HOW TWO DIFFERENT LEVEL INSTITUTIONS CAN COOPERATE FOR THE SAME PURPOSE: TO MOTIVATE STUDENTS TO LEARN MATHEMATICS

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Abstract

The aim of this paper is to introduce an active method in math to foster problem solving and research skills in the context of linear systems. The implementation of our research was supported by a project funded by the Porto City Council with a partnership between an institution of higher education, the Porto Accounting and Business School (ISCAP) and the Cerco of Porto, an Elementary and Secondary School. This school and the specific class were selected because some serious problems were identified by school teachers and managers, with regard to learning and motivation. The goal of this project was to promote students' scientific culture, autonomy, and passion for learning. Particularly in mathematics, the project intended to introduce confidence in knowledge and skills acquisition. Our desire was to develop collaborative work around projects that support reflection and action, in order to improve learning outcomes and quality, with students-centered learning. In addition, we envisage promoting creativity in the elaboration of everyday problems that can be solved through systems of equations. Throughout this paper, we present our research and the details about the more important self-active activities that were produced by students. Furthermore, a survey was developed and answered by students to ascertain their opinion about the project. In general, the results were very positive and gave good feedback that allows us to proceed with the project in the future, disseminating it to other classes.

Keywords: Student-centered Learning, Problem solving, Cooperation Project, Linear Systems.

1 INTRODUCTION

Motivation is fundamental for any of us and whatever we have to deal. Having motivated students can be a determining factor for a student to succeed in any discipline and achieving good results in the classroom. Motivation also allows the student to engage more deeply and committed to learning [1, p. 170]. Students should feel that they are responsible for their actions and grades and teamwork could be a strategy that can strengthen that will and ties between students. However, getting the student to engage and focus on the goals of the class is not always easy.

The reasons, to implement this project, were supported in various aspects, namely, the ones presented in [2, p. 159]: problems in educators' beliefs and perceptions, and family and social values. There was observed in Cerco's school that there are many problems around the areas of school intervention. Most of the members of a big number of families do not have a stable job, and/or the family does not follow their children's' and the respective studies at home. Concerning specifically the class being intervened in the project, it was identified in the last years that this class has got many problems with motivation to study, specially in Mathematics. Also, the City Hall knowing very well the population around the school and having some autonomy, according to the Dean of the school, could promote some projects with Higher Education Schools and Research Centers to introduce some changes. These changes, coming from schools' improvement plans, aim to stimulate some tasks related to learning, motivation and also to introduce confidence in knowledge and skills acquisition by the students. Similar projects are documented in Gysbers & Henderson [3]. The identification of the reasons to implement this project, follow Gysbers & Henderson [3] citing Lapan (2005), alert that "The Comprehensive School Improvement Plan is one place to look because it contains critical problems and anticipated outcomes that the school district or building leadership have identified as being important. In addition, in your work with students and teachers you know about specific problems that individual students or groups of students are facing and student problems with which teachers are dealing in the classroom."

This project wanted to go a little further and find out how two different level institutions could cooperate for the same purpose: to motivate students to learn mathematics. This is aligned with Serdyukov [4],

that considers that two different level institutions (higher Education and Elementary and Secondary School) could cooperate instead of following separate paths.

In addition, the project also tried to innovate by getting interaction with all of the intervening "actors". This is an important factor, as stated by Serdyukov [4]: "the audience is not only the educators but also students, parents, policy makers, and all other members of society who act either as implementers or consumers of the innovation".

The implementation of our research resulted from a partnership between an institution of higher education, the Porto Accounting and Business School (ISCAP), where a group of four Mathematics teachers was involved and the Cerco of Porto, an Elementary and Secondary School, where three teachers were involved (two Mathematics teachers and a manager) and was supported by a project funded by the Porto City Council.

This study involved a class of the Cerco school, with 16 students from the 8th grade. The choice of this particular class was due to the fact that some critical problems were identified by school teachers and managers, with regard to learning and motivation.

The purpose of this project beyond promoting students' scientific culture, autonomy, and passion for learning, was also to introduce confidence in knowledge and skills acquisition. For this, the topic "problem solving in the context of linear systems" was chosen from the math syllabus of the 8th grade and was worked in various ways by the teachers and the groups formed with the 16 students.

Aiming to achieve the purposes of this project, we are aware that "Learners, according to the Constructivist theory, are not passive recipients of information but are active agents engaging in constructing their own knowledge." [5, p. 320]. As Rowell & Hong [2], we think that applying strategies that are applicable to several motivational components will help students to become more autonomous learners. Thus, the contents and activities in this project were developed focused on Student-Centered Learning. In Brandes & Ginnis [6] we can find a description of important aspects related to Student-Centered Learning, and despite this study having a few years old (1986), it is more than adequate for today. In the study, the authors state that this method can and should be applied to students of any age and meets the latest ideas on pedagogy at any level of education. In short, it can be said that the method is intended to be activity-based learning rather than teaching, teacher-student collaboration rather than instructional. Students have to be held responsible for their learning with the teacher being a facilitator. This is resumed in Table 1 [7].

Table 1. Student–centred and teacher–centred continuum.

Teacher–centred Learning	***Student–centred Learning***
Low level of student choice	Learning High level of student choice
Student passive	Student active
Power is primarily with teacher	Power primarily with the student

We also consider Problem-Solving in our research, to complement the Student-Centered Learning, trying to change the way the class learns Mathematics. A classical model to teach and assess Problem-Solving in a mathematics classroom was presented by Polya (1957). This model consists in a 4-step process: i) understanding the problem; ii) devising a plan; iii) carrying out the plan, and iv) looking back. These steps have undergone some evolution over the years, but in essence, this model remains [8].

Pajares & Graham [9] present that self-efficacy beliefs, especially in problem-solving, is the only motivation predictor of mathematics performance. A later study from Usher & Pajares [10, p. 100], "revealed that each of the four sources of self-efficacy correlated significantly with the four mathematics self-efficacy measures and with motivation-related constructs such as mathematics self-concept, invitations, task goals, and optimism."

The main contributions of the study are to show that it is possible for two different levels of schools to work together in order to intervene in the environment and increase students' motivation, and consequently improve students' learning and skills, both hard and soft skills.

With the aforementioned ideas in the background, this paper is structured in the following way: section 2 describes the project design and the activities developed, in section 3 students' opinion is

scrutinized by the analysis of a questionnaire where the main results are outlined and the last section presents the conclusions.

2 ACTIVITIES DEVELOPED

The activities developed in the scope of the project took place from December 2018 until May 2019. In the first stage, the teachers of Cerco' School and ISCAP researchers decided about the math subject that will be explored with pupils and the activities that will be designed. The topic "Linear Systems of two equations in two variables", hereinafter referred to as LS, is part of the content covered in the curriculum of the 8th year and there was enough time to prepare it with the students. In addition, students often reveal difficulties in this topic [11], namely, a) to understand the problems; b) to translate the problems in mathematical models; c) to find a problem solving strategy, and d) to do mathematical procedures [12].

The activities developed within the project are set up to promote the conceptual mathematics of linear systems of two equations. Besides, it was envisaged to promote students' scientific culture, autonomy, passion for learning and engagement. So, the students' involvement was essential in all the phases of the work, and at the initial stage, they chose the name to the research project - "DICAS" (***D****esafio, **I**SCAP, **C**erco, **A**lunos a resolver **S**istemas).*

The students attended a research seminar at ISCAP in January 2019. This seminar aims to promote research skills and to teach how to use the Google search engine efficiently. Also, notions of plagiarism and the importance of referring research sources, were addressed. In class, this knowledge was practiced in the development of a mini-MOOC where pupils design the problems, structured and recorded a video about LS. This video was presented to the parents and to the academic community at the end of April. At the beginning of April, the students took part in a second seminar at ISCAP. Here, they participated in a competition (MATDESAFIO) solving mathematical problems in LS in the *MatActiva* web site. On the same day, the students participated in the "Math Pedipaper" discovering information inside the ISCAP campus. The "Math Pedipaper" is a kind of challenging test divided into stages in which competitors have to walk a certain route at a given time and answer a questionnaire involving solving tasks.

The project ends with the showcase of DICAS at the Almeida Garrett Municipal Library Auditorium, where all the projects by other schools designed as part of the *Society, School and Research Porto City Council Project* were presented to the community.

Figure 1. Showcase at the Almeida Garrett Municipal Library Auditorium

In order to ascertain students' opinions about the implications of DICAS in their lives, a questionnaire was delivered. The results are presented in the next section.

3 RESULTS

From 16 students participating in DICAS, 15 (11 female and 4 male) shared their opinion about the project and completed the questionnaire. It entailed several questions separated into three sections concerning students' demographic characterisation, students' opinion and an open-ended question allowing personal comments. The 23 items regarding students' opinions were measured on a five-point Likert scale (with 1 = strongly disagree and 5 = strongly agree). These questions intended to

analyse the importance assigned by students to the project on various aspects, namely, activities developed, communication, motivation, and attitudes towards mathematics and the school.

The mean and standard deviation of the responses to each question was computed and data summaries are presented in figures below.

Figure 2 shows the opinion of the pupils about all the activities developed within the DICAS project. All the activities are assigned with very high means demonstrating that students enjoyed the initiative. The students' favorite activity was the “Pedipaper held at ISCAP” with the highest score (mean=4.73, sd=0.59). It was corroborated by the open question where four students asked “More Pedipaper’ activities”. The presentation of the project to the community at the Almeida Garrett Municipal Library Auditorium had a mean of 4 points (sd=1.73).

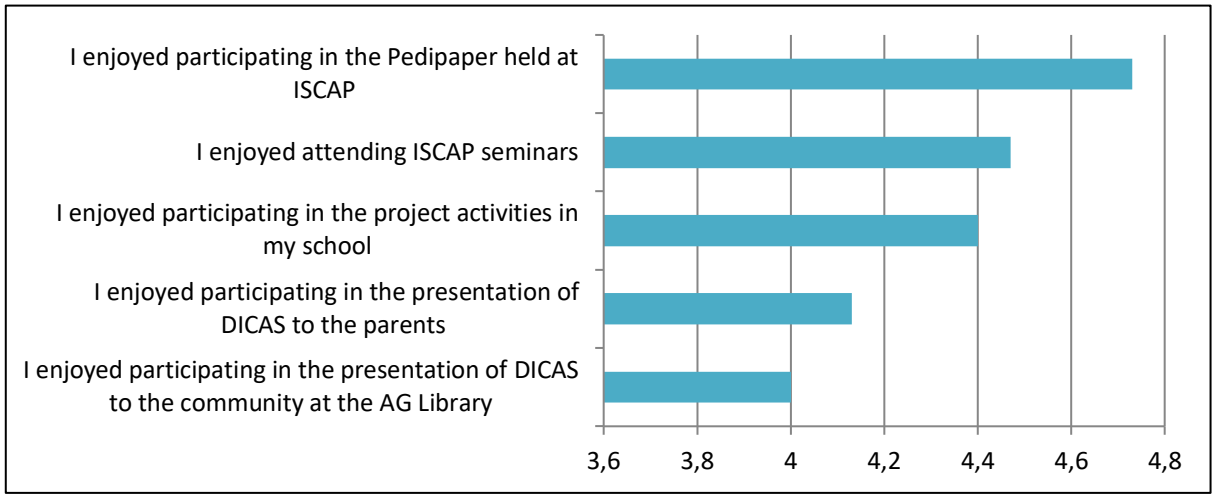

Figure 2. Students’ opinion about the activities developed

DICAS project enhanced the communication within the class, as shown by high means obtained in questions in Figure 3.

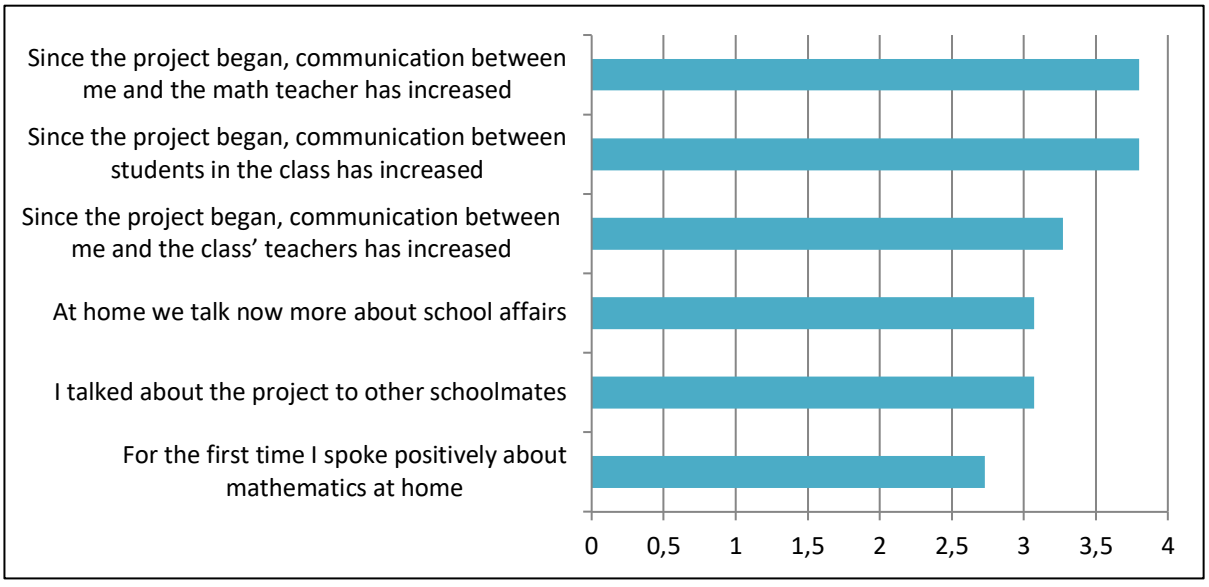

Figure 3. Students’ opinion about communication

One of the main goals of the project was to promote students’ autonomy, passion for learning, motivation, and engagement.

The students feel that the project helped them become more responsible (mean=3.67, sd=0.98), fostering motivation (mean=3.27, sd=0.8) and seeing the school more positively (mean=3.2, sd=1.01).

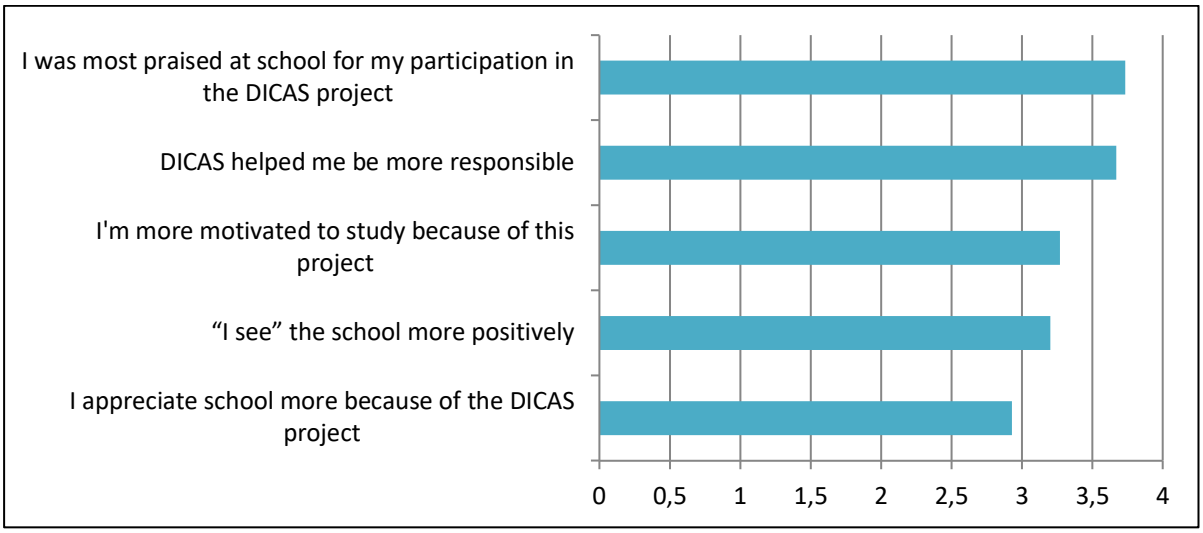

Figure 4. Students' opinion concerning motivation

Undoubtedly that DICAS affects the students participating on it when they are aware that "this kind of project improves learning" (mean=4.07, sd=0.96) or that "DICAS has made it easier to understand other Mathematics contents" (mean=3.93, sd=1.03).

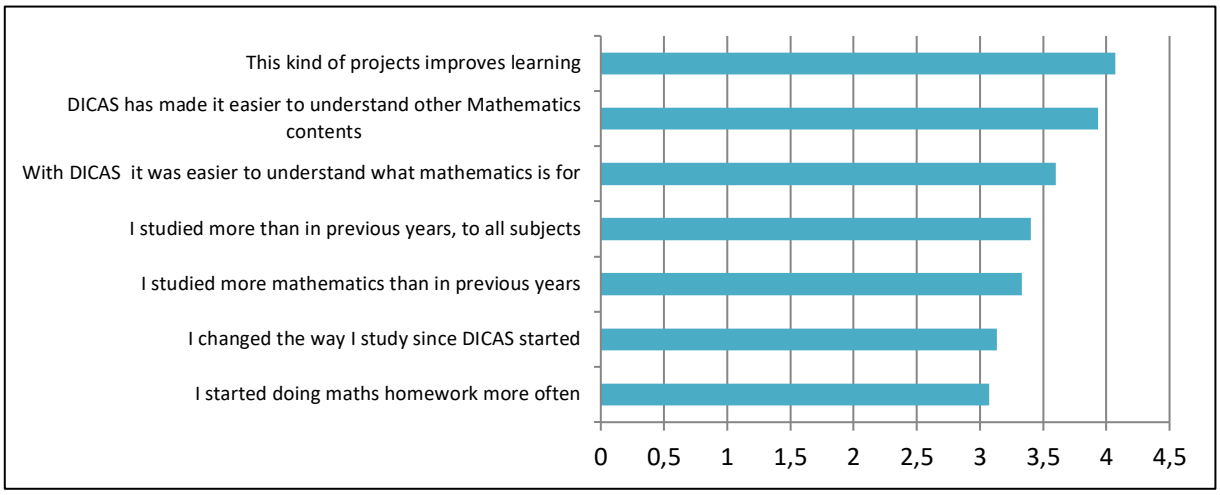

Figure 5. Students' opinion concerning the impact of DICAS in learning

4 CONCLUSIONS

In this project, Student-Centered Learning and Problem-Solving methods were used as support to the development of a wide range of activities that lead to the achievement of the goals initially defined. Activities, such as the Pedipaper or the mathematical challenge using ICT, allowed the students to leave their usual school environment, contact other teachers from a different school level, and contact different environments from the ones they were used to. The presentation of the developed work (Linear Systems of two equations) in the school attracted the students' tutors to the schools, thus a bigger involvement of them in the scholar activities. The presentation of the students' work in front of the students and teachers of the other schools intervened by the city council, allowed to increase their self-confidence, motivation, and engagement.

All these activities have woken up several emotions in the students, providing them with additional motivation to study mathematics.

The questionnaires showed that the students felt additional encouragement to work harder to get more success in Mathematics.

Our project had similar results than others such as the ones presented in [13], [14].

We are pleased with the results of this project and in the future, we would like to continue to implement and improve this strategy with other working groups.

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