including design, the work teams were composed by voluntary students and researchers and use hands-on approach and problem/project based learning. Students came from public high school and university

Figure 1: General view of the whole kit.

and comprise from freshmen in high school to senior master students. The main tests with these kits were carried out mainly in two situations: controlled and non controlled environment. Whereas the controlled environment means a class with a responsible teacher and/or a monitoring service, the non controlled situation leads to available kits but no interaction with any instructor, although a senior researcher usually evaluate the response by direct observation and concomitant filming. Moreover, each participant was also monitored with non-structured interview regarding important issues, from easiness of teamwork to difficulties of kit assemblage, etc.

This work complies with Green Engineering and Green Chemistry principles. Therefore, the research considered the use of environmentally friend fluids, mainly air and organic solvents, such as alcohol.

Results & Discussion

As previous reported, since the beginning this research work was developed by interdisciplinary teams, composed by researchers, high school, undergraduate and graduate students. A brief description of these students and respective functions are shown in Table 1. On the table, the number of participants means the average amount present on each step of the development. Regarding team work activities in each development phase, it is worth noting that, since the kit and devices are prototypes, these steps followed prototype methodology for development of electronic product and process (CAMBURN et al, 2013). Therefore, on the research-planning-design phases, probably due to the uniqueness of the situation, up to 10 different participants were involved. This beginning was especially attractive for young persons from secondary technical schools of electronics that even proposed some small PCB layouts. On the development-testing phases the enthusiasm was not the same; however, some college persons showed interest in specific task, such as the production and tests of packed reactors and videos classroom. After setup was well defined the general interest seemed to return, especially among freshman college students; nonetheless the interaction with the devices was characterized by "how does I manage it?" or "which parameter is the important one" than "how does it work?" or "how can I modify it", in other words, they were not willing in disassemble the parts and pieces, as was expected by the developer persons.

Tests were carried out composing different teams and situations, as follows: team of four high school students was invited to use the kits during the whole semester. In this case there was an advisor appointed and the mission to produce a monograph at the end of the period; b) single classes with or without the use of handouts/workbooks. To these classes attended high school and undergraduate freshmen students and the mission was explain verbally the main concepts present in each setup tested and also proposed another ones; c) undergraduate student acting as an instructor; in this case video lessons should be produced. The expected syllabus content to be tested or envisaged with these kits and handouts is highly concentrated on physic concepts, such as kinetic theory of gases, aerodynamics and thermodynamics, but certainly not limited to; thus some chemical issues, such as environmental impact, might also be discussed.

Table 1: Brief description of the team involved on kit development

Personnel	Number*	"Job" description	Obs.
High school student	4	Tests of "big" reactors	Used on static mode
Undergraduate student	2	Development of packed and capillary reactors and video instructions	Used on continuous mode
Graduate student	1	Researcher and PhD student	Kit developer
Ph D	2	Users	Advisor; tests in the classroom, etc.

*average number on team works

The main results pointed out to easiness of data acquisition and interpretation. Therefore, no matter if it was a high school student or a graduate one they both reach almost the same conclusion regarding the reasons for the events they witness, most of the time a correct answer. On the other hand, as expected the ability to explain the observable phenomena is not the same; thus high school student partially failed on the task of provide a monograph regarding the use of the instruments, nonetheless, they were able to associate the measurements with some common scenarios on environmental impact, such as contaminant detection and dispersion. Moreover, sensors detection of simple contaminants catches up the attention of all students. Monitoring instructor was able to explain the phenomena and all the instruments but failed in using the correct scientific language. The relationship among high school and undergraduate students works well, with the more advanced people trying to help the rookies. Furthermore, the undergraduate students showed interest in provide new experiments but not the high school participants. Direct interview of all students showed almost unanimity on the approval of using such devices on the class or making them available for out class use. At least one graduate student showed interest in developing similar instruments inside the research team.

Regarding the maintenance phase of kit development, i.e., the continuous use after the initial ideas and manufacturing phase, it is worth noting that the kit has been used in a chemistry basic discipline uninterruptedly during the last four semesters. Up to now, no needs for replacement of vital parts were reported.

Conclusion

In conclusion, it was possible to observe that simple and low cost equipment plays an important role on the development of skills on STEM area. It is worth pointing out that low cost devices also assure that minorities can be attended. Fluid mechanics proved to be an interesting subject for improve interdisciplinarity; therefore, whereas high school student possibly correlates the behavior of gaseous continuous flow with environmental impact the undergraduate students tend to associate it with technological constraints on detection system. In other words, although the student background seems to be important parameter in guiding the answer the correspondent discovery is equally meaningful.

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INQUIRY BASED TEACHING: AN EXPERIENCE WITH THE TEMI E.U. PROJECT

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| INTRODUCTION

With the aim of giving new skills to engage their students with exciting new resources and of supporting teachers in their work to implement IBSE (Inquiry Based Science Education) in their classrooms, at the universities of Milan and Salerno various didactical activities for high school teachers have been planned and implemented in the last years. In particular, the Physics Education Research Group (PERG) of Milan, one of the 13 partners of the European project TEMI (Teaching Enquiry with Mysteries Incorporated) (TEMI), in cooperation with the Physics Department of Salerno, has planned and organized a training sessions (called cohort) with a group of 34 high school teachers that has been held in Salerno. Following the TEMI approach to IBSE, teachers have been involved by directly making them experience the 5E inquiry methodology (Bybee, 2006) to be tested in their classes. Teachers have been engaged by a suitably chosen physics mystery and fostered to explore, to discover and find explanations of the mystery in order to practice scientific investigation. All the IBSE activities proposed had the main purpose of reducing the gap between standard high school practice and well known education techniques, by offering concrete strategies and specific tools for physics teaching. In this work, we will briefly describe our training experience and outline teachers' practice in their classrooms.

Inquiry based teaching and the temi eu project

IBSE is a well-known methodology based on the constructivist educational paradigm that can rooted back even to the pioneering work of Dewey and Piaget. This methodology is an active process that allows students to construct their own knowledge by means of active work, discussion of questions and cooperation between classmates, teachers, scientists, and using resources from the educational environment. The just finished EU-FP7 (Science and

Society) TEMI project gathered 13 partners from 11 countries across Europe, had a duration of 42 months and a supposed long-term legacy. It was part of the EU actions towards the implementation and diffusion of the IBSE methodology across Europe. TEMI aims at embedding four innovations in teachers' practice: to create curiosity with mysteries, to teach skills with gradual release of responsibility, to maintain motivation with showmanship and to teach concepts with the 5E learning cycle. To this purpose, teachers have been trained following the same five phases of learning they are required to implement in teaching activities: Engagement, Exploration, Explanation, Elaboration and Evaluation. Engage gets students' attention using the Mystery and leads them towards formulating a preliminary inquiry question. Explore makes students plan experiments, collect observations and data. While, in the Explain phase, teachers can make sense of the data and, drawing upon previous scientific ideas, try to answer the inquiry question. In the Extend phase, they apply the conceptual understanding gained to solve another problem. Evaluate is the phase in which students, with the help of teachers, assess their understanding and skills. This methodology is applicable at all levels of formal education, from infant schools to universities, and takes place in informal as well as formal learning contexts. Thus far, about 60 TEMI cohorts have been delivered in nine countries, reflecting country-specific issues as regards curriculum and suitability of context. Conferences and events have also taken place to disseminate the results, a website with downloadable mystery-based materials, a TEMI Book of Mysteries, a booklet guide for teachers titled "Teaching the TEMI Way" and smartphone apps on mysteries have also been produced by the project partners (TEMI).

Our inquiry learning laboratories experience

In order to overcome a teaching approach based only on theoretical aspects, and remedy to the general students' disaffection to the study of physics, we proposed, on the basis of the TEMI guidelines, a teachers' training devoted to promote physics understanding through the development of self-made inquiry activities (Windschitl, 2006; Sherborne, 2014; Barbieri et al, 2014 (1)) in ten different schools of the provinces of Avellino, Salerno and Naples (Italian towns with a high students' density). The TEMI trainers of the University of Milan activated inquiry attitudes in teachers by proposing experiments stimulating the 34 participants to the cohort in asking questions and proposing scientific hypothesis. Starting from the introduction of "Mysteries", interactive lessons and hands-on activities concerning various physical phenomena, based on IBSE were proposed (Collins et al, 1991). The teacher training was divided into two phases consisting each of a two-day workshop (brief lesson and inquiry based laboratory activities) plus a follow up activity in the classroom. In the first day, the IBSE workshop concerned oscillations and harmonic motion (Barbieri et al, 2015; Giliberti et al, 2014)); in the second day, teachers have been involved in laboratory activities about geometrical optics and the vision of colours. (Barbieri et al, 2016). After the first two days' workshop, teachers tried to implement IBSE in their classes at least with a brief sequence of a few hours.

The second two days of Inquiry learning experience concerned mainly the gas laws, electrical circuits and the electromagnetic induction (Barbieri S R et al, 2013). After the second workshop, the teachers made a second activity with their students. This activity was carried out in steps. Step 1), the training topics have been agreed with the trainers and some training materials have been collected. Step 2), teachers implemented in their own classes some of the activities proposed in the first step, using the TEMI methodology. Tutors (researchers and teachers from the Physics Department of Salerno) supported teachers' classroom activities, by giving hints for the planning of the activities or describing them how to use lab material with students. Step 3), a discussion among trainers and teachers about teachers' work in their classroom, took place. All the teachers that decided to work in this phase of the project (about 50% of the trainees), choose to present the activity "Guess the colour" (Barbieri et al, 2016). This activity permits to introduce relevant physics phenomena through high level of empathy, with fun for the students. Moreover, this activity can be modulated at different levels so to be suited to students of different kind of school. By presenting a "mystery" about light and colours, teachers led their students through a qualitative study of the additive synthesis of lights, of subtractive synthesis of the coloured pigments, of the vision of colours under coloured lights and fluorescence, making inquiry with easily available materials. Tutors supported teachers' classroom activities (the classroom involved were eight, in three different schools).

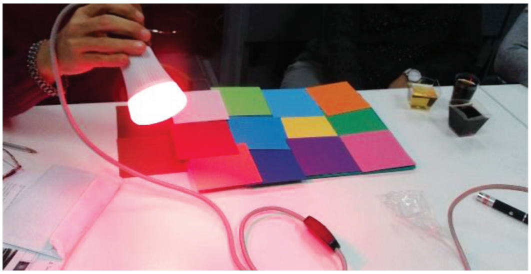

Figure 1: Inquire learning laboratory "Guess the colour"

Results and conclusions

In order to investigate how the teachers perceived their professional development during the workshop, the teachers answered a questionnaire at the end of each enquiry lab, and a final questionnaire. From comparison of questionnaires at the end of each of the two days' workshop, teachers appeared satisfied for what concerns the interest, the clarity, and the enjoyableness of the workshops. For what concerns the applicability of the IBSE methodology proposed, they were significantly more comfortable after the second series of workshop. In the third, final questionnaire, 60% of the trainees affirmed of having never used IBSE before, despite 83% of them had more than 15 years' experience. 100% of the teachers said that the workshops met their expectations (50% completely, 50% to certain degree), that the "productive mysteries" presented in the training were appropriate for their context, and the activities proposed were varied enough to fit all the levels of teacher experience and helped them tackle various aspects of the curriculum. 50% of the teachers declared to have gained new tools for teaching and 40% also a motivation to renew their own teaching from the training. Moreover, 70% of the participating teachers declared that they got a chance to implement the TEMI approach and techniques in their classroom, in the way presented during the training course or adapted/combined with other approaches. In our opinion, it is important to notice that teachers declared to want to introduce or improve inquiry in their classrooms in the future. In Table 2 a synthesis of the answers, on a 5-point scale (5 = strongly disagree, 1 = strongly agree) is reported.

Table 2: On a scale from 1 to 5, how confident do you feel to apply in your classroom the following topics that have been addressed during the training?

	1	2	3	4	5
Inquiry Based Teaching	13%	33%	41%	13%	0%
"Productive mysteries"	20%	47%	33%	0%	0%
The 5E enquiry cycle	0%	40%	40%	20%	0%
Apprenticeship (GRR - Gradual Release of Responsibility)	7%	31%	54%	8%	0%
Showmanship	31%	31%	22%	8%	8%

The attention paid by PER group of Milan and Salerno to teacher's professional development in order to build bridges between high school and university seems to have been really appreciated by teachers and will probably have future dissemination.

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SECONDARY SCHOOL 5

THE STUDENTS' INTERPRETATION OF QUANTUM MECHANICS CONCEPTS FROM THE FEYNMAN´S SUM OF ALL PATHS APPLIED TO LIGHT

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| INTRODUCTION

Our global research goal is to teach basic quantum mechanics concepts from the different aspects of light (Arlego, Fanaro, y Otero, 2012; Fanaro, M ; Arlego, M, y Otero M.R., 2014a ; 2014b). We employ the Multiple Paths method, developed in 1949 by Richard Feynman. This framework allows to do a meaningful study of probability; superposition and correspondence principles.

In this work we analyze part of the implementation of a didactic sequence (Fanaro, Elgue and Otero, 2016) to teach different aspects of light in a unified non traditional framework. The goal was to propose the quantum theory of light as a universal framework to describe different phenomena observed. The syllabus corresponding to this age group (second to last) in high school advocates the teaching of light phenomena.

The Feynman approach was used by researchers thought differently. For example it was used in undergraduate courses for non-specialists (Taylor et.al and Styer in EEUU; Hanc & Tuleja, in Slovakia). In other cases it was employed in proposals in high school curriculum (Cuppari et al., in Italy; Ogborn in UK). Furthermore, in the Advancing Physics AS (2000) project of an A-level physics course for the British high school system the quantum physics chapter was treated using the sum over paths approach (Dobson, Lawrence and Britton in UK). The works of Malgieri, Onorato & De Ambrosis in Italy about teacher training and secondary school implementations adapted the Feynman method, too. However, there are still few results about the viability of introducing this alternative way of quantum mechanics teaching in high school.

We designed a didactic sequence (14 situations), adapted to mathematical and physical knowledge of the students based on the Feynman´s approach. Then, we implemented the didactic sequence seeking to understand the students' conceptualization process about quantum interpretations about reflection, refraction and the double slit experiment (DSE). The research questions addressed in this work are: *How do the students interpret the quantum mechanics concepts from the Feynman´s Sum of All Paths applied to the DSE? Is this sequence viable to teach basic quantum mechanics at secondary school?* The key concepts analyzed are probability, maxima and minima, and the discrete detection of light.

The key didactic viewpoint consists in teaching with questions and facing the students with the situations. They are genuine problems that students must get engaged with and solve in groups. Every situation makes emerge the concept to be taught.

We adopt the theoretical frame of the Vergnaud theory (Vergnaud, 1990), where the conceptualization is defined as the process of the identifications of concepts, their properties and their relations with other concepts. (Otero, et.al, 2014). The concepts are well defined in this framework by a set of three interrelated elements: C=(S,I,R), where S represents the set of situations that make the concept useful and meaningful; I is the set of operational invariants that can be used by individuals to deal with these situations, and R: the set of symbolic representations, linguistic, graphic or gestural that can be used to represent invariants, situations and procedures.

The didactic sequence started from the students´ prediction of the results of the experiences of reflection, refraction and the double slit experiment (DSE). Then these experiences were carried out in the classroom, using a laser light source. Later the results of the DSE showing individual detections were presented through a sequence of real images of the DSE with very low intensity light. This enabled to show the individual detection events on the screen which evolved into a definite pattern of alternated fringes on the screen.

The laws of quantum mechanics for light using the Feynman´s "Sum of all Paths" approach (SAP), adapted to the mathematical level of the students was proposed as a model to explain these experiences. Graphic representations and basic operations with vectors capturing the essential aspects of the theory were used. Simulations made with the software GeoGebra(R) were created to help students visualize the SAP technique results to the simple case of light emission and detection, and light reflection and refraction. Then the SPA was applied to the DSE to describe those results obtained in the situation relative to the localized detection and the alternated fringes pattern.

Method

The sequence was carried out in four courses of two state secondary schools, with **N=83** students aged 15-16, during 23 school hours. The syllabus advocates the teaching of light phenomena. Qualitative methodology was based on all the students' productions when they were faced with the situations. Thus, we analyzed the conceptualization process, based on Vergnaud´s theory: to identify possible aids and obstacles in the conceptualization.

An answer categorization was done aiming to understand the student´s conceptualization process when they were solving the questions of the last stage of the sequence. We present the analysis of the use of SAP method and quantum reformulations about these experiments to seek to understand the student´s conceptualization process about quantum interpretation. In this way it was possible to know how viable the sequence was and which changes could be necessary for future implementations.

Results

In the last stage (fourth) the calculation of probability of light detection in the DSE (Fig. 1) was proposed. Applying previously concepts studied in the sequence and doing simple mathematical operations, it wasn´t difficult to obtain the expression of P(x). In this case, the model of SAP applied to the DSE allows to get the expression:

$$P(x) = k \cdot \cos^2\left(\frac{d \cdot D \cdot x}{2}\right)$$

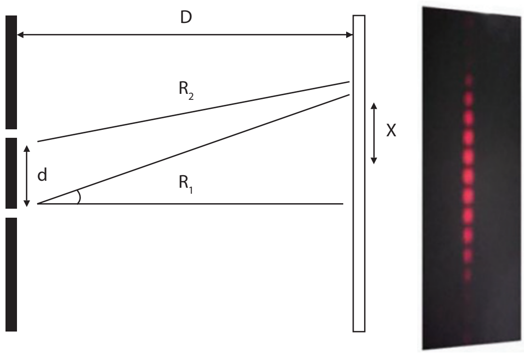

Figure 1: Scheme of the DSE and the corresponding results obtained in the screen

The students had to relate the minima and maxima of the P(x) with the results of the DSE, and to answer:

$Q_{4.1}$) What characteristics has the P(x) graph got? How does probability with x distance to the center of the screen change? Consider D (distance from the slits to the wall) and d (distance between slits) and the value of the proportionality constant k, which corresponds to the red laser, and draw it.

$Q_{4.2}$) Which is the relation between the minima and maxima of P(x) drawn above with the results of DSE ?

Then, the students had to run the simulation of the DSE, which some snapshots are presented in Fig. 2. The students had to relate the sum vector with the probability function.

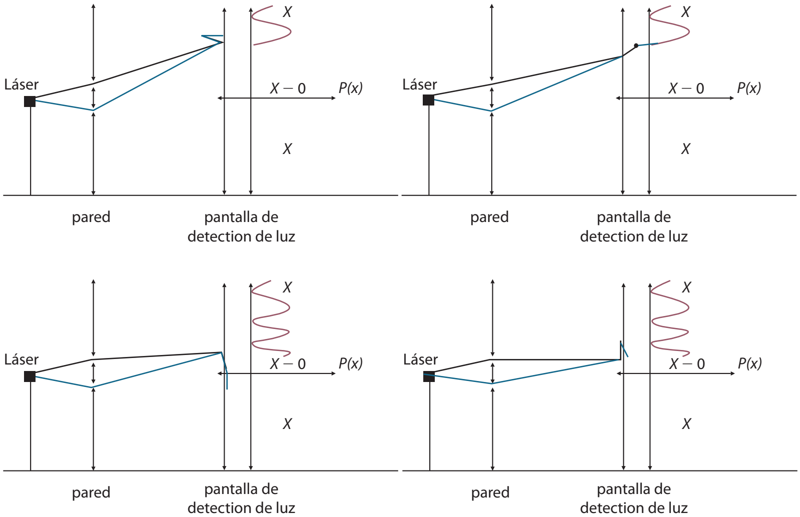

Figure 2: Scheme of some snapshots of the DSE and the corresponding P(x)

The question raised was:

Q4.3) Which is the relation between the sum of the associated vectors to each main path and the P(x) function drawn by the software?

In this paper we are focused on the the student´s conceptualization process about quantum interpretation, so we are going to consider the answers to Q4.2 and Q4.3 of the N=83 students.

a) Regarding the relation between the characteristics of the graph of P(x) and the results of the DSE (Q4.2)

Most students (n=70) could interpret the graph of P(x) previously obtained. A half of them (34/70) used the probability concept in the relationship, and the other half (36/70) did it without using this concept, only expressing "where there is a minimum of probability, there is darkness". It is important to highlight how the students represented graphically the modulations observed in classes, although it wasn´t considered in the SAP, as shows Fig. 3.

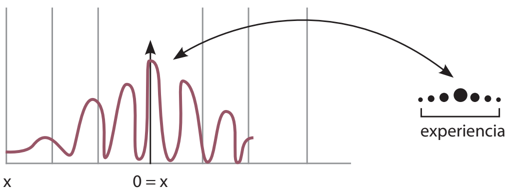

Figure 3: Graph done by a student representing P(x)

These students graphically represented the modulation observed in the experiment, which is not considered in the SAP calculation.

A few students (n=13) either did not answer Q4.2 or gave a confused answer. They could neither conceptualize the DSE classically nor quantically, since he considered that light copies the shape of the slits as it goes through (even until 4th situation!).

Other students of this group, apart from not using the proper concepts of maxima and minima of probability established the relationship inadequately considering the maxima as the absence of light and the minima as the presence of light. To consider that light copies the shape of the slits as it goes through, presents a very important obstacle for the conceptualization of quantum concepts.

n) Regarding the relationship between the sum of the vectors associated to each main path and the P(x) function drawn by the software (Q4.3), more than half of the students (n=47) established the adequate relationship, using the probability concept.These students established that the sum vector represents the probability of detecting light at the screen. Additionally they reinforced the concept by pointing maxima and minima on the P(x) graph. Fig 4 shows a student´s answer diagram overlapping the real probability function (not simply the modeled by SAP), the DSE image obtained in class and the sum of the two associated vectors, all in spatial correspondence. It is outstanding that this diagram was designed by the student himself denoting the high level of conceptualization reached.

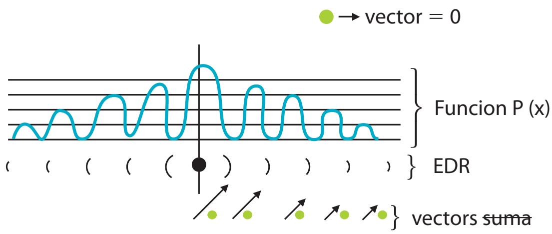

Figure 4: Scheme student´s answer diagram of the DSE

A group of n= 21 students established an acceptable relationship, but without making reference to the probability concept.

Finally, the rest of the students (n=15) neither answered nor established a clear relationship. For example, the answer in Fig 5 shows that this student graphed the function without considering its periodicity, and therefore he drew the vectors sum with the same length. Here, we conclude that the conceptualization was poor.

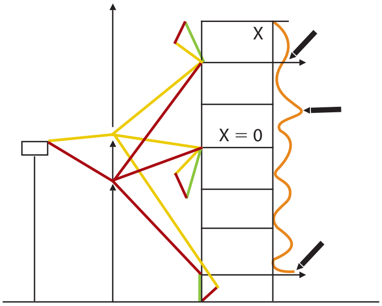

Figure 5: A student´s graph of DSE and its corresponding function P(x)

Conclusions

We conclude that is possible to teach basic quantum concepts from Feynman's approach to the secondary school students. However, minor changes in the sequence would be necessary to prevent some obstacles identified in the conceptualization process. These changes mainly aim at reformulating the situations to attain a better qualitative understanding and improve the students´ management of the model.

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INTERPLAY OF PHYSICS, MATHEMATICS AND METAPHORS IN TEACHING QUANTUM PHYSICS

Gesche Pospiech

| INTRODUCTION

Quantum physics is a fundamental theory of physics with still ongoing developments clarifying its fundamentals. It heavily relies on its description by mathematical structures. So teaching quantum physics for high school students faces the problem of adequate teaching strategies especially as the mathematics is mostly beyond high school level. In order to have an additional method for teaching we discuss the use of metaphors for making the quantum physical mechanisms understandable and more insightful. Here we want to explore the possibilities of unusual metaphors avoiding the reference to classical physics.

Metaphors And Teaching Quantum Physics

As a fundamental theory quantum physics should be part of the physics education at high school. The content analysis shows that quantum physics is characterized by uncertainty and entanglement with the notion of superposition as basic idea. The appropriate understanding of these concepts has to be supported by e.g. an adequate verbal explanation or visual representation. The analysis of text books, however, reveals that many visual aids may be misleading as they refer to classical concepts such as particles, waves or trajectories. This has the effect that classical views will not be reflected and thus remain unchanged. On the search for understandable as well as correct explanations for high school students metaphors often are used to describe the quantum physical concepts. In this contribution we will discuss how "unusual" metaphors could build a bridge between the mathematical operations and their physical meaning.

A metaphor is a figure of speech that identifies something as being the same as some unrelated thing. It brings together two concepts from different conceptual domains. It may provide clarity and identifies or creates hidden similarities between two concepts. Johnson (1995) stresses the overall presence of often unconsciously used metaphors in daily language. He transfers this use of metaphors shaping the human understanding to the scientific discourse where metaphors taken from one area to another area of physics influence scientific thought. However, he refers to physicists who know the realm of physics and hence communicate in a joint framework. That this is not the case with learners, students at high school as well as at college, is pointed out by Brookes&Etkina (2007). Also Niebert, Marsh and Treagust (2012) stress the differences between students and teachers in employing, understanding and developing metaphors in scientific communication. They also hint to the difficulties students have in correctly adopting the meaning of a metaphor presented by the teacher. Their conclusion is that the metaphors have to be embodied and reflected. Physicists use many different metaphors, mostly taken from classical physics as kind of analogy, but also from everyday life. The wording often belongs to the physics jargon (Brookes & Etkina 2007). As metaphors relate two objects of different domains with each other, at least two of the three parts of the relation - source domain, target domain and the mapping between those objects (or domains) - have to be known to the students. Only if the students know the source domain and the mapping then there is a chance that they also understand the target domain. If not, they might come up with an ad hoc mapping that is inappropriate to a given situation.

The opportunities metaphors might provide in visualising quantum physics or in illustrating quantum physics have early been recognized. The master of metaphors was Schrödinger inventing some of the most famous metaphors. Metaphors with strong images might lead to the effect that students are being distracted by the metaphor, reducing their focus on quantum physics. It might also be that students understand the physical ideas, but are confused about the language used to express the physical ideas, (Brookes&Etkina 2007). Students might be led to an overly literal interpretation of the metaphorical language they encounter in lessons on quantum physics. It is observed that most explanatory metaphors for quantum mechanics are only used in very specific circumstances hence cannot serve as a reasoning tool (Brookes&Etkina 2007).

Research Questions

The goal of the paper is to analyse the use of metaphors and analogies and its connections to the mathematical structure. Herewith we focus on unusual metaphors I.e. they do not refer to elements of classical physics.

– In which way are metaphors suited for learning the main concepts of quantum physics uncertainty and entanglement?

– What are the pre-service teachers' views about metaphors?

– Do pre-service teachers view metaphors as a possible help in building a bridge between the mathematical operations and their physical meaning?

Metaphors In Teaching Quantum Physics

Analysis Of Metaphors In Popular Science Resources And Text Books

In popular science books no knowledge about the mathematics of quantum physics can be supposed. So the authors have to resort to vivid images. We want to know which possibilities the authors use and how accurate the created metaphors are. In a first step we perform a content analysis in eight popular science books with focus on metaphors of uncertainty and entanglement not referring to classical physics. An example would be:

> "I do not know where your bone is, but I can tell you exactly how fast it is moving." (Orzel, 2009).

We identified some metaphors and discuss their suitability to provide an adequate picture of quantum physics. It turned out that the metaphors are quite rich and taken from all areas of life, but only weakly mimicking the mathematical- physical background. As a rule the mapping between metaphor and the physics often is not obvious:

> "Just an atom was chained in a microphysical dungeon but in the next moment it has freed itself from the bonds and on the quiet stole away into the night." (Chown, 2008)

Often the metaphors are embedded into a storyline. An example is a found in the book "Einsteins's veil" by Zeilinger (2003): "The tyrann and the oracle"1 needing several pages to evolve. On the other hand shortness often implies descriptions which are too much simplified. One well-known example are "Bertlmanns socks" especially if only one variable is used. So it seems that the length or the complexity of a metaphor is coupled with its correctness. The possible mathematical description is introduced a bit deeper in the following description of uncertainty:

> "If he closed his fist even tighter he sensed how the thing fidgeted even violently. The counter pressure developing in his hands became so strong that he soon did no longer have the force to keep hold on it."

However, here the principle of two different incompatible quantities is only vaguely addressed. One example concerning entanglement reads:

> "If it is said that somebody had his hands **entangled** then this implies that the fingers of both hands are slid in such a way that they can no longer be turned independent of each other."
>
> (translated by author, taken from: Hüfner&Löhken (2010)).

This metaphor focusses on the fixed interrelation between the objects (hands). There is no mapping of the tensor product so that this metaphor could only induce some preliminary everyday understanding of quantum physics.

Construction of Own Metaphors

One method to construct own metaphors relates persons or objects according to the mathematical structures and rules of quantum physics. This process is best illustrated by an example, a metaphor of uncertainty:

> "A farmer owns a herd with cows and horses, which are either white and black. These he wants to count. In order to do so he uses a double gate: At the left gate only the cows can go through, at the right gate only the horses. After separation of the cows and horses, in a second step, he removes the horses and brings them to a far away field. Then he sorts the cows according to their colour in order to get a herd with only white cows. Now he wants to be sure that his sorting was done correctly. He tests by sending only the white cows again through the double gate. Suddenly horses are found in the herd."

This example mimics the well-known Stern-Gerlach apparatus with two crossed magnetic fields and there is a one to one-mapping between the metaphor and the mathematics of the Stern-Gerlach-experiment.

Pre-Service Teachers' Views On Metaphors

In this section we analyse the views of pre- service teachers on the relation of the developed metaphors, physics and mathematics for teaching and learning quantum physics. The participants of the study were 18 students, near the end of their study participating in a seminar on didactics of quantum theory. They answered during one lesson a questionnaire with seven questions requiring open answers on the suitability of metaphors for understanding and three questions concerning given metaphors and their relation to physics and mathematics.

1 This is a metaphor of the Greenberger-Horne-Zeilinger-States.

Most future teachers (12/18) agree that metaphors can clarify the differences to classical physics because they can show its absurdity or a contradiction. The other (6/18) agree at least partly. The metaphors have to be well explained and the teacher has to be aware that confusion with classical physics might be possible. They mostly think that metaphors can give an impression of quantum physics but no precise knowledge.

Nevertheless the future teachers would use metaphors in their teaching (13/18 agree at least partly). However 5 of them think that the condition is important that the students have to already know quantum physics and that the formalism may not be neglected. Metaphors have to be related to known concepts. 8/18 would let invent own metaphors in order to see if the

Metaphors In Teaching Quantum Physics

students understood the quantum concepts properly. Many teacher students hold the formalism in high regard: 6/18 agree that the correct mapping from metaphor to mathematics is necessary, 4/18 think it not necessary in detail, 4/18 think to make the relation explicit would be too difficult for the students. On the whole they think a good agreement with the physical foundation is necessary, but think it is possible only for single aspects (7/18). Concerning the relation of physics and mathematics some think metaphors could be a help (5/18), but only if explained adequately (4/18). Most reasons against the use of metaphors in teaching quantum physics are borne from fears that the students might not understand the concepts properly: metaphors could be puzzling (5/18), induce misconceptions (3/18) or that its limitations are unclear (6/18). On the other hand most teacher students see the advantage of metaphors in that they could serve as clarification if embedded properly into the lesson.

Conclusion

Concerning the problem of teaching quantum physics with restricted mathematical and physical experience of the learners the use of unusual metaphors could be an additional feature supporting the use of visualizations. On the whole we can identify the following main traits of teacher students: They react mostly positively to the use of unusual metaphors and agree that metaphors can be a help in grasping quantum physics and could be useful, but have to be embedded in a careful designed course. Metaphors have to be explained well in order to build a bridge to understanding, especially because of their imaginative character.

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WRITING IN PHYSICS CLASSES IN HIGH SCHOOL: POSSIBILITIES

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| INTRODUCTION

Writing at school can be problematized from different perspectives: it is usually understood as a school subject or as a pedagogical communication vehicle in school assessments. A seldom explored perspective is to understand it as a learning tool in the various school subjects (CARVALHO; BARBEIRO, 2013). In Physics classes in high school it appears to be more common its use as a means of expressing knowledge in assessments. Literature review also indicated that there are few works studying the perspective of writing in the construction of knowledge in Physics classes.

Writing requires planning and the creation of expressive and situational supports (VYGOTSKY, 2008). It can assist in building of knowledge, also related to Physics, because it requires an active and conscious action of the individual, reflecting on their thinking and thus making it more defined and concrete.

In this work it is explored this potentiality of writing, from a didactic proposal developed in the third year of high school in a public school in Brazil, by inserting the writing as an important process in building knowledge about electromagnetism. It were adopted elements of the Vygotsky theories (1984; 2008), which discusses the importance of written language in learning process and the need for intrinsic motivation for learning; and Bakhtin (1992), defending language as essentially dialogical. It is understood that every enunciation is a link in the verbal communication chain; which is linked to previous (echoes and memories) and successors enunciations (when formulating an enunciation it is tended to presume an answer from the other one).

Production conditions

For the development of the study, it was elaborated a didactic activity considering the content that were being studied in that term, and the material available. The activity was previously submitted to the teacher for his suggestions or amendments.

The activity was implemented in the third year of high school in a public school in Brazil, in two classes of 50 minutes each. The proposal consisted of two main activities: 1) First class: Reading of two texts from the textbook that address historical aspects of electromagnetism; individual reading followed by answers to questions; and 2) Second class: Writing a letter to the scientist William Gilbert.

Before the second activity the teacher makes a contextualization, telling a story about the existence of a time machine that could send the letters from the students to the past time. After that, interviews were conducted with some students, seeking to understand the sense they attributed to the activity. In this paper, it is analyzed letters and interviews with ten students.

Summary Of Results

In the letters it was analyzed the production context of the enunciation, considering the author, the interlocutor and the enunciation itself, including the student´s personal expression. In the interview, it was sought the sense attributed by them to the activity. A summary of the results is presented in the CHART 1.

Chart1: Synthesis of analyses. [S = Student (1 to 14)]

	PERSONAL	STUDENTS INTERLOCUTOR	TOPIC DISCUSSED	ATTRIBUTED SENSES
1	Different	Professor/Explicity copy	Eletromagnetic Induction; Lenz's Law; Henrich Lenz	To talk about knowledge (tell information)
2	Interesting	Gilbert / Elaborate copy, coated with personal expression	Eletromagnetism; Attractive Force between magnets; Faraday; Technologial advance	To thank and Talk about knowledge (tell information)
3	Different	Gilbert / Personal expression	Technologial advance	To thank and Talk about knowledge (tell information)
4	Interesting Different	Gilbert / Personal expression	Magnetism and Eletricity; Technologial advance	To thank

*outlined responses from interviews

	PERSONAL	STUDENTS INTERLOCUTOR	TOPIC DISCUSSED	ATTRIBUTED SENSES
6	Not necessary	Professor / Personal expression	Eletromagnetism; Technologial advance	To thank
8	Liked Different	Gilbert / Elaborate copy, coated with personal expression	Magnetism; What is Physics; Applications; Technologial advance	To thank and Talk about knowledge (tell information)
9	Innovative	Gilbert / Personal expression	Magnetism; Technologial advance	To thank and Question personal doubts
10	Interesting	Gilbert / Personal expression	Eletromagnetism; What is technology and a fridge; Technologial advance	To thank and Talk about knowledge (tell information)
11	–	Professor / Explicity copy	Eletromagnetism	To thank and Talk about knowledge (tell information)
14	Difficult	Professor / Personal expression	Technologial advance	To thank

*outlined responses from interviews

The results show that while six students have the scientist William Gilbert as their interlocutor in the letter, four seem to write to the teacher, perhaps because they are not used to take authorship in school activities, serving more to what they believe to be the teacher's expectations.

Regarding the building up of ideas, four students (that are highlighted in the CHART 1) were able to better structure their statement: those who engaged in the proposal to write the letter to a scientist. Regarding the sense provided, in less elaborated letters, most - exception to copies - brings a sense of gratitude to William Gilbert, and almost all mention technological advances in the actual society, thanks to the science from the Gilbert´s time. These aspects seem to be the predominant voices in the letters.

Two students (S1 and S11) were not able to put personal expression in their enunciation, copying information from the internet in their productions. They didn´t read the indicated texts in the first activity, which emphasizes the importance of a context of meanings that can generate motivation and allow them to build a personal answer from their understanding of the activities.

Final considerations

In the majority of letters, the scientific concepts are slightly or not cited, which on one hand may indicates that the scientific concepts learning is still in process, not being possible yet to operate with them through writing. On the other hand, it is understood that the attempting itself to operate with such knowledge through writing, as a learning tool, is a process that can lead the students to their development. This idea is also expressed by some students in the interviews.

It is important to emphasize that the pedagogical practice discussed in this paper was performed under the time and space conditions of a real classroom, and even with needs of improvement, it is possible to indicate its potentiality in the learning and development processes. This experience indicates relevant discussions to reflect on needed transformations in the school culture, to adopt writing activities also as belonging to the culture of Physics discipline, at high school.

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PROPOSAL TO HIGH SCHOOL STUDENTS IN THE CONTEXT OF PIBID: LIGHT, COLOR AND VISION

Taynara Nassar Da Silva, Bruno Araujo, Gabriel Carvalho, Rodrigo Tonon, Vinícius Martins, Vanessa Albuquerque, Renata Alves Ribeiro, Cristina Leite

| INTRODUCTION

The Institutional Program Initiation Grant to Teaching (Pibid) sustained by the Coordination of Superior Level Staff Improvement (Capes) supports projects with the objective of promoting inclusion of the graduation students in contexts of public schools by developing didactic and pedagogical activities guided by a graduation teacher and a basic school teacher (CAPES, 2016). In this context, it is presented a teaching proposal structured in the methodological model Three Pedagogical Moments (3PM), named Initial problematization (PI), Knowledge organization (OC) and Application of knowledge (AC). They are labor organizers which seek to promote the systematic use of dialogue. (MUENCHEN; DELIZOICOV, 2010). This choice was made for the possibility of obtaining an active student participation during the process of teaching and learning. The intervention seeks to promote the understanding of how we see, through the study of the light and imaging, the human eye and optical illusion.

Methodology

In order to promote the integration of graduation students in the context of public school, at first the university students attended the physics classes. At the same time, a questionnaire of the student profile was been developing to help set the theme and the activities of the intervention. Once the students had indicated that they were interested in subjects related to arts, literature, film and poetry, a teaching proposal from the subject "light, color and vision" was structured. It was believed that this choice would facilitate such approach. Furthermore, we chose to use experimental activities as a teaching strategy, as students had also indicated this interest. The learning and the involvement degree of students could be measured by analyzing the recording of classes as well as students' answers to questionaries made during the intervention. Students were also asked to write essays in which they told what they had learnt and their impressions about the course.

Teaching proposal

The teaching proposal was performed with two classes of the second grade of a public technical high school in a suburb of Barueri. In order to offer a panorama of the proposed course, it is presented the Table 1, containing each activity of teaching proposal, the pedagogical moment and the main objective of the activity. Both the structure and each activity of the proposal are based on the model of 3PM.

Table 1: teaching proposal synthesis

ACTIVITY	CLASSES	OBJECTIVES	INITIAL PROBLEMATIZATION	KNOWLEDGE ORGANIZATION	APPLICATION OF KNOWLEDGE
Activities circuit (PI)	2	Arouse the curiosity and interest of the subjects addressed throughout the teaching proposal	a) dark room experience: sensitize the students abouth the importance of light for us be able to see; b) money in perspective experience: observe the phenomena involved in optical illusion; c) the prism and the poem Physics, by Jose Saramago; appreciate the light decomposition in different colors; d) insibile cup experience: evidence optical phenomena of refration	Discussion to undertand the phenomenon observed	Questionings that lead the students to perception that the light is related at the solutions of the problems presentes in the PI.
Light and imaging (OC)	1	Understanding of the principles of light propagation	Questionings about what are the importante elemtns necessaries to see	Discussion about the light sources and the light propagation principles. Dark chamber experience.	Comparison of imaging the dar chamber and in the human eye

ACTIVITY	CLASSES	OBJECTIVES	INITIAL PROBLEMATIZATION	KNOWLEDGE ORGANIZATION	APPLICATION OF KNOWLEDGE
The colors of the light (OC)	1	Present the necessary elements to understand how we see the color.	Questionings about how we see different colors.	Discussion abour the prism, eletromagnetic spectrum and the color of an objective by reflection. Experience wirh colorful filters.	Questions involving the lights of an object by reflection of the white light, monochromatic light and the sum of the primary colors
Human eye (OC)	1	Understanding about the elements of the human eye an it's funcitions	Questionings about how the human eye structure identifies the colors.	Discussion about the elements of the human eye. Accomodation problems and correction	Question comparing the human eye and a photographic camera.
Optical illusion	1	Understanding about the optical illusions	Problematize the relation between the image in retina and the brain's interpretation.	Discussion about the brain's interpretation about the vison, difference about see and recognize	Proposition of figures of optical illusions for the students interpret and explain the phenomena
The light and the invisible (OC)	1	Understand the relation with light refraction and the vision	Questionings about the possibility of making invisible an object	Discussion about the laws of the refraction of light.	Discussion about the invisible cup experience. Exercises about tje Snell's Law
Magic show (AC)	2	Verify the students understanding about the themes discussed throughout the proposal	Presentation of the experiences previously chosen by the students	Discussion about the phenomena involved in understanding of the student's experiences.	Evaluation of the presented experiences.

Findings and conclusions

Throughout the teaching proposal the students answered questions about absorption and reflection of light, structure of the human eye and did exercises about the Snell's Law. Questions about the visible light spectrum and the color of an object by reflection indicates that most students (75%) understood the relationship between white light and the color of an object observed by reflection of this light and the object's color illuminated by monochromatic light. However, students (67%) had difficulty understanding that the same color is observed by reflection for object illuminated by white light or the three primary lights simultaneously. About the structure of the human eye, the students were requested to associate the diaphragm, the objective lens and the photographic film with human eye elements. The responses indicate that the majority of students (69%) understood the functions of the iris and crystalline lens, since its functions were associated to the diaphragm and objective lens functions. However, some students (28%) confused the function of the retina and optic nerve, which indicates the importance of discussions about the functions of these two elements. And on the understanding of the concept of refraction and the application of Snell's law it is possible to say that the majority of students (91%) understood the concept and knew how to apply them in problem situations. Difficulties are more related to algebra than the application of concepts. In essays written at the end of intervention, in which students were asked to comment what they have learned, in general, they described the lessons and experiments, mentioned that the physics learning can be interesting and the activities experienced were interesting due to the experimental part of the course. Also they commented they liked the activities, because it was dynamic and count with the participation of students. Regarding the project, it is important to note that this allows a connection between the school and university relations. Consequently, in addition to experiencing the daily school life differently, following a school teacher, the graduation students have the opportunity to work in the elaboration, implementation and analysis of a teaching proposal. It is expected that this intervention can motivate other teachers to bring everyday problematizations for their classes, in order to promote the participation and interest of the students in their own learning process.

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UNIVERSITY PHYSICS

6

FRESHMEN COLLEGE STUDENTS AND PHYSICS LEARNING IN A BRAZILIAN FEDERAL UNIVERSITY

Hugo R. Detoni, Carlos A. D. Zarro, Marta F. Barroso

| INTRODUCTION

Retention of freshmen students is a major issue at STEM careers in general, including the Physics Institute of the Federal University of Rio de Janeiro (UFRJ). In a former study (De Almeida et al, 2001) some of the students' most common difficulties were documented, among which poor reasoning skills play an important role. The scenario was recently worsened by an implementation of a law of quotas, according to which low-income students, mostly coming from poor and weak schools, were warranted access to the university. The existence of a mismatch between pre-college students and the traditional university curriculum was heavily deepened. In order to bridge that gap help-out classes were implemented. However, results are still not living up to expectations and students' performance is apparently not being enhanced. The present work describes an attempt to reverse the situation through direct intervention in the course material used in help-out classes.

Performance background, tutorial development and assessment

Student Performance Background

The weak performance of freshmen students has led the academic community to create help-out classes in physics, which are nowadays obligatory to all entering students of specific courses. Such classes intend to provide these students an opportunity to enhance their skills in solving physics problems. On the other hand, little improvement has been observed and the cause is believed to lie in the format such classes are held. Students deal mostly with traditional end-of-chapter exercises requiring raw application and manipulation of memorized mathematical equations; little or no conceptual reasoning is needed.

Such help-out classes were closely monitored during the year of 2015 and important insights have been drawn concerning students' difficulties. It was verified that many of their present difficulties were closely related to previous mathematical and reasoning ones. In addition, teachers and physics education researchers had already documented a vast array of such difficulties over the past decades.

Development of Tutorial Exercises

The use of tutorials in introductory physics has been largely encouraged since late 1990's, and the field comprises an increasing body of work, including Tutorials in Introductory Physics (McDermott et al, 2002), developed by the Physics Education Group of the University of Washington (USA).

The previously mentioned difficulties, among others, have guided the development of a new set of inquiry-oriented tutorial-like exercises in basic mechanics – divided in five units: (1) vectors, (2) 1D Kinematics, (3) 3D Kinematics, (4) Dynamics and (5) Work and Energy – applied during 2016's first semester help-out classes. Such exercises aimed at the development of basic concepts and the improvement of reasoning skills through specific cognitive processes.

The tutorials' ultimate goal is to provide the students targeted help to develop an understanding of the basic concepts that extends beyond the ability to apply formulas. An effective instructional approach is to help them develop facility in applying the operational definitions (Shaffer et al, 2005).

Assessment of Tutorials

The efficiency of this approach was assessed through pretesting and post testing. Such pre-tests and post-tests were composed of conceptual multiple-choice items; both tests for each investigation unit contained equal amount of items and required the application of the same skills in similar physical situations.

Pretesting took place immediately before students' contact with the tutorials designed for a specific unit and post-tests were administered one week after contact with such tutorials.

In order to make assessment mathematically possible, some measuring indices were established.

– Gain: Percentage of students who responded incorrectly to an item on the pre-test and correctly to its equivalent item on the post-test.

– Loss: Percentage of students who responded correctly to an item on the pre-test and incorrectly to its equivalent item on the post-test.

Since gain and loss indices can be independently determined for each item inside a specific unit, these are supposed to indicate whether tutorials are producing the expected effect upon students' cognitive structure concerning specific skills.

Results and discussion

Preliminary results indicate that the aforementioned approach has been moderately effective. Some units display gain indices over 30% and low loss indices. The results are summarized in the following table, where G. stands for "gain" and L. stands for "Loss".

Table 1: Gain and Loss for items in each unit.[4]

Unit	Item						
	1	2	3	4	5	6	7
1	*	G. 21% L. 15%	G. 31% L. 5%	G. 23% L. 36%	G. 15% L. 15%	G. 18% L. 10%	G. 15% L. 5%
2	G. 8% L. 6%	G. 14% L. 6%	G. 17% L. 6%	G. 6% L. 44%	G. 36% L. 6%	G. 22% L. 8%	G. 17% L. 8%
3	G.18% L. 5%	G. 18% L. 13%	G. 15% L. 8%	G. 21% L. 21%	G. 28% L. 33%	-	-
4	G. 13% L. 6%	G. 13% L. 25%	G. 9% L. 9%	G. 9% L. 9%	G. 16% L. 3%	G. 3% L. 28%	-
5	G. 30% L. 4%	G. 4% L. 35%	G. 17% L. 35%	G. 13% L. 30%	-	-	-

4 Units are represented by their respective number. The asterisk (*) indicates that the item experienced problems with stem/distractors formulation and was therefore discarded – no Gain and Loss results were obtained. The en dash (-) indicates that the item was not part of the respective unit.

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PHYSICS LEARNING AND SELF-EFFICACY BELIEFS: A Case Study with Team-Based Learning Method in an Introductory Electromagnetism Course[1]

Tobias Espinosa De Oliveira; Ives Solano Araujo; Eliane Angela Veit

| INTRODUCTION

Introductory physics courses are very important for the physicists and engineers' formation. In these courses, they usually take the first contact with the main concepts of physics, which form the basis for more advanced courses and further professional life. However, it is well known that most students are not too much enthusiastic about the conventional lecture-based physics courses, characterized by transmission of information, teacher-focused and passive learning. The results achieved with this kind of teaching are: high dropout rates; rote learning, promoting a low and temporary conceptual understanding; and lack of motivation associated with a feeling, or a belief, of his/her own inability to learn physics. These beliefs are directly linked to motivation, because they are based on judgments made by the individuals about their own capabilities to organize and execute specific courses of actions, which affect their performance, amount of effort and persistence to achieve their goals.

As alerted by Albert Bandura, "Self-belief does not necessarily ensure success, but self-disbelief assuredly spawns failure." (Bandura, 1997, p. 77) That means, students who belief they are able to learn physics can succeed, but those who are unmotivated and who do not believe in their own abilities, will fail. In other words, it would be derisible to promote a high self-efficacy in our students, since it is vital for their success.

Here is the challenge for teachers! Beyond improving conceptual learning, how do we inspire people to feel competent? The educational research recommends teachers to change the classroom, shifting the focus on the teacher to the student and making him/her active. Researches show that active teaching methods, such as Peer Instruction, have the potential to improve the conceptual learning. Moreover, such methods can positively influence on the self-efficacy beliefs of the students.

1 This work was partly funded by the Coordination for the Improvement of Higher Education Personnel (CAPES) from Brazil.

Knowing the potential of active teaching methods, we chose to investigate how the conceptual learning of physics and self-efficacy beliefs in learning physics are influenced by Team-Based Learning (TBL) (Michaelsen, Knight & Fink, 2004), which is a still little used method to teach physics, especially in the Brazilian context. We chose this method because besides improving the learning, it aims to develop collaborative skills through a structure involving: the management of learning teams, preparation and application of conceptual tasks, constant feedback and peer evaluation.

Specifically, we intend to answer two research questions:

a) How TBL affects student performance on tests about basic concepts of electromagnetism, in an introductory physics class (electromagnetism) of a physics course in a Brazilian public university?

b) How TBL affects the students regarding their self-efficacy beliefs in learning physics?

In order to answer these questions, we have adopted Yin's methodological guidelines for case study and the Social Cognitive Theory, in particular, Bandura's concept of self-efficacy explained in the next section.

Theoretical framework: social cognitive theory

The Social Cognitive Theory, created by Albert Bandura in the late 70s, describes human motivation and action from a social cognitive perspective. Self-efficacy is the most important concept used by us. Self-efficacy belief is a judgment that people have on their own ability to organize and conduct courses of action. For instance, some statements expressing such beliefs, and used in our questionnaire are: I can learn conceptual physics; I can solve introductory physics problems; and I can apply a concept of physics in different situations.

Why such beliefs are so important? Students with a high level of self-efficacy in learning physics, for instance, will see difficult tasks as challenges to be overcome, not as a threat. In addition, they persist more on these problems and have greater resilience. The judgments that individuals make about their own ability affect the level of stress and anxiety that they experience in an activity. The self-efficacy beliefs also affect the decision making process. People tend to select the ways in which they feel confident and competent and avoid those that make them uncomfortable.

Bandura highlights four main sources of self-efficacy: positive experiences, vicarious experiences, social persuasion e stress reduction.

Having this in mind, the main idea we want to investigate with this research is whether TBL may contribute to physical learning and development of self-efficacy beliefs in learning physics.

Team-based learning method

In the implementation of TBL, a course is structured in modules. Each one is divided into two main parts, involving preparation and application activities, both out of class and in class. In the preparation phase, before class, students perform a prior study, usually a reading of some sections of the textbook, and they answer three questions: two about the physics contents and one about the parts of the reading they found difficult or confusing. They send their answers electronically to the teacher, who analyzes and takes it into account to prepare the next class. In the classroom, the teacher performs a mini lecture presentation focused on the doubts mentioned by the students in their homework. Then students answer an individual readiness assurance test (iRAT) related to the reading they have done. After that, the team performs the same test (tRAT). In this phase, students dialogue with teammates and receive a card with a grid to mark their answer consensually defined by the team. If they have any objection to the question or its correction, they can submit an appeal. The preparation phase ends with the teacher doing a second mini lecture about the remaining questions of the test.

After the main module concepts are discussed, the teams engage in the application tasks that are gradually becoming more complex. The application phase begins with individual tasks to be done outside of the classroom, and finish in class with team tasks. The tasks performed in class are usually the resolution of context-rich problems, which require, in addition to a mathematical resolution, a coherent conceptual analysis. All teams solve the same problems, and at the end of each solution, they expose their answers on small whiteboards, discussing among themselves and the teacher. At the end of each discussion, the teacher introduces a new problem.

Methodology

The exploratory case study was conducted at a Brazilian public university (Federal University of Rio Grande do Sul) in an introductory electromagnetism class for physics majors. The course lasted eighteen weeks, comprising six hours per week. There were twenty-seven students in the class, divided into six teams.

Three kinds of instruments were used to collect the data: i) conceptual tests (Brief Electricity and Magnetism Assessment, Electric Current in Simple Circuits Test and Faraday and Lenz's law Test), used as pre and posttest to evaluate student performance; ii) a questionnaire with eight statements (some of them mentioned above), in which the student should express, on a scale of 0 to 100, his/her confidence level to perform a certain action related to physics learning before and after the course, in order to evaluate changes in self-efficacy beliefs in physics learning; iii) semi-structured interviews to understand how the TBL affected (if so) the changes in student's self-efficacy. We invited fifteen out of the twenty-seven students for an interview, the ones who showed more changes in self-efficacy. We asked them to tell us about their experiences during the semester, trying to justify the change in their judgment of self-efficacy detected in the questionnaires. Our purpose was to check whether the students invoked the sources of self-efficacy proposed by Bandura (positive experiences, vicarious experiences, social persuasion and stress reduction).

Results and analysis

The student's performance in each conceptual test was analyzed by calculating the average normalized class gain, as shown in Table 1. The gains were compared with results of the same test in classes with different teaching methods, (conventional lectures and active methods), both from the same university and from outside of Brazil. The gains from TBL are similar to those obtained by other active teaching methods, as seen in columns 2nd and 3rd of Table 1. Moreover, the gains of TBL are significantly higher than those obtained by traditional teaching methods (4th column). So, the answer to our first research question is: TBL contribute positively to conceptual physics learning, as much as other active methods

Table 1: Average normalized class gain in the three conceptual tests with TBL and other methods

Conceptual test	<g>	<g> active methods	<g> traditional methods
BEMA	55% ± 15%	40% - 54% (Vieira, 2014) 33% - 47% (Pollock & Finkelstein, 2008)	< 30% (Kohlmyer et al., 2009)
Test about Electric Current	55% ± 34%	50% - 65% (Vieira, 2014)	< 9% (Dorneles, 2005)
Test about Faraday-Lenz Law	67% ± 20%	50% (Vieira, 2014)	

The self-efficacy beliefs obtained with the questionnaire are shown in Figure 1, before (blue bar) and after (red bar) the use of TBL. All students, except by the fifteenth one, changed positively their self-efficacy.

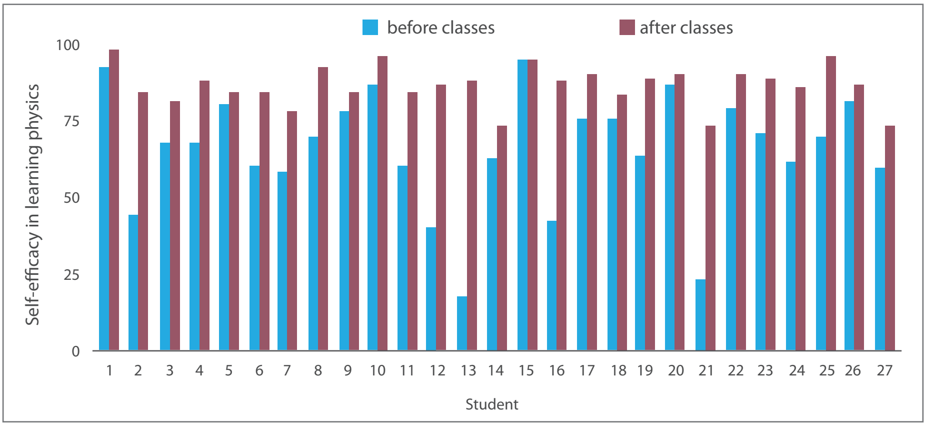

Figure 1: . Level of self-efficacy beliefs before and after the use of TBL obtained in the questionnaires.

The mean values of self-efficacy in physics learning before and after the TBL intervention were 66 ± 19 e 87 ± 7, respectively. Performing a paired t-test, we found a t of -6,38 and significance $p < 0,000$, meaning that there is a statistically significant difference in the average self-efficacy of the class. Analyzing the data collected with the interview of 15 students, we gathered evidences that TBL has contributed for the presence of the four sources of self-efficacy pointed out by Bandura. Unfortunately, in this short paper we do not have space to show the evidences revealed by Oliveira (2016).

Conclusions

We conclude that TBL has the potential to foster a conceptual learning of physics and developing student's self-efficacy beliefs in learning physics. Our results show that active exposure to concepts, through the tasks and group discussions, facilitates conceptual understanding of the students and encourages them to seek this kind of knowledge, which is usually overshadowed by the overvaluation of mathematical aspects in traditional approaches. Students who participate in these activities have increased their sense of self-efficacy, which can cause them to persist in the face of adversity. They also face more complex problems as challenges to be overcome instead of seeing them as a threat, having less stormy emotional reactions to academic difficulties. Further research is necessary to continue this exploratory study, by investigating deeper into learning through a specific theoretical reference and relate it to the change in perceptions of personal efficacy provided by the TBL.

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CASE STUDY OF BASIC LABORATORY DISCIPLINES OF THE EXACT SCIENCES COURSES AT THE FEDERAL UNIVERSITY OF JUIZ DE FORA

Giovana Trevisan Nogueira, Júlio Akashi Hernandes

| INTRODUCTION

In the last decade, Brazilian Federal Universities have undergone profound structural changes due to the actions of the federal government regarding vacancies expansions, enrollment and new courses in federal education institutions, especially with the REUNI (Program of Restructuring of Federal Universities) (MACEBO, 2015). While this expansion was beneficial because it allowed access to the public universities from lower income families, it did not come accompanied by an improvement in the quality of high school and elementary school courses (RIGGOTO, 2005). As a consequence, a significant portion of students enrolls in exact science courses without basic knowledge of Physics and Mathematics (ARAUJO, 2002). In this context, we analyze the performance of students in two initial laboratory disciplines of the Exact Sciences Interdisciplinary Bachelor Course of the Federal University of Juiz de Fora (UFJF), created in 2009 in the context of Reuni, in order to identify if some high school deficiencies can be eliminated with a university-level first-year leveling laboratory disciplines and/or traditionally-taught disciplines.

As part of REUNI, in 2009 UFJF created the Exact Sciences Interdisciplinary Bachelor Course, that unified the entrance to the traditional courses of Physics, Mathematics, Chemistry, Computing and Statistics and increased the number of new students per year (from 200 to 400). To reduce Physics and Mathematics deficiencies coming form High School several changes in basic disciplines were made, among them the creation of a leveling discipline (Science Laboratory), enrolled in the first semester of the course, while Physics I and Laboratory Physics I were moved form the first to the second semester of the course.

To identify if some high school deficiencies can be eliminated with a leveling laboratory disciplines and/or traditionally-taught disciplines, we analyzed the performance of students in Science Laboratory and its impact in a subsequent laboratory discipline, Laboratory of Physics I. The first discipline has two week-hours for a total of thirty hours. Its objective is to give initial experience in laboratory to beginner students in an interdisciplinary environment. It has a minor mathematical rigor and less concern with written formalities than usual university laboratories. The conceptual level of its experiments and its examinations are close to the high school level. The second discipline is Laboratory of Physics I, that introduces elements of statistical data analyses with classical mechanics experiments, with two week-hours for a total of thirty hours. This discipline has Sciences Laboratory as prerequisite.

Science Laboratory Discipline

To identify deficiencies in the students formation, we analyzed the question with the lowest hit index in the last assessment of a written test of the Science Laboratory discipline for two groups of students: one of them with students that enrolled at the university in 2009 and the other that enrolled at 2010. Both groups enrolled in this discipline together in the first semester of 2010. This question has a diffraction experiment as a subject and asked what is the number of slits per mm given the distance between two slits in a diffraction grating.

Table 1 shows the typical errors found in this question. In particular, it draws the attention that the group of 2009, that had previously attended Physics Laboratory I, Calculus I and Analytic Geometry disciplines, had low and almost the same success rate the group of 2010 (28% and 29% of hits, respectively). The typical errors are also the same for both groups. Despite the high school-level of Sciences Laboratory discipline, the failure rate of this course is approximately 40% of enrolled students among both groups.

Table 1: Typical errors found in the question with higher number of errors. The group of 2009 had low and almost the same success rate the group of 2010.

		Common errors (%)			
	Number of students	Wrong answers (%)	Guessing and blank answers	Wrong unit conversion	Incorrect use of experiment parameters
Total	423	71	29	22	38
2009	213	72	31	31	33
2010	210	71	28	28	43

Physics Laboratory I and Sciences Laboratory Disciplines

We present in figure 1 the historical approval rate of students in the disciplines of Science Laboratory and Physics Laboratory I, to identify the influence of a leveling laboratory on the performance of students in subsequent experimental subjects. There are three important aspects that we see in this data: the approval rating of Physics Laboratory I has a drop preceding the implementation of REUNI (2009); in the last 5 years, the failure rate of both disciplines is approximately 40% of enrolled students; we can see a relation between both disciplines in the same semester, but Sciences Laboratory does not help Laboratory of Physics I in the subsequent semester.

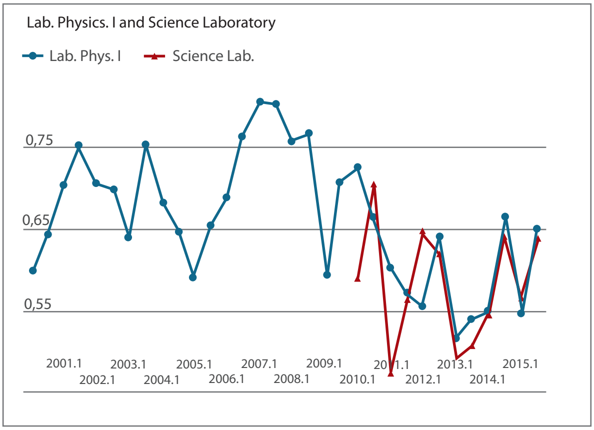

Figure 1: Historical performance of students in Science Laboratory and Physics Laboratory. Here There are a decline that precedes the implementation of REUNI.

Conclusion

UFJF actively participated in the expansion of Brazilian federal universities in 2009, due to REUNI. This expansion has brought many benefits, such as the expansion of the faculty and the creation of new graduate and undergraduate courses.

However, this program was not able to work with problems of poor preparation of students in the high school. The performance of beginner students in Physics Laboratory I has a decline that precedes the implementation of REUNI, but the changes in the Exact Science courses such as the delay in the start of Physics I and Physics Laboratory I did not brake this fall.

The implementation of a leveling discipline also did not presented the expected results. Our analyses identifies deficiencies coming from High School, such as problems with unit conversions, interpretation of statements and trigonometry, that this discipline and even the first year of superior classes were not able to eliminate.

In our opinion, REUNI should have been done in parallel with a redesign and enhancement of the basic education.

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INITIAL PHYSICS EDUCATION

7

PISA, STRUCTURING THEMES AND UNIFYING CONCEPTS IN PHYSICS TEACHING THROUGH INTERACTIVE SIMULATIONS

Wagner Duarte José, José André Peres Angott

| INTRODUCTION

In Brazil, large scale assessments as the National Standard Exam of Middle School (ENEM) and the Programme for International Student Assessment (PISA) are reference for High School and for initial and continuing teacher training. Its critical appropriation by students mediated by the teacher can result in cultural gains of the essential knowledge of Science and Technology (S&T) as citizenship instruments. Knowledge, skills and abilities common to the PISA and the Structuring Themes of Physics Teaching (STPT) proposed in the Brazilian education guidelines1 can be developed in the teaching-learning process through Unifying Concepts (UC): transformations, regularities energy and scale. These concepts include the mediation with free and open Information and Communication Digital Technologies (ICDT) (Angotti, 2015).

We propose the development of open didactic approaches to PISA's contextualized and interdisciplinary thematic units through Hypermidiatic Study Activities (HSA) with physics students in initial teacher training. We intend to investigate the question: do PISA's thematic units in dialogical-problematizing and conceptual unifying perspectives make possible desirable changes in educational practice? It is our objective to highlight the educational potential of PISA-STPT-UC articulation in didactic approaches to openly solve problems in a unifying conceptual perspective.

Hypermidiatic Study Activity "Climate Change" Through An Interactive Simulation

The unifying conceptual approach considers the central role of the unifying concepts in the teaching-learning process: transformations (in space, time, mass), regularities (related cycles, laws, rules), energy (a much deeper concept, studied together with its conservation) and the scale (related to the understanding of the amplitude of a certain phenomenon). José, Braga, Nascimento and de Bastos (2014) and José, Angotti and de Bastos (2016) investigated the educative potential of STPT and UC in appropriation of ENEM and PISA assessments, respectively. The authors highlighted contributions to problematize the content-methodology pair in teacher training and essential aspects for the interdisciplinary and contextualized school work in view of the curriculum inclusion of openly solving problems in the perspective of scientific and technological education.

We intent to connect PISA, STPT and UC with ICDT through Hypermidiatic Study Activity (HSA), as conceptualized by Vidmar & de Bastos (2015). Upon defining the problem situation (a PISA's issue, for example), an educational hypermedia (interactive simulation, animation, applet or other), the corresponding STPT and relevant skills and abilities, the teacher constructs a heuristic serving as a guide for interaction with students in the resolution of the problem situation.

However, the transformation of the wording of the question into a problem situation requires a justification in the case of teacher training. The purpose is to formulate the problems that the students do not formulate, pedagogically implement the Translator Dialogicity (Delizoicov, Angotti & Pernambuco, 2011). This implies understanding, values and "philosophies" that learners commune about the knowledge in S&T, discussing their visions of science.

We present in Table 1 a HSA elaborated from the PISA's thematic unit called "Climate Change" (OECD, 2006, p.22; Instituto Nacional de Estudos e Pesquisas Educacionais "Anísio Teixeira" [INEP], 2011). It is contextualized and interdisciplinary, involves S&T thematic related to the production and use of energy and its effects on the environment, highlighted on a scale dimension.

Table 1: HSA "Climate Change"

Thematic	Crosscutting theme Environment, specifically, radiation interaction with greenhouse gas molecules.
Open Educacional Resource	Interactive simulation of "the Greenhouse Effect" (tab Photon Absorption), available on the PHET website. https://phet.colorado.edu/en/simulation/legacy/greenhouse. Copyright 2016 by University of Colorado Boulder.
Goals	q) To verify regularities observed in the simulated interaction of photons with trace gas molecules at microscopic level. - To analyze the effects/transformations in the atmosphere (macroscopic scale). - To highlight the radioactive balance competition between driving forces) via energy conservation.

4 The General training goals, learning objectives, training and structural axes established for the natural sciences and their technology areas in the National Curriculum Common Base, in national discussion at the moment, are included in the educational dimensions of the STPT.

Definition Study Activity actions	- Problem situation: PISA's UT "Climate Change". - Transformation of the wording of the question: Considering that the energy production and consumption cause climate and environmental changes such as the greenhouse effect, how to outline a human activity that minimizes these variations in the environment?
Definition of Study Activity operations	Step 1: Select the top right tab "photon absorption." See in the right corner the atmospheric gases and in the left lower corner the options
	- Step 2: In the right table, select the "CH_4" option and slide the center bar of the flashlight to the right, at first with the selection "infrared photon" and then with the selection "visible photon". What happens on a microscopic scale?
	5. Step 3: Repeat the procedure for the N_2 and O_2 gases, which account for 99% of the atmospheric composition, and for the trace gases called CH4, CO_2, H_2O, writing the observed regularities down in a table. What can be affirmed about the absorption and emission of photons by molecules of these gases?
	6. Step 4: Now, select the "Build Atmosphere" option and put a number of molecules for each gas, according to the atmospheric composition (the most present in greater numbers, without percentage correspondence between molecules). Then click in the "infrared photon" option and slide the center bar of the flashlight to the right. What happens in macroscopic scale? What transformations may occur in the atmosphere system with respect to energy?
	7. Step 5: Considering that the atmosphere cooling caused by particles (aerosols such as SO_2 gas, for example) could be result of radiation reflected into space by more concentrated clouds (aerosols could act as condensation nuclei for water vapor droplets), what can be affirmed about the radioactive balance of the thermodynamic system Earth-atmosphere?
	8. Step 6: Considering what you have observed in these five steps, solve the problem-situation.

The transformation of the wording of thematic unit "Climate Change" is the first step toward the "translation" we refer to. Decoding occurs while performing the steps of the heuristic that we made to manipulate the interactive simulation "The Greenhouse Effect" as outlined in Table 1. The problematizing dialogue goes from descriptive to analytical allowing the detachment of the epistemic subjects teacher and students of the problem situation in order to return it critically, in a similar move to the Three Pedagogical Moments

(Delizoicov, Angotti & Pernambuco, 2011). In the case of this heuristic own unifying concepts are highlighted in it making clear its contribution to the phenomenological approach.

Hsa "Climate Change" In Teaching Situations

We exercise the proposal through teaching situations in two groups of undergraduates in physics from the Federal University of Santa Catarina (UFSC) and the Southwest State University of Bahia (UESB), totalling 28 students. The workload was 4 hours-class generally (only one class there was a greater availability, 7 hours-class). It was accepted, therefore, variation and flexibility in didactic approach, comprising the presentation and problematization of PISA-STPT-UC articulation and realization of HSA "Climate Change".

Our data from the audio record of the held classes signal positively about the potential of the phenomenological discussion of the problem situation mediated by the four unifying concepts. The dialogue-problematizing was guided by regularities evident in the interaction of infrared photons with trace gas molecules at the microscopic level; effects of this interaction/transformations in the atmosphere (macroscopic scale); analysis of radioactive balance by energy conservation.

The students verified that the greenhouse effect is a consequence of transformations resulting from an energy balance phenomenon between contributions for heating/cooling of the atmosphere. As a summary, they perceived that the understanding of global warming is still open and controversial topic of discussion between different research groups and global policies under constant political, economic, social and environmental interests.

Just right when physicists students in initial teacher training seize the concept of Einstein's quantum of energy (which introduces the idea of the dual nature of light in the quantum paradigm) or the contribution of the radioactive energy balance for global warming (considering the first and second laws of thermodynamic), they do through specific actions and procedures made heuristics.

However, it was not possible to see that they are actually appropriate the PISA-STPT-UC-ICDT articulation. We believe if they exercise the implemented proposal planning themselves a similar teaching situation or even developing into a supervised training activity they may give the desired qualitative leap. We also note that more advanced classes in the course (sixth semester) and students in supervised training or already give classes in high school showed larger depth of discussion on the comments about the potential of activity.

Final considerations

Positive signs for the issue investigated suggest that connections between the concept of Translator Dialogicity and Unifying Concepts emerge from these teaching situations by teaching mediation in line with simulations or other Open Educational Resources. Broad themes, compatible with the Brazilian scientific and technological context, are able to identify socio-historical contradictions with different intensities in different regions (Angotti, 2015). These themes gain significance for the teaching practice of Translator Dialogicity capable of transforming the wording of questions in exams such as PISA and among others into problem situations of the S&T daily lives of educational subjects, in the language of their prevalent knowledge (first culture), so we can dialogue around them. Hence the importance of the teacher, who has universally systematized knowledge of S&T, to move between the two cultures.

The Unifying Concepts can facilitate and strengthen dialogue, problematization and communication between epistemic subjects, teacher and students, avoiding dispersions and excessive fragmentation of knowledge. With support of ICDT, the process can be richer and deeper, more collaborative and flexible among disciplinary content, its contextual dimensions and interdisciplinary and cross relations (Angotti, 2015). The development of this HSA can contribute to some curricular transversality or, at least, to integration between disciplines.

We emphasize that the quality and intensity of the translator dialogue is needed in different spaces and times. HSA with mid-level learners require more contour and focus on the phenomenological discussion made possible by interactive simulation. Spaces of initial and continuing teacher training assume larger abstraction and discussion of pedagogical, scientific and technological knowledge with a degree of depth to be negotiated with the actors, taking into account the time available.

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ASSESSMENT OF PRE-SERVICE PHYSICS TEACHERS ABOUT THE SUPERVISED TEACHING INTERNSHIP

Tatiana Iveth Salazar López; Roberto Nardi

| INTRODUCTION

We present here partial outcomes of a PhD research aiming to answer the question: how academic production in Science Education dialogues with the knowledge and practices of pre and in-service teachers in different levels and educational spaces? The thesis aims to interpret the process of articulation theory-practice among future physics teachers; consequently, this study is about teachers' training, particularly initial training of physics teachers. Aiming this goal, we are studying the Supervised Teaching Internship (STI) activities, part of an undergraduate program to high school physics teacher (called licenciatura in Brazil). We develop here some theoretical discussions about the STI and present the students' assessment of each one of the discipline of STI with their respective analysis and considerations that lead to proposals for activities that aim to improve this process. Knowing these conceptions of future physics teachers about STI is important to improve the structure of these activities and to have a better training process.

Supervised teaching internship and teachers' education

To understand the training process developed in the STI we start with the concept of Professional Development of Teachers, since it allow us to understand the complexity of the process of becoming a teacher. Therefore, we must consider that STI is only a part of the initial training process to becoming a future teacher. The central idea of the Professional Development of Teachers concept is that teacher training is an ongoing process that starts from experiences as a student in the school, goes through initial training, the first years of the practice of teacher training and goes beyond all the teachers' professional life. Tardif, Lessard & Gauthier (2001) present moments of the formation, their nature and the places in which this formation happens (Table 1).

Table 1: The Professional Training of Teachers as Continuum.

Training before profession (pre-service)	Initial training (in-service)	The Begining the profession (in-service)	Continued Training (in-service)
School Training Personal Formation.	University education Practical training Supervised Teaching Internship	First contact with the profession Development of practical knowledge	Improvement of practice.
School, Family, friends, society	University, School	The classroom, The colleagues, The practice, The School.	University, School, Associations.

According to Table 1, teachers' training takes place before, at the beginning of the studies in Higher Education and continues with the practice of the profession. This conceptualization of teacher education surpasses the idea that people learn to be teachers simply during their initial formation. Table 1 also shows that the training of teachers is not restricted to higher education programs, since this offer an introductory and limited way to the practice of the profession, and this practice will enable the constant construction of other knowledges.

In this sense, it is possible to say that the teacher who enters the teaching profession is not yet "ready" to carry out a teaching practice that evidences all the splendour of the profession, since this professional will begin to develop learning from his practice and this process will allow him/her to enhance his/her practice as a teacher. Lima (2012, p. 39) points out that:

> "We do not become teachers overnight. On the contrary, we do constitute this identification with the teaching profession in the course of our lives; both, by positive examples, as well by the denial of models. It is in this long road that we constitute ways of being and being in the magisterium ".

An important process during the initial training of future teachers is the STI. The National Curriculum Guidelines for Teacher Training in Brazil states that the STI is a particular instance to develop with further deepening practical issues of the profession. The STI represents a part of the practical component in teacher training courses, and these are fundamental in the training of future teachers, since the graduates have been building theoretical paths on different teaching knowledge that need to be organized and articulated to develop proposals for teaching, learning and evaluation that bring changes in the problems of the school system and also changes in the wider context that would be the society.

The STI is thinking as the moment to accompany and offer subsidies to the future teachers in this return to the School, the field of their profession, and a place in which it is possible to struggle to transform social realities. Therefore, STI in the training of future teachers are fundamental to:

33 Introduce to the teacher in the field of Profession; b) Assist in the construction of the Teaching Identity; c) Develop a critical eye on the School; d) To develop teacher knowledge, especially knowledge of experiences; e) Articulate the different knowledge built; f) Test innovative teaching proposals; g) Develop reflection-action-reflection processes. According to Pimenta & Lima (2004), the purpose of STI is:

> "To integrate the student's training process, future professional, in order to consider the field of action as an object of analysis, research and critical interpretation, from the links with the course subjects. The supervised teaching internship is a field of knowledge, therefore, it returns to a broad view of this"

It is clear that STI are fundamental disciplines in the training of teachers, that contribute from different perspectives in the construction of teaching knowledge. Learning to teach is a lifelong task for the teacher. The STI, because it is the disciplines that take the future teachers back to the school, must develop in them the capacity to critically reflect and build knowledge from experience, that is, the STI should promote that future teachers understand the theory-practice-theory sequence, sequence that makes it possible to think of the classroom as a field of research.

Methodology

In this paper we set out to analyse the conceptions of future teachers who went through the sequence of four semesters STI disciplines. To identify these conceptions in the context of a Physics undergraduate program (licenciatura), we prepared assessments at the end of each of the four semesters STI (two last years of the four years licenciatura). The assessments were make considering key issues such as: The course offered contributions to your education? What aspects?; What suggestions would you do to improve this discipline?; What were the most significant learnings, possible from the observation made in the high schools? The answers to the assessments were analyzed using content analysis techniques, from the perspective of Bardin (1977), who proposed to develop categories of analysis to interpret and generate answers to a central question. Below we present some of the answers obtained from each of the questions.

Data analysis

Did the course offer contributions to your education? What aspects?

a) Bring proposed solutions to the identified problems.

b) Identify the relationship established between school and society.

c) In the construction of views to understand the school reality.

d) Discussion for planning lessons.

e) Think elements derived from research in the Physics Teaching to think Education.

The answers given by the future physics teachers, allow saying that the STI enables an approximation and interpretation to the reality of the Schools. Think the STI as a theoretical activity that makes possible an approximation to reality, is the proposal of Pimenta (2012), that the reality experienced in schools is the basis for establishing reflexive processes and thinking about the theoretical elements constructed during the initial training with the intention of 'instrumentalize' the future teacher for praxis.

What were the most significant learning you got from the observation made in the school?

a) See the classroom in a different way; now, as a teacher.

b) Understand that teachers and students are minor characters, inside a larger political and social system.

c) That the teacher has almost no autonomy, the public school is having problems of autonomy with the government's actions.

d) Reflect about the best way to students learning.

e) Know that the students are an important element to take into account to prepare different plans for each lesson.

Observation of the schools, their principals, students, teachers, classes, among other elements, is a central activity of STI. The goals intend that future teachers interpret the actions that happen within the school, from the filter of the theories discussed during their initial training. That the student assumes to be a future teacher and from this position of critical intellectual in the process of training, interpreting the reality, in an inverted symmetry basis. In this sense, we identify in the answers of the future teachers important reflections on the relation between school and society.

What suggestions would you do to improve this discipline?

a) Discussing more about the preparation of daily classes.

b) Further discussion on plans.

c) Exploring more the development of the planning lessons.

d) Knowing the planning lessons from the other students to make improvements.

e) To knowing previously about schools' students for planning better.

f) Reducing the hours of observation at School.

g) More coordination among the subjects of the licenciatura in physics with the STI.

The future teachers' answers on this question, propose at least four elements to rethink the proposal of the STI: the elaboration of the classroom diaries, the planning process, the hours of observation and the dialogue between the STI and the others disciplines that make up the curricular structure of the licenciatura. One element to consider is about the hours spent in of observation of school classes. It may be convenient to reduce some hours and invest them in the designing of teaching proposals that will be applied in the last STI discipline.

What do you think was missing in their initial training to improve your performance in the classroom?

a) Develop more practical activities.

b) Stimulate to develop research in physics teaching

c) Discussions on the organization of contents.

The answer to this question reveals the need to think in the curriculum of teacher training the possibility of generating more spaces of contact between the school and the university. Future teachers need more time to implement and discuss their teaching proposals. From the data collected and the analysis made, it was possible to identify positive views, among the future teachers, on the way the STI have been conducted, since these experiences provide important reflections and subsidies for the practice of the teaching profession. The answers obtained from the future physics teachers also allow rethinking the proposal that is actually developed in the disciplines of STI with the intention to improve them.

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POSSIBLE IMPROVEMENTS IN THE PHYSICS TEACHERS' TRAINING COURSE:

Expectations And Suggestions Of Evaded Former Students

Sérgio Rykio Kussuda; Roberto Nardi

| INTRODUCTION

In Brazil, we have observed a great demand of high school teachers, including in São Paulo, the country's most important state, with many universities and teacher training courses (called licenciaturas), as pointed by Kussuda (2015). However, this does not seem to be an exclusive problem in Brazil, as showed by document of The Organization for Economic Cooperation and Development (OECD, 2005). According to this document, the teaching career has become less attractive in several parts of the world, due to the emergence of new careers and difficulties of the profession, often publicized by the media.

However, the decrease in the number of people interested in pursuing this career is not the only problem that affects the number of teachers. We can highlight two other factors that influence the lack of teachers, like, for example, the number of individuals who, after concluding the teacher-training course, opt for other professions (Kussuda, Nardi 2014) and the number of students who do not complete this course. The evasion in Higher Education can bring several problems related to the institution, itself, as: i) the cost to keep the course due to the need to hire teachers to teach for few students, as highlighted by Sampaio et al (2011); ii) to the individual who leaves the course, as emotional problems, as Cunha, Tunes & Silva (2001); and iii) social problems such as the lack of professionals with this training and, consequently, disinterest of the students for the discipline, as highlighted by Gomes & Moura (2008). In the specific case of teacher training courses the problem of the lack of professionals becomes even more relevant, since the lack of teachers has led, in Brazil, to the adoption of a policy that allows teachers specializing in other disciplines to teach in the disciplines in which teachers are missing, allowing government to seem to lessen the problems of teacher shortage in certain disciplines, yet this hides the perception of the actual teacher shortage.

Gomes & Moura (2008) argue that this lack of specific teachers, such as physics teachers and, consequently, substitution by teachers with another specialty, such as Mathematics, creates a cycle of malformation and lack of teachers. The teacher with another training does not have in-depth knowledge of the content to be taught in Physics or of the pedagogy of the content of the subject to be taught, which leads to the difficulty of learning in the discipline physics. In this way, fewer students are interested in this subject and consequently seek graduation in this area, leading to a decrease in the number of people interested in attending physics, as well as the quality of the candidates, which causes greater difficulty in completing the course.

According to Brazil (1996), avoidance in Higher Education may be linked to different factors, from reasons related to the socioeconomic context of the student to factors related to the experience in the Institution of Higher Education. Among these factors, we can highlight the non-correspondence with the expectations that the student has on this level of education, as highlighted by Ambiel (2015). Thus, it is important to know the expectations and suggestions of the alumni who left the teachers training course to reduce dropout in these courses and, consequently, increase the number of individuals who can teach.

In Brazil, there are public and private universities; in the first, it is not necessary to pay any amount to attend their courses; so the cost is not a prominent factor for evasion, however these institutions do not offer food or stay for all their students, which leads to the need for money to pursue higher education. In this country there are specific courses aimed at the training of teachers called "licenciatura"; In this way, for this research, we try to analyze the main expectations and suggestions for the improvement of the Physics teachers' training course (licenciatura) according to ex-students who left this course.

Methodology

In order to obtain the research data, we applied an online questionnaire with former students who left the physics teacher training course of a public university in the state of São Paulo, Brazil. The online questionnaire was sent, via the e-mail, to the former students, obtained through different forms. One of them was through the contact with the University's Office of Academic Affairs[1], where we obtained the names of the former students, who left the course; in possession of these names, we searched their e-mails in different sources such as the Lattes Platform[2], search engines and social networks. The data obtained through the online questionnaire were analyzed according to the concepts of Content Analysis presented by Bardin (2002).

1 Section of the university responsible for organizing university data, it is also responsible for registering students who enter, complete or leave course.
2 The Lattes Platform represents the experience of National Council for Scienti c and Technological Developmentin the integration of databases of Research Curricula, Research Groups and Institutions into a single Information System.

Data Analysis

According to data obtained through the University's Office of Academic Affairs, between 1988 and 2014, 354 former students completed the course, 378 evaded spontaneously, 71 transferred to another course and six were not able to complete the course because they remained above the maximum time allowed; So the questionnaire was sent to the 455 students who did not complete the course in this period, 37 of whom answered the questionnaire. The students who answered the questionnaire had several expectations, it was possible to classify the answers into four categories: Academic, university structure, economic and personal. We classify as "academic" category those related to learning or improvement of content (didactic or physics), possibility to carry out research or project, more practical classes, knowledge of physics as disclosed in scientific documentaries,

Possible improvements in the physics teachers training course: expectations and suggestions of evaded former students possibility of eliminating subjects for later transfer, disciplines similar to engineering course, in addition to learning to speak in public and that the course would be difficult. In the category "university structure" was classified the answers regarding the university structure as library and laboratory. As "economic" category is the expectation of academic support. In the "personal" category is the possibility to dedicate to the course without working, to progress in the course without retention, to complete the course and to teach. Among the diverse expectations presented by the former students, some were more recurrent, especially those that referred to learning, both physics and didactics, others less recurrent such as that related to the university structure that had only one quotation. Only a few of these expectations have been fulfilled, they are the possibility of teaching, participating in projects and research, learning to speak in public, learning physics and didactics, being able to eliminate subjects and transfer, besides the expectation that the course would be difficult.

Although some students have reported that the expectation of learning didactic and physical have been fulfilled, others report that this did not happen, which is possibly related to the need for improvement in the teacher's way of teaching, as it is possible to notice next, when it is discussed the necessary changes to the course according to the same former student.

On the suggestions for improvement of the course, the former student point out the need to change the activities developed by the teachers, how to make the class more attractive, but does not expose what they consider to be a "more attractive class" and that the evaluation should focus on what student learn, not math skills.

Among the possible modifications in the course were indicated several suggestions that can be classified in didactic, economic, curricular and social.

In the "didactic" category, the suggestions related to the teacher's work are gathered, among them the need to consider the difficulties of students who works, to make classes more dynamic, to hire teachers graduated in teacher training courses (due to didactic reasons), evaluation not only based on tests, but based on activities developed in class and not on mathematical skills, separation of teachers who want to teach from those who just want to research, teachers need to improve didactics, more dynamic classes, less arrogant teachers, listen to complaints of the students and to rethink in the didactics from the complaints, to extend the use of lists of exercises, to consider the different learning time of each student and to consider the first year of the course as a transition from High School to Higher Education.

As "economic" were classified the improvements related to the offer of incentive for the student to remain in the university. In this category were classified a greater offer of scholarship and possibility of association with High Schools so that the student could work without leaving the context of the course, aid for housing, food and study for those who are economically disadvantaged.

In the "Curricular" category, the modifications that have to be carried out at curricular level were classified, among them is the extension of the course to five years and reduce the number of weekly subjects, besides introducing disciplines of Physics, Chemistry, Mathematics and Portuguese, inclusion of didactics subjects atthe beginning of the course, make the subjects more practical and less theoretical and become annual duration.

It was also indicated the need to be clear that the course is a teachers training course, but that teaching is not your only work option after completing the course, propose individual activities according to the difficulty of each student, focus course in the physics and technology, greater dissemination of the projects and research of the university in which the student can participate.

Among the answers that we classify as "social" is increasing the value of the student who wants to be a teacher and increase the value of the course.

According to the answers provided by the former student, we can note that most of the possible improvements indicated are related to the didactics of the university professor, indicating that they should rethink their practice and form of interaction with the class, since there was even an account of the teacher's need to be less arrogant. In addition, it is remarkable the need of the university professor to consider the difficulties of the students, especially those who work or are in the first years of the course, moment of transition between levels of education.

Final Discussion

Through the analysis of the expectations presented by the alumni we can note that, except for the fact that he was able to teach, all other expectations fulfilled belong to the academic category and even if some former students report having learned or improved the knowledge of other physics and didactics, other former students say that they did not obtain this knowledge, possibly due to the didactics of the university professor, a factor that presents a greater suggestion to improve the course.

Suggestions for improving the course also indicated the need for the teacher to consider the student's difficulties, especially the worker, since he cannot devote his time to studies like the other students, since this is a moment of transition between High School and Higher Education. The issues presented above deserve to be emphasized, since they can be solved by changing the performance or way of thinking of the university professor, regardless of external factors such as educational or university policy. However, we must not forget the other factors pointed out by the former student, since, although they depend on other institutions for their occurrence, the changes indicated are important for the improvement of the course.

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TEACHER PROFESSIONAL DEVELOPMENT

8

ASTRONOMY EDUCATION: AUTONOMY OF TEACHERS TO EXPERIMENTAL ACTIVITIES IN THE BRAZILIAN ERATOSTHENES PROJECT

Rodolfo Langhi; Fabiana Andrade De Oliveira; Janer Vilaça

| INTRODUCTION

The objective of Brazilian Eratosthenes Project is the development and application of teacher professional development actions according the docent autonomy concept to basic Astronomy teaching. These actions include socials relations with Brazilian schools and international schools using Communication and Information Technologies (TIC). Schools are helped to plan their interdisciplinary experiments with gnomons according the Earth radius measurement done for Eratosthenes. Argentina coordinates the project in South America, and Brazil works in this project since 2010 with the theme "Projeto Eratóstenes Brasil" in the homepage: http://sites.google.com/site/projetoerato

Then, the central objective of this research is to study development of autonomy of teachers when they are submitted to create experimental activities to teach Astronomy.

Conceptual Framework And Research Problem

A bibliographic study about Astronomy Education and the use of Eratosthenes Project was realized. In this bibliographical survey, we saw how important is to research how our teachers are developing their autonomy (according the concepts of Contreras, 2002) to construct and use experimental activities (Langhi & Nardi, 2012) to teach Astronomy: this was our research question.

METHODOLOGY

Since 2010, the project received hundreds of Brazilian schools with different experiments that were constructed with autonomy, because our site doesn't show some itinerary pre-ready to elaborate the experiments, according our conceptual framework points. To collect data of this research, we used interviews via skype with the teachers and a questionary using their emails. These data were analysed using the proceedings of Discourse Analysis (Orlandi, 2002) to reveal behind their words what they think about the didactic experimentation and docent autonomy.

Results And Discussions

In six years (2010 to 2015) we had a increase the number of Brazilian schools who submitted their measurements at project's homepage, while other countries not. Argentine project coordination uses statistics models to choose the pairs of schools to result in a best Earth radius average (Bekeris et al., 2011). However, we observe that some schools prefer to use their autonomy to choose a pair. But this choice is not mandatory in the Eratosthenes Project. Then, teaching professional practice could change and we see modifications in the teacher's work, what depends of their realities and context.

This project intends to respect the docent autonomy, but offers help and mediation with Astronomical Pole "Casimiro Montenegro Filho" and Astronomical Observatory of UNESP. This autonomy – that is to responsible for modifications during continued teacher formation – is called "activist formative model" according our studies (Langhi & Nardi, 2012).

Table 1: Results of the project from the beginning of the Brazilian participation source:Brazilian coordination of the project).

	2010	2011	2012	2013	2014	2015
Radio (km)	6.375	6.460	6.430	6.350	6.360	6.360
Schools	348	300	220	300	300	400
Students	15.000	15.000	12.000	8.400	6.800	8.000
Inscriptions	460	310	282	390	415	353
Participants	226	198	169	222	167	174
% Particip.	49%	64%	60%	57%	40%	49%
Countries:	Argentina, Brazil, Colombia, Cuba, Mexico, Uruguay, Venezuela, Chile, Peru, Bolivia, Spain, Catalonia, France, Honduras, Italy, Portugal, Czech Rep., Morocco, Romania					

Although there have been certain changes in the teacher's work, the analysis of discourses (Orlandi, 2002) of teachers indicated the following main results:

a) There were difficulties in understanding the measurement process with the gnomon;

b) They did not read all the information about the Eratosthenes Project;

c) The teachers want a kit or ready model of gnomon;

d) These activities and Eratosthenes are new things for them;

e) They ask for a script to be technically followed about the experiment.

This leads us to conclude that even investing in the development of teacher autonomy, he continues with a tradition of teaching in technical rationality, because it was formed in this way in college or other formation courses.

Our results show that teachers at work, in general, do not seem to be prepared to professional autonomy. Maybe this fact occurs because in their initial teacher education, he rarely has the opportunity to develop their autonomy. So even if a mediation to occur for the development of the autonomy of teachers, we think there are other issues to be investigated.

Considerations

This project discusses about researches in Astronomy Education - still extreme rarely in Brazil, when we compare with other topics in Physics Education. We believe that actions like this Eratosthenes Project could motivate the students and teachers to learn more Astronomy. Furthermore, this national action can be a rich source of data to investigations about teaching formation and scientific divulgation. With help of researches groups of undergraduate and graduate students, we can produce more researches and papers, contributing to bibliographic academic production about Astronomy Education and Teachers Education.

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CULTIVATING A PROFESSIONAL LEARNING COMMUNITY VIA LESSON STUDY CULTURE

Kyoko Ishii, Yoshihide Yamada

| INTRODUCTION

In knowledge-based societies, the teacher's role has changed from that of knowledge provider to facilitator, in an effort to reform schools into learning organizations. To succeed with such educational innovations, it is important to cultivate a professional learning community (Hargreaves, 2003; Lieberman & Miller, 2008,). Meanwhile, a "lesson study" is also regarded as a professional development tool for professional learning communities (Lewis, 2004; Stigler& Hiebert, 1999).

However, most learning communities are comprised of school colleagues, and the topics of their lesson studies are usually focused on a particular subject in a particular grade level. It is also difficult to collaborate between local schools and universities, between elementary and high school, and between training teachers and veteran teachers. These communities should be spread more widely across the school, to encourage the collaboration of all members who are concerned with education. Moreover, the structure of teachers' development programs requires the viewpoint that a teacher's development is a continuous, lifelong process and that teachers are reflective practitioners (Schön, 1984).

The purpose of this study is to explore both the structure and process of a specific professional learning community, the Fukui Active Learning Group. It consists of elementary teachers, middle school teachers, high school teachers, graduate students, professors, and an educational adviser to the Board of Education. The members primarily teach science in Japan's Fukui prefecture. It is unique that the teachers, students, and professors make up this learning community, because it is common for teacher training and professional development efforts to be separated in Japan.

Project design and method

This study investigates the structure and organization of the Fukui Active Learning Group. The research question is: How is this learning community organized and operated? A narrative approach is used to describe the structure, motivation, and process of the project, based on records of its practices. The framework for the research is based on the perspective of Wenger's (2002) community of practice. Data are gathered from the reports of the group's meetings. Teachers' individual reports and Facebook data are also used to collect information about these meetings.

Results

Structure

The Fukui Active Learning Group was established in April 2013 with the objective of conducting practical research in order to improve science lessons and enhance children's inquiry. It consists of elementary teachers, middle school teachers, high school teachers, graduate students, and professors who primarily teach science. The meetings are held two or three times per semester on Saturdays in the science education laboratory at the University of Fukui.

Usually, 10 to 15 people attend the meetings; some core members attend frequently, but there are no membership requirements. Anyone is free to attend the meetings. At the beginning of each meeting, the participants introduce themselves and tell a bit about their interests and practices. The topics are varied, and have included electricity, light, molecules, pulleys, chemical changes, and so on. Anyone who has an idea or question can discuss each topic freely.

Motivation

The motivation for participating in this learning community is varied. Some teachers want to share and reflect with others about their teaching experiences based on students' reactions. Faculty members and graduate students see the meetings as a good opportunity to find out more about students' learning in real classroom settings. Some participants bring new idea to discuss with others, and some come just to hear and learn from others' discussions. All share a common interest in improving their teaching and their students' science learning. At the same time, they love to learn about science, to investigate nature, and talk about their students' reactions.

Notably, most of the core members are alumni of the Graduate School of Education at the University of Fukui, where they studied in the Department of Professional Development of Teachers (DPDT Fukui). The main curriculum in the department is based on establishing communities of practice (Ishii, 2013; Wenger et al., 2002). Participants have similar experiences engaged in "longitudinal, collaborative action research based in schools," which consists of reflections on practice, along with discussions about teachers' own practices; listening to one another; reading case studies and theories; and writing about the processes involved in their own teaching practices. They have the shared motivation of managing and facilitating the community of practice.

Process

At first, the organizer (Author; Ishii) presented several themes, such as an introduction presentation, "Physics by Inquiry." Some participants regarded this as a workshop that delivered new material or information, but gradually they started to engage in the scientific inquiry together. Then, they started to bring their own ideas for experiments and teaching plans for next Lesson-Study, and children's notebooks. They began to enjoy sharing and reflecting together as a community of practice.

Some ideas have been discussed repeatedly, tested by the participants, improved, and shared among teachers. For example, the "Energy House" plan was first introduced by a veteran teacher as secondary school topic at the Christmas meeting in 2013. Through repeated discussions, he created a lesson plan for it and presented at the lesson study in his school (Nambu, 2016). An elementary school teacher later refined it and used it in his class.

Conclusion

As a result of this study, certain key characteristics of the Fukui Active Learning Group became clear: 1) they hold meetings regularly to improve their lessons; 2) while there are core members, participation is flexible; 3) they share practices with one another via Facebook; 4); all participants attend meetings on a voluntary basis; x)all participants have equal status; they respect each other and have no hierarchy; and 6) any member can propose a theme for discussion

The results of this study show that a learning community is only sustainable when it includes reflective practitioners. Everyone must respect the other members, and everyone must have a positive attitude toward the idea of learning from other participants. There are three fundamental elements for forming a "community of practice; a domain of knowledge, community of people, and the shared practice the they are developing to be effective in their domain" (Wenger et al., 2002, p. 27). In the future, this community will discuss and develop its curriculum based on these practices.

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CONCEPTIONS ON TEACHING-LEARNING: WHAT DO HIGH SCHOOL TEACHERS THINK?

Natália Pimenta, Maria Inês Ribas Rodrigues

| INTRODUCTION

The Brazilian university today has its main influences in three models of teaching: Jesuit (traditional or practical craft), French (technical or academic) and German (hermeneutic or reflective). According to Anastasiou (2001), in spite of the countless researches already done on the importance of initial and continuing training for teaching in higher education, there are still teachers who are transmitters of one Disjointed and fragmented content, taken as true and not historical, with strong remnants of the Jesuit and French models, making the University not fulfill its role of enabling the processes of knowledge construction. Today, teaching is considered a complex phenomenon that has in teaching a social practice. In this perspective, the function of Didactics is not only to understand how teaching in situ and what its social functions, but also to dialogue with several areas of knowledge, because a complex phenomenon is not studied from a single view. Finally, it should carry out critical reviews of the knowledge already produced, creating new ones according to the needs that emerge from the teaching situations. In this way, an essentially reflexive characteristic of the teaching profession and the processes of continuous professionalisation is observed (Pimenta and Anastasiou, 2011). Experiences of collaborative work among teachers on classroom practice have led to reflection, learning and change (Rodrigues and Carvalho, 2002).

Methodology

The research was conducted at the Federal University of ABC with professors who teach the discipline (BC0103) Quantum Physics. This course is part of the compulsory common core of the bachelor's degree in Science and Technology (BC

a) We had nine subjects with whom we conducted an individual and semi-open interview with a semi-structured script. The interviews were recorded in audio with the consent of the interviewees and later transcribed for use of the discursive textual analysis in the sense of Moraes (2003). For this author, the analysis process takes place in three stages. The first is the deconstruction of the text so that we can look at the parts that make up the whole. From this first step of analysis arise the units of meaning or meaning, which, in the case of this work, emerged from the reading text. We seek similarities of meanings and meanings to construct the categories of analysis pertinent to our goal. Finally, we seek to establish relationships between categories to enable the emergence of new understandings.

Analysis

Observing the speech of P1 in the table below, we see that this teacher realizes that transmitting is a difficult task in the information society (intelligent students who can seek information, "excellent bibliography", "no use reproducing"). However, P1, as well as P2, P5, P6 and P7 bring in their discourse, conceptions maintained both by habitus, and by imaginary and collective memory, that teaching is a transmission task. This conception is present in the Jesuit and French models of teaching and school institution. In addition, as mentioned by Pimenta and Anastasiou (2011), there is still a lack of preparation and scientific ignorance of what is the teaching-learning process in higher education institutions, so conceptions of what teaching is transmission-reception are part of a widely accepted collective Among these teachers. In the teaching process, the teacher selects content that he or she deems most important, "transmits" them to the students, and then verifies whether learning has occurred.

Table 1: Teaching-learning is transmission-reception

Teacher	Speech
P1	I think that way, to try to carry information, to show the students where it is being applied. (...) I think that teaching-learning contains a lot of that, of you trying and exposing the most essential things, and then verifying that that learning actually took place. If those essential ideas spread to the students. That you tried to convey, if the students absorbed that, if they somehow embodied those ideas. (...) Of course, I am sometimes like this, a little too pessimistic, especially after the evaluations, you see, but ... (...) That is even a subjective thing a little, that is, it has That menu is the goal, but what is more subjective of the teacher is to point out the themes that are most relevant and the learning, well, if the student is able to capture those ideas, which you deem the most essential.

Teacher	Speech
P2	We use the concept instead of note, so the structure itself is made for us to look at the student not only as a number that he attains, but rather that he actually obtains ... Look at it in a broader way. That is, how much he was able to learn from what he was taught. And try somehow to see how satisfying his training ... That is, his learning in front of what was taught. Unfortunately in practice, with the numerous rooms, we end up doing a process that is even more numeric.
P5	What is important is trying to pass on experience. So you have to study to also be able to convey to the student something deeper for him. (...) I think you have to convey something, try to convey the issues. To make the student also discover some things for himself. So you have to be a gateway to the student. You have to open the mind of the person, taking new concepts, but the student also has a way that is it also try from those discover new things.
P6	So we have to look for several alternatives to do this. Several different forms, multiple media, or multiple channels of learning so that it can internalize what you want. (...) So my goal is for the student to internalize a certain thing, so what are the concepts that I'm going to work for him to internalize that? What are the means that I will use to achieve the goals? Basically that's it, so in this process, the teacher's role is to think in this thread. What are the means for him to internalize the concepts to achieve the goals. (...) but what I see we have to do, one of our activities is to
P7	transmit the knowledge that we have acquired for new generations and this we do in a traditional way, which is to tell the What we understand about certain issues, in the case of Quantum Physics. So this would be for me the concept of teaching-learning, we will try to find some way to convey what we already know a little better because we already have a certain amount of time working with it.

The P4 talk about teaching-learning shows how this teacher sees the interaction: the methods applied in the classroom, the activities that the students develop, alone, with other students (monitors) and with the teacher. The P5 speech falls into two categories simultaneously. The teaching task is complex, just as the teachers' conceptions are. In addition, the university scenario is influenced by several models, in addition to the Jesuit and French models mentioned above, we also have the German model, which brings together the idea of working together between teachers and students to solve questions using scientific constructs. A partnership relationship for the construction of knowledge. We attribute this complexity of conceptions and practices to this universe of diverse models and influences present in the construction of teachers' identity and in the development of their knowledge.

Table 2: Teaching-learning is interaction

Teacher	Speech
P3	(...) one side trying to help the other to understand a subject, but I do not think one is the boss who commands and the other has to do, it would have to be more interaction, it is together that one learns things together , The teacher also always learns things when teaching.
P4	And it is this interaction, it is fundamental the teacher's dialogue with the students, the conversation that we have, whether in the classroom or in the classroom. (...) So, from the actual lesson itself, even all those other activities that take place around it, are part of this process, which we call teaching-learning.
P5	Because when you go to give a lesson, basically you have to learn to teach. It is a two-way process, it is not just the student who has to learn.
P8	You give lessons, you think different ways of talking about the same subject is an enrichment of the teacher himself. I think this serves as a fuel for a teacher's career. The classroom ends up being the environment of mutual exchange, there is an apprenticeship of both parties, the students and the teacher as well. Whenever you prepare a class it's kind of ... At least in my case, it's a kind of suffering, because you have to sort of fill in gaps that you yourself have. Then there is a great learning from the teacher, during the preparation of the lesson and during the classes themselves. This is why it is also important that students participate in class, etc. (...) Teaching-learning for me is an exchange. Classroom is a laboratory where there is an exchange. The lesson for me occurs when there is this exchange of knowledge. If either part is not working, the lesson does not work. (...) The teacher is more a kind of provocateur, he has to work his curiosity to learn, his creativity. And try to stimulate the student in difficult times, in very abstract situations. The teacher is nothing more than a student with a little more experience. But there with a meeting of several people who are trying to learn something. And I tell you that the teacher learns a lot. (...) this exchange stops to occur and the teacher also loses the fuel, it is difficult for you to prepare the following course.

Final considerations

From the analysis we can consider that the conceptions about teaching and learning that the teachers of Quantum Physics of the Federal University of ABC are composed of several factors: the perpetuation of the models of Jesuit and French teaching, besides the protagonism in the German model in the current discourses about teaching. We perceive, through the analyzed discourses, that the complexity of the teaching task is present in the cultural repertoire of these teachers. These data, combined with the theoretical assumptions previously presented, indicate that a better relationship between theory and practice, discourse and action can be achieved through reflection on practice. In this way, space is opened to expand this research, in the sense of creating opportunities and situations where it is reflected on the practice collaboratively. Thus, it is possible to analyze these situations in context and to study their potential for improvement of teaching practice.

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PERMANENT EDUCATION AND THE INTEGRATION OF DIGITAL INFORMATION AND COMMUNICATION TECHNOLOGY IN PHYSICS EDUCATION IN SANTA CATARINA

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| INTRODUCTION

Teacher education, whether initial or continuing, has been a permanent challenge in all educational levels. In the specific case of Physics teachers, the largest problem lies in the shortage of qualified in-service professionals. This paper is part of doctoral research that had as its central axis two demands surrounding the education of these professionals: the first refers to the social changes brought about by Digital Information and Communications Technologies (DICT), which vindicate a (re)signification of the school and the teacher's profile; and the second speaks to the high percentage of teachers working without having the adequate qualification for the profession. The objective was to develop and evaluate a proposal for continuing education, as well as its contributions to teacher education and to the teaching of Physics in the schools within the Santa Catarina (SC) state-level public school network. The investigation's central question was essentially concerned with understanding what contributions the proposal in question can offer towards meeting the demands present in the teachers' education and practice in the context of the Santa Catarina public state schools. This investigation had a qualitative nature, constituted by action research, which immerged its participants in a continuous process of reflection and action. In view of responding this question, a continuing education course was organized around the proposal of the Three Pedagogical Moments. It sought the teacher's personal and professional growth and the demand of a continuing and in-service education, pointing towards the creation of a virtual community of practice (VCP) conducive to knowledge-sharing around the teaching of Physics and to the constitution of a network of Physics teachers. Instruments for data collection included questionnaires given to the teacher-participants of the continuing education course, activities developed throughout the course and records kept of the in-person sessions, of the online interaction and moments of reflection, in addition to an online questionnaire sent to all Physics teachers in the SC public school network. The research was grounded in three dimensions. The epistemological dimension, based on the ideas of Fleck (2010), mainly the notions of thought-collective and thought-styles, circulations and complications. The didactic-methodological dimension, sustained by the ideas of Freire (1977, 2011a, 2011b), especially in regards to the categories dialogicality and problematization; and the technological dimension, based on the perspective of education media (BÉVORT; BELLONI, 2009; FANTIN; RIVOLTELLA, 2012) and Mishra and Khoeler's (2006) Technological Pedagogical Content Knowledge (TPACK). These dimensions were used in the organization and development of the course, as well as for its analysis. This paper will focus on the integration of the DICT within the practices of the teacher-participants, as well as the potential of these technologies for the ongoing permanent education process.

About the permanent education course

In order to contribute towards the education of Physics teachers in state-level schools in Santa Catarina, we have structured a course proposal from our experience with the teaching of Physics and the education of teachers in this subject, taking into consideration the demands perceived by them in the practice of the profession and underscored by researchers in this area. Our goal for the course was to promote the construction of reflexive and investigative attitudes, elements indispensable for the performance of the physicist-educator, having the perception and confrontation of complications present in the reality of the school and specifically in the teaching-learning process of Physics as a starting point (LEONEL, 2015; LEONEL e ANGOTTI, 2016). In this manner, we planned a continuing education course, called "Teaching Physics: A New Glance over the Practice", in line with "Training System for Educators of the State Teaching Network". The course was blended, a modality known internationally as Blended-Learning or simply as b-Learning, and had 48 hours of in-class learning and 52 hours of distance learning, adding up to a total of 100 hours. There were six monthly in-class meetings, of eight hours each, which were held at the computer lab in the Center for Distance Learning (CDL) of the State University of Santa Catarina (SUSC). On the other hand, the distance classes and interactions occurred primarily in the room organized in the Moodle platform. However, as the DICT were introduced, they also came to serve to promote and maintain the distance interactions. During the in-class meetings and in the distance interactions, the mediations always endeavored to contribute towards the perception and confrontation of complications present in the day-to-day of school life with the aim of developing critical thinking around the use of the different resources, such as experimental apparatus, different styles of language and DICT. Such actions promoted the gradual conscious acquisition of these resources, having as the horizon the planning of didactic-methodological strategies which contribute towards the confrontation of problems raised by the teachers in the beginning of the course and in the interactions that followed. The DICT that were used were selected based on the demands brought forth by the teachers in the first in-class interaction, so that the objective of the course could be met, having, however, its usability by teachers with their students as the main criteria. Thus, as they learned to utilize them, reflections were provoked in the sense of contemplating digital inclusion as well as a glance towards the DICT as an object of study and pedagogical tool, the three dimensions raised by Bévort and Belloni (2009), as necessary for education in the perspective of education media. A few free applications were selected, in addition to simulations and social media which could be used by the teachers in their practice. In the proportion that they became familiar with and explored these resources (collaborative writing, blog, Laifi, Youtube, among others), they interacted within and through the resource at hand, already contemplating different possibilities of how to integrate them in activities with their students.

The integration of dict in the teaching of physics

The course had ten teachers, but only eight concluded it. Before participating in the course, only two, among the eight teachers who concluded the course, made no previous use of DICT in the teaching of Physics. Among the six who had some previous experience, four recognized that the potential of the DICT had not been explored in favor of the construction of knowledge, but only to give a "feeling of modernity" in the classroom and grasp the attention of the students. All suspected that the DICT could contribute towards the teaching-learning process and that, for this, time for planning and skills in using these technologies were needed. For teachers P.03, P.05 and P.06, the lack of skills was the greatest obstacle for the use of DICT in their Physics classes. However, for P.08, P.09 as well as for P.05, the biggest problem was to be found in the lack of appropriate resources for the use of the DICT in the Physics classes. For P.08, the awakening to the use of DICT promoted a better use of class time and a breaking of barriers that many times separate teachers and students. The teacher P.05 did not care for DICT before the course, "but now I notice its importance for interacting with students in the exchange of information and also to aid in the educational process". And P.06 felt encouraged to innovate in his/her activities: "Making use of DICT to communicate with the students, that was interesting and productive. I wouldn't have had the courage to ask them to complete an assignment only through the distance module had it not been for the course. In general, the course promoted in the teachers: a greater use of video-class available on-line, in preparing for class, as an object of study for teachers as well as to be used as an aid in the classroom; a greater use of digital learning objects; an expansion of online communication of teachers with their respective students; indication of websites for their students, complementing school content and seeking DICT that could contribute with the teaching-learning process of Physics.

In consideration of the fact that most of the teachers had not used these technologies in the teaching and learning process and some had not made any personal use of them, their integration within the teaching and learning process of Physics happened more quickly than expected. It can be inferred that the development of the activities and discussions around the pedagogical practice resulted in the comprehension of the critical and creative use of the DICT. However, it is important to clarify that an integration such as this is a slow and gradual process. The DICT used helped the teacher come out of isolation and the option of having problematizations and circulations as a starting point encouraged interactions, collaborative productions and its use in the teaching-learning process in Physics. Using the set of resources with their course colleagues, noticing its potential, the teachers planned practices that permitted its integration within their own practices. This happened because, in the first place, the starting point was the teachers' own demands and questions, which required that the course be planned in a dynamic and intense fashion, coherent with the references adopted in this research. Secondly, because the resources were presented in such a way as to instigate their use, through problematizing circulations. Although it had some limitations, the constitution of the Virtual Community of Practice met the objective of knowledge-sharing and practice-sharing, of socializing material and of disseminating information about current topics in Science and Technology and events in continuing education. What was sought and exercised was a process of reflection in action, motivating the search for solutions in the confrontation of complications present in the practice, with the support of the DICT, without presenting answers elaborated in advance. The teachers' extensive workload poses a barrier that needs to be broken with urgency. Organizing time for research, readings, planning and analysis becomes difficult because of it.

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INFORMAL PHYSICS TEACHER TRAINING IN THE CZECH REPUBLIC: A POSSIBLE INSPIRATION

Irena Dvořáková, Leoš Dvořák

| INTRODUCTION

Teacher training is a very important and really necessary part of their professional career. We would like to present two long-term activities aimed at Czech physics teachers. These activities are based on voluntariness principle; teachers attend them because they want, not because they are forced to be there by somebody (e.g. their headmaster). The activities described here are: "The Heureka Project" (Heureka, 2016) and "Elixir for Schools" (Elixir, 2016). These projects can be taken as examples how informal system of teacher education can be created and developed as a useful counterpart to a formal in-service teacher training system.

The Basic Description Of The Activities

Heureka is a project existing for about a quarter of a century. It was described in detail in (Dvorakova, 2014) so it is sufficient to remind just a few details. It includes a two -year cycle of weekend seminars for new participants (ten seminars altogether), some further seminars and an annual conference "The Heureka Workshops". All activities of the project are very informal. Their main goal is to help teachers both to improve their understanding of physics, and their physics teaching at their schools. Although teachers do not obtain any formal credits for their career advancement when attending the seminars, they perceive the activities so useful that they come back for further seminars and events. Apart from some other ways of finding out the impact of the seminars this is a very important informal feedback for us.

Three years ago, the experience and "human resources" of Heureka provided the basis on which the project Elixir for schools was built. This project established 21 regional centres in the whole Czech Republic. Leaders of these centres are experienced physics teachers, often teachers who "passed through" Heureka seminars. Once a month, an afternoon seminar is organized in each centre with a program prepared mostly by the leader of the centre but sometimes also by some participants themselves. Also, there is a possibility to borrow some teaching aids; sometimes teachers go on some excursion, invite some expert to give them a lecture, etc. The project also established its own conference to help interconnect teachers from different regions. Elixir for schools attracted additional physics teachers who did not participate in the Heureka project. Although it has existed just a few years, the project seems to have potential to become long-lasting activity. Also, it appeared that both projects positively influence and inspire each other.

The main characteristics of the both activities

We would like to describe which characteristics are (in our opinion) important and critical for our long-term teacher training.

Active work

Maybe it is self-evident that the seminars for teachers should be led the active way. Nevertheless, we consider it so important, that we mention it here in the first place. The active work is a key learning approach in our seminars. Teachers solve problems, do experiments, and make various simple teaching tools. We are firmly convinced that it would not make sense just to lecture (to a passive audience) about active ways of teaching-learning approach. Our experience confirms that teachers appreciate the active way of the seminars quite a lot.

Community

Being a teacher is quite often a lonely profession. According to teachers' feedback the possibility to meet other colleagues, share ideas, problems, etc. is one of the most important reasons for attending our seminars. We know it, so when preparing the program of seminars we try to let enough time for informal discussions.

Voluntary and free of charge; Informal

These characteristics are maybe the most specific for our seminars in comparison with other teacher training in Czech Republic. As it was mentioned above, teachers attend our seminars and meetings because they want to, not because they are forced to go there by some authorities. Also, we want teachers not to depend on the decision of their headmasters, whether they allow them to attend the seminar or not. Therefore, activities in both projects are organized during teachers' free time– Heureka seminars during weekends, Elixir for Schools meetings in the afternoon. For the same reason all our activities are free of charge. If teachers had to pay the market price for the seminars, many of them could not afford it.

All these aspects are very closely related with informal nature of our seminars. Seminars and meetings take place in schools. Participants of the weekend activities of the Heureka project sleep in classrooms in their sleeping bags and they take care of their food by themselves. This enables spontaneous evening discussions and sometimes experimenting till late night and helps to develop friendly relations in the whole group of teachers.

Long-term

To change one's mind takes time. It is not a problem you can solve in several minutes or hours. So, if we want to help teachers to teach better, we need a lot of hours for working with them. New participants of the Heureka project are invited to the course, which takes ten weekend seminars in two years, altogether about 180 hours. (In spite of such time demands we still have enough applicants; in the school year 2016/2017 the ninth cycle of seminars has started, each of them with about 25 participants).

The project Elixir for Schools has a bit different character. Meetings of the regional centres are open; everybody can come whenever he or she wants. However, almost 70% of participants come regularly, so their attendance is also long-term. This proved to be effective. The data from feedback and evaluation show that 83% of participants feel that their attendance in the centres affected their teaching. They say, that they more frequently include experiments into their lessons and use equipment manufactured or borrowed from the centre. Also, 52% of participants feel more confident in physics.

Extensive and growing

Both our activities are extensive and growing. Although Heureka started in the early nineties originally as an activity of just a few people, now there are almost three hundred teachers involved in the project. More than 120 participants and lots of their children come to the annual conference of Heureka. In the school year 2015/16, a new cycle of seminars for new participants has started, as well as a new cycle of seminars for high school physics teachers. Nowadays, three parallel cycles of seminars run.

The project Elixir for school has not such a long tradition. However, on average almost three hundred of participants came each month to the centres (together for 21 centres) in the school year 2015/16, so about 14 participants attended each centre in a month.

Our seminars and meetings are attended by physics teachers from all types of schools from the whole Czech Republic. Among them, there are teachers, who have no formal education of physics, but they were asked to teach it in their schools, as well as experienced physic teachers who can offer their ideas and opinions to their colleagues. On the other hand, there are few participants, who do not teach physics at school at all, but they take their participation in seminars as their own brain training.

Support

It is evident, that such broad projects require from their leaders a lot of "human energy", enthusiasm and also willingness to be open and learn how to push things further. Nevertheless, some money is needed, too. Heureka ran for some initial years practically without any financial support, than the situation improved. Nowadays it is supported by the Faculty of Mathematics and Physics, Charles University in Prague and by the Depositum Bonum Foundation; this allows organizing of all the seminars and meetings. Faculty of Mathematics and Physics gives the Heureka project not only financial support, but also all the necessary background – administrative, technical and scientific. Thanks to the Depositum Bonum Foundation the project Elixir for Schools was started and is still under development. People from this foundation organize meetings for leaders of the centres, they provide project administration, organize annual conferences of the project, etc.

Conclusions

Both projects described here proved to be viable and useful for the physics teachers in the Czech Republic. We hope that our experience can be inspiring and important for people who would like to organize similar activities. Our main message is positive: building and developing such informal teacher training activities is demanding but very rewarding; and also much appreciated by the teachers.

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PHYSICS CURRICULUM | 9

PHYSICS AT THE NATIONAL SECONDARY SCHOOL EXAMINATION (ENEM) AND EDUCATION FOR LIFE ESTABLISHED BY THE BRAZILIAN CURRICULUM GUIDELINES FOR SECONDARY SCHOOL (DCNEM)

Maria Ines Martins; Yassuko Hosoume

The Brazilian Curriculum Guidelines for Secondary Education, DCNEM, reflects the high school education as a social right of each person to his fully citizenship exercise. The document advocates the comprehensive student training, gathering principles, fundamentals and procedures to be followed in curricular organizations by education systems and their school units. It is understood that in an "Education for Life" perspective, the scientific knowledge acquisition is essential but not sufficient for satisfactory citizens' preparation, who need to understand the surrounding world, being able to interpret, reflect and act in the social, economic and political reality. The DCNEM mentions the National Secondary Education Examination, ENEM, updated in 2009, as an integral component of the Basic Education Evaluation System. The Exam has the purpose to "create a national reference for the high school curricula improvement". We seek for the "Education for life" materiality prescribed at the DCNEM by analyzing the ENEM items throughout the Zabala (1998) prescriptive curriculum perspective which presupposes a formation guided by the knowledge development classified in conceptual, procedural and attitudinal contents. Considering the DCNEM view we focus on Physics curricular subject in four ENEM editions, after the Guidelines publication, totalizing 59 (fifty nine) items, from 2012 to 2015. We note that all items evoke conceptual content, 80 % evoke procedural content and only 25% evoke attitudinal contents. We established the categories Conceptual (C), Conceptual/Procedural (CP) and Conceptual/Procedural/Attitudinal (CPA). The items are distributed as follows: 18 items (30%) are Conceptual (C), 31 items (53%) are Conceptual/Procedural (CP); and 10 items (17%) are Conceptual/Procedural/Attitudinal (CPA).

Considering the research boundaries that analyzed the ENEM materiality in its prescriptive curricular perspective, we verify that the Exam focusing on the conceptual knowledge acquisition is far from the "Education for Life" defended by the DCNEM.

Keywords: National Secondary School Examination (ENEM); Education for Life; Brazilian Curriculum Guidelines for Secondary Education (DCNEM)

| INTRODUCTION

To discuss "Education for Life" in Brazil we considered as a Secondary Education International Reference the document (UNESCO, 2001) entitled UNESCO International Expert Meeting on General Secondary School Education in the XXI Century: trends, challenges and priorities. It consists in a meeting report that focuses on: the Impact of the new economic and School Context; the Mass Secondary Enrolment, Democratization and Equity and the Need for Modernization and Innovation at the Secondary Level. As Brazilian legal assumption to Secondary School we consider the National Curriculum Guidelines for Secondary School, DCNEM (BRASIL, 2012).

The Secondary level is assumed in Brazil as the final step of Basic Education to ensure the Education for Life, indispensable and necessary formation to the performance of a suitable citizenship and to enable progress at work. The idea is to guarantee at least the Secondary Level to every Brazilian citizen.

The National Curricular Guidelines for Secondary Education, DCNEM (BRASIL, 2012) advocates a comprehensive student training, gathering principles, fundamentals and procedures to be followed by Brazilian educational systems through their schools. The Guidelines considers Science as "a systematized knowledge set, socially produced throughout history, that searches for nature and society understanding and transformation" and the Guidelines conceptualizes Curriculum as " the proposed educational activity constituted by a knowledge selection built by society, expressing itself by school practices that unfold themselves in relevant and pertinent knowledge, permeated by social relations, linking students experiences and knowledge and contributing to their identities development, and cognitive and socio-emotional conditions". The Guidelines also mention the National Secondary Education Examination, ENEM, our focus of analysis, as a component of the Brazilian Basic Education Evaluation System that considers the Exam as a curricular reference.

To sum up, based on these documents, we consider that in an Education for Life perspective, the scientific knowledge acquisition is essential but not sufficient to satisfactory citizens' performance. We assume that people need to understand the surrounding world, being able to interpret, to reflect and contribute to social, economic and political reality.

The national secondary school examination (enem)

The ENEM is the most relevant Brazilian examination because it is required to: apply to: several Brazilian Programs (Science without Frontiers, National Program for Access to Technical Education and Employment, Student Finance Fund etc.); Secondary School certificate (young adults with more than 18 years old) and admission on many undergraduated Brazilian universities and some Portuguese ones. In its new version, from 2009 on, the ENEM is used similarly as the American Scholastic Assessment Test, USA SAT, required for admission on undergraduate courses to many American Colleges and Universities. The ENEM applicants has been increased all over the years and achieved in 2016 more than 9 million.

Physics at Enem and education for life

The ENEM is applied annually in November since 1998, and from 2009 on it is conceaved by the knowledge areas: Natural Science, Human Science, Languages and Math. The Exam is applied in 2 (two) days as followed: 1st day lasting 4h30min: Human Science and Natural Science (45 multiple-choice items each) and 2nd day lasting 5h30min: Composition (1 text production) and Languages and Mathematics (45 multiple-choice items each). The items of each knowledge area are structured in a Competence Reference Matrix and a table of contents. The Physics Contents are: Basic and Fundamental Knowledge; Movement, Equilibrium and the discovery of Physics laws; Energy, Work and Power; Mechanics and the functioning of the Universe; Electric and Magnetic phenomena; Oscillations, Waves, Optics and Radiation; Heat and Thermal phenomena.

Studies about enem physics items

There are several studies about ENEM Physics items, most of them focusing on the Exam itself without analyzing student performances. Pinheiro & Ostermann (2010) studied Interdisciplinary and contextualization. The authors show advances in contextualization linked to technology and environment problems but they did not find many interdisciplinary questions. Silva & Martins (2013) classified the items from 2009 to 2012 by content showing that "Oscillations, Waves, Optics and Radiation" and "Movement, Equilibrium and the discovery of Physics laws" were the most required contents and "Basic and Fundamental Knowledge" and "Movement, Equilibrium and the discovery of Physics laws" were the least ones. Hernandes & Martins (2013) established categories based on competences and classified the Physics items from 2009 to 2011. The authors verified in each competence items connected with daily life showing a tendency of exploring how things work. Silva & Martins (2014) analyze Physics items from 2009 to 2013 according to the Revised Bloom's Taxonomy. Among the knowledge dimensions the authors highlight the conceptual and the procedural ones and related to cognitive processes, the items are mainly distributed in understanding and application levels, indicating that the Exam emphasizes intermediate complexity levels. Marcom & Kleinke (2016), otherwise, focused student performance in Physics items from 2009 to 2012 throughout the multiple choice distractors. The authors verify that some students use nonscientific concepts to solve the questions, have difficulties in transposing the problem to another context, use intuitive reasoning and symbolic forms for questions that require a mathematical approach to be solved.

The analysis

According to the DCNEM, the ENEM was created as a national reference for a high school curricula improvement. Considering this examination prescriptive purpose we analyze the Physics item throughout Zabala (1998) prescriptive curriculum perspective. The author advocates an Education for life instead of a propaedeutic one, conceiving an education guided by the knowledge development typified in learning contents (conceptual, procedural and attitudinal).

We analyze 59 Physics ENEM multiple-choice items from 2012 to 2015 at the editions applied after the DCNEM, published in 2012. We seek for Education for

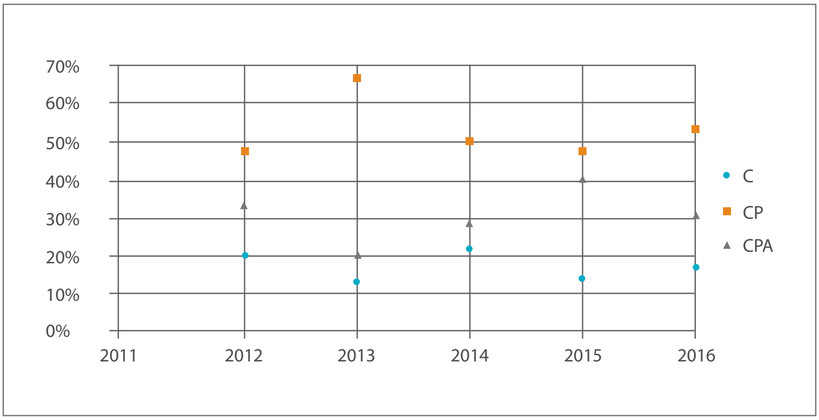
Life in each item, identifying learning contents according to the Zabala typologies: C – conceptual (what to know); P – procedural (what to do) and A – attitudinal (how to do). We consider that one item can require one, two or three typologies. The results are shown at the following table (Table 1).

Table 1: Typology of Physics Items - ENEM (2012 to 2015)

ENEM										
Typology		2012		2013		2014		2015		Total
C	15	100%	15	100%	14	100%	15	100%	59	100%
P	12	80%	13	87%	11	79%	11	73%	47	80%
A	6	40%	3	20%	4	29%	2	13%	15	25%
Total Items	15	100%	15	100%	14	100%	15	100%	59	100%

Source: research data

The data shows that all items (100%) require conceptual knowledge, 47 items (80%) require procedural knowledge and 15 (25%) require attitudinal knowledge. From these results we established the three categories: C – Conceptual; CP – Conceptual/Procedural; CPA – Conceptual/Procedural/Attitudinal. Each item were identified in one of the categories and the results are shown in Graphic 1.



Graphic 1: Categories of Physics Items - ENEM (2012 to 2015)

The items are distributed as follows: 31 items (53%) at Conceptual/Procedural category (CP); 18 items (30%) at the Conceptual category (C) and 10 items (17%) at the Conceptual/Procedural/Attitudinal (CPA). Despite the ENEM 2013 shows an atypical frequency behavior with procedural content above average and attitudinal content below average, we notice a decrease tendency of non-conceptual content requirements all over the years. Is the Exam becoming more conceptual?

Final Considerations

The conceptual typology is always present (in 100%), followed by procedural (in 80%) and attitudinal (in 26%). The items classified in the C/CP/CPA typology categories representing 17%, 53% and 30% average respectively, are in general, stable from 2012 to 2015, except for the ENEM 2013. No item is identified in a CA category The frequency of content typologies shows, in general, from 2012 to 2015, a slight decrease of non-conceptual ones (P and A). Is the Exam becoming more conceptual!?

In one hand this tendency reflects the Zabala assumption that the conceptual content is a priority of Secondary Level and the procedural and attitudinal ones are priorities of Fundamental Level. On the other hand the DCNEM insists on all contents. We consider that the Zabala assumption is suitable if procedural and attitudinal learning contents were developed enough at Fundamental level, that doesn´t seem to be true in the Brazilian case. In fact, Prado & Martins (2014) investigating content typologies in Brazilian Science Textbooks used at Fundamental level, detected contents distributed among C and CP categories, 49% each, reserving just 2%.to CPA one. It means that it is expected to work with all contents as demanded by the DCNEM in order to overcome the CPA gap at the Secondary level.

Considering in one hand that the CPA category as the best representative of the Education for Life required by the DCNEM and on the other hand the ENEM a national reference for the high school curriculum, particularly the Secondary Level, we expect a turning point at the Exam learning content requirements in order to explore more the attitudinal typology to pursue the so desired Education for Life.

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CONSIDERATIONS ABOUT THE PRESENCE OF NATURE OF SCIENCE IN OFFICIAL EDUCATIONAL DOCUMENTS: A BRIEF COMPARISON BETWEEN DCN (BRAZIL) AND NGSS (USA)

André Noronha

| INTRODUCTION

The consensus view of nature of science

Nowadays the importance of History, Philosophy and Sociology of Science (HPSS) for science education is a consensus in the research area. One can find several proposals in the specific literature about HPSS, mainly applications in classrooms, from elementary school to colleges. After generating such academic impact, HPSS and also what it is known as Nature of Science (NOS), slowly took place in the official educational documents, school curricula and syllabus, as teaching sequences proposals, and so on. At the same time, long discussions took place in the academic sphere about how to conceptualize the NOS in the way didactically applicable and pedagogically interesting. After several years, it was built what is called today Consensus Vision of Nature of Science (CVNOS), based mostly in the works of Lederman and collaborators (2007) and also McComas (1998), among others. Below the most famous list of tenets elaborated by Lederman group (2007)

- **a)** Science is empirically based;
- **b)** Theories and laws are different kinds of knowledge;
- **c)** Scientists are creative and imaginative;
- **d)** Scientific knowledge is theory-laden;
- **e)** Science is culturally and socially embedded;
- **f)** There is no the scientific method;
- **g)** Science is tentative.

One could add to the Lederman's list the McComas and Nouri's list (2016):

1) Scientific knowledge is not entirely objective;

2) Science cannot answer all questions;

3) Cooperation and collaboration are part of the development of scientific knowledge;

4) There is a distinction between science and technology;

5) Experiments have a role in science.

The CVNOS, or the "Lederman's seven" as it is known (Matthews 2012) (or, the "McComas' twelve"), was an important achievement in the area, however, only after some few years its contributions came up explicitly or effectively inside official educational documents worldwide. Nevertheless, when it became a new fashion, heated debates arose about the philosophical foundations of the CVNOS. And it paved the way for several critics (not only philosophical) over the so-called Lederman's Seven (McComas' twelve)

In this work we briefly show some of the CVNOS impacts in the discourse of two official educational documents: the Diretrizes Curriculares Nacionais (DCN, or National Curriculum Guidelines) in Brazil (Brasil, 2013) and the Next Generation Science Education Standards in the United States (NGSS, 2013). Our NGSS' analysis was based on a recent work by McComas (2015) and McComas and Nouri (2016). Although DCN and NGSS do not have necessarily similar structures and political intentions, the NOS subject transpires in both of some peculiar ways. In the NGSS the tenets of NOS appear in a similar way like in the Lederman's seven, but even in a simpler and uncontextualized way. On the other side, in the DCN the subject is not mentioned explicitly - it is possible, however, to grasp its discourse using basic features of Ducrot's analysis and find some NOS important elements guiding the construct of the science syllabus. Finally, we comment some critical concerns about the NOS-tenet approach in official education documents, from the point of view of critical theories of curriculum.

Brazil's national curriculum guidelines and nature of science

The chapter "National Curriculum Guidelines for Secondary School", inside the Brazil's DCN (2012), is basically composed of a report that aims to justify (in many dimensions, especially politically and socially) and clarify the new guidelines. In general, the report does not present any explicit criteria for the selection of the scientific knowledge content to be introduced in the last stage of basic education. However, throughout it, one can grasp some elements that could be understood as "metacriteria" for that selection. It must be emphasized that it is subtly suggested in some parts of the document. At least three elements of metacriteria were identified using Ducrot's analysis (1990):

14. Science is an endeavor that unveils the reality through a method that starts from empirical concrete;

15. Scientific knowledge is cumulative, socially accepted, and its apprehension of reality is of a progressive kind;

16. Scientific knowledge is both a historical and cultural construction, made by humanity through social interrelations.

Naturally these are debatable elements. They are consensual by communities of philosophers and scientists, but at same time they are controversial and deserve a more serious and careful discussion. Anyway, it is an important fact that meta-scientific questions at last have its presence in official educational policy documents. They reflect, directly or indirectly, important issues in science education research, specially about NOS. Despite the fragilities identified in the document, the possibility of listing metacriteria seems to reflect a particular trend of science education researchers in the last twenty years.

USA's next generation science education standards and nature of science

Although the construction of the CVNOS was seen as a major achievement in the area of science education research, it have taken a long time for political incentives to be effectively included in the curricula of basic education. McComas (2015) emphasizes that a more substantial inclusion of (consensus) elements of NOS occurred in the United States only in a revised version of the NGSS in 2013. Until then, all major US national educational documents - including the Project 2061 of 1989, the Benchmarks of Science Literacy of 1993, and the National Science Education Standards of 1996) - did not take into account the contributions of Lederman, McComas and others (ibid). Inside the revised version of NGSS, one can find eight simple and direct assertions about the NOS. It's called NOS categories:

1) Scientific investigations use a variety of methods;
2) Scientific knowledge is based on empirical evidence;
3) Scientific knowledge is open to revision in light of new evidence;
4) Science models, laws, mechanisms, and theories explain the natural phenomena;
5) Science is a way of knowing;
6) Science knowledge assumes an order and consistency in natural systems;
7) Science is a human endeavor;
8) Science addresses questions about the natural and material world.

But the critical point, according to McComas and Nouri (2016), is that NOS has no prominence in it, mainly because it appears in an appendix, although its essence one can find throughout it. The main educational approach in NGSS is the crosscutting themes – something that appears in DCN though modestly. This no prominence was shocking for some science education researchers. In Lederman words, NGSS have chosen to bury NOS. Despite, the next step according to McComas and Nouri is take advantage of NOS presence in NGGS and hoping it guide national assessments featuring NOS. This would encourage teachers to include NOS more extensively in science teaching.

Final remarks

A brief comparison highlights some visceral features of both documents. NGSS is more 'representative' of current research topics on NOS in science education – DCN avoids itself (inadvertently) some of the criticism over the CVNOS. We must stress that DCN contains a naïve conception of NOS (NGSS don't), but is not explicit. NGSS most positive feature: explicit mention to NOS. But its most negative feature is to mention explicitly CVNOS by tenets. And our main critique is that tenets usually take the form of simple, uncontextualized and presumably universal assertions. Furthermore, they avoid controversial topics about the NOS, which is a central feature of science endeavor and of its historical development.

Beyond this comparison, our focus and main concern rely on McComas and Nouri regard about CVNOS tenets presence in educational assessments. Probably, in the following years we shall see in USA (also here in Brazil) CVNOS tenets in big national assessments. There are a big number of critical curriculum theorists that alert us about the problems with national assessments and similar educational policies. Wayne Au (2011) observed in several USA' public schools the phenomenon called 'teaching to test', which consist of teachers teaching subjects aiming only to those big national tests – dismissing any serious or critical learning process. Also, this 'teaching to test' process is a path to the neotaylorism in education, according to Au (ibid). In turn, neotaylorism is a symptom of the commodification of education process (Charlot 2005), as alerted by several authors in the last years. Michael Apple (2006) show us that this process is closely related to the neoliberal wave in the 1990s, that still rages on. The neoliberal ideology is present in educational policies and curriculum discourses through what Apple (1979) calls an anticonflict ideology. In turn, this reflects in science education as an anticonflict view of NOS (Noronha & Gurgel 2016). We conclude this work exposing the main argument of our Ph.D thesis (forthcoming), that CVNOS approach tends to fully represent the anticonflict ideology in science teaching.

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ANALYSIS OF THE PERFORMANCE OF UNDERGRADUTE PHYSICS STUDENTS IN BASIC PHYSICS DISCIPLINES

Julio Akashi Hernandes, Paulo Henrique Dias Menezes, Giovana Trevisan Nogueira

| INTRODUCTION

REUNI (Restructuring and Expansion of Brazilian Federal Universities) was implemented from 2007 in Brazil, with goals such as to achieve an average completion rate of ninety percent in presential courses, and the the increase of places offered, especially in the night shift. It was expected (BORGES, 2006) that such an initiative would bring an encouragement to critical areas such as the formation of physicists and in particular the formation of physics teachers. Surveys carried out at that time (FERRAZ, 2008) showed a deficit of 371,000 teachers with specific degree in the country. Of this total 56,000 were physicists. The fact is that investments were made, new jobs were created and almost nothing has changed.

We conducted a longitudinal study on the performance of students in basic physics disciplines, and in the bachelor and teaching degree in physics at a federal public university from 2000 to 2015. Our objective is to relate the impact of REUNI in these courses. The study was conducted at the Federal University of Juiz de Fora (UFJF), which is located in a medium -sized city of southeastern Brazil. REUNI was implemented in this university with projects from 2009 till 2013 (MANCEBO, 2015).

COURSE BEGINNING: PHYSICS I, II & III

The disciplines Physics I, Physics II and Physics III are compulsory to courses in Mathematics, Physics, TI, Chemistry, Statistics, and Engineering, including Electric, Mechanics, Construction and Production. Physics I to III are enrolled by students from second semester onward, in parallel with other science disciplines (Calculus, Geometry, Chemistry, Informatics, etc). Figure 1 shows the total annual enrollments in these disciplines, and Figure 2 shows the annual pass rate. Most of the students choose formally their course after approved in these basic disciplines.

We can see from Figure 1 that since 2009 we have had an increase in all disciplines, but particularly enrollments in Physics I have more than doubled. Because the number of new places offered in these courses have not changed since 2009, we can see from Figure 2 that the main reason for this increase is the low pass rate, i.e., most of enrolled students in Physics I are repeat (fail) students.

We also note, from Figure 2, that the pass rate for Physics I has been steadily decreasing from before 2009, although it has decreased even further from then.

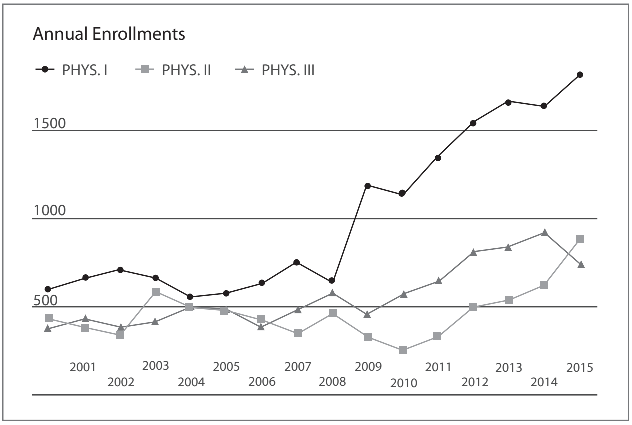

Figure 1: Annual enrollments on Physics I, II and III, due to all courses in exact sciences and engineering. Since 2009, there is a particularly steep increase on Physics I.

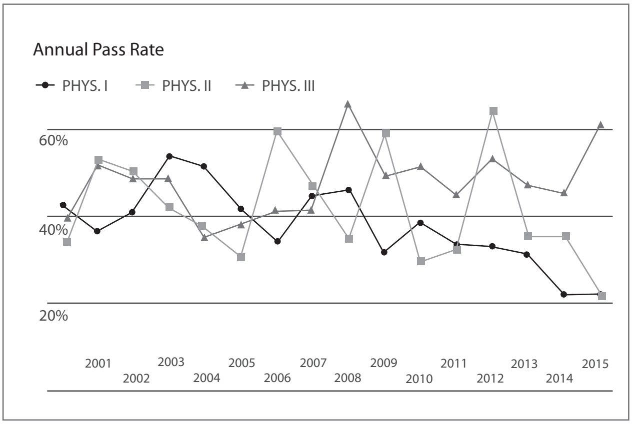

Figure 2: Annual pass rate for Physics I, II and II, due to all courses in exact sciences and engineering. The average fall on pass rate for Physics I comes from before 2009.

Course Ending In Physics: Diplomas

We now focus on physics courses: teaching (to graduate teachers) and bachelor (to graduate researchers). We can see in Figure 3 that the annual diplomas in Physics Teaching have been decreasing since its peak in 2003.

This is particularly troubling, considering that fewer and fewer students choose to remain in physics courses, particularly teaching. For example, we have nowadays 5 and 4 students (total, including bachelor and teaching) in the middle of physics courses that should graduate in 2 and 3 years (2017 and 2018), respectively.

Given the low efficiency of basic physics disciplines (i.e., pass ratio), it is not surprising that few students select physics courses. We should also note that teaching in Brazil is not considered as an attractive profession, associated with low income, high workload, intellectually unmotivating and not a priority for most brazilian governments.

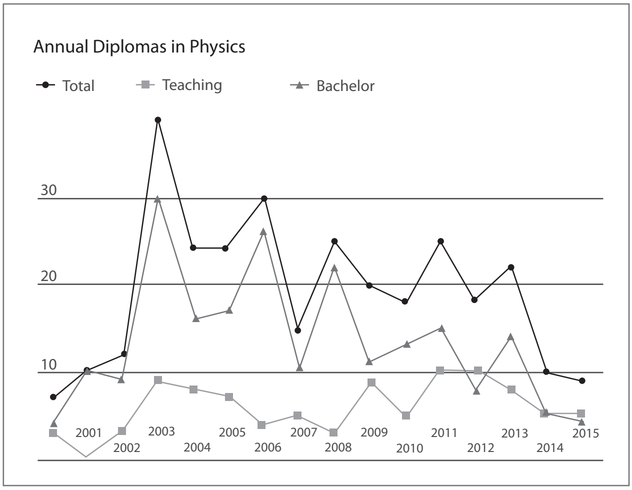

Figure 3: Annual diplomas in Physics, including Teaching and Bachelor (Research).

Conclusions

Our results corroborate the low efficiency of physics undergraduate courses (teaching and bachelor) and present a troubling diagnosis on the number of physicists that graduate in the university investigated. We conclude that it is not enough to increase the number of university places (REUNI) if this increase does not come accompanied by a profound change in the organization and offering of these subjects. In short, the study carried out makes us believe that, in the case of physics graduates, we are not forming more or even better. To address this problem we suggest that changes should be made in the curriculum in order to make the physicist career more attractive and dynamic by entering current research topics in physics, more experimental activities related to theoretical subjects, and insertion of professional lines of technical training that also allows physicists to aim for jobs in business and industry after graduation, or to increase their school performance possibilities in more areas of knowledge in basic education (eg, obtaining two or more Degrees). Finally, basic physics disciplines should also become more attractive, intellectually challenging and incorporate current research topics.

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CONTRIBUTIONS OF “PROBLEMS SOLVING STRATEGIES” FOR ENEM PHYSICS ISSUES

Guilherme Stecca Marcom,
Maurício Urban Kleinke

| INTRODUCTION

Brazil has some large-scale assessments, for instance, state or national exams to evaluate basic education, higher education admission process, and the national high school exam (ENEM) which is for sure the most important. ENEM is not a compulsory exam, it is used for multiples purposes, such as: (i) the only entry point for free of charge federal institutions of higher education; (ii) can provide scholarships in private institutions; (iii) gives the possibility to get a high school graduation, if the student is over 18 years old and for some reason left the educational system. Not only students that are finishing the school take the exam but also students that have already completed high school and students in the middle of high school also take the ENEM to practice. In other words, it is possible to do ENEM as many times as Brazilian students want, but it is only possible to access higher education if one has finished high school.

ENEM consists of two-days test. In total there are 180 multiple-choice issues plus an essay. There are 45 issues for each academic discipline: math, languages (Portuguese and Spanish or Portuguese and English), natural sciences, and humanities. The first day consists of natural sciences and humanities in a 4h30min test, and the second day consists of math, languages and an essay in a 5h30min. So each day the students take 90 multiple-choice issues. We must point out that if the students keep one hour for the essay, they will have 4h30 for 90 questions, an average of 3 minutes for each question, and since the majority of the issues contains text and/or table or graphics, the lack of time for the reasoning of the problems can lead to a random guess. For the admission process, the score for each area is treated based on the Item Response Theory (IRT), which tries to minimize the effect of random guesses.

Natural Science's test includes issues of disciplines Biology, Physics and Chemistry. All issues should represent problem situations to be resolved, with only one alternative is correct. Wrong alternatives (distractors) should be reasoning hypotheses of candidates. These two assumptions about the issues present in the ENEM open space for many different forms of analysis on the knowledge of the candidate. A way to analyze the candidate mistakes is to inferring the distractors' analysis. We analyze the candidates' problem-solving strategies to identifying possible mistakes made during the resolution of the issue; as well as the possible causes of these errors. This way of analyzing allows expand our range of knowledge of candidate's physics difficulties. We expected that, it could be transformed in useful tools for physics' public teachers.

The Brazilian educational system consists of public schools (state, local, technical and military) which are free and private schools. Most students, approximately 80%, are in public schools, state schools mostly. Our sample represents these students, there are graduating in public school in the year before ENEM's test.

We use the researches on problem-solving strategies, because they provide a number of difficulties associated with the resolution of questions of physics. One of the first approaches of the researches, discusses the strategies used by novices and experts (CHI et al, 1981; CHI et al, 1982; LARKIN et al, 1980; MALONEY, 2011; SABELLA and REDISH, 2007). Novices, because they are less experienced, are more susceptible to make mistakes, especially with mathematical modeling, equations reflecting physical concepts (LARKIN et al, 1980; SHERIN, 2001). One of the possible interpretations for this difficulties, is the concept of symbolic form (SHERIN, 2001), which is related to the mental model that students retain the different equations, they take contact in basic education. Sherin suggests possible problems faced by students to "make" a formula, even knowing the concept associated with it. Not scientific concepts also impact directly on problem solving strategies (KOU et al, 2013; SABELLA and Redish, 2007). Other difficulties can be highlighted relate to the graph or images interpretation (BEICHENER, 1994; HALE, 2000; KOHL and FINKELSTEIN, 2006).

Methodological Approach:

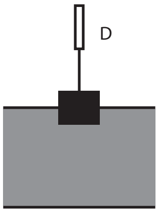
As seen, know the difficulties presented by beginners in their solution strategies of a problem can suggest ways to understand what are the reasons signal a wrong alternative. These possibilities can be returned to schools as a way to assist teachers and administrators in improving the teaching quality, especially publics. In this work we analyze physics ENEM's issues (between the years 2009 and 2012). This questions were classified and compared independently by two physics experts as “physics issues”. In the four years tests, 62 issues were classified as physics; but only 13 are related to general mechanics domain.

For the four years analyzed, around 20 million of candidates realized ENEM’s test. Approximately 80% of candidates are from public schools. The distractor’s analysis using the rate in the alternatives. This micro data can be accessed in http://portal.inep.gov.br/basica-levantamentos-microdados. Statistical analysis, to rating alternatives, was conducted using SAS 9.4 software, with 3.175.897 students.

Wrong alternatives with higher rate, could be used to identify the strategies to solve the proposed questions. All of issues where solved by the authors, carefully searching possible alternative tracks to the issues solutions. Alternative tracks, were compared with the rates item, searching to explain the students’ physics knowledge used in the issues solutions. See the example:

Table 1: Example to analyze a issue.

To determine experimentally the lake water density, we used a dynamometer D graduated from 0N to 50N and a homogeneous cube with edge 10cm and mass 3kg. When the cube was attached to a dynamometer and suspended in the air, scale dynamometer shown 30N. when half cube was diving in lake the dynamometer reading was 24N.
Considering the local acceleration of gravity is 10 m/s^2, the lake water density (in g/cm^3) is



A 0,6.
B 1,2.
C 1,5.
D 2,4.
E 4,8.

ENEM 2011	A	B	C	D	E
ISSUE 73	14%	22%	23%	31%	10%

Resolution Process

$$W_{C\ LAKE} = W_{C\ AIR} - F_{LAKE}$$
$$F_{LAKE} = \rho_{LAKE} g$$
$$P_{LAKE} = \frac{1\ W_{C\ AIR} - F_{LAKE}}{V_{LAKE\ g}} = \frac{30 - 24}{0{,}5 \times 10} = 1{,}2\ \frac{g}{cm^3}$$

Alternative D

$$F_{LAKE} = \rho_{LAKE} g = 24N$$
$$\rho_{LAKE} g = 24N/V_{lake} g$$
$$P_{LAKE} = 2{,}4\ g/\ cm^3$$

Alternative C

$$W_{C\ AIR} = \rho_C \times 30N$$
$$W_{C\ water} = \rho_C \times \frac{V_c}{2} + \rho_C \frac{V_c}{2} \times \frac{V_c}{2} = 30N$$

Or

Intuitive reasoning in solving problems motivate for the image.

Results and Conclusion

The strategies analyzes results in the following inferences: a not correct use of units of measurement; the presence of symbolic forms (SHERIN, 2001); intuitive reasoning in solving problems (CLEMENT, 1994); not scientific concepts (KOU et al, 2013) and wrong images' analysis present in item (BEICHNER, 1994; Berg and Smith, 1994).

We can see two clusters of wrong and your relationship with the problems-solving strategies.

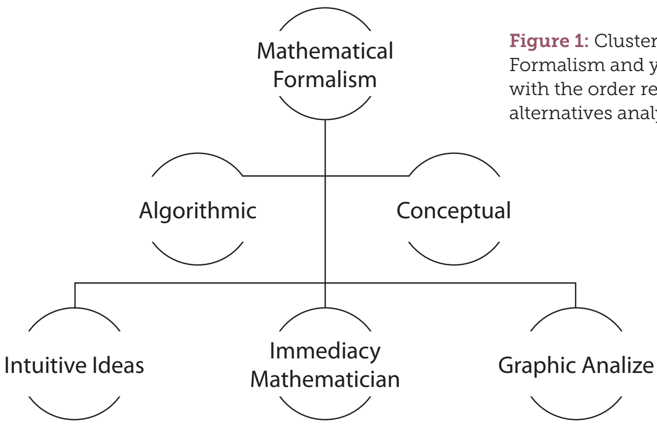


Figure 1: Cluster 1_Mathematical Formalism and your relationships with the order results of the alternatives analyzes.

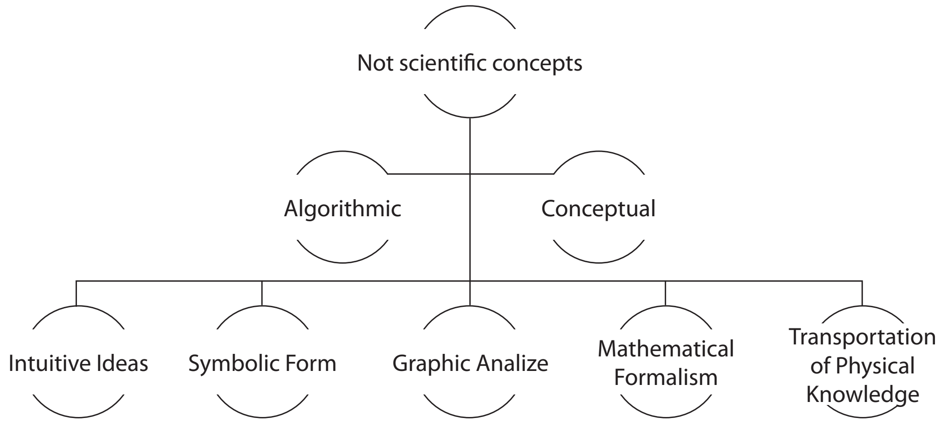


Figure 2: Cluster 2_Not Scientific Concepts and your relationships with the order results of the alternatives analyzes.

With the results we can construction of a reference matrix indicating which the mistakes made by students and the possible reasons that led to commit such errors. At the time that this array was returned to school and interested owed would be considered as a feedback element that essential to the development of a formative assessment (BLACK, 2009; TARAS, 2010). If the results returned for the schools teaches and managers can be used to promote learning, and we expected that physics teachers, use those information to improve the students' knowledge, in physic area on public schools (Author 1, 2015; Author 1 and Author 2, 2016).

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MOTIVATIONAL STRATEGIES 10

“STATIC”: AN EDUCATIONAL GAME EXPERIENCED BY MAJOR STUDENTS OF IFSP

Elias Guilherme Correa Lovato,
Bruna Cavallini E Rodrigues

| INTRODUCTION

Beyond presenting contents, the learning process needs to fit the way each person perceives the world, approaching this content to previous experience and to practice. This is better done with a pluralistic approach, especially when it involves discussing about the content. This way, the individual takes a more active role in the teaching-learning process and tends to seek further development of knowledge, stimulating the student to become more reflective and critical (FREIRE, 1974).

A teaching tool that provides this is the educational game. As a way to simulate a specific reality, it allows this simulation to be manipulated by players in a playful manner, an also brings to this simulation educational aspects. Thus, teaching through games aims to deal with school subjects, developing in the individual the need to better understand the associated content, so the student can improve the strategy to win the game (CAVALLINI E RODRIGUES, 2013).

Educational games may be classified by their way of presenting academical content, as the learning process can be explicit or implicit. Explicit learning, per Paula and Leme (2010), requires the student's understanding of well-defined, clearly presented content. Similarly, an explicit game openly shows the subject of study, often decorative, stating the purpose of the activity as assimilation of information (CAVALLINI E RODRIGUES, 2013).

Conversely, implicit learning ways "... are based on the (…) extraction of environment regularities and allow the increase of the predictability about them." (PAULA and LEME, 2010). Since the processes require the development of logic to build true knowledge, they help the learning by creating meanings naturally. Similarly, implicit games are those that present contents in a less prominent form, mingled with the rules (CAVALLINI E RODRIGUES, 2013).

When we pair this classification with Grando’s ideas (2000), which state that through the games we develop the "capacity for abstraction (...), working with the different meanings of simple perception of objects" (GRANDO, 2000), we can affirm implicit games would fulfill the role of educational tool better, allowing the student to build mental models to understand and explain the world.

Despite the advantages, only a few papers are found when observing the status of this study in Brazil, most of these dedicated to the study of explicit educational games. This highlights the need for the development of new implicit games and research their potential as an educational tool.

Research Description

For data taking, two multiple choice questionnaires were created. Besides them it was also considered the observation of students during the activity with the game.

Questionnaire A was designed to be filled before the activity. It was developed to overview the experience and the acceptance of Physics contents and educational games. Questions 1 to 5 asked about their experience with Physics in High School classes. Questions 6 to 9 were focused on their experience with games.

Questionnaire B was used after the activity with the game. The four first questions asked about the game "Static", its playfulness, its potential as an educational tool and if, and how, they would use the game in the classroom. Questions 5 to 7 requested their views about the structure of "Static" (the ease of its construction and the malleability of rules and pieces).

The activity and the questionnaires were presented to six groups of major undergraduate students: two of Physics, two of Mathematics, one of Biology and one of Chemistry. Data analysis is presented below.

For more information about the game or the research, please contact the authors.

Analysis

The proximity with Physics discipline seems not related with the way it was presented to the students in High School classes. Most of them reported to have had traditional classes (with theoretical explanations, exercises lists and closed books tests). Nevertheless, most of them have some proximity with Physics, with exception of Biology major students. The same pattern presents in answers about the experience with games, as only Biology students report to be indifferent or have little interest. This could indicate these students would not enjoy "Static".

However, when asked about the fun of the tool, all undergraduates said they had enjoyed the activity and would like to repeat it. This points the tool as much a playful object, as an educational tool, since most of the students pointed the Physics concepts could be seen clearly. In addition, all participating students would use the game in classes, pointing they believe in its potential.

The analysis shows most respondents would use "Static" before formal classes, which indicates it could be used as an intuitive method of introduction, diverging of traditional conceptions of teaching. The subsequent use, option chosen by about a third of undergraduates, also brings a change in the standard way of teaching, since the game would replace exemplification by an experimentational way.

The answers to question 5 of questionnaire B show, apart from students of Physics, others consider it easy, favoring its making in the classroom. According the observation during the activity, the construction of the game provides a greater involvement with the game, and makes the experience meaningful for their learning and interaction with the tool. To the Physics class that build it, doing this was very significant for most, but the preparation caused them to lose some class time, which, to some students, disrupted the activity.

Regarding the structure of the rules and game pieces, the opinions of the respondents are divided, but most prefer that the rules allow a choice by the participants, leaving them more open.

Conclusion

Since none explanation of the contents involved was made and most students perceived it clearly during the matches, there is evidence of an implicit process presented by the game. This implicit process, that starts from features extracts by players, is an agreement with Paula and Leme (2010) theory. The presence of Physics content in this implicitly form allows individuals to not only know the concepts, but also start to understand them as processes that can be extrapolated and that are part of everyday life. We expect the player can understand the content, use it to improve its strategy, and outside classroom, be able to understand and interact with their reality. The discussions and explanations observed are an example of the construction of knowledge as a group, as described by Freire (1974), where everyone teaches the others all the time. The collective construction shows the breakdown of traditional teaching methodology. Participants became active in the educational process, contributing to the process. They investigated the doubts as a group, instead of just receiving knowledge. But this change in the structure of education fosters a new question: how the use of this tool influences High School students about learning of these Physics contents? A new Scientific Initiation is being developed within IFSP in 2016 to investigate it further.

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A FLIPPED EXPERIENCE IN PHYSICS EDUCATION USING CLIL METHODOLOGY

R. Capone, M.r. Del Sorbo, O. Fiore

| ABSTRACT

Physics' curricula of Italian Scientific High Schools in the last years have been enhanced by the introduction of Quantum Mechanics and Content and Language Integrated Learning (CLIL). Education monitoring reveals that ast year's students are experiencing many issues in learning in their second language (L2) and advanced and counter-intuitive contents. Our experiment is aimed at understanding and then overcoming those problems using educational methodologies based on social aspects. Thanks to the Internet, a communicative style can be exploited where teachers could keep teaching, playing the role of semiotic mediators. Multimedia and simulations broadly available in MOOCS suggested a flipped classroom approach coping with the project of CLIL lessons. In our experience two classrooms of students were selected, starting from very similar performances and skills. The first one was taught with traditional lectures and tests; the second one, instead, attended to experimental lessons. Students could share their ideas and learning supports through a Facebook group, a blog, virtual classrooms and a website. Nevertheless, at the end of the experience an eTwinning exchange was planned, to spread the experiment towards foreign schools. The outcomes of the tests performed on the students were analysed and unexpected results were drawn. An extension to larger numbers of students, the introduction of different methodologies and the research about different topics in Physics could potentially develop this research.

Introduction And Methodology

This work is the result of a teaching experimentation, through a Quantum Mechanics CLIL learning module presented to two last year's classes in an Italian Scientific High School. The rationale of our investigation is based on the fact that this topic has been introduced only recently in Physics' curricula of High Schools and it has been proven that students encounter quite a lot of problems in learning its advanced and counter-intuitive concepts (Deslauriers, L. et al.,2011; Tsaparlis, G. et al., 2009; Singh, C. et al., 2006). Trying to fix these issues, we founded the choice of our educational methodology on social considerations: nowadays knowledge transmission is widely supported by digital technologies, featuring large amounts of information conveyed at high speeds and a high grade of interaction. Digital Natives, exhibiting noteworthy changes in behaviour, cognition and communication skills, need new educational approaches (Prensky, M., 2001). Current cultural models are somehow centred on the concept of "collective intelligence" (Woolley, A., 2010), where no one knows everything, everyone knows something and all knowledge belongs to all of mankind. Thanks to digital devices, constantly connected to the Internet the most colossal knowledge repository ever realized, a communicative style, strongly characterized by virtual interactivity, autonomous production and sharing of individual contents, speed and communication efficiency is now emerging. In this completely new background, however, teachers still holds the role of semiotic mediators. Therefore a flipped classroom approach seemed to cope with the project of CLIL Modern Physics lessons: multimedia and simulations broadly available in MOOCS, in cloud learning environments and in social educational platforms could help teachers in their scaffolding task. The most appropriate contents, properly selected by teachers and shared with students, could be a strategic tool for students to deepen their knowledge out of the classroom independently. So the classroom comes to be a lab, where even complex ideas are discussed and higher level thinking skills are exploited in order to project and realize concrete experiments and applications to actual study cases, with the side effect of a fluid cognitive and linguistic development. In our experiment two classrooms of students were selected, starting from very similar performances and skills. The first one, A, attended to experimental lessons; the second one, B, instead,. was taught with traditional lectures and tests.

Activities

To increase the interaction level, a Facebook group and a blog were founded, where students very easily shared their ideas and materials. Besides, a website was created, as a repository of contents contributed by students but revised and selected by the teacher. Specifically, flipped activities were organized so that one subgroup collected as many information as possible about a specific part of the topic and then shared it with the entire group.

Students discussed each part of the topic developing ideas and redefining in a more precise way the key concepts. Exhibits and models were built to leave a tangible footprint of the activities.

Besides, a laboratorial activity, focused on a simplified version of the double slit experiment, was carried out by students. "…Richard Feynman famously said that interference of particles captures the essential mystery of quantum physics; at the time, this was still mostly a thought experiment, but in the intervening fifty years, the exact experiment he discussed has been done numerous times, with numerous particles." (Orzel, C., 2015).

The double slit experiment, first performed by Thomas Young in the early nineteenth century, could be considered a key to understand the microscopic world and in particular the wave-like properties of light. In the original experiment, a point source of light illuminates two narrow adjacent slits in a screen, and the image of the light that passes through the slits is observed on a second screen. The dark and light regions that we can observe on the second screen are the interference fringes, the constructive and destructive interference of light waves. Also the matter produces interference patterns, as we can see by firing a stream of electrons instead of light.

Students performed this experiment using a piece of smoked glass scratched using a pin, drawing different couples of very thin lines, the slits (about 0.1 mm, 0.2 mm and 0.05 mm), to detect different interference patterns. After that, they illuminated the slits using a coherent light source, such as a laser beam from a laser pointer. So different Fraunhofer diffraction pattern appeared on a screen, placed 4 meters away (see Fig.1). The measurements should be taken in a darkened room or in constant natural light. If this is not possible, a longish tube about 4 cm in diameter and blackened on the inside (such as a card-board tube used to protect postal packages) can be used.

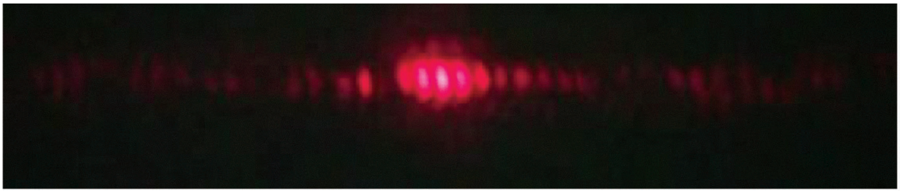

Figure 1: Interference pattern

Using the same experimental setup but with a single slit, they also proved the uncertainty principle: the thinner is the slit, the wider is the position of the photons on the screen.

Testing and outcomes

At the end of the module, both the classes A (flipped classroom) and B (traditional education) were tested using a similar online form. Two sets of 30 items were selected with the aim of detecting the skills obtained by the students. Besides, in order to limit cheating and other kinds of mutual influences, the testing system scrambles the multiple questions and answers and ask different questions to different students.

Testing procedure also included the production of a report of the experiments: the sharpness and the quantity of information of group A was largely higher than the one of the group B.

Finally, testing procedure also included the verification of the results after a month.

Also in this case, students were tested by an online form with 30 multiple choice questions and the results confirmed that the flipped classroom group A obtained a more persistent knowledge as in the next diagram.

The histograms depicted in figure 2 a), b) and c) show a synthetic version of the results.

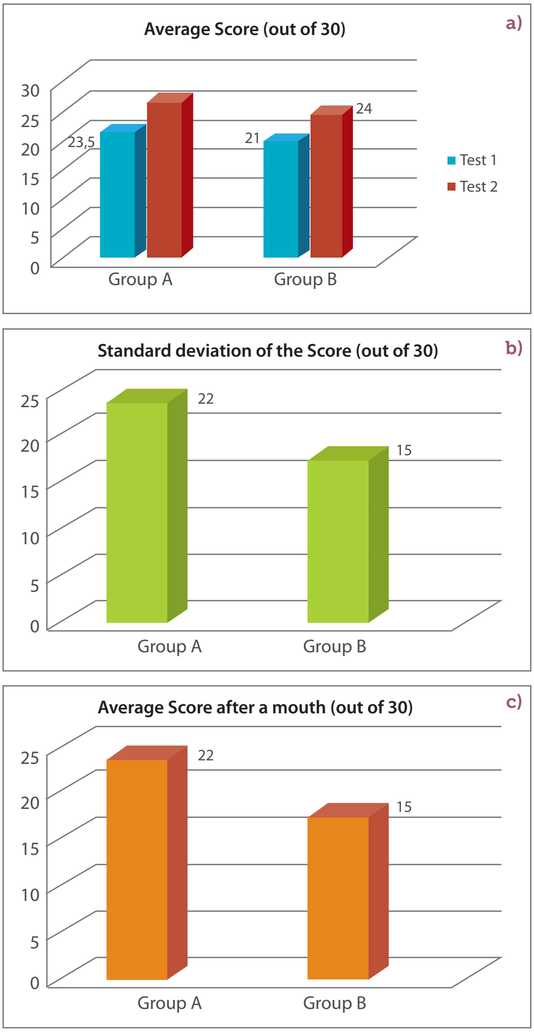

Figure 2: Testing outcomes: a) average scores of a multiple choice test; b)standard deviation; c) persistence of the results

Conclusions And Future Developments

This experiment has shown that performance of secondary school students can benefit of flipped classroom strategy in learning difficult topics, such as quantum mechanics in CLIL methodology. These outcomes, very persistent in time, were gathered by a multiple choice questionnaire and reports.

Potential future developments of this experience are the extension to larger numbers of students, the introduction of different methodologies and the research of the similarity of the issues encountered in quantum mechanics with the ones encountered in other similar topics.

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HISTORY AND PHILOSOPHY OF PHYSICS

11

"QUANTUM HEALING": SCIENCE, POPULAR SCIENCE, PSEUDOSCIENCE OR MYTH?

An Analysis Based On Ludwik Fleck

Marcia Tiemi Saito, Ivã Gurgel

| INTRODUCTION

The demarcation problem in sciece education

In Science education, there is an established consensus about the importance of Nature of Science (NOS). This subject is important for students to form a critical view about science. And it has been advocated as a critical educational outcome by many science education reform documents worldwide (Lederman, 2007).

In spite of the agreement about the importance of NOS, there is little agreement about what exactly that nature is (Martins, 2016). Nevertheless, some authors defend that these disagreements are irrelevant to K-12 children instruction, and they advocate the existence of a consensus view about the NOS for educational proposes (Abd-El-Khalick, 2012; Lederman, 2007; McComas, 2008). This consensus view is very criticized by other authors (Dushl and Grandy, 2013; Mathews, 2012; Van Dijk, 2011, Clough, 2007).

However, if the aim of teaching about NOS is to develop a critical view about science, the discussion about what is NOS is a great opportunity to develop this criticism and philosophical thinking in the students. In particular, the demarcation problem, or the problem of what can be considered as science and what not, is an interesting and objective subject to discuss about NOS.

Thus, at the present work, we analyze the cultural phenomenon called "Quantum mysticism" (Pessoa, 2011). This phenomenon has its origins in the Quantum Physics itself, on the discussions about the need for a conscious observer in the result of an experiment occurred during the period of construction of this theory (Marin, 2009). And, it can be considered a cultural phenomenon, because of the different and widespread uses of Quantum Theory on non-scientific communities. In this way, it is a subject strictly related with the demarcation problem.

Specifically, we analyze the mystical Deepak Chopra's book, entitled "Quantum healing". The definition of "quantum healing" in this book is based on the assumption that mind can produce body healing and the author explains that by using the concepts of Quantum Physics. However, scientists consider this explanation inappropriate. Thus, the aim of this work is discuss if this uses and explanation can be considered as science, popular science, pseudoscience or myth, according to Ludwik Fleck's epistemology. We consider that this is a concrete subject, related with NOS and the demarcation problem, which can develop critical views about science, philosophical thinking and help students to make informed decisions about alternative medicine methods and socioscientific issues in general.

The epistemology of ludwik fleck (1896-1961)

The theoretical framework used to analyze this problem was Ludwik Fleck's epistemology. In his book "Genesis and development of a scientific fact" ([1935]1979), Fleck discusses the differences between science, popular science, pseudoscience and myth, in a socio-historical perspective. Thus, indirectly, he discusses the demarcation problem. Fleck does not present these four elements as categories, but he discusses them in the formulation of his epistemology. At the present work, we present a brief outline of his main concepts.

For Fleck, the construction of knowledge is not made by means of a dual relationship between subject and object. This relationship is necessarily mediated by the current state of knowledge, which includes historical and style factors. According to him, knowledge is a result of a historical, social and collective process. This means that the collectives imprint their marks while they are building knowledge. That is why he defines the thought collective as a community of persons mutually exchanging ideas or maintaining intellectual interaction. It can be understood as a "special „carrier" for the historical development of any field of thought, as well as for the given stock of knowledge and level of culture" (Fleck, 1979, p. 39). Every thought collective is characterized by a thought style, which is defined as "the readiness for directed perception, with corresponding mental and objective assimilation of what has been so perceived" (Fleck, 1979, p. 99). It is a kind of coercion of the thought, a directed perception and action, which defines "what cannot be thought in another way". According to Fleck, a neutral and impartial observation does not exist. The thought style guides the way a certain thought collective perceive the form/phenomenon and act on them, it establishes the way of seeing, feeling, the methodologies adopted, and the way they construct knowledge. It is not fixed, but it changes and mutates over time.

Thus, for Fleck, science is a thought style, proper to a specific thought collective, which is characterized by common features in the problems of interest to this community, by the judgment which they consider evident, and by the methods which they apply as a means of cognition. This thought collective is organized in an internal esoteric circle and an external exoteric circle. The "experts" are placed in the esoteric circle, i.e., the researchers who creatively approach a problem or related problems. And, the exoteric circle comprises the more or less "educated amateurs", i.e., individuals who share the thought style indirectly by means of the esoteric circle. Therefore, the esoteric circle is the place of the expert knowledge and the exoteric circle of the popular knowledge. Thus, popular science, in the strict sense, is science for non-experts, characterized by the absence of details and especially of controversies, which produces an artificial simplification of the scientific concepts. It is placed on the exoteric circle, and, the further we go away from the esoteric circle, knowledge is more secure and obvious. It is the background that determines general characteristics of a thought style, because it shapes specific public opinion as well as a worldview about it. Consequently, the relationship between science and popular science is of interdependence, since popular science emerges from specialized knowledge and it also has a retroactive effect upon the experts, once it shapes the public opinion.

Fleck also explains that every stable thought collective, like science, cultivate certain exclusiveness, both formally and in content. This exclusiveness causes a limitation upon the problems admitted by the thought collective and, consequently, a rejection or ignorance of many problems, usually considered as trifling or meaningless. Thus, according to Fleck, a universal or consensual judgment about what can be considered a "bogus problem" or "pseudoscience" does not exist. There are just problems considered meaningless or trifling by a specific thought collective.

Finally, to distinguish science from myth, Fleck uses the concepts of passive and active connections. The passive connections are related to the so-called "objective", to what is inevitable, to what cannot be thought in another way, and to the maximum coercion of the thought. And the active connections are related to the so-called "subjective", to what is possible to come from the individual, and to what can be considered freely invented. Of course, these two are not strict and separate concepts, but they influence each other. For Fleck, not a single statement can be formulated from passive connections alone. But, science tries to include in its system a maximum number of them, while myth contains only a few of these passive elements. That is the difference between them.

Quantum healing in fleck's view

Firstly, based on Fleck's concepts, we analyzed if Deepak Chopra's "quantum healing" can be considered as popular science. To do this, we looked at the definition of "quantum" at the following excerpt of Chopra's book.

The word that comes to mind when a scientist thinks of such sudden changes is quantum. The word denotes a discrete jump from one level of functioning to a higher level – the quantum leap. (...) In layman's terms the quantum is a building block. Light is built up from photons, electricity from the charge of one electron, gravity from the graviton (...), and so on for all forms of energy. (Chopra, 1989, p. 15-16)

We can observe that the author presents part of the Quantum Theory without mentioning its controversies, as a solid theory, composed of many definitions that can only be understood by analogies with other known concepts, as an explanation for the layman. Through these analogies, he also makes an artificial simplification of the concepts, using an illustrative and aesthetically pleasing explanation. These are elements of the fleckian popular science. However, the author makes some conceptual mistakes, when he says that quantum is the discrete jump, "the quantum leap". This conceptual mistake takes him out of the exoteric circle, and consequently from the popular science category. Thus, "quantum healing" cannot be considered as popular science, but it has some elements of this category. Therefore, it may also determine general characteristics of its corresponded thought style.

Second, we analyzed if "quantum healing" can be considered pseudoscience by looking at the following excerpt of Chopra's book.

The word holistic, which tends to offend orthodox doctors, simply means an approach that includes the mind and body together. I belive Ayurveda does this better than any alternative, althought it may not be very apparent on the surface. (Chopra, 1989, p. 11)

Here, the author recognizes that may have a rejection by the scientific thought collective, which he represents as "orthodox doctors". Then, he tries to defend himself painting his theory as something simple and completely compatible with the science thought style. Thus, because of this rejection, we conclude that "quantum healing" can be considered as pseudoscience, but only from the point of view of the scientific thought style.

Finally, we analyzed if "quantum healing" can be considered science or myth, by looking on how Chopra defines this term at the following excerpt.

I would like to introduce the term quantum healing (…). There have always been patients who do not follow the normal course of healing. (…) Many cures that share mysterious origins – faith healing, spontaneous remissions, and the effective use of placebos, or "dummy drugs" – also point toward a quantum leap. (…) In all of these instances, the faculty of inner awareness seems to promote a drastic jump – a quantum leap – in the healing mechanism. (Chopra, 1989, p. 16)

From the extract, we can see that the author explains some healing processes based on analogies with scientific or quantum theories. This explanation based on analogies drives us to the use of active connections, once it can be considered a freely invention. Besides that, the explanation about the "quantum healing" shows us a dependence on other thought styles explanations, since he uses scientific concepts. This can be interpreted as a non-existence of an own methodology and show us a low number of passive connections, i.e., a low coercion of the thought. Thus, we can conclude that "quantum healing" departs from science and approximates itself of the myth category.

Final considerations

It was possible to observe that we cannot totally fit "quantum healing" in any of the categories. This term cannot be considered popular science, but it has some of its characteristics and, consequently, it may determine general characteristics of the corresponded thought style. It also can be considered pseudoscience just from the point of view of the scientific thought style. Finally, "quantum healing" has some characteristics which makes it depart from science and approximate itself of a myth. Despite the difficult on fitting "quantum healing" in a category, this discussion allows us to make a philosophical analysis about the differences between scientific and non-scientific interpretation of phenomena and its possible consequences, which is an analysis related to the demarcation problem. Thus, it can help students to develop a critical view about science, philosophical thinking and make informed decisions.

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THE EPISTEMOLOGICAL MOVES OF MARIO SCHENBERG BETWEEN 1934 AND 1944

Alexander Brilhante Coelho, Ivã Gurgel

| INTRODUCTION

According to a research carried out by an agency of the Brazilian government (CENTRO DE GESTÃO E ESTUDOS ESTRATÉGICOS, 2015), only 12% of Brazilians can mention the name of any national scientific research institute, and only 6% of Brazilians can mention the name of any national scientist. Although the Brazilian scientific production is recent and of a limited reach, it is possible to state that these figures express the ignorance of the Brazilian citizen regarding Brazil's scientific production, given that other Latin American countries with a scientific production tantamount to that of Brazil display much higher figures, as is the case of Chile and Venezuela, countries where almost 30% of the population can mention the name of some scientific institution.

Gurgel et al (2016), in their study of the role played by cultural identity in the learning process, defend that, largely, the lack of engagement of the Brazilian students in the scientific subjects, more so than the mere effect of motivational or affective factors, is the result of the students acknowledging – more or less consciously – an incompatibility between the cultural elements that make up their identity and the school's scientific culture. That is, not acknowledging their country as a place that takes part in the construction of the scientific knowledge entails the construction of an identity which hinders the learning of the sciences.

The following work aims at contributing to change this state of affairs, thus contributing to the development of the historiographical production concerning the Brazilian physics, while providing material to future propositions for the teaching of sciences which seek to take the Brazilian scientific production into the classroom. That is the spirit of this work on Mario Schenberg, one of the pioneers of physics in Brazil, and a character of prominence in the Brazilian intellectual life of the twentieth century.

Heterodoxy and institucionalism

Mário Schenberg was born in 1916, and in 1934 he publishes his first article, Principles of Mechanics, which we will analyze. In the following year, with the establishment of the Universidade de São Paulo, he joins the first class of Mathematics. In 1937, Gleb Wataghin, an Italian physicist responsible for starting the researches on Physics at Universidade de São Paulo, appoints him as assistant professor of Theoretical Physics, and has Schenberg go to Rome to work with Enrico Fermi. Around this time, Schenberg meets several internationally renowned physicists, and in 1940, goes to the United States, where he works with George Gamow and Subramanyan Chandrasekhar, who would later win the Nobel prize, and they publish together the article On evolution of the main-sequence stars, which originated the "Schenberg-Chandrasekhar limit". In 1942 he is named professor of Superior Physics at USP, and in 1944 becomes University professor of Celestial and Rational Mechanics.

Mario Schenberg builds a solid reputation in these ten. Beyond his institutional role, the singularity of his epistemological stance has influenced countless Brazilian physicists, particularly in the final years of his life, when, in his conception of physical theory, the rationality and formal precision of the mathematics begin coexisting with elements that are not usually linked to the scientific production, as intuition, spirituality and Marxism.

A fair portion of our research is devoted to understanding this sui generis configuration of Schenberg's thought. We are intrigued by the fact that this configuration manifests itself in the main character of the institutionalization of Physics in Brazil, for, in general, the outsiders are the spokespeople of the heterodoxy.

Material analysed and work plan of the research

We are going to present the results of the analysis of two of Schenberg's early works. The first, the article Principles of Mechanics, published in 1934, deals with the epistemology of Physics, and was written while Schenberg was still a student. The second work, also titled Principles of Mechanics, was published in 1944. These works, allowed us to characterize the move of the epistemological stance of the young Schenberg.

In our work plan, we try to analyze the works internally, in order to find the prevailing epistemological stance, our goal being the characterization of the prevailing epistemological stance in each period. Besides the internal analysis, we seek to establish the connections between the epistemological elements that are present in the works of other authors whom Schenberg resorts to.

Work from 1934: predominatly inductivist epistemological stance

In order for our characterization of Schenberg's epistemological stance in 1934 to be clear, we will resort to some passages of the article. The first passage reads as follows:

If we take a battery from Daniel and connect it to several circuits, we will notice a different current in each case. If instead of simply making a table with the results we tried to find a law, we would arrive at Ohm's law. (SCHENBERG, 1934)

The formulation of a law, in this passage, has an inductivist flavor, there being no reflexion concerning the complexity of the leap between the data on a table and the formulation of the law.

The next passage, on the other hand, establishes a hierarchy between inductivist and deductivist theories, with a clear superiority of the inductivist theory. According to Schenberg:

The new fields of science belong to the deductivist theories, where an interest in discovering new phenomena prevails, despite some aesthetical sacrifices, It is for the inductivists theories to substitute the deductivists theories on the already established fields, considering its aesthetical perfection and superior accuracy of its methods and results. (SCHENBERG, 1934)

The deductivist theories are thought to be aesthetically inferior and less accurate than the inductivist theories. Furthermore, Schenberg suggests that the history of physics unfolds in the discoveries of new phenomena and by the substitution of deductive theories by inductivist ones. In other words, physics is thought to evolve by widening the realm of phenomena that could be described accurately, more emphasis being placed on the stability of the physical laws than on their historicity and constructive aspects.

Schenberg's epistemological stance in 1934 owes a lot to Mach and Duhem. In the next passage, which, by the way, opens the article, Schenberg states his filiation to the Ernest Mach's idea of economy of thought. He says:

Science has as its end the prediction of future phenomena from known past phenomena, in the most economical way possible. The idea of economy advocated by Mach is universally accepted today. (SCHENBERG, 1934)

The concept of physical law is stated as follows:

Laws are relations between abstract elements which we make correspond to the phenomena by means of our measurement devices (SCHENBERG, 1934)

This idea, which articulates – without making them identical – the phenomenon, the measurement, and the mathematical relation, can be found in other physicists from the end of the nineteenth and beginning of the twentieth century, as, for example, in Pierre Duhem; in Duhem it is present in a very similar form.

Another aspect in which Schenberg follows Duhem closely regards the association between the explicative theory and metaphysics (contrary to the representative theory, associated to a metaphysics-free science). We can, in a sketchy way, associate the idea of explicative theory to the idea of a theory which contains non-verified suppositions. The condemnation of this kind of theory can be found in several authors, but the way Schenberg presents his arguments and the jargon he uses have a clear inspiration in Duhem.

Work from 1944: a more constructivist epistemological stance

We will now move on to the analysis of the work "Principles of Mechanics", from 1944. Besides sharing the same name, the works have homologous parts, which makes them particularly interesting in order to notice the shift in the epistemological stance in this 10-year gap between the works.

Objectively, what matters in a theory is the description of the phenomena it encompasses. Subjectively, the explanations, besides their immense heuristic value, are indispensable. Each theory necessarily contains an explanation, (…) an image of the physical phenomenon. (SCHENBERG, 1944)

The first passage we selected shows that Schenberg stops condemning the explicative theory. In the work of 1934, Schenberg condemned this type of theory, labeling it as metaphysics. Ten years later, Schenberg affirms that they are indispensable for the construction of an image of the physical phenomenon.

The second passage we selected emphasizes the role of the subject in the construction of physical theories:

The multiple explicative theories of a phenomenon make use of different idealizations of experimental data, and for that reason provide different images of the phenomena. The image present in a theory is characterized by the choice of its concepts and postulates, i.e., by what is called axiomatic of the theory (SCHENBERG, 1934)

As we can see, Schenberg moves away from the inductivism as it was present ten years earlier, when he referred to the relation between the data and Ohm's law. The role of the subject's choices, of the different possible idealizations in the construction of the images of the phenomenon, are present, ten years later, with much more power.

Another change that seems quite clear refers to the way Schenberg understands the historicity of physics, as we can see in the third selected passage:

Each theory corresponds to a determined historical stage of knowledge, and sooner or later is in conflict with the experimental data, having to be substituted by an improved one.

Here, although there is an idea of progress, there is no idea of a secure knowledge, and the fate of every physical theory is to be defeated by the experimental data. This idea is quite different from the idea of the evolution of physics expressed 10 years earlier.

We shall now leave the internal analysis of the work and look for Schenberg's epistemological filiation in 1944. It seems that in the work of 1944 the association between the idea of theory and the idea of image is the pivotal issue of the epistemological change. This association is strong in Hertz, whom Schenberg mentions explicitly in some passages of his thesis. As is the case with Schenberg, Hertz emphasizes the active role of the subject of knowledge, the role of his choices, in the construction of theories, also emphasizing the possibility that various different theoretical constructions are equally possible and pertinent. We believe that what Coelho says about Hertz also applies to the 1944 Schenberg. According to him:

The proposition, 'a physical theory is an image build by us', synthetizes Hertz's philosophy of science (COELHO, 2007)

It is in this sense that we affirm that Schenberg has a more constructivist epistemological stance. The term constructivism is certainly not a good term, given that, besides being quite polisemic, evokes the idea that the theoretical construction is a social construction, idea which is absolutely alien to the work of Schenberg. We have used the term constructivism as it is meant in Coelho's comment regarding Hertz, i.e., as opposed to an inductive idea of the theoretical formulation.

Final considerations

We have tried to clarify Schenberg's epistemological moves between 1934 and 1944. It is our hope to have shown that in a decade Schenberg goes from an inductivist stance to a more constructivist stance, parts from Mach's and Duhem's epistemology, and gets closer to Hertz's epistemology, abandoning the aversion to metaphysics while approaching the idea of image. Moreover, he changes his understanding of the historicity of physical theories.

We hope this work contributes to the development of the historiography of the Brazilian science, and, moreover, that this work can provide support to the Brazilian teachers in the craft of educational propositions which discuss historical and philosophical issues of the sciences in the classes of physics, by resorting to the ideas of a Brazilian scientist.

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VARIOUS TOPICS 12

GROWING TALL POPPIES: FINDINGS FROM A PARTNERSHIP PROGRAM BETWEEN STUDENTS AND SCIENTISTS

Peter Hubber & Eroia Barone-Nugent

| INTRODUCTION

There is widespread concern about the engagement of students with school science and uptake of Science Technology Engineering and Mathematics (STEM) disciplines in the post compulsory years of schooling (Osborne & Dillon, 2008). Within the Australian context the participation rate of Year 12 students undertaking the subject of physics as a proportion of the total Year 12 cohort fell from 21% to 14% over the period 1992 to 2012 (Kennedy, Lyons & Quinn, 2014). Over this period the proportion of girls in Australian Year 12 Physics cohorts decreased from 29% to 24% (see Figure 1) indicating a significant gender imbalance. The underrepresentation of girls in Year 12 Physics accentuates the flow on effect of fewer girls pursuing and being represented in tertiary physics-based courses and work beyond Year 12.

Hazari et al (2010) suggests that the lack of sufficient growth in both female and overall participation in physics at secondary schools makes it imperative to re-examine the current approach to the teaching and learning of physics with calls for more inquiry-based approaches that better represent contemporary practice in the sciences. Student–scientist partnerships is one strategy that employs authentic, inquiry-based learning to provide students and teachers with access to the scientific community that gives students insights that will enable them to make informed career choices (Houseal, Abd-El-Khalick & Destefan, 2014). Such partnerships imply more than a one-way flow of information from an expert to learner as the term 'partnership' implies direct benefits for all parties involved. The ways in which partnerships between schools and universities become established and maintained, to support students at secondary schools, are not well documented (Tomanek, 2005). Identifying the key elements of successful partnerships between scientists and students can provide clarity about how to support girls' engagement and uptake in secondary school physics.

This paper describes the national implementation of an Australian student-scientist partnership program aimed to increase the participation of girls in physics beyond the compulsory years. It is a three-year fulltime federally funded (2015-18) project in its second year of implementation. The project entails the widespread implementation of the Growing Tall Poppies (GTP) program (Barone-Nugent et al, 2012) where Year 10/11 female students attend a science organisation for 3 to 5 days wherein they work with scientists to undertake an authentic research project directly related to a current research area. As part of the GTP program students are expected to present their findings on a poster and give an oral presentation to peers, teachers and scientists. These are uploaded to the GTP website (http://www.growingtallpoppies.com/).

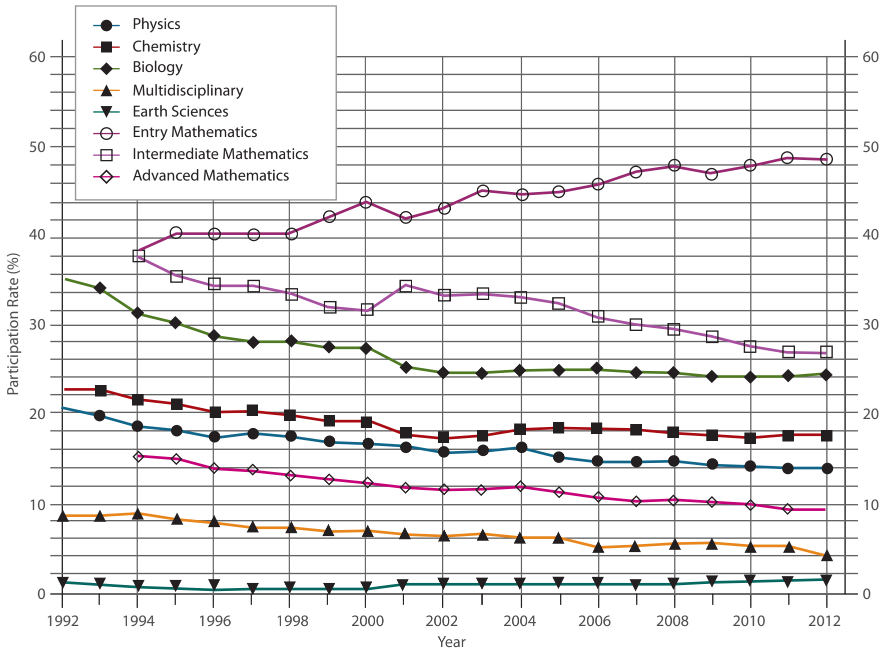

Figure 1: Student sex ratios within each subject 1992-2012 (Kennedy, Lyons & Quinn, 2015 p.39).

Upscaling the growing tall poppies (gtp) program

The GTP program began in 2008 as an initiative between a metropolitan girl's school and a large research centre of excellence that was working in the interdisciplinary areas of physics and biology. Since GTP's implementation at the school there was a statistically significant increase in girls enrolling in physics in Year 11 and completing Year 12 Physics (Barone-Nugent et al., 2012). The aim of implementing the GTP program on a wider scale in Australia is to enhance the status of school physics by partnering more schools with science organisations and to increase the retention of girls beyond the compulsory years into Year 12 Physics.

The central role of developing partnerships with physics organisations is to provide authentic out of class experiences to address the mindset girls may have about the interdisciplinary nature, the stereotypes and the career opportunities available by studying physics. The key elements for this partnership program are:

Growing tall poppies partnership program

ff) A facilitator to broker participation of scientists and teachers, such as between a research Centre of Excellence based on crystallography and diffraction imaging and one or more participating secondary schools;

gg) A framework to guide the development of an authentic student-inquiry programs with scientists, such as 'Colder than the depths of space' based on current research project where students, mentored by the scientist, design and test a diffractometer and apply it to crystallography;

hh) A professional development program for the scientist – mentors to prepare them to lead the groups of secondary school aged students to participate creatively in the inquiry project; and

ii) Students are supported to take leadership with their project and work alongside scientists to produce a report to elaborate the authentic experience and publish their project outcomes onto the GTP website.

Methods

In 2015 seventeen schools and three science organisation participated in GTP programs and scientists, teachers and students from four schools and two science organisations were interviewed (semi-structured) about their experiences. Data included posters constructed by the students, which outlined their findings of their inquiry project and gave any new insights they had in relation to physics, physicists or careers in physics and included professional and personal histories of their science mentors.

Findings

The key findings in the initial phase of the project relate to perceptions of science mentors, students, and school mentor experiences of the GTP program.

Science Mentor Perceptions

The scientists gained experience in science communication skills to enhance their curriculum vitae to pursue career advancement, satisfaction in being able to explain their work to a general audience, and providing mentoring to young aspiring scientists.

The science mentors gained experience in communicating their science to the non-scientific community which that saw they considered as an important skill as a scientist. This view was expressed in the following comments by the scientists:

It (the GTP program) assisted me to refine my ability to communicate science in lay language that would excite the students - an important skill for science communicators… I think as a scientist, it is our role to show the next generation how fabulous science is, and that there is an amazing career available should they pursue it!

I gained confidence in my communication skills… the skills of communicating and promoting interest in physics shouldn't be minimised for researchers.

Helps me understand what I know because to explain it I really have to understand it. It is about explaining the core of the science to people who are not scientists, and it's possible to do physics without being an Einstein type genius.

There was a view that participation in programs such as GTP was not as valuable to the scientist in terms of status as publications might provide, but did give "something else on my CV (Curriculum Vitae) for future job applications as teaching is often associated with more permanent positions as member of faculty."

Student Perceptions

Students gained enhanced understanding of the personal histories and every-day activities of contemporary physicists, careers related to physics, and how contemporary physics research is interdisciplinary and socially constructed and relevant. Such views are expressed in the following comments.

Through this programme I have developed a better understanding of physics on a broad scale. In a short period of time, I have developed a clear image of the opportunities associated with physics and the possibility of a career in physics.

I gained an understanding of what it's like to be a scientist…of how science is applied in the real world.

It is really important that we break down this stereotype (only men are physicists), as women have a lot to offer in the physics field, they just need to be given the opportunity.

We get to investigate all areas in science that we don't get to cover in school….it gives an indication of whether science is a path I should follow in my future. We got to do things that scientists would do.

I can now honestly say that I can see myself doing something in the physics field or at least pursuing it at until year twelve. I have developed an understanding of the many avenues physics can take you in and the broad spectrum of work of which physicists do. I am definitely going to continue my study of physics to the end of high school and will seriously consider continuing into university.

School Mentor Perceptions of the Program

The school mentors found that the GTP program addresses elements of the science curriculum that deal with the 'nature of science' and 'science as a human endeavour'.

Growing tall poppies partnership program

The program gives students some exciting experiences, the chance to look at real science and the environment in which scientists work as well as meeting the scientist to give them a more realistic idea about the sorts of people scientists are, you know ordinary and varying but with passion for what they do.

I think it is vital for the future of school science to give the students an authentic link to the real world of science and scientists and give them the opportunity to be more informed about the possibilities for a possible career is the science and technology fields.

Conclusion

In conclusion, the evidence from the GTP partnership program indicates that providing students with planned, short but intense experiences with scientists can motivate and increase the likelihood of girls to continue their study of physics beyond the compulsory years of school. The GTP program's success on a small scale is being supported as a model for wider implementation and the support it has gained at a federal government level recognises that ongoing research and exploration is needed. Partnership success requires clarity around the pathways for scientists and schools to collaborate to produce authentic learning experiences that underpin socially relevant contemporary science as a means of engaging and motivating students to study physics. The critical aspect highlighted by the GTP program is the need for facilitating individuals (brokers) and a centralised communication network (website) in establishing the initial partnerships and then getting scientist and teachers to collaboratively design and create a project of mutual benefit to all participants.

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AAPT ACTIVITIES

Gordon P Ramsey

Paper presented at the WCPE2 conference in Sao Paulo, Brazil, 11 July 2016

This paper outlines some of the activities presently occurring within the American Association of Physics Teachers (AAPT) and some future plans for the organization. AAPT is an international organization of about 8000 members, representing every inhabited continent in the world. Its mission is: "to enhance the understanding and appreciation of physics through teaching". See http://aapt.org for details.

About AAPT:

AAPT's membership spans the globe and consists primarily of physics educators at all levels from many different countries. The Board of Directors provides the governance of the organization, carrying out the Strategic Plan, setting policies and overseeing its major activities. The Executive Officer and staff run the daily operation of the organization. AAPT has local sections throughout North America that operate local and regional meetings, and activities supporting physics education. Each section elects a representative to the national organization. The section representatives connect the local members with the national AAPT. Area Committees are topical in nature and advise the Board of Directors and the Executive Office on issues related to their particular focus. They provide valuable input in governance issues.

AAPT's goals include:

a) Increase AAPT's outreach to and impact on physics teachers

b) Increase the diversity and numbers of physics teachers and students

c) Improve the pedagogical skills and physics knowledge of teachers at all levels

d) Increase our understanding of physics learning and of ways to improve teaching.

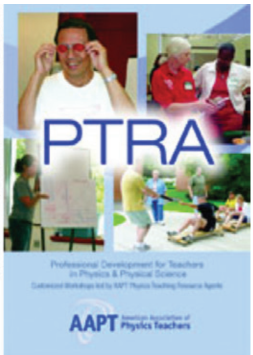
These goals are accomplished through the various activities sponsored by AAPT.

Teacher training:

AAPT provides teacher training both pre-service as undergraduates and in-service while teaching in secondary school. Separate workshops are held for two-year college and university faculty. The Physics Teacher Education (PhysTEC II) program is co-sponsored with the American Physical Society (APS) and is designed to support physics departments to recruit undergraduate students to be high school physics teachers, support best practices and work with colleagues in education schools to establish teacher-training centers. Emphasis is on hands-on activities, laboratories and pedagogical approaches to teaching. Specific practices are supported by physics education research (PER) findings.

The Physics Teacher Resource Associates (PTRA) have been involved in secondary education teacher training for over thirty years. Topical workshops are periodically held at various locations throughout the US. Teachers are certified to hold workshops in local regions. This way, the effect of these workshops is quickly spread throughout the country.

The Resource Agents meet at national AAPT meetings to discuss results and plans for future workshops.



The PTRA teachers continue to develop topical resources and make them available to teachers for classroom use. The PTRA program serves in-service K-12 physics and physical science teachers. For further information, see http://www.aapt.org/PTRA/.

For ongoing teacher training, AAPT has recently been awarded a grant from the 100K in 10 project for the "Microchip" program. This includes forming a group of experienced teachers to advise AAPT in K-12 professional development efforts.

Faculty workshops and conferences:

AAPT in partnership with APS, the American Astronomical Society (AAS) and the American Institute of Physics (AIP) conducts new and experienced faculty workshops in physics and astronomy on a continuing basis: http://aapt.org/Conferences/#workshops. These are funded by the National Science Foundation. The New Faculty Workshops are aimed at four-year college and research university faculty. In addition, AAPT offers a New Faculty Experience for two-year college faculty. These experiences address the special challenges faced by faculty in two-year colleges and the needs of their students.

Joint with APS and AIP, AAPT hosts an annual Department Chairs Conference. Physics department chairs from universities are invited to participate. These include discussions of successful physics programs, grants available, dealing with administrations in support of physics and a special Congressional Visit Day. Chairs have the opportunity to visit with Congress and their staff to discuss physics education related policies.

The affiliated Advanced Laboratory Physics Association (ALPhA) conducts frequent workshops and topical conferences on equipping and running state-of-the-art advanced physics labs. The "Beyond First Year Physics Labs" triennial conferences (BFY) and special summer "Immersions" are conducted by ALPhA in partnership with AAPT and are funded by NSF. These programs concentrate on curriculum development and faculty-staff training in lab activities. See http://www.advlab.org/ for further information.

K-12 workshops and outreach:

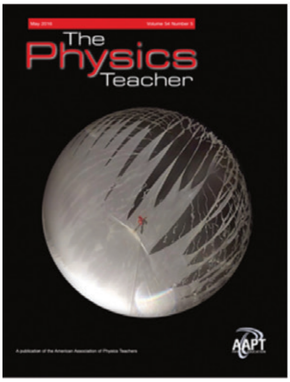
AAPT offers workshops for K-12 teachers at national meetings and periodically, at the AAPT headquarters in College Park. Recently, AAPT in conjunction with the Optical Society of America (OSA), has held workshops for teachers, where the participants take home optics equipment and curriculum for use in teaching waves. A combined workshop, involving AAPT, OSA and the Acoustical Society of America (ASA) with joint planning is in progress. This will address waves from an optical and acoustical perspective.

Significant online resources are available to K-12 teachers, including networking that connects beginning teachers with experienced teachers through the eMentoring program (http://ementoring.aapt.org). AAPT also offers e-mail discussion lists, resources for new teachers, connections to YouTube related sessions at AAPT meetings, awards and funding for K-12 physics teachers. For further details, see the K-12 portal at http://aapt.org/Resources/K-12.cfm.

Research and Publications:

AAPT edits and distributes two publications: The Physics Teacher (TPT) and the American

Journal of Physics (AJP). We also cosponsor Physical Review Special Topics: PER with APS. TPT is focused on secondary and beginning college physics topics, while AJP concentrates on beginning college through university levels. All are peer-reviewed.



The Physics Teacher (http://aapt.org/Publications/tpt.cfm) is published nine months per year and includes articles and columns such as Figuring Physics, Little Gems, Astronotes, Physics Challenge for Teachers and Students, Fermi Questions, Visual Physics, IPHYSICSLABS, and Websights. These cover a wide variety of topics that are of interest to secondary physics teachers and beginning college instructors. General physics articles that can be used in physics classrooms are often included. Three articles per issue are available free through Scitation.

American Journal of Physics (http://aapt.org/Publications/ajp.cfm) is also published monthly. In addition to journal articles, AJP publishes periodic Resource Letters that give an overall review of a contemporary physics topic and comprehensive references related to that topic. These resources are designed to be used as part of courses in physics where connection to current research is needed. Articles on Physics Education Research are included, as well as book reviews and announcements.

AAPT cosponsors Physical Review Special Topics - Physics Education Research, a peer reviewed electronic-only journal (http://aapt.org/Publications/perjournal.cfm). The scope of the journal includes the full range of experimental and theoretical research on the teaching and/or learning of physics. This includes review articles, replication studies, descriptions of the development and use of new assessment tools, presentation of research techniques, and methodology comparisons/critiques.

ComPADRE:

ComPADRE is a digital library http://www.compadre.org/ that provides a wealth of resources for all levels of physics teaching. It has links to physics education organizations that provide resources and assistance in all aspects of physics education. Many AAPT projects, including "Intro physics for the life sciences", a 4-year project involving eight universities funded by NSF, establish comPADRE sites for materials to use in physics courses designed for the life science students.

Curriculum and Programs:

In addition to the comPADRE library of resources, AAPT is involved in development of programmatic and curricular materials for physics education. The Joint Task Force on Undergraduate Physics (JTFUP) is a joint program with NSF and APS to develop guidelines for enhancing undergraduate physics programs for training in diverse careers. The Task Force report (http://www.compadre.org/jtupp/report.cfm) provides information about the skills and knowledge that employers of physicists are seeking, and describes ways in which physics departments can help students acquire those skills and that knowledge. The Physics Teaching Education Coalition (PhysTEC) addresses the shortage of secondary physics teachers by hosting conferences and workshops, and providing guidelines for training students in the profession.

Curricular projects include developing curriculum and guidelines for Physics in the Life Sciences (IPLS). A majority of service courses in U.S. universities provide physics instruction for pre-medical and biology students. This project helps to identify the physics concepts that are most important to these students and best practices to present this material. The emphasis is to help these students understand physics concepts and how they apply to biology and medicine. "Implications of Computational Physics in Majors Courses" is a project funded by NSF aimed at providing knowledge and experience of various aspects of computation that are necessary for doing physics and engineering. It will provide guidelines on the adoption of computational work throughout undergraduate physics programs. Faculty development and training on integrating computation into the curriculum will also be provided.

International Activities:

Approximately 14% of our members are from outside the U.S.A. As such, we are involved in many international activities. Our members contribute and attend international conferences in physics education and are involved in international activities. There is an Area Committee on International Physics Education that consists of members both within and outside the U.S. AAPT supports US participation in the International Union of Pure and Applied Physicists' (IUPAP) International Conference on Women in Physics. AAPT has supported travel for U.S. Delegates, the conference proceedings and a video

(https://www.youtube.com/watch?v=ofE-mJFJR5w)

with funding from NSF. The recently formed Jossem Fund has provided funds to this conference to support attendance of developing countries to WCPE2. There is an AAPT representative to the U.S. Liaison Committee (USLC) of IUPAP. Many of our members participate in the IUPAP Commission C14 working group in Physics Education. Announcements of International Conferences can Be found at http://de.physnet.net/PhysNet/conferences.html, as well as links to international physics education organizations: http://aapt.org/Resources/#ICP. AAPT also offers membership for individuals from developing countries. Students can apply to the Yamani Fund (http://www.aapt.org/Programs/grants/Yamani.cfm) and practicing physics educators can apply to the Fuller Fund (http://www.aapt.org/Programs/grants/fullerfund.cfm).

AAPT future projects:

This paper highlights some of the activities sponsored and operated by AAPT, but only touches the surface of activities. AAPT.org has a comprehensive coverage of the projects in which our members participate. There are projects in the planning stage as well.

We are working to expanded workshops for middle school teachers (grades 6-8). We presently offer an optical waves workshop in conjunction with the Optical Society of America. In addition, we are planning to expand this to include acoustical waves. This will include input and materials from the Acoustical Society of America.

AAPT members are seeking to collaborate on common projects in cooperation with worldwide physics education organizations. In addition, we are working on reciprocal agreements with these organizations for memberships and conference fees.

The American Institute of Physics (AIP), a federation of ten U.S. based physics professional societies, is seeking to increase collaborative programs with their member organizations, including AAPT. We will continue to pursue effort such as these. Any suggestions are always welcome.

Acknowledgement: I gratefully acknowledge Beth Cunningham, Executive Officer of AAPT, for careful reading of the manuscript and providing useful suggestions.

Afiliation

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LABORATORY ACTIVITY FOR CENTRE OF MASS & MOMENT: CLIMBING WHEEL

Beril Yilmaz Senem, Canay Pekbay

| INTRODUCTION

Description of science education changed from transferring of text materials to making science activities. The term "hands-on" which allows students experience science by doing, is commonly used in science education. Hands-on activity involves students in manipulating objects to gain knowledge (Haury & Rillero, 1994). Rutherford (1993) states that hands-on in general means learning by experience. Moreover, working in a hands-on activity offers a more realistic and exciting experience of the content (Franklin & Peat 2005; Nott & Wellington 1996).

There are many studies showing that using hands-on activities causes positive motivational outcomes. For example, in biology teaching, Vogt et al. (1999) studied how interesting precise phases of the biology lesson were perceived to be by students. Phases including topics of relevance for students or practical work, such as working with microscopes, were regarded as highly positive. Moreover, Renner et al. (1985) made interviews with students how they feel regarding learning activities like laboratory work. They identified laboratory work as being 'interesting' as compared to other more 'boring' instructional formats like watching films or listening to the teacher. Thompson & Soyibo (2002) asked students two different settings within their chemistry classes. The experimental group was taught in small groups, electrolysis for nine lessons by a mixture of lecture, teacher demonstration, class discussion and practical work. On the other side, the practical work was substituted to control group by teacher demonstrations. After the treatment, the experimental group showed more positive attitudes towards chemistry, measured by indicators such as enjoyment of chemistry and interest in chemistry inquiry, than the control group.

It can be concluded that students generalize their understanding and knowledge to enable application in contexts when they think their actions (Collins, 1991; Wilson & Cole, 1996). Since constructivism asserts that learning is an active process, there is a need of activities which allow students to be active, take part in decision making, working and discussing in groups, and writing reports.

Recently, being a scientist may become less exciting career for students in modern societies (Sjoberg & Schreiner, 2005). In order to maintain this issue students should be encourage to behave like scientist. In science classes, hands on activities play important role to generate such an environment for students as mentioned above. In this paper a hands-on activity about "centre of mass" and "moment" is described through introduction, implementation and assessment.

Implementation of the activity

Participants

The hands-on activity was implemented to 54 preservice science teachers (Mage=21.7, 16 male, 38 female). Participants were taken a laboratory course in second semester of their third year. They were taken 8 different laboratory courses up to now as; General Physics Laboratory I, II and III, General Chemistry Laboratory I and II, General Biology Laboratory I and II and Elementary Science Laboratory I. They have attended the course of Elementary Science Laboratory II during the study.

Procedure

The activity was adapted from the book "Physics, Fun, and Beyond" (Valadares, 2013). It was implemented to participants at elementary science laboratory sessions for three weeks. Each week had its own plan named as introduction, implementation and evaluation. At introduction week, students were divided into 18 groups. Students were free to choose their group members. After they decided the group members, they were asked which session they would prefer to attend the course morning or noon. There were 8 groups in the morning session and 10 groups in the noon session.

At the first week, before delivering the activity sheets, "Is it possible for a wheel to climb upward on an inclined plane?" question was asked to groups. Students were given ten minutes for brainstorming and group discussion. After students discussed question in groups, activity sheets introducing materials and to do list, was supplied to groups. So, the activity was introduced to students.

At the second week which was named as implementation week, students brought all necessary materials to laboratory. They prepared two different setting by using material list in order to answer the question of activity. The first version was made by metal box where the second one was made by transparent plastic bottle. Moreover, the metal box was released on a standard inclined plane. Conversely, the second one, transparent plastic one was released on a special inclined system made by two sticks and books. After making wheels prepared, students released the boxes one by one and observed each movement. Students discussed how two versions were different from each other by using science concepts like "centre of mass" and "moment". As a homework of second week, groups were requested to prepare a report about the activity in a week. In reports, they were expected to relate what they observed in laboratory with science concepts.

At the third week, namely evaluation week, groups' report were collected first. Then, students were expected to explain the movements of two boxes. So, classroom discussion session was held on about movement of wheels in frame of "centre of mass", and "moment". Finally, students were asked to evaluate the activity by filling a form, individually during laboratory session. After they filled, evaluation forms were collected at the end of third week's lesson.

The Activity: Climbing Wheel

Common sense says that wheels roll downward. Actually, we built two different wheel that moves upward when we leave on an inclined plane. The material of the activity are tin box, magnet similar to one used in speakers, battery, insulation tape, and piece of wood plane. First, join the magnet to bottom of the box or join the battery very tightly to side of the box. In order to make an incline plane it is enough to put on side of wood on a book which is plenty high. Leave the box on inclined plane ensuring that battery or magnet will be up side of the box (Figure 1). When you leave the box, it will roll uphill. Observe what happens to magnet or battery during rolling uphill. What happens is that the weight attached to box changes the position of the centre of mass and so make the box climb.

For second version we need 2 unit plastic bottle 2lt, 2 unit wooden chopsticks, and insulation tape. After getting all necessary material, cut the bottles 8 cm from above and obtain 2 identical cones. Pay attention that the side you cut to be smooth. Join the two identical cones together by using insulation tape (Figure 2). Now, you have your wheel. Prepare the inclined plane with two chopsticks; join one points together, and put other points on book. Leave your wheel on inclined plane and observe its movement. What happens to the wheel? What happens is that the weight attached to box changes the position of the centre of mass, which moves closer to the ground as the wheel rolls uphill.

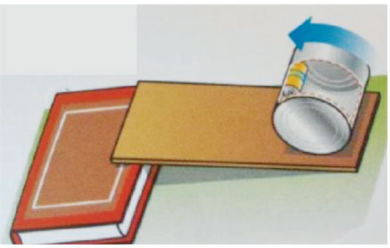

Figure 1: Setting for first version

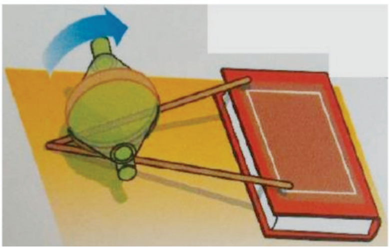

Figure 2: Setting for second version

Data Collection

The data was collected through groups' report, and individual evaluations forms of students. Students' behaviour and participations were observed by researchers. Students were expected to prepare an activity report in groups. Questions of reports are; (1) What is aim of the activity? (2) Explain how you prepared the wheels. (3) What are the important point of the procedure? (4) Explain the working principle of wheel by making relations with science concept.

The other instrument for collecting data is evaluation for prepared for the activity. This form was applied individually to students. The evaluation forms of the activity includes seven questions as;

a) What is the aim of activity "Climbing Wheel"?

b) What is the most exciting thing about the activity and its implementation?

c) What is the worst thing about the activity and its implementation?

d) What would you recommend to make the activity better?

e) Would you use this activity when you become a science teacher? Why?

f) If your answer to previous question is "yes"; what kind of modifications will you make while using this activity?

g) What have you learnt by the "Climbing Wheel" Activity?

Finally, students were observed by two researchers during 3 weeks. Laboratory

session was recorded by camera. Students' behaviour in groups, participation and level of interest were observed. After video records were watched, two researchers came together and discussed their observation notes.

Result

Data was gathered by activity reports in groups, evaluation forms filled individually and observation notes. Activity report was used to reveal students' knowledge about science concept related to the activity. How they relate observed phenomena with science concept especially "centre of mass" and "moment" was focus of the activity. Next, the quality of activity was determined by evaluation form. Observations were used to understand if students really enjoy participating in activity. Data gathered by observation was analysed in order to verify students' answers of evaluation form.

According to reports, groups described movement of the wheels by using concepts of "centre of mass", "potential energy", "torque", "friction force", and "gravitational force". Although they used physics concepts, they could not make satisfactory explanations. For example, most of groups stated that "the wheel moves upward, because the centre of mass changed due to extra mass we put on". However, they could not explain why the wheel stops on inclined plane by using this argument.

According to evaluation sheets, students' thoughts about activity were changed due to whether they understood the activity or not. Students who understood what happens to the wheel told that the activity was amazing and enjoyable. In addition, students expressed they would use this activity when they will be science teacher. Moreover, they mentioned that the activity has advantages such as being interesting and having low cost materials. Nevertheless, students recommended to make bigger size of wheel and use a transparent material for the first one in order to observe inside. On the other side, students who had difficulty in understanding what happens to wheel, declared that level of the activity is high. They underlined that it was a tough activity. These students also emphasized that they would not prefer to use this activity when they will be science teacher.

Discussion

This study presented a hands-on activity aiming students comprehend the science concepts as "centre of mass" and "moment". The study included implementation and evaluation of the activity. Due to results, it is revealed that students were physically active but they were not mentally active enough in this activity. It was caused by the list of material given to students. Allowing students to decide the size of materials used in settings can be an alternative way which may improve the implementation. If students are given responsibilities to make decisions about activity, they may be both physically and more mentally active.

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STUDY OF THE IMPLANTATION OF AN EXPERIENTIAL APPROACH IN SCIENCE TEACHER TRAINING IN FRENCH MINORITY SETTINGS: A DESIGN RESEARCH

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| INTRODUCTION

At the last survey conducted by the Program for International Student Assessment (PISA 2012) undertaken by the countries members of the Organisation for Economic Cooperation and Development (OECD), Canadian students of minority education systems have scored significantly lower in science compared to their counterparts in majority education systems (CMEC, 2013). To remedy this situation, it is important that training programs prepare student teachers (STs) in Canada to meet the challenges of science education in minority communities by offering them a training approach seeking a better balance between theoretical and practical training (Scharmann, 2007).

To this end, we propose an "experiential" approach to science education training in minority settings in which student teachers (STs) are encouraged to explore their representations about science teaching and learning during lived experiences in these settings, to reflect on these experiences by linking them with prior knowledge, and to begin the process of inner transformation of their representations to improve their teaching skills in minority communities (Seed,2008). This experiential approach to science education training consists of the following phases (Fig. 1):

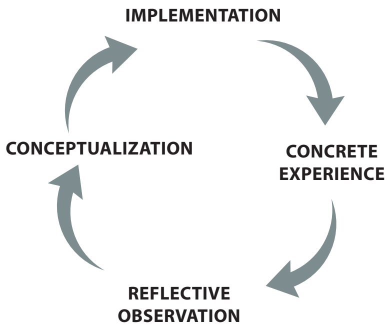

Figure 1: Experiential learning

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The commitment of the student teacher (ST) in a concrete experience, which is essentially to get in touch with a situation at school; 2) reflective observation, which enables the ST to objectify the situation and study it from different perspectives; 3) abstract conceptualization, where the STs tries to link the properties observed with a framework of interpretation (learning theories and teaching models) to conceive an action plan; 4) implementation when the ST verifies the plan conceived in the previous steps by implementing it in the chosen minority educational setting (Bourassa, Serres & Ross, 1999).

In this regard, our research aims to identify the conditions of implementation of this experiential training approach to science education within francophone minority schools and communities.

Methodology

The experiential approach was implemented in two science education teaching courses during the fall session in 2014 by a member of the research team of a francophone education faculty in the province of Ontario. The syllabus of these courses gave student teachers the choice between the experiential approach and a more traditional approach. The choice of the school was made on the basis of its proximity to the Faculty of Education, which allowed volunteers to get there easily without affecting their studies.

This research was done within Design Research framework (Collins, Joseph & Bielaczyc, 2004; McKenney & Reeves, 2012). As such, there are three main steps in design research process (McKenney & Reeves, 2012): 1) analysis and exploration; 2) design and construction; 3) evaluation and reflection. The first step is about to take contact with the setting, analyse the needs of the participants, and review the literature. These operations should be taken concurrently, and one could say interactively, s that an initial prototype is conceived and tested in the chosen setting.

Moreover, it should not be forgotten that, even if the stages of this research process seem well delimited, their systemic characterFigure 2. Design Research Process implies that, at each iteration, a set of evolving prototypes, say prototypes 1-2-3, of the experiential approach was constructed and tested along the way (see fig. 2) (Trudel & Métioui, 2010, McKenney & Reeves, 2012). Since the aim of this research is to increase the interaction between the school environment and the science education training environment, the first prototype and its followers must contain dispositions that take into account the characteristics and needs of these two environments, overcome their differences and eventually build bridges between them (Marble, 2006; Scharmann, 2007). This is reflected in the figure 2 above by the double arrow between conception and implementation.

To determine the conditions of implementation of the prototypes in the target environment, qualitative methods were used such as the diary written by a member of the research team (Altrichter & Hollly, 2005). Moreover, we collected also documents produced by STs when planning activities for the school (e.g. lessons plans, videos, etc.) to determine how well those activities were fit for use in practice. Regarding the qualitative data collected, we followed the method developed by Miles and Huberman & Saldaña (2014) to classify data in predetermined categories or create new categories.

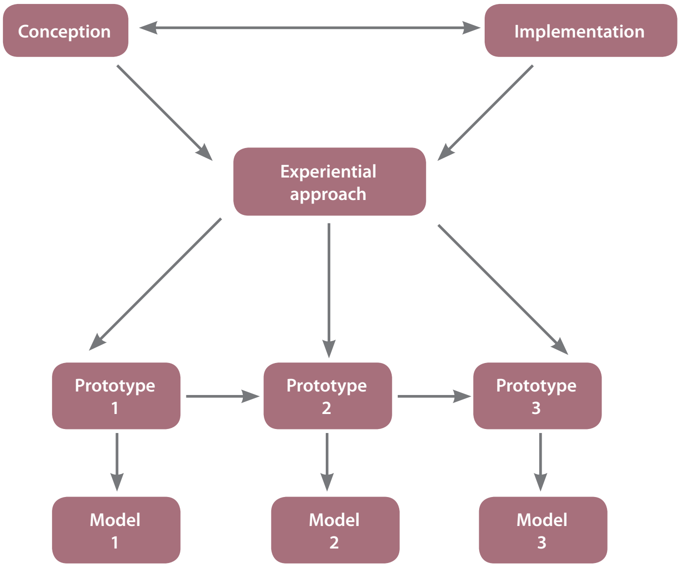

Figure 2: Design Research Process

Results

We present here results of the implementation of the first prototype of the experiential approach in the Francophone schools in Ontario, focusing on identifying difficulties encountered, implementation processes, and adaptation of educational tools conceived by our STs to the context of selected minority communities. Implementation of the other prototypes, namely 2 and 3, will be presented in following papers (fig. 2). In the following tow sub-sections, we will describes the components and the implementation of the experiential approach.

Components of the experiential approach

One important characteristic of the design research adopted here is that there is no clear demarcation line between the conception and implementation. Hence, the initial prototype of the approach changes as implementation progressed as the result of the collaboration between the school and the faculty. However, what can be called the initial prototype contained the following elements (Estep, 2006):

uu) Participation of student science teachers: Besides their activities in regular courses at the Faculty of Education, volunteer student teachers to the number of 13 had been involved through visits of half a day a week with the chosen school. Thus, STs had the opportunity to become familiar with the characteristics and needs of school environments.

vv) Attending science education courses: In their science education courses, STs had been introduced to various concepts, strategies and pedagogical tools of science education. Workshops were given on the nature of science aimed to inform STs about various theoretical frameworks and orientations regarding the nature of science and its relationship with society.

ww) Feedback and supervision: Since their pedagogical knowledge develops over time, it was necessary to plan ahead the approach of future teachers and to ensure that they not only had all that they require to continue their learning but also that they receive information about their own approach to correct it if necessary. In this regard, supervision of student progress was assured in several ways. In the first place, formative evaluation was carried out by the professor in collaboration with the coordinator via the Google website. Moreover, STs had also to complete time sheets where they report their allocation of time to the activities chosen in the school which were later evaluated and commented by both the coordinator and the professor (see table 1).

xx) Communication: Communication was an important factor to foster collaboration of participants, say STs, onsite coordinator and professor. Information about various important events in the process, such as communicating the dates and times of meetings with coordinator, recalling the dates of returning assignments, etc.

No	Date	Duration (Hours)	Description	Status
1	-------	-------------	--------------	-------------
2	2014-oct.-09	1 :30	We discussed about tutoring in mathematics and the production of videos. After that, we will be assigned to days in order to….	Approved
3	-------	-------------	--------------	-------------

Table 1: Time sheet completed by a student teacher in community engagement service

Unfolding of activities in experiential approach

Upon presentation of the project to the director of the school and science teachers, several objections were raised by the participants. The first one was about the safety of students at school because they would likely interact with our STs. There was also some confusion between the experiential approach and a practicum. In this regard, several teachers were concerned about the additional burden their involvement in the project, such as supervising STs, could bring to them. After answering all of the school's concerns, the research team was informed later that a science teacher had decided to participate in the project implementation in the school. Given that this teacher was very active in scientific projects, and additionally enrolled in a master's program in education, the research team estimated that it would be a welcome addition as project coordinator in the school. This role also gave him the motivation and the necessary funding to organize the activities of our STs in school.

These activities consisted in participating to tutoring sessions with pupils after classes, designing critical thinking activities in science, creating videos to teach students the concepts of science and mathematics and planning protocols for science laboratories. All volunteers STs (13) chose one or more of these activities to complete their twenty hours required for their participation in the project. It is noteworthy to state that all of them reached the 20 hours plateau and that many of them did more than the required time.

According to their comments, STs enjoyed their involvement in the community, which had allowed them to become familiar with the characteristics and needs of teaching in minority communities sciences. However, some STs lamented about the lack of time that did not allow them to explore sufficiently the different ways a specific activity may take in its implementation in the classroom. Consequently, activities that have made our STs for school were appreciated by the teacher but she considered that they will need to be refined before she could include them in her practice.

Discussion and conclusion

To implement the experiential approach in minority schools, it was important to address the concerns expressed by stakeholders in this environment. They should also agree on the rules of collaboration, and chose a school speaker who can bridge the gap between the two communities (Scharmann, 2007). Furthermore, the use of information and communications technology (ICT) had allowed us to promote interaction between participants (Graham, 2013) and facilitate feedback with respect to the conception of activities by STs (Instance, Vincent Lancrin, Van Damme, Schleicher & Weatherby, 2012). Finally, time constraints and scheduling, both by practicing teachers and STs, require a balance to be struck between the demands of university science education programs and the needs of minority education settings (Bruno & Chaliès, 2011). This research has helped us identify certain conditions to set up in order to implement an experiential approach in Francophone Minority Schools and assess qualitatively its effect on the development of science teaching skills within student teachers. Regarding the limitations of this research, they include the convenience of site selection and the voluntary nature of participation that does not allow us to generalize the findings beyond the chosen site and our sample. We intend in future research to test the robustness of our results to other sites.

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REPORT OF EXPERIENCE 13

A CLASS ON THE UNIFORM CIRCULAR MOTION UNDER THE CONSTRUCTIVIST LOOK

Maximiliano Da Fonseca Cordeiro,
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| INTRODUCTION

The application of constructivist proposals, interaction between groups and the use of non-formal environments are currently tools of great importance in physics teaching and learning process. The search for new forms of approaches to teaching has been a crucial factor in the motivation of the current student.

Theoretical introduction

For Piaget (1974), learning depends mainly on the child's developmental stages and these stages are influenced by four factors: biological maturation, the role of experience, social transmission, and balancing or self-regulation. For that reason the teacher must look for strategies to build knowledge obeying the limitations of each stage. According to Piaget (1976) when the learner is placed in successive levels of balance and unbalance, it depends on the facilitator to measure these steps to make the teaching-learning process easier. As Piaget was an epistemologist, we need to study pedagogical proposals that utilizes his ideas as directives of a didactic-pedagogical work, aiming the teaching-learning process, Ferraciolli (1999), Demo (2004) and Palmer (2010) .

Methodology

This work was based on a class held for high school students. The majority of this group was composed of 2nd and 3rd year students, with average age of 17 years. Initially each student received a ruler and chose an object that was used as an instrument in the construction of their knowledge. These chosen objects had both circular cross-section and

Figure 1: measuring the length of the circumference

dimensions diferents, for example: cans, PET bottles, etc. To begin the activities, the teacher determined that each student measured the diameter of the object with the ruler and the length of the circumference of this object using a string. (figure 1).

Figure 2: students going through the circuit

After this procedure, each student was asked to write down all these measurements in a notebook and to determine the mathematical relationship between them. It was proposed that they divide the measured circumference length of the object by its diameter and thus finding the number close to PI = 3, 14. In the next step we used a group activity that was based on the cooperation between the components, causing a healthy competition among the teams. First, each group built its circle, which was the circuit to be covered in this activity. Then the teacher proposed that each student should run his circuit as quickly as possible within the one-minute time interval (figure 2).

In this activity, each component of the group had a different function: to measure the time taken at each turn, to count the number of laps and the last one, to write down the data in a notebook and to make the respective calculations proposed. When the first student walked the trajectory, all these variables were noted and the activity was repeated with another student and so on. After this moment, the teacher asked them to analyze the variables and say who got the longest lap, the longest distance traveled, the fastest lap and identified the student who was the fastest during the race and then performed the calculations to obtain these results and compare with their previous answers. At the end, the concept of period and frequency was described for the group.

Results

First the students were surprised that the number pi = 3.14 appeared in all the divisions realized of the circle parameters. When students used the ratio (pi = lap / diameter) to calculate a complete lap in the court circuit, a great difficulty occurred, since now the variable was in the numerator, needing to use the product and not the division anymore. The space traveled was easily calculated, because with the possession of the value of the lap they multiplied the number of laps executed in the circuit by the value of a complete lap. The students successfully used the concept of average speed to get the speed in the circle, since it was already known by all of them. Some have proposed speed calculation using the space traveled in the circuit by dividing it by the total time, showing a degree of maturity in the mathematical thought used in this task. We've noticed that a group presented many difficulties in mathematics, which was perceived due to lack of initiative to carry out the proposed calculations. A small portion realized that the period and the frequency of the event depends mainly on the number of laps performed by the student in a given time interval in the activity.

Conclusion

This activity strongly stimulated the student, causing the perception that all the variables of the kinematics and of the circular movement are extremely important to determine the winner of a race and that the concepts of physics are strongly linked to the world of sports, mainly those connected to speed and that it is possible to use logical reasoning to accomplish physics problems without using a lot of equations. Thus, we consider that this activity was very important, because in it realization, the student was agent of his actions in the construction of knowledge in a significant way all the time.

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THE PROPORTIONALITY RELATIONS AS ADVANCE ORGANIZERS FOR THE PHYSICS CONTENTS IN ELEMENTARY SCHOOL 9TH GRADE

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| INTRODUCTION

This research presents elements from a didactic sequence, taken from classroom observations which aim is to improve the teaching and learning relation of Physics concepts, based on the students' previous knowledge about the proportionality relations. Therefore, problem-posing situations contextualized in the students' daily lives and activities in didactic laboratory were used. One notices that a considerable part of Physics concepts taught at school keep, in their characteristics, proportionality relations between the quantities that define them. So, the study of quantities involved in sciences, observing how they are related to proportionally, could reduce reduce the gap concerning what is studied and what is practiced. Thus, we start from the hypothesis that is possible to improve the efficiency of the Physics concepts understanding by means of proportionality. Therefore, we search answers to the question: Which are the implications of using the direct and reverse proportionality as previous organizers, by means of problem-posing situations, in the improvement of Physics learning of Elementary School 9th grade? The didactic sequence is justified on the Ausubel, Novak and Hanesian (1980) meaningful learning theory, and the chosen topic as a learning unit to implement the activities was the concept of Pressure. The work was mainly focused on the development of concepts. At first, a survey about the students' previous knowledge regarding proportionality was done. Afterwards, we used the problem-posing situations focused on students' daily lives, aiming to show a previous organizer about the proportionality relations discussed overall, such as meals in cheap restaurants, public transport by bus services and drinking water in a fountain. This teaching sequence is supposed to be adapted to other educational environments, according to differences on students' daily lives. So, the subject about Pressure was treated in a specific way, according to Ausubel, Novak and Hanesian (1980), searching for the progressive differentiation and the integrative reconciliation. The developed activities were qualitatively analyzed based on data taken from problem-posing situations solved by students and from observations made in experimental classes. A global evaluation of the didactic proposal reveals the importance of the meaningful learning theory guiding this research. The previous organizer about the proportionality relations and the activities, both expository and experimental, were adequate to be classified in a potentially significant material concerning the concept of pressure. The few situations experienced by the students were enough to discuss the theme. These discussions challenged the existing common sense knowledge, allowing the changing or even their replacement, creating new subsumers through the assimilation principle. Seeking for evidence of meaningful learning, as recommended by Ausubel, Novak and Hanesian (1980), we try to avoid the mechanical stimulation of students by means of "typical problems", formulating otherwise problems involving a new and unknown way to require the maximum transformation of existing knowledge. The contribution of this methodological approach is to propose and provide the teachers an alternative for the beginning of a new approach of physics teaching. Our methodology was applied to students of a state school in Curitiba city, Brazil, obviously, despite the positive results, this proposal must be always evaluated, adapted or modified in order to reach its final goals concerning our students' scientific literacy.

Methodology and results

Activity

Following the set of procedures suggested by Moreira (2011, p.170), we formalized the choice of the concept of Pressure as content to be used in the implementation of the didactic sequence. In order to do that, we analyse the official document contained in the website of the State Secretariat of Education of Paraná (SEED / PR), the textbook adopted by the School and the teacher work plan (PTD) prepared by the teacher, identifying the repeated physical quantities in the three documents; We elaborate a list a list including every quantity which maintain relations of direct or inverse proportionality in its definition; We verified that the concept of pressure was approached in a superficial way by the textbook. Thus, we find that it would be an appropriate choice for a didactic intervention to work together with students as they relate force and surface area in the definition of physical variable pressure. Having chosen the teaching unit and elaborated the didactic sequence, following the principles of meaningful learning, we implemented the project. We present below a brief description of the applied didactic sequence:

First Activity: Pre-test, which purpose was to identify the previous conceptions students had about proportionality relations. This was done through problem situations involving two different types of analogy: The first made reference to the distance travelled and the time spent to cover this distance. In the second situation, the approach was based on the relationship between the daily use of a video game and the useful life of the device.

Second Activity: Application of a previous organizer that consisted of an expositive class that would rescue the relations of proportionality. In addition, we posed a problem situation involving possible relationships between price of food per kilo, total price paid, and amount eaten during a lunch at a kind of restaurant establishment commonly called a buffet per kilo. After resolution and discussion, we proposed another material more closely related to the content of Sciences, using the concept of Flow, where they relate to each other the quantities volume, time and time rate of water coming out of a faucet. We aim to present the material to be learned from a wider point of view, the situation described previously by "buffet by kilo" and gradually to promote, according to Ausubel, Novak and Hanesian (1980), the progressive differentiation of the concepts that were being developed according to their specificities, in case of the situation called previously "flow". Subsequently, we would promote a new progressive differentiation using the concept of pressure.

Third Activity: Experimental activity developed in order to explore the concept of pressure as being a quantity determined by a force distributed over an area. The activity consisted in supporting parallelepipeds on a surface covered with wheat flour and checking the "damage" caused. Using the relations of proportionality, we seek to conceptualize pressure by relating it to the "damage" caused on the surface. Pictures taken with appropriated light incidence allow to compare different "damages" in terms of depth. First, we varied the support area and maintained the constant force, as shown in Figure 1. Then, the area remained constant and the force was varied, as shown in Figure 2.

Figure 1: Deformations caused by the parallelepiped supported on the major and minor faces

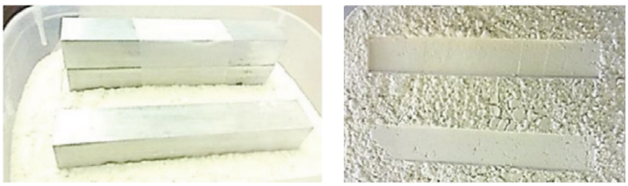

Figure 2: Deformations on wheat flout caused by the parallelepipeds with different weights supported on faces of the same area measure

Assuming that students have progressively differentiated the two types of proportionality relationship, we expected that at the end of the activity they would be able to solve problems by making a combination of the concepts of inverse proportionality relative to the area and direct with respect to the force, thus obtaining the general concept of Pressure, promoting inclusive reconciliation. Our expectation was that at the end of this activity students would construct themselves by a mathematical expression for the calculation of pressure.

Fourth Activity: We use this moment to solve together with the students two classic problems related to Pressure. The objective would be to reinforce of pressure and to address the issue of unity of pressure, from the expression obtained in the third activity.

Evaluation: The evaluation was carried out concomitantly to the implementation of the didactic sequence, where the students' answers were verified, seeking to emphasize what can be considered evidence of significant learning of the proposed contents. In addition, we proposed questions that aimed to verify students' understanding and assimilation of concepts.

With regard to the questions applied for evaluation of learning, three problem situations were used. The first one referred to a "leg-leg" sand racing between father and son. The purpose was to analyse whether he students perceived the direct relation between pressure and force, keeping constant the contact area between the surface of the parallelepiped and the surface of the sand The second problem situation, we aimed to verify whether the students knew how to calculate the pressure value adopting correctly he unit of force per unit area. In addition, we verified if there was an understanding by some students regarding the existence of an inverse relation of proportionality between pressure and area, maintaining constant force. Finally, the last problem situation had as objective to evaluate if the students could carry what was verified in the laboratory, depth of the "damage" caused in the surface related to the pressure, for the construction of shallow foundations of a building .This situation was not addressed in the activities described above. We were proposing something new in order to verify whether there was an extrapolation in the application of proportionality to the concept of pressure.

Results

At the beginning of the didactic sequence, the answers presented incorrect solutions of the problems proposed to verify the previous knowledge of the students, which suggested that the contents on relations of proportionality previously studied in the mathematics discipline, were assimilated in a superficial way. We then characterized that the class in general had no relevant subsumers established in the cognitive structure.

After applying the previous organizer that consisted of lectures and problem-solving, named "restaurant per kilo" and "flow", satisfactory indexes of understanding of proportionality relations were obtained. Thus, we start to use these relations to introduce the concept of pressure, which refers to a prior knowledge of force and surface area. We did not choose to make use of organizers for these contents because, according to the class teacher, they had already previously conceptualized the two quantities exhaustively.

The development of the activities revealed an evolution in the understanding of the concept of pressure, from the previous knowledge on the subject until culminating in solving similar problems to those worked in the classes and in the problem solving with text and approach different from the previous ones. In the analysis of the problem situation in which reference was made to the shallow foundations of a building, whose circumstances required an extrapolation of the problem situations carried out in the activities described previously in the application of proportionality with respect to the concept of pressure, the class was divided equally among those who were without significant learning signs and those whose marks showed satisfactory results. The application of the didactic sequence occurred during a troubled period of school, because during this time period there was a prolonged teachers' strike, constant changes in school hours, withdrawal followed by classroom students for extracurricular activities and systematic evaluations of the conclusion of the school year. Therefore, it would be possible that the measurements could be better if the didactic sequence was performed under less troubled conditions than described. Despite these difficulties, we understand that the results were acceptable and that if proportionality relations were systematically used in physics teaching, naturally a greater number of students would establish meaningful relationships of similarities between concepts already studied and new ones to be learned.

Final considerations

Evaluating the whole didactic proposal, from conception to the implantation in the classroom, one can perceive the importance of the theory of meaningful learning in the orientation of this work. The verification of prior knowledge, the previous organizer about proportionality relations, and activities, both expository and experimental, were adequate to be classified in a potentially significant material regarding the concept of pressure. The situations experienced by the students during the classes on the concept of pressure were enough to discuss the topic. These discussions challenged existing common-sense knowledge, allowing it to be modified or even replaced, creating more comprehensive or modified subsumers through the principle of assimilation. Finally, for the satisfactory results obtained in this investigation, we understand that the relations of proportionality, contextualized and applied to the contents of Physics, can lead to the improvement in the learning of Science in the 9th year of Elementary School.

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TRAVEL ACROSS THE PARTICLE ACCELERATOR, A TABLE GAME TO LEARN QUANTIC PHYSIC

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ABSTRACT

In the current world, with the advances of technology and progress of Science, describes about Quantic Physic is like tell a chapter of Humanity History, but, unfortunatelly, the most of people never heard nothing or almost nothing about this subject, despite to receive a lot of benefits from this science's big tools brought and bring in these days to our life. The knowledge of Quantic Physic is essential to understand the modern world and very important to job market insertion. This subject hasn't work in public brazillian middle schools and short in private schools. This's happening because the students don't have theoric basement to study it and the most of teachers doesn't know this subject in the classes. The oldest teachers didn't learn about particle accelarator in their graduations and need to be in continuous study and conexion with news. The present work is a game inspired in the "Monopoly" table game and it was prepared by a little group of students from a public middle school and oriented by their physic teacher. In 2014, the students and the teacher were to "Masterclass" event, promoted by Instituto de Física Teórica (UNESP – São Paulo). After, they started a project in the school, with the idea of show this game to other students. The game was developed to explain the basic characteristics of particles accelerators, detectors, curiosities and functions of CERN co-workers. The project was realized in 3 stages: First, the students reserched and prepared the game. Second,

the played with another teenagers from the 3 series of the middle school and collected their opinions about the game. Finally, in the third stage, the game was improved by the students that went to Masterclass 2016 event. The Travel Across the Particle Accelerator was developed by the students who participated in the optional subject "Qui-Brincando com a Física" along the one semester, time requested to build the game. We perceived that play this game, became a challenge for the students, because the never had had a contact with this subject and aroused interest to learn more. A project prepared by students to help other students to learn more about subatomic particles physic.

Objective

Build a table game to help students of high school, understand the physic from subatomic particles.

| INTRODUCTION

The knowledge of Quantic Physic is essential to understand the modern world and very important to job market insertion, but, unfortunatelly, the most of people, in Brazil. never heard nothing or almost nothing about this subject, despite to receive a lot of benefits from this science's big tools brought and bring in these days to our life. This subject hasn't work in public brazillian middle schools and short in private schools. It's happening because the students don't have theoric basement to study it and the most of teachers doesn't know this subject in the classes. This paper shows an idea about how can the teachers work about Quantic Physic in the middle school classes.

The game

The present work is a game inspired in the "Monopoly" table game and it was prepared by a little group of students from a public middle school and oriented by their physic teacher. In 2014, the students and the teacher were to "Masterclass" event, promoted by Instituto de Física Teórica (IFT – UNESP – São Paulo). After, they started a project in the school, with the idea of show this them to other students. The game was developed to explain the basic characteristics of particles accelerators, detectors, curiosities and functions of CERN co-workers.

Monopoly is a traditional table game and a lot of teenagers like and know how to play this game, because this, we decided to create a similar game. Our cards have questions and answers about Quantic Physic, and our money Newton, it a reference to Isaac Newton. When the students started the game creation, they were learning on the physic classes about Newton. The Figure 1 is picture of the game.

The Masterclass's event is a sequence of activities where the students have an opportunity to learn about Quantic Physic. The event happens in 2 days. In the first morning, they and their teachers have an introduction and a theoric class, in the afternoon, the teenagers have a lot of pedagogic activities about general physic and they love this part, while the teachers have a practical class to analyze dates of CERN laboratories. It's very interesting, because we can learn how can detect some subatomic particles. In the second morning, the students have the same class than teachers to analyze subatomic particles in the CERN experiments and the teachers help their students and in the second afternoon, everybody go to an international video conference to show what the students from the different countries learned in these two days.

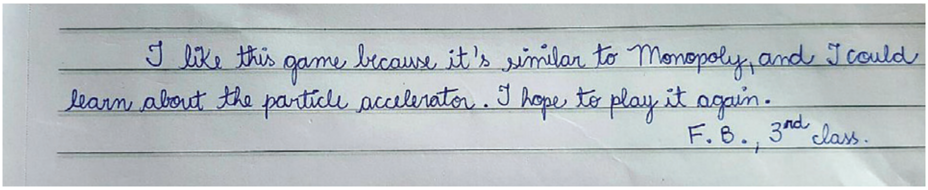
Figure 1: The Travel Across the Particle Accelerator Table Game

The rules

First each player receives banknotes: 1 of 1000 Newtons, 2 of 500 Newtons, 3 of 200 Newtons and 4 of 100 Newtons. The players should play a dice and move the piece in the squares, when someone stops in determined places, must answer the questions of 4 different levels (bonus, 1, 2 and 3). When someone answer right, the person can move in the next time and receives a banknote of 100 Newtons, if the person answer wrong, she can pay (400 Newtons) to continue in the next time or wait for the next chance and try to answer another question. If the person answer wrong again, she will pay 900 Newtons and continue the game. Each time that a player raisin by the start square, he will receive 200 Newtons. The winner is determined when the other players failed.

The final considerations

The Travel Across The Particle Accelerator was considerated by the teenagers and some teachers like a big tool to lean Quantic Physic. The game was developed by the students who participated in an optional subject, the time requested to build the game was a semester. After the game was applied to another students from the school and we perceived that play this game aroused interest to learn more and became a challenge for the students, because the never had had a contact with this subject. The students liked build and play the game. The Figure 2 is a testimony from one of my students about the game.


I like this game because it's similar to Monopoly, and I could learn about the particle accelerator. I hope to play it again.
F. B., 3rd class.

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