Peer Instruction method in introductory Math courses

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ABSTRACT

Learning is not a spectator's sport. Students do not learn much by just sitting in class listening their teachers, memorizing pre-packaged assignments and spitting out answers.

The teaching-learning process has been a constant target of studies, particularly in Higher Education, in consequence of the annual increase of new students. The concern with maintaining a desired quality level in the training of these students, conjugated with the will to widen the access to all of those who finish Secondary School Education, has triggered a greater intervention from the education specialists, in partnership with the teachers of all Higher Education areas, in the analysis of this problem.

Considering the particular case of Engineering, it has been witnessed a rising concern with the active learning strategies and forms of assessment.

Research has demonstrated that students learn more if they are actively engaged with the material they are studying. In this presentation we describe, present and discuss the techniques and the results of Peer Instruction method in an introductory Calculus courses of an Engineering Bach.

KEYWORDS

Peer Instruction, calculus, teaching-learning process, learning strategies, assessment.

I - INTRODUCTION

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Considering the particular case of Engineering, it has been witnessed a rising concern with the active learning strategies and forms of assessment.

Research has demonstrated that students learn more if they are actively engaged with the material they are studying. In this presentation we describe, present and discuss the techniques and the results of Peer Instruction method in an introductory Calculus courses of an Engineering Bach. This course has over 500 students, a little over half of them repeating. Students' motivation to attend the course is probably the lowest among all of the program's courses. Thus the need arose to apply a new learning method that would result in a positive change in students' attitude towards the course.

This paper is structured as follows. Peer Instruction is described in Section II. In Section III, we present the used techniques and in Section IV the assessment results.

II - PEER INSTRUCTION METHOD

Peer instruction (PI) was developed in the 1990's at Harvard University by Eric Mazur. It has become a successful interactive teaching method in physics [2, 6]. PI is gaining popularity in calculus classrooms but there is limited documentation about its effectiveness [8, 7].

In this method,

- The teacher presents students with a qualitative (usually multiple choice) question that is carefully constructed to engage student difficulties with fundamental concepts.
- The students consider the problem on their own and contribute their answers in a way that the fraction of the class giving each answer can be determined and reported.
- Students then discuss the issue with their neighbours for two minutes and vote again.
- The issues are resolved with a class discussion and clarifications.

This method, besides having the advantage of engaging the student and making the lecture more interesting to the student, has the tremendous importance of giving the instructor significant feedback about where the class is and what it knows.

To often, we use the "union of knowledge principle" -- if any student in the class knows something, we assume the whole class knows it. The response system gives us much better information about the distribution of knowledge among our students. This method also offers significant opportunity for engaging the students in discussions of reasoning and epistemology (how we decide which answers are right and under what circumstances the answers hold).

III – TECHNIQUES

Data sources included classroom data show, a white board and "fingers" (no clickers).

There were 558 students enrolled in 10 small sections of 50 to 60 students. These small sections were taught by 3 different lecturers.

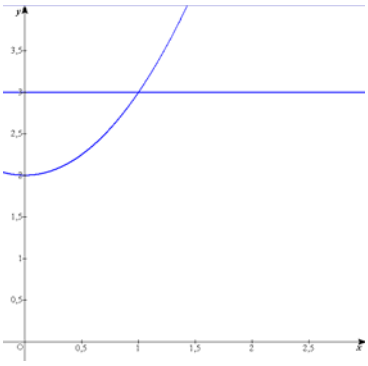
As a large number of our students are working student and not have much time to study at home. At the beginning of class, the

first 30 minutes, the lecture did an extensive summary of the subject.

The next 20 minutes were dedicated to the PI method. Some multiple-choice questions are presented to the class and the lecture gives a few minutes o the student gives their answer. The students think by themselves and register their vote. After this, the lecture asks the students to discuss the issue with their neighbours, preferably a student who gave a different answer.

If the lecture put the following question:

1- Find the area shown shaded in the diagram, bounded by the **y**-axis, the line $y = 3$ and the curve $y = x^2 + 2$



Answer:

a) $\int_0^1 (x^2 + 2)dx$

b) $\int_2^3 (x^2 + 2)dx$

c) $\int_0^1 3 - (x^2 + 2)dx$

d) $\int_0^1 3\,dx$

e) None of the above

Some of the questions the students make to their neighbours would be:
"What you answered? ", "Why?", students share their reasoning and their math knowledge for four or five minutes and vote again.

With the question we present to students we assess whether student have learned the lecture objectives.

III – ASSESSMENT RESULTS

Table 1 presents the results of the Calculus course since school year 2006/2007; the year ISEP programs adopted the Bologna format. Over 50% of the program's students are typically enrolled in this course, making it the course with most students in the program. The results are detailed for new students and re-enrolling ones, the last ones being the majority.

Table 1
Summary of the Calculus course results since 2006/2007

Year	Students	Succeed	Fail	Abandon	Total
2006/07	**New**	32	53	132	217
	Re-enrolment	141	40	232	413
	Total	173	93	364	630
2007/08	**New**	50	97	73	220
	Re-enrolment	72	84	237	393
	Total	122	181	310	613
2008/09	**New**	93	90	50	233
	Re-enrolment	93	33	224	350
	Total	186	123	274	583
2009/10	**New**	75	66	89	230
	Re-enrolment	81	36	206	323
	Total	156	102	295	553
2010/11	**New**	148	31	39	218
	Re-enrolment	163	34	143	340
	Total	311	65	182	558

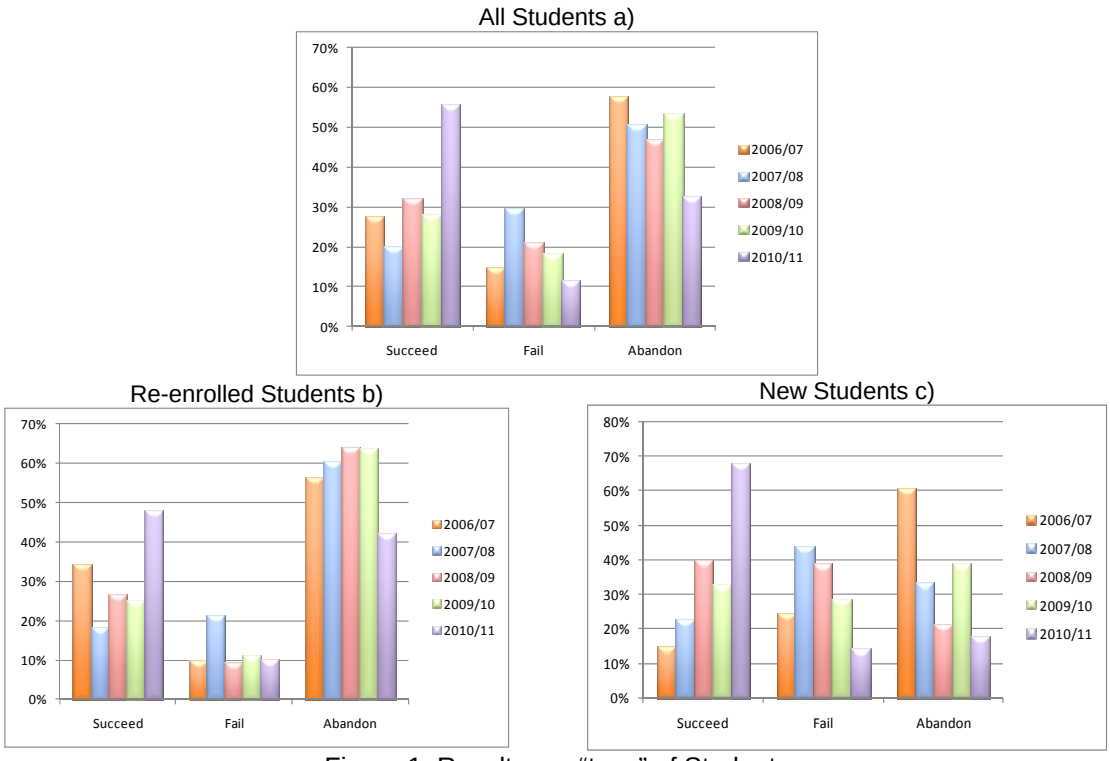


Figure 1. Results per "type" of Students

Figure 1 depicts the evolution of the course's results per type of student. The school year 2006/2007 results were extraordinarily bad for new students. The results for this group have been improving steadily over time, though always below the 40% success rate. On the other hand, re-enrolling students results have been deteriorating over time, albeit slowly. The major cause of failure for both new and re-enrolling students is abandon, i.e. the students stop attending classes and don't do the exams.

The PI approach was introduced in school year 2010/11 and the overall success rate increased dramatically to a little over 50%. This increase did occur not only for new students, but also for

re-enrolling ones, which increased from 30% to 48% Figure 1b). This increase was due to the decrease in the number of students who abandoned the course, as shown in Table 1 and Figure 1a). In fact, the number of the student who abandoned the course was nearly halved. The same happened for new students, as depicted in Figure 1c). To better understand what happened, the actual grades are depicted in Table 2 and in Figure 2. The grades are presented in the [0; 20] grade scale used in Portugal. Students pass with a grade of 10 or more.

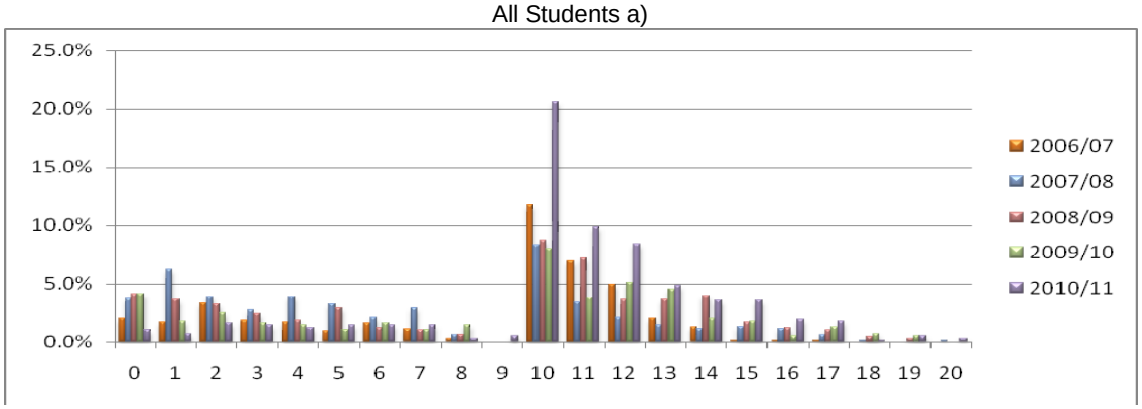
Table 2
Grades ([0; 20] grading scale, pass at 10)

Year	Students	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2006/07	New	9	9	12	7	7	3	4	2	0	0	17	3	8	2	1	0	0	1	0	0	0
	Re-enrollment	4	2	9	5	4	3	6	5	2	0	57	41	23	11	7	1	1	0	0	0	0
	Total	13	11	21	12	11	6	10	7	2	0	74	44	31	13	8	1	1	1	0	0	0
2007/08	New	17	21	14	9	12	10	8	6	0	0	21	12	4	1	3	3	2	3	0	0	1
	Re-enrollment	6	17	10	8	12	10	5	12	4	0	30	9	9	8	4	5	5	1	1	0	0
	Total	23	38	24	17	24	20	13	18	4	0	51	21	13	9	7	8	7	4	1	0	1
2008/09	New	19	15	15	10	11	11	6	2	1	0	26	16	14	10	11	5	5	5	1	0	0
	Re-enrollment	5	6	4	4	0	6	1	4	3	0	25	26	7	11	12	5	2	1	2	2	0
	Total	24	21	19	14	11	17	7	6	4	0	51	42	21	21	23	10	7	6	3	2	0
2009/10	New	23	6	9	7	5	4	6	3	3	0	20	10	14	14	5	5	1	3	2	1	0
	Re-enrollment	0	4	5	2	3	2	3	3	5	0	24	11	14	11	6	5	2	4	2	2	0
	Total	23	10	14	9	8	6	9	6	8	0	44	21	28	25	11	10	3	7	4	3	0
2010/11	New	2	1	4	6	3	4	2	3	1	2	47	31	24	14	10	9	4	5	1	2	1
	Re-enrollment	4	3	5	2	4	4	6	5	1	1	68	24	23	13	10	11	7	5	0	1	1
	Total	6	4	9	8	7	8	8	8	2	3	115	55	47	27	20	20	11	10	1	3	2

One first conclusion is that there was an overall improvement in the course's grades in the interval [0; 12]. There was hardly any increase in grades above 13 points. This increase at the low end of the grading scale leads us to conclude that PI may have been responsible for motivating low end students to attend classes and to try to succeed on the course. Many did actually succeed, albeit achieving only low-end results.

This conclusion is supported by student attendance to lectures during the whole semester, which actually rose after the first few weeks. This is completely unheard of at this type of course. The opposite usually happens, with many students stopping attending classes after 4 or 5 weeks. Furthermore, the increase in attendance was mostly noticed in re-enrolling students.

All Students a)



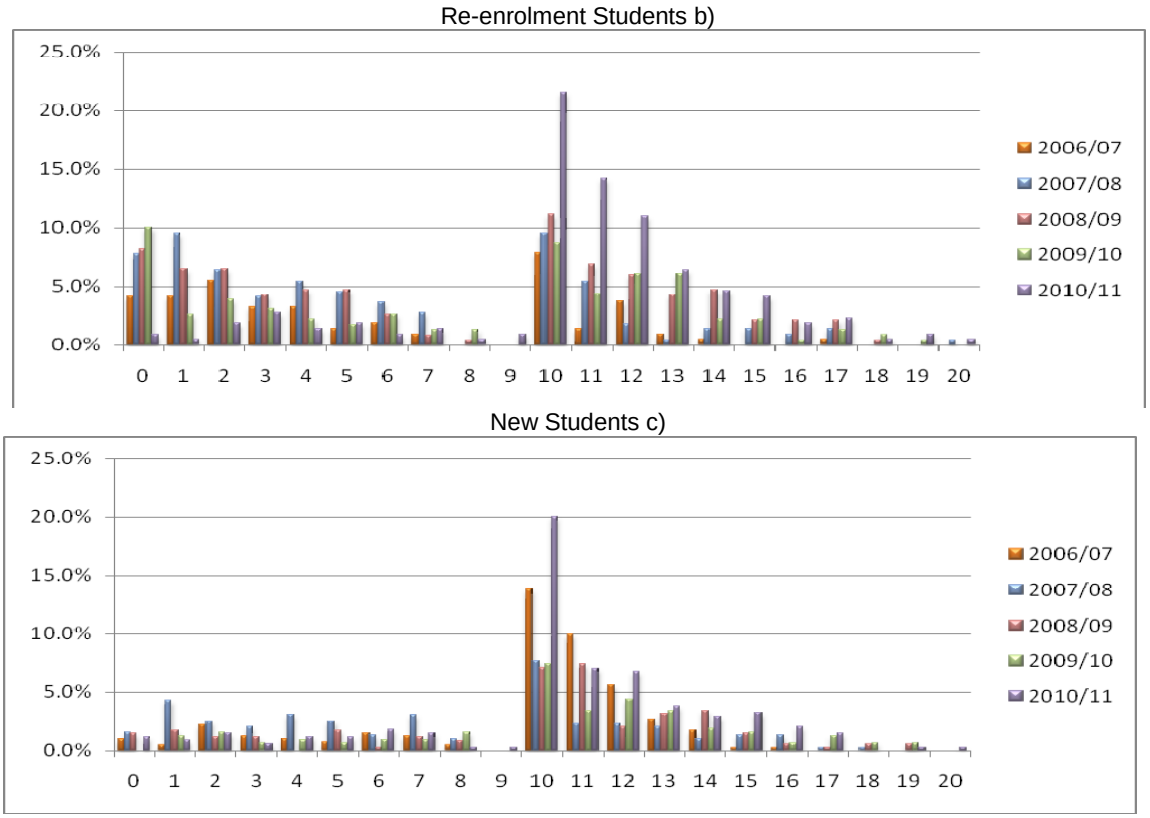


Figure 2. Grades per "type" of Students

The students' feedback on the PI method was overall positive. The students felt that PI was beneficial to themselves and their classmates. Here we present some student's comments: "I feel that it teaches more to the students, because we are not hearing a lecture from the same old professor."; "We were genuinely interested and wanted to share our opinion."; "Having students (peer teaching) teach gives it a fresh outlook and a creative take on material."

At the end of the course, a non-mandatory inquiry was made, asking students to evaluate their satisfaction of the PI method implementation, Table 3 . 80.28% answered the PI lessons were more interesting and that they learned more using it than with the traditional lecture method. Only 21.13% said that, regardless of the method used, they would always learn (9.15%) or do not learn (11.97%).

Table 3
Inquire to students (145 answers)

It made the lessons more interesting and I learned more in classes which the method Peer instruction was applied	**Doesn`t matter, I learned always**	**Doesn`t matter, I didn't learn anyway**
80,28%	9,15%	11,97%

CONCLUSION

Over half of the students in one of ISEP engineering programs were enrolled in the Calculus course, which had a typical failure rate of 60 to 70%, mostly due to students quitting the course. To address this problem, an innovative approach had to be used in order to motivate the

students to actively participate. Peer-assisted instruction allows students to express themselves, participate in their own learning, and further engage in a course. Thus it was selected to be used in this "problematic" course.

Overall results improved with the PI approach, though mostly at the low end of the scale. PI was thus successful in engaging low-end students to fully participate in the course. Most students praised the atmosphere created through the use peer instruction in lectures.

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Biographical Information

Eduarda Pinto Ferreira is a professor of Mathematic at ISEP - Instituto Superior de Engenharia do Porto, Portugal. PhD in Science Engineering. Chairman of 1st CDIO Iberian Workshop (ISEP), March 2011. Chairman of the 3rd ESICUP Meeting (EURO Special Interest Group on Cutting and Packing), international conference in Porto (ISEP), March 2006. Member of the Scientific Committee of JBLE-09 (Jornadas Luso-brasileiras de Engenharia), Porto (ISEP), February 2009. Attend all CDIO conferences since 2008. President of Pedagogical Council since January 2010.

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