Learning by projects: theory and practice in Brazilian teachers education

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Abstract

In this article, we share some of our experiences and lessons learned from a practical implementation of Carl Roger's approach of Project Based Learning, as well as, we discuss the Ausubel's principles of "meaningful learning", which underlies this theory, in a situation involving future High School maths teachers. Our declared goal was to train and encourage these students, who often worked full-time and arrived to the evening classes, to apply Project Based Learning effectively in their own future teaching practice. In our research, which was conducted during the second semester of 2013 in the Federal Institute of Alagoas, we analyzed the progress of these students based on their productions (presentations, reports, peer- and self-assessment, etc.) and on the data collected in a questionnaire and semi-structured interviews. The preliminary results indicated that the students took more responsibility for their own learning showed an increase in self-efficacy and procedural knowledge and developed a positive attitude towards applying Project Based Learning in class. However, we also observed deficiencies in the gain of conceptual knowledge that required to be addressed in the course design before embedding this approach in the curriculum.

Keywords: Project based learning, Teacher training, Adult education, Meaningful learning.

Resumen

En este artículo, compartimos algunas de nuestras experiencias y lecciones aprendidas de una implementación práctica del enfoque de aprendizaje basado en proyectos de Carl Roger, así como también discutimos los principios de Ausubel de "aprendizaje significativo", que subyacen a esta teoría, en una situación que involucra futuros maestros de matemáticas de secundaria. Nuestro objetivo declarado era capacitar y alentar a estos estudiantes, que a menudo trabajaban a tiempo completo y llegaban a las clases nocturnas, para que aplicaran el aprendizaje basado en proyectos de manera efectiva en su propia práctica docente futura. En nuestra investigación, que se llevó a cabo durante el segundo semestre de 2013 en el Instituto Federal de Alagoas, analizamos el progreso de estos estudiantes en función de sus producciones (presentaciones, informes, autoevaluación y autoevaluación, etc.) y de los datos recogidos en un cuestionario y entrevistas semiestructuradas. Los resultados preliminares indicaron que los estudiantes asumieron una mayor responsabilidad por su propio aprendizaje, mostraron un aumento en la autoeficacia y el conocimiento procedimental y desarrollaron una actitud positiva hacia la aplicación del Aprendizaje Basado en Proyectos en clase. Sin embargo, también observamos deficiencias en la obtención de conocimientos conceptuales que debían abordarse en el diseño del curso antes de incorporar este enfoque en el plan de estudios.

Palabras clave: aprendizaje basado en proyectos, formación de profesores, educación de adultos, aprendizaje significativo

I. INTRODUCTION

Our teachers have a great mission to inspire the next generation and excite it to acquire scientific knowledge from the subject they teach. Thus, the teacher training should prepare and equip them with methods and techniques to encourage the engagement of their students in meaningful learning activities as written by David [1].

Normally, in the Brazilian undergraduate degrees, future teachers learn about different teaching methods, however, there is subsequently a large discrepancy between what they have learned and what, in fact, they apply in the classroom,

as well as students who do well in school, but do not use this knowledge in their daily lives [2]. In the process of teacher education, as in many other situations, what they hear or read account far less than what they do while they learn. Therefore, the distance between one thing and another is a major problem that now faces graduation courses in Brazil.

The state of Alagoas in Brazil needs to review their practice in relation to the training of teachers in mathematics and natural sciences. This state, due to the absence of efficient and effective public policies, presents several problems of socioeconomic order. One of the biggest problems is related to education: an illiteracy rate of 24.6% and 36.5% of functional illiteracy. Moreover, according to the PISA (Program for International Student Assessment), Alagoas has the worst results in all three areas evaluated by the program (Mathematics, Reading and Science), although, it is worth remembering, the performance of Brazilian students varies greatly from one state to another.

Yet, the training of future teachers is of great responsibility because the result of this training can affect, positively or negatively, over a long period of time, the future of many students in high school and elementary public and private schools in Alagoas and in other Brazilian states. It is with this understanding that we report in this paper, the way we approach the topic of Project-Based Learning (PBL), according to the reference of Carl [3, 4], in the Federal Institute of Alagoas (IFAL) with 13 undergraduate students in Mathematics, who attended the Sciences Teaching Laboratory subject, in the last half of 2013.

The main function of PBL is the direction and future vision of teaching with learning, with guidelines on norms and guidelines that can reconstruct students' study processes [5].

[6] Thus resulting in a simple process and obtaining efficiency and efficiency in solving problems.

The PBL methodology was chosen for this investigative study because it offers students an opportunity to bring to the research environment their own knowledge. Knowledge derived from their workplace, hobbies or personal interests, and at the same time, relate these activities/interests to the teaching of the mathematic as well as their present or future professional activities. Moreover, the PBL methodology allows the students, in the course of its activities, the acquisition and development of skills related to the ability to work in groups, be socially responsible and responsible for their own learning, meet deadlines, communicate results clearly and objectively and act independently. All this because students received little teacher instruction in the process.

As the Mathematics Degree Course happens during the night this fact brings some particular challenges:

1. Most students work two shifts during the day and therefore arrive late and tired in the school;
2. Some students are parents and therefore have many family obligations;
3. They have irregular frequency in the course;
4. Have less time to devote to the extra-class activities at home;
5. Have different knowledge background because they are from different private and public schools and so on.

Students involved in this activity were adults and therefore had typical learning characteristics and a particular relationship with their peers and teachers.

Therefore, in a formal learning situation involving adults, the teacher must: to establish a climate of respect for another's experience; demonstrate the usefulness of the subject studied in class; drive the activity for solving significant problems for the students; let the students participate in the process as a whole, including the evaluation of the process. These characteristics were described by [7] in the seventies, however, but they are still disregarded by the teaching practice. This need to consider the subject of learning in their evolutionary status (adult), in their learning environment (formal education) while he is studying in a certain period of the day (in the night), eventually imply the obligation to permanent review the program of each discipline and the course itself to make it ergonomically efficient.

A. Theoretical Framework

The environment in which the research was performed, the subjects involved in it and even the methodology applied (PBL) in the process, suggest, in our view, that the theoretical framework appropriate for the situation is the Meaningful Learning Theory (MLT) from David [1].

B. Just a little bit of MLT

According to [1], the one who wants to facilitate meaningful learning (ML) must find out prior knowledge of the student and teaching accordingly to it, because this is the most important variable influencing the learning process.

The ML involves the selective interaction between the new learning material and the pre-existing ideas in the cognitive structure. We use the anchorage term to suggest a link between new and pre-existing ideas over time. For example, in the subsumption process, the pre-existing ideas dock the new ones, subordinating them, in order to make them meaningful in the learning process David [1].

For ML to occur, it is necessary that the new content is related, interactively, with the cognitive structure of the learner, that is, there must be the interaction of the new knowledge with the old one. The result of this process Ausubel calls assimilation. To [1], cognitive structure is a hierarchical structure of concepts that are representations of sensory experiences of the individual and the name received by these concepts already present in the cognitive structure is subsumers. The ML is progressive, that is, the meanings are captured and internalized gradually and, in this process, social interaction and language are very important.

In the process of ML proposed by David [1], other very important element is the cognitive anchoring, is the subject

to acquire new knowledge in a meaningful way, internally, and anchors the new information in their subsumers. For this to happen the student should be predisposed to learn.

Also, according to David [1], the process of detailing, refinement and specificity of a subsunsor is called the principle of progressive differentiation. This part from the general ideas (most important) towards the specific ones (working through examples, exercises and situations). If one links different knowledges, recombining them and relating them to each other, seeking the differences and similarities between them, this is known as integrative reconciliation. What, by the way, was used in the lectures of this experience.

When students do not have subsumers for the potentially significant learning material, one can also use previous organizers, which together with the V diagram and conceptual maps are facilitating strategies of learning. These elements are used to analyze the process of construction of knowledge, but in the specific case runs off a little, the objective pursued by this article.

Project Methods in [3] Perspective

The pioneer of Method Project was Carl Rogers. According to Carl [3, 4] people are intrinsically motivated. Often the school rebukes such motivation forcing the students to learn what the system wants to, although, most of the times, these matters are not motivators for students who want to learn other things.

As society, technology and science change rapidly, there is a lot of knowledge being produced all the time, so it is essential that people are able to learn how to learn, to search for, to pursue knowledge itself, becoming responsible for their own learning. Partly because formal education is temporary and it is necessary that they are active in their social environment, been able to learn for themselves. “The only man who is educated is one who has learned how to learn, have learned how to adapt and change, knowing that no knowledge is secure, that no process of seeking knowledge offers a safe bas” [4].

The author poses as important points for the student to learn how to learn (self-initiated learning) the following items:

1) Build knowledge about real problems. For self-initiated learning to take place, it is necessary that the person faces a problem that is meaningful to her [8].

2) Promote resources. The teacher, who seeks self-initiated learning, rather than taking the time to prepare lesson plans, needs to find resources that can provide students with a learning experience through the corresponding need of them. He should also take care that such resources are clearly available, must imagine and simplify the practical and psychological stages that must enable the students to use them.

3) Use contracts. In these contracts, students set their goals, what they want to do and how they would do it.

Carl [3, 4] provides the following sample of contract: all students pass with a C if they do certain activities and prove that they made examinations relating to the matters contained therein. If students want to take A or B, they should plan, for themselves, the activities that they need for such grades, writing them in the contract. The teacher must examine the contracts before the students begin to run them. When the student and the teacher come to a mutual agreement on the contract, the student is sure that he will take an A or a B provided they have met the contract’s obligations before the end of the stipulated time.

Organization of learning facilitators groups.

Students can be divided into groups that have curiosities and common goals (learning group facilitators). The teacher, in this context, helps these groups in their organization to solve problems and encourage the problems formulation.

C. The research orientation

The teacher establishes the research through stimulation for the emergence of problems, creating, in the process, a receptive environment for students, giving them the needed assistance in the act of investigation and trying to make them autonomous learners.

D. Using simulations

According to Carl [3, 4] a wide variety of everyday situations can be simulated. The simulations are complex and therefore, participants must have prior knowledge about the system. Such simulations provide the student experience with various processes that occur in real life. It is in these simulations that students take personal responsibility for their decisions.

On the question of evaluation of the process, we must understand that in the adopted perspective, the teacher should not individually assign grade to the student. The student also needs to self-evaluate. The assessment should include the criteria that the subject judges his work, the importance of this work in the social and personal level, why the subject adopted such criteria and finally the note. If the teacher considers other relevant criteria for assessing the student, both (teacher and student) should discuss them in order to reach a conclusion about it.

The proposal of teaching, which emphasizes the importance of education for social change, is also present in Freire's work, when he argues that, the student assimilate the object of study making use of a dialectical practice with his reality. This is opposed to what Freire calls banking education, a technicity and alienating education, which chooses, organizes and provides what is going to be studied, regardless of who is studying what.

In the specific case of this research, we add to this methodology a previous reflection of the social reality, guiding the work projects to take into consideration the community's living conditions. Analyzing the group’s relation to their communities in order to develop projects for the transformation of these societies.

Another very important author, related to Project Method, is Oswaldo Frota-Pessoa. His work in this area stands out in Brazil. For [9], analogously to [3], the Project method should consist of short works, developed by teams. These works should generate reports, and these reports

should, at least partially, generate the evaluation. These projects should also be showed in Fair Sciences or in the classroom to colleagues. It is important that the subject of the project and its planning be decided in the group as well as its progress and completion.

According to these authors, it is relevant that the project relates to a common theme, which in the case of this research, gravitated in terms of rational and economic use of water and energy sources. However, to respect the principle of freedom of students in subject choices, some projects - such as the mathematical game, were not related to this issue.

For [9] projects are activities that result in a final production made by students, their function is to solve a problem and the issues are matters that centralize the study and discussion. In addition to encouraging the formation of teams, the teacher needs to raise problems and provide some information. The teacher can also, if necessary, give students problems to be solved, referring to several bibliographical sources, colleagues and others, encouraging them to bring their solutions/questions to this discussion. Thus, the assessment of learning should be based more on the realization of projects than on evidence.

This work methodology provides students with a development of responsibility, autonomy, reflection, cooperation and criticism during the teaching-learning process. Once developed and established these skills, they will be co-responsible for their own learning. Students should then: select information sources and collect them, set criteria to interpretation of the collected data, resume doubts and questions, represent in a linguistic, mathematics or pictorial form the whole process its final results and and lastly, evaluate the material produced and its applicability. As you see, all this has been hitherto sufficiently discussed

II. METHODOLOGY

This research discussed here was eminently qualitative. And we know that from the perspective of a qualitative research, there is no independent objective reality, because the reality is socially constructed. The researcher is then more concerned with the understanding of what happens in the classroom, for example, than with the identification of the causes of a problem. The validity of a qualitative research is determined by their degree of credibility, of persuasion. Therefore, the qualitative researcher need to do a detailed analysis of the studied object in order to have several arguments to justify the conclusions reached. The qualitative approach emphasizes the actions and experiences of people. This is essentially interpretation but does not exclude quantitative information. Such an approach, as Marco claims, “tem como interesse central, a questão dos significados que as pessoas atribuem a eventos e objetos, em suas ações e interações dentro de um contexto social e na elucidação e exposição desses significados pelo pesquisador” [10].

Interpretive research seeks to critically analyze each meaning in each context, since the meanings and actions are contextual, so such research cannot be generalized, unless, repeating the search in several different contexts, one finds the same results.

For Marco [10], the differences between quantitative and qualitative approaches do not result from the study itself, but the way it is studied. In a qualitative study like this, the researcher seeks to develop hypotheses and not test them. It starts with assumptions that guide the researcher. Such assumptions, unlike quantitative research, may change over the research.

Methodologically, the qualitative researcher observes the object of research, writing down everything that happens in a logbook, collecting materials such as student work and recordings of discussions made by them. The researcher, in this perspective, describes everything that happened with his research object, in order to seek to convince the reader of his conclusions. Thus, the researcher allows the reader to have elements to agree or not with the results. This feature of qualitative research makes possible repetitions of the application of research. According [11] credibility is associated with the quality of the analysis. It is necessary to work the data, synthesize them, organize them, find out what is important and what is secondary, decide what will be said in the final product of the research.

These are some of the general characteristics of qualitative research. There are three main methods within this approach: the case study, ethnography and action research. A detailed presentation of these methods lies in [12]. Let’s talk just a little about ethnography that is the methodology used in the research here commented.

A. Ethnography

According to [13] ethnographic research seeks to describe and understand a culture, ideas, values, assumptions and beliefs. The behavior and actions of individuals are important and are taken in observation and interviews. Still, according to this author, ethnography hypotheses are formulated for the development of research, i.e., theories emerge from the data. The result of the research is the understanding that the researcher has, in a social group, of a situation and of a culture. In our case, we were concerned to monitor the learning of concepts related to Natural Sciences and Mathematics, from the use of PBL methodology in view of [3, 4].

For [14], ethnographic studies in the educational context have some main characteristics:

1. The observation of the participant, the interviews;
2. The analysis of documents;
3. The interaction between the researcher and the researched object;
4. The emphasis on the process and not on the final results;
5. The concern with the meaning;
6. The importance of the participants' personal vision;
7. Of the field work, of the description;
8. Of the formulation of hypotheses of induction and the research;
9. The concepts;
10. Abstractions;

11. Theories, etc.

> A observação é chamada de participante porque parte do princípio que o pesquisador tem sempre um grau de interação com a situação estudada, afetando-a e, sendo por ela afetado. As entrevistas têm a finalidade de aprofundar as questões e esclarecer os problemas observados. Os documentos são usados no sentido de contextualizar o fenômeno, explicitar suas vinculações mais profundas e completar as informações coletadas através de outras fontes [11].

Thus, the research of ethnographic type, which is characterized primarily by direct contact of the researcher with the researched situation, allows rebuilding processes and relationships that shapes the daily school experience, and that is why it was chosen for this work.

B. Research Instruments

The instruments were validated internally and externally by three professors from UFRGS (Universidade Federal do Rio Grande do Sul). However, it is known that there are several threats to internal validity: experimental procedures, treatments or experiences of the participants that threaten the ability of making right inferences from the collected data, misuse of procedure and problems related to treatment application and finally, threats from the characteristics of the participants. These all threats were considered in this study.

As for the external validity, there is no major concern about it because such validity depends on the researcher's details that need to convince the reader of the accuracy of its search tools. However, potential threats to external validity must be identified. These threats arise when experimenters make incorrect inferences from the sample data, to other people, other environments and past or future situations. Such generalizations are not made in this research.

C. The Research Stages

The study was divided into two phases. The first one had the following steps:

1. Literature review, in the period from 2000 to 2012 on the Project Methodology in Brazil;
2. Study of teaching strategies that have been used;
3. Validation of the instruments;
4. Implementation and evaluation of Project Method in the discipline Science Teaching Laboratory in IFAL;
5. Data collection;
6. Analysis of the collected data.

The second phase the following steps:

1. Dissemination of the results obtained in the first phase;
2. Re-evaluation of the research;

3. Proposed curriculum change for the Federal Institute of Alagoas (IFAL – Instituto Federal de Alagoas). *Methodology of Classes Laboratory of Science Teaching* subject in the Degree Course of Mathematics by IFAL happens in the fourth semester of the course, during the night shift. It has a total workload of 60 (sixty) class hours and a weekly charge of three (3) class hours two days a week. On the first day (Thursday) with a lecture, addressed to the Project Methodology, on the second day (Friday), with two class hours, the time was used up for the group meetings, construction of the minutes, guidance on the making of the project, report presentations, colleagues' work assessment and self-assessment.

D. Data Collect

To collect data, a quasi-experimental design was used for equivalent time samples [15]. Qualitative tests were performed on the research tools: contract analysis of students; analysis of the students' project; self-evaluation indicators; students' presentations; minutes; semi-structured interviews; peer review.

E. Data Analysis

The projects and work contracts were evaluated in order to verify that these had procedural and declarative knowledge, and if this had an application in society or at school. Bardin's content analysis [16] and Krathwohl's [17] categorizations were used. The other qualitative instruments were evaluated based on the content analysis of [14].

In order to encourage students to apply the PBL methodology later in their professional activity as basic education teachers, we structured our strategy on three pillars:

1. They should try this method from the perspective of students;
2. They were offered a theoretical framework and tools for planning, management and dissemination of the project. That is, a dual approach: theoretical and practical.
3. Using the co-evaluation they learned how to access the new educational method (PBL) to evaluate other groups, and inevitably, to perform a self-assessment. Leaving, in the way, the teacher with more space and time to evaluate and diagnose the meta-learning process.

It is worth mentioning here that before we begin the activities, the students were informed that the main objective was to prepare them to apply the PBL methodology in their future pedagogical practice, and the projects developed by the groups should have a tangible outcome in the time they had to develop them. By this time, they were also told that researchers would accompany all this process from UFRGS. The design of the subject is showed in Table 1.

III. RESULTS

A. General Considerations

The results discussed below describe the experience in a public educational institution in the implementation of PBL methodology, from the perspective of teachers and students, as well as an outside view. A qualitative research, because it was a small group of individuals observed (thirteen

students), small observation time (six months), great variety of subjects (students with diverse background knowledge) and the impossibility of having a control group. All this being taken into account, we observed that:

TABLE I. PBL methodology in Science Teaching Laboratory.

Month	Theorie	Practice
1º	Overview of PBL Methodology; Basic ideas on project management.	Training groups and searching for research topics.
2º	How to write an employment contract?	Preparation of employment contract.
2º	How to write the minutes of meetings?	Group meetings in the classroom and documentation of the minutes.
3º	How to present the partial results of the research? Seminars.	Presentation of pre-projects (20 min) - difficulties and results obtained, perspectives.
3º	How to evaluate colleagues and self-evaluate? Evaluation criteria.	Evaluation of groups and self-assessment - Construction of small evaluation texts.
4º	Discussion on evaluations - criticism and considerations.	Review of the assessments.
5º	How to write a report on the activities of the Project?	Construction of the report.
6º	Face-to-face orientation and by email on the final report.	Report delivery.
6º	How to present the final results of the research? Seminars.	Presentations of projects (20 min) - difficulties, results and perspectives.
6º	Face guidance and by email on the final report.	Delivery of the final report.

B. Evaluative Perspectives

a) From the Perspective of Teachers

The students are committed to their projects. In addition to teaching the PBL methodology, most of the projects developed had tangible educational tools for teaching Natural Sciences and Mathematics.

Although some students are not yet teachers, they have shown a positive attitude towards the PBL methodology, some areas of the mathematics undergraduate curriculum need to be improved, redesigned before integrating the PBL methodology.

It must be necessary to study the PBL methodology from a national and international perspective, it is also necessary to translate the content of the pedagogical theory into practical activities, so that the teacher can use what he learned during the training period.

Where it should be placed that the subject itself (Science Teaching Laboratory) must be reallocated in the program to appear in the first half of the curriculum.

This would favor the development of projects throughout the course and not just for a semester.

b) From the Perspective of Students

Six categories mentioned by students can be highlighted:

b.1 A vision of the social change

Lets see some quotations from the students:

Student 1 (S-1): "O aquecedor solar melhorou as condições de vida em minha casa, o que provocou uma economia de energia. Hoje eu queria trazer o aquecedor, mas ele já está instalado em minha casa e minha esposa já está utilizando-o".

S-2: "Nós escolhemos desenvolver um gerador eólico, porque em nosso estado há inúmeros lares que não têm eletricidade, especialmente no interior. Nós queremos melhorar o nosso protótipo e ajudar a essas pessoas que precisam" .

b.2 The research capacity

S-3: "No começo não sabíamos o que era um projeto, como avaliar meu próprio trabalho ou o trabalho de outros. Afinal de contas, não estávamos acostumados a atuar como juízes. Não sabia como apresentar trabalhos. A partir do método de projetos, nós criamos alguma coisa nova, o jogo matemático. Apresentamos ele em um evento aqui, no IFAL e junto com o professor, planejamos desenvolver o primeiro artigo sobre o assunto".

b.3 Learning how to learn and metacognition

S-4: "Quando o professor nos falou que poderíamos escolher qualquer assunto para o estudo eu fiquei paralisado. Não sabia o que fazer. Eu nunca, em minha formação educacional, havia me deparado com essa possibilidade: ser responsável pela minha própria aprendizagem, fazer minhas próprias escolhas. No começo foi difícil, mas junto com os colegas, eu tinha que aprender e aprendi melhor. Eu sabia o que não precisava aprender, o que não sabíamos ainda e como ajudar os colegas a chegarem lá".

b.4 Critical Sense

S-4: "Eu me tornei mais responsável quando fazia críticas a mim mesmo e aos meus colegas. É uma tarefa difícil porque nós não estamos acostumados a criticar e receber críticas. Eu tinha medo de ficar chateado com os comentários dos colegas, mas com o passar do tempo, começamos a ver a crítica como uma coisa útil para o desenvolvimento de nossa aprendizagem e a crítica se tornou mais natural".

b.5 Self Efficacy

S-5: "Com o tempo em que estivemos envolvidos com o método de projetos não me sinto seguro a ensinar usando essa metodologia. Na minha opinião, precisávamos de mais disciplinas com essa metodologia. Isso também nos daria mais tempo para melhorar os nossos protótipos".

b.6 Integration with Laboratory

S-5: "A única sugestão que eu dou é que deveria haver, em tempos regulares, aulas no laboratório de ciências. Eu gostaria disso, pois eu nunca estive em um laboratório.

c) From the external observators perspective

From the perspective of the observers from the Federal University of Rio Grande do Sul (UFRGS) there is a strong

motivation among students to apply the PBL in class, but at the same time, most students do not feel sufficiently prepared to implement the methodology projects by themselves. According to students, rather than a discipline based on PBL, thy need a curriculum change in the course; It was also identified that although the course encourages students to take more responsibility for their own learning, conceptual knowledge [17], it has several shortcomings. Thus, the courses based on projects need to be complemented by conceptual knowledge, avoiding some criticisms that accuse this kind of work as experimental activities like as "cake recipes" [18, 19], where there are various activities and often, one do not think about them.

To improve learning of concepts one can use potentially significant units [20], because all students, involved in this kind of approach, showed improvement in procedural knowledge (how to do something), along with an increase in self-efficacy and metacognition [17]. And beyond that, we have, in the classroom, an atmosphere of mutual respect, participation, appreciation of errors. All these are critical and indispensable features for the PBL methodology.

C. Some other Observations and Comments

There was no drop-off observed with regard to the projects; the students with the following titles developed six projects: homemade solar heater, educational game for teaching mathematics, electromagnetic cannon, simple distiller, self-sustaining wind device and water filter. All projects were concluded, except for one: water filter. They were positively evaluated, but as mentioned earlier, some of them had conceptual knowledge problems, and others had difficulties to build the final reports, using the information obtained from the meeting minutes.

We also observed that most students had basic deficiencies in the ability to document their work, which leads to major differences in the results of activities undertaken by the groups.

For example, some groups had initial goals easy to reach and others one, very difficult goals.

Some other groups took a long time to deliver documents, such as minutes, and when they did, they were still simple prototypes; some groups, such as the wind generator, found themselves regularly, had members who were committed, produced good documentation, but at the end of the month, found that their goals were not achievable for the time available; another group (Math Game – Picture; had clear and achievable goals, committed members, but were not always present in class).

Nevertheless, they progressed quickly, tested the prototype of the game with elementary school students, presented their findings to colleagues in the classroom and in a conference that took place in IFAL.

Silent workers composed another team. We observed them in the classroom and they seemed to be a weak and deficient group. Nevertheless, at the end of the semester, they demonstrated that its members were committed to the work, held frequent meetings at home and achieved excellent results.

Students of another group were able to deliver all materials, obeyed deadlines, managed to build the distiller from recyclable materials and made a scheme of the compounds so that other future students could improve their work.

Another group (Water Filter) showed low yield. They had an easy goal to achieve and could even find a pre-existing prototype in internet, a sand filter for rainwater. However, they failed to achieve their goals. The students of this group did not show organization and a good relationship between them. They failed to collect the necessary materials, they were disorganized when planning, developing and could not show a final prototype of the filter, just some preliminary ideas.

IV. CONCLUDING REMARKS

From what was mentioned above, we see that some groups were very organized, had a good documentation, were quick (characteristics that did not happen, usually, concomitantly), while others required more attention and a closer monitoring.

However, we observe that they learned how to plan, to document and to implement their projects. Thus, in our point of view, in the future, they will be able to implement the PBL methodology with their students, if they wish so. This is not only the opinion of the teachers and researchers who worked directly in this experiment or even the external evaluator's opinion but also the opinion of a student of the course from an earlier period, who had already taken this discipline in this institution.

This student, in the final presentation of the projects, commented that he was amazed with the results achieved by the students and he thought that the discipline have improved a lot. Nevertheless, we understand that there are major changes to be made in the curriculum of the course, so that the students have access to this methodology continuously throughout it, and thus, the results achieved will be even better.

A change to be made in the program of Mathematics would be to work with PBL methodology in the first semester, in order to engage students in a project that would last for almost the whole course. This does not seem to be complicated, since it has everything to do with the course proposal that seeks to be eminently a practical course.

From everything we have seen above we can conclude that the PBL methodology is an excellent opportunity for educational institutions in Brazil - mainly in Alagoas to rethink his ways for Science education. We also realized that the PBL methodology brings with it a fundamental issue, which is the need of a deep respect towards the students who cannot be considered simply as an object of a study, but a thinking subject and more than this, a son of God.

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