Modifying the student's resistance towards active learning with more active-learning

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Abstract

The application of methodological innovations in the teaching of engineering has been promoted and justified for several years now, especially those based on active learning and problem-based learning. However, the adoption of these new methodologies by universities has been slower than expected. Although many of the indicated causes refer to resistance by professors (e.g. a lack of time for implementation), there are also those that are based on resistance by students. In particular, an attitude of distrust is mentioned with regard to these innovations, which normally require greater student participation. However, if the student has been part of passive learning during the majority of his life, how valid is his opinion about a methodology that he does not know?

In order to analyze this, we performed a two-stage study on the perception about learning methodologies on university students in Universidad de los Andes, Chile. The first stage consisted in changing a course to the active learning methodology and surveying the course's students (N=56) at the beginning as well as the end of the course, asking them to describe their ideal class. The results showed that the attribute "participative", which is key in an active learning methodology, went from a selection of 41% before the course to 68% after the course was finished. The second stage corresponded to a general perception study of the engineering students at the same university, which was performed two years after starting to take 3 of the major's courses with methodological innovations based on active learning. The study included 581 students (62% of the total students at the School), who were asked to describe their ideal class. We compared the results of the opinions of freshmen (N=198) with upperclassmen that had taken courses with active learning (N=210) and those who had not (N=173). This study showed different cases where the description of the ideal class was the consequence of the previous courses that the student had taken, such as the example previously shown about how the attribute "participative" was chosen significantly more by upperclassmen than by freshmen, which coincides with the passive methodologies proper to the country's schools where they had studied. In this way, in this paper we show through diverse situations the influence that experienced methodologies can have on a student, and how through these same methodologies we can change these opinions and make them favorable towards methodologies based on active learning.

Introduction

In recent years there has been a growing interest for changing pedagogical practices in the teaching of engineering[1 2]. This tendency responds to the necessities of economic globalization, rapid advances in technology and cognitive science[3 4]. In addition, in many of the world's countries it has been observed that the graduation rate of engineers has fallen in relation to the projected demand for these professionals[5]. This fact poses engineering schools a clear necessity to offer a better quality education in order to retain qualified engineering students in the numbers required to meet current and future needs for engineers[4]. In line with improving the quality of engineering teaching, there is a worldwide tendency towards accreditation of engineering programs, which requires that engineering schools be successful in developing and clearly

articulating learning outcomes[6 7]. Regarding accreditation, it is of special importance to equip students with so-called soft-skills such as effective communication and teamwork[8], as well as to assess students' learning, both during and after the process. For the development of these skills, teaching and assessment methods are required that are not traditionally found in engineering education, and are unfamiliar to most engineering educators[9 4 10].

Faced with the necessity of changing the pedagogical practices in the teaching of engineering curricula, faculty members cannot simply assume that the instructional methods that worked for them should work just as well for their students[4]. Professors must consider the characteristics of the actual generation of students; they are used to getting information in short visual bursts, they are getting more and more used to being involved in participatory cultures[11], and so they have less patience for lectures and textbooks than their counterparts in previous generations[12]. Improved learning may occur when teaching styles match learning styles than when they are mismatched, thus it is important that engineering education respond to the learning styles dominant among the population of students.

Evidence strongly suggests that one of the crucial factors in the educational development of undergraduate students is the degree to which the student is actively engaged or involved in the learning experience. Studies in Science, Technology, Engineering and Mathematics (STEM) education[13 14 15 16] have informed on teaching methods centered on the student, such as inquiry learning[17], problem-based learning[18 19], project-based learning[20], and just-in-time teaching[21]. These methodologies almost always involve students discussing questions and solving problems in class, with much of the work in and out of class being done by students working in small groups[22]. Experimentation with some of these methods has demonstrated that students achieve better conceptual comprehension and problem-solving capacity learning with them[23 13].

Although pedagogical innovation in STEM education can lead to improved teaching and learning, the adoption of innovations is a potentially long-lasting process, posing challenges to institutions regarding curriculum development, technology adoption and cultural change[24 1 25 26]. Several barriers exist to the use and adoption of novel teaching methodologies based on RBIS[27 1 28]. These include student resistance, negative expectations of content coverage, faculty time, departmental norms discouraging innovation, inadequate class size and room layout, rigid time structures and financial resources.

As mentioned previously, resistance by students is one of the barriers considered by professors to not include learner-centered teaching methods. The influence of this barrier is due to the fear that professors have of lowering their course evaluations, which are done by the students[29]. Although there are no detailed studies on the causes of this resistance, there are explanations that relate it to the extensive previous experience students have with traditional methodologies, with a perception of an increase in the time required by the student and with errors by professors at the moment of implementation[30]. Thus, how trustworthy is the prior perception of students faced with these methodologies? Moreover, is it possible to change this perception considering the lessening of the causes previously mentioned?

In this paper we present two studies that seek to answer the questions recently asked. In the following, the first study is presented, which consists in measuring the changes in the students' description of the ideal class both before and after taking a course with active learning (i.e. JiTT),

in order to see whether the new methodology generated changes in their perceptions. Then, the results of the second study are shown, which measure and compare the perception of the ideal class among freshmen, upperclassmen who had taken courses with active learning and upperclassmen who had not, seeking to analyze if there were differences in perception among these groups. Finally, the results are discussed and conclusions are presented.

Study 1

This first study was performed at the School of Engineering of Universidad de los Andes, Chile. The pedagogical model that is practiced by most of the academic staff in the Faculty is based on traditional lecturing supported by PowerPoint slides, whiteboard notes, or a combination of both. Class lectures are scheduled on a twice-per-week basis, with each class lasting 100 minutes. Generally, course evaluation is based on two tests, 5-6 written quizzes or a course project, assignments or lab sessions and a final exam. Courses are planned according to a semester schedule, comprising 16 weeks of instruction and 2 weeks of exams. On average, each course is assigned 6 ECTS credits, which are equivalent to 180-hours student dedication.

The study consisted in changing the methodology of the Relational Databases course (henceforth "DB course") to an active learning one during second semester 2012. This course is mandatory for students of Industrial Engineering and Computer Engineering. Additionally, this course is programmed to be taken in the third year of the major, with the duration of the entire curriculum being six years. Up until the semester preceding the study, the DB course had been taught in the traditional fashion.

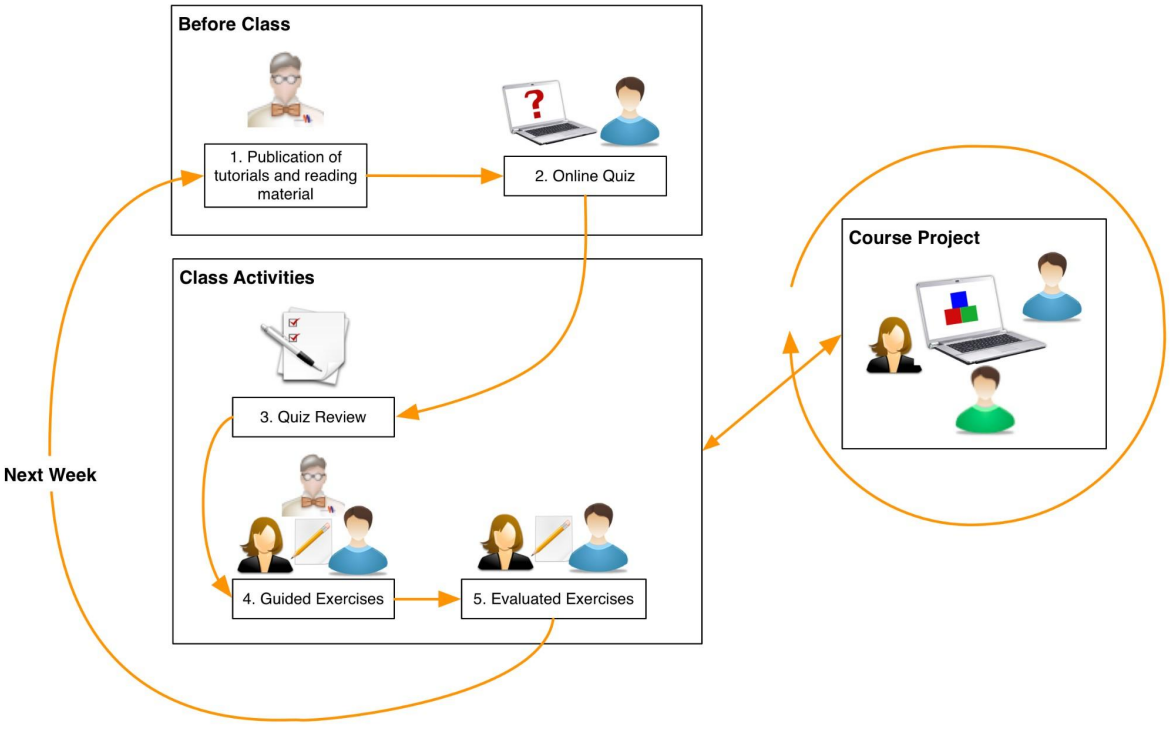

Figure 1. The pedagogical model used in the present study.

In this version of the course, 56 students participated, with 25% being women. Additionally, 93% of the students were pursuing the major of Industrial Engineering and only 7% were majoring in Computer Engineering. Given that the DB course is not a prerequisite for other courses in Industrial Engineering, many students decide to postpone this course and take it in a semester later than planned in the curriculum. Consequently, the course had a mixed cohort of students, ranging from the third year students (25%) to sixth and later (27%) years.

The methodology used was based on Just in Time Teaching (JiTT) [21 16] and Problem-Based Learning[18 31]. Figure 1 shows the activities associated with each weekly session. Face-to-face class time was reduced to one class per week lasting 150 minutes.

Students were asked to answer an anonymous questionnaire both on the first class of the semester as well as after the final exam. Both questionnaires were the same and were paper-based. The questionnaire contained questions about personal information (i.e. gender and age), academic information (i.e. college entrance year, curriculum followed) and inquiries regarding students' opinions about a traditional class and an ideal class. In these latter inquiries, the students were presented with a specific list of 13 attributes, and were asked to select three of them matching their appraisal of a particular class (see below). The set of 13 attributes was chosen based on the main characteristics of passive and active learning methodologies, and considering attributes that commonly appear in students' assessment of Faculty courses at the end of each semester. In this way, the students had to choose attributes for the following situations:

1. A typical class of a course at the engineering school (only in the first questionnaire)
2. An ideal class
3. A class of the DB course (only in the final questionnaire)

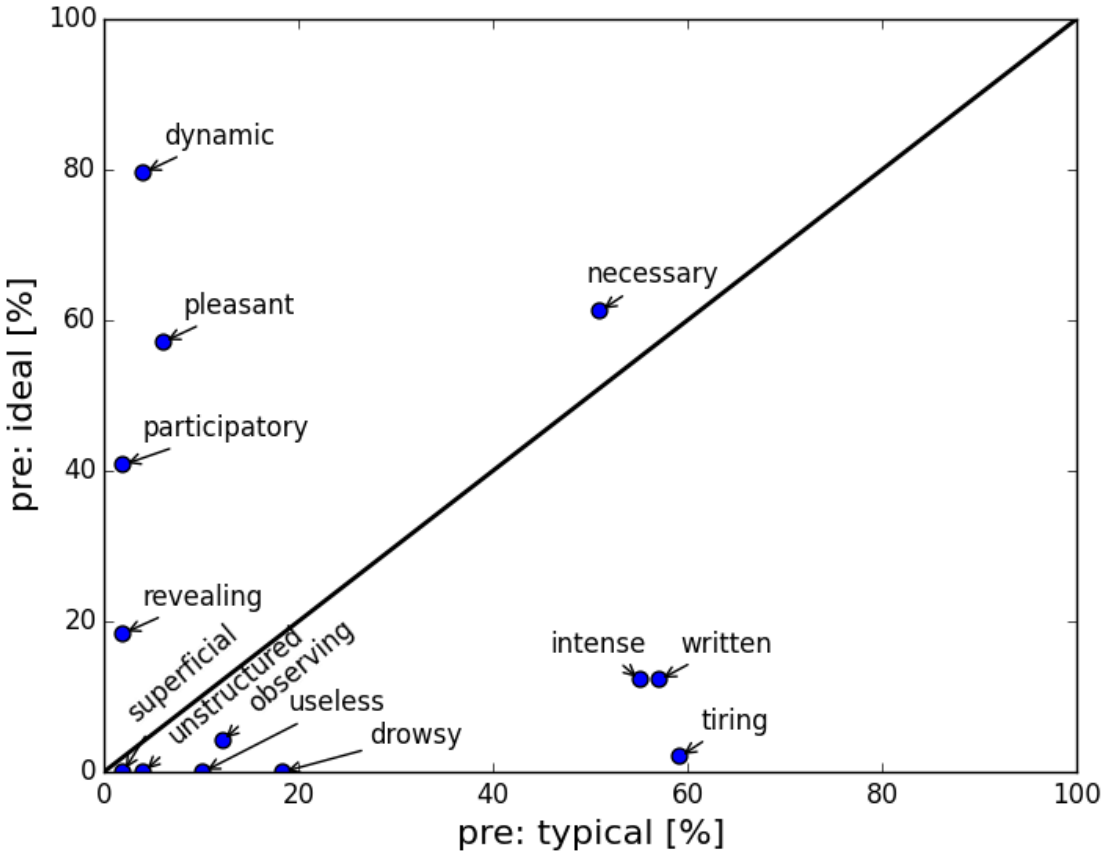

Figure 2. Students' selection of attributes characterizing a typical class (horizontal axis) and an ideal class (vertical axis) in the questionnaire ran in the first session of the DB course.

The first session's questionnaire was answered by 49 of the 56 students registered in the course. The results of the attributes chosen by the students for a typical class and for an ideal class are presented in Figure 2. The most chosen attributes to describe a typical class were: tiring, written, intense, and necessary. In contrast, in the case of the ideal class, the most chosen were: pleasant, dynamic, necessary, and to a lower degree, participatory. Thus, the attribute "necessary" was the only one that was repeated in both characterizations. Analyzing the differences in the selections of each student, we found that 45% repeated only one attribute, with this always being "necessary". Only 10% repeated two attributes and none repeated the 3 attributes selected for an ideal class with those for a typical class.

After the course's final exam, the students were asked to answer the questionnaire again, but now adding the characterization of the recently finished DB course. In this occasion, all 56 students registered in the course answered. Figure 3 shows the results of the attributes chosen for the DB course and for the ideal class in the final questionnaire. For the DB course, the attributes dynamic and participatory stand out, and to a lesser degree tiring and intense. In the case of the ideal class, the most chosen attributes were also dynamic and participatory, in addition to necessary and pleasant. Thus, there is an evident similarity between the selections made for the characterization of the recently finished DB course and the ideal class for the students. Analyzing the individual answers, we found that only 11% of the students did not have coincidences between their

selections for the DB course and the ideal class, while 34% coincided in one attribute, 45% in two and 11% in three.

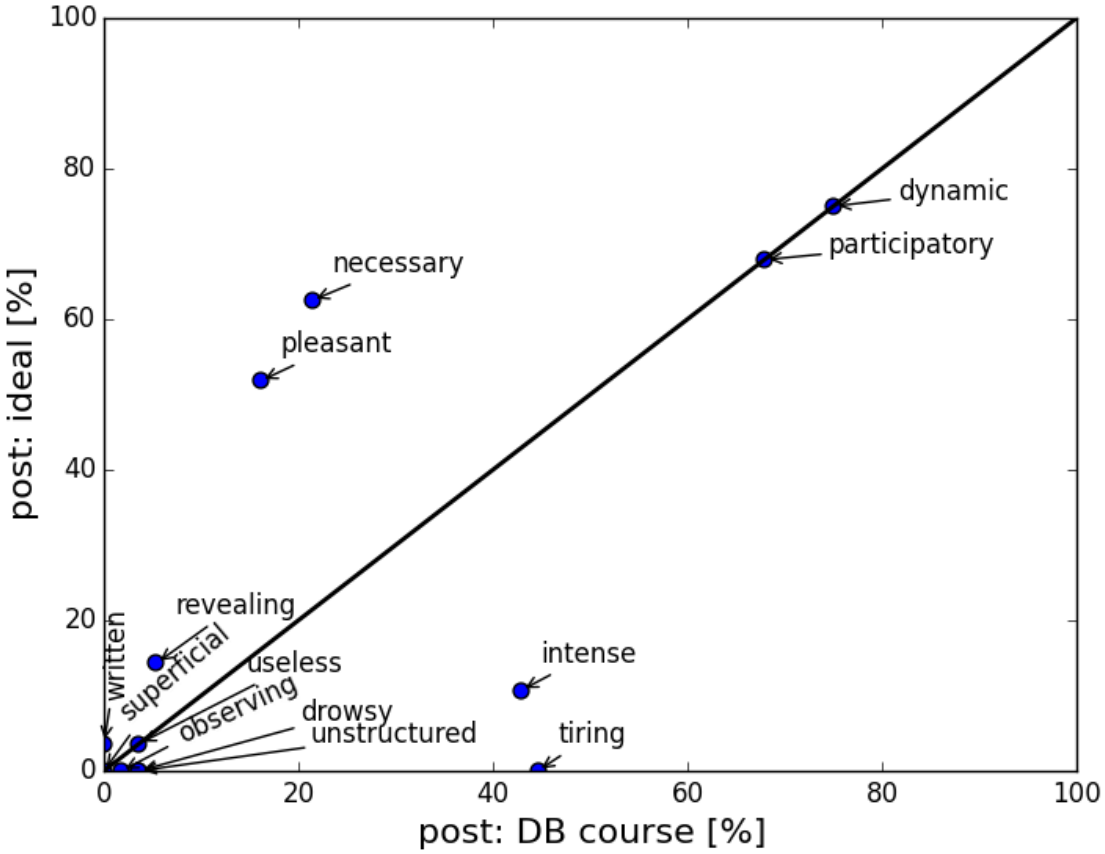

Figure 3. Students' selection of attributes characterizing a class in the DB course (horizontal axis) and an ideal class (vertical axis) in the second questionnaire ran in the DB course.

It is even more interesting to compare the selections made for the ideal class before and after participating in the intervened course. As can be appreciated in Figure 4, while the selection of the three most chosen attributes remains stable (pleasant, dynamic, necessary), the attribute "participatory" has an increase in its choice from 41% to 68%, becoming the second most important attribute. Thus, the two principal attributes chosen to characterize an ideal class in the second questionnaire are dynamic and participatory, which are characteristics directly related to active learning methodologies.

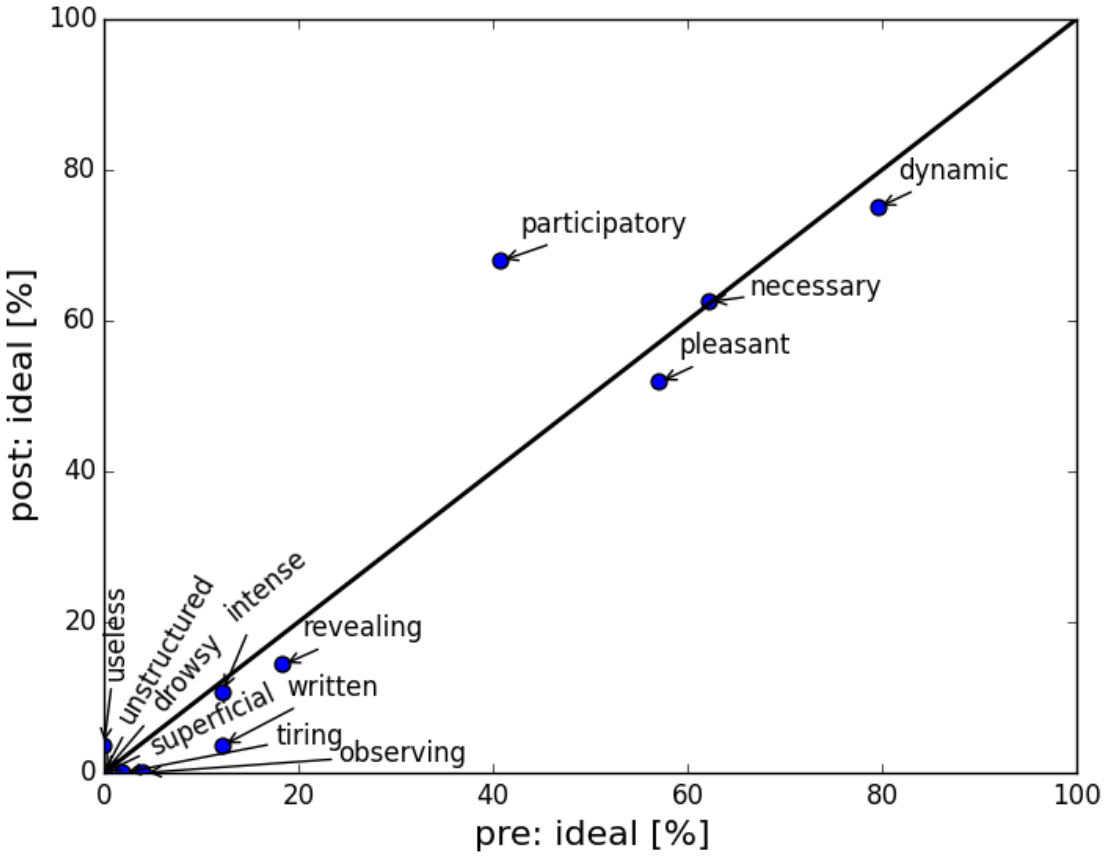

Figure 4. Students' selection of attributes characterizing an ideal class (horizontal axis) in the first questionnaire ran in the DB course and an ideal class (vertical axis) in the second questionnaire.

Study 2

This study was performed in the same School of Engineering as the prior study. Starting with the experience of the DB course during the second semester of 2012, methodological changes oriented to active learning were made in two additional courses: Introduction to Programming (two semesters in 2013) and Linear Algebra (second semester of 2013). Both are first year courses and obligatory for all of the specialties offered by this School (Industrial, Civil, Electrical and Computer). Thus, during the beginning of the 2014 academic year, a study was performed seeking to analyze the influence of these methodological changes on the perception of the students with respect to their ideal class, in addition to considering a comparison with the opinion of freshmen, who had only taken two weeks of classes at the university.

The study consisted in applying a questionnaire, asking the students to chose three attributes from a list of 14 that best describe a typical class and an ideal class, following the same line of the questionnaire from study 1. The questionnaire was paper-based, and for the selection of the students, the principal courses of each year were chosen and students were asked in person in class to participate. Table 1 shows the composition of the students that finally answered the questionnaire, which totaled 60.5% of the engineering students in this School.

Group	Men	Women	Total participation	Total School	% Participation
Freshmen	165	33	198	209	94.7
Upperclassmen	320	63	383	757	50.6
Total participation	485	96	581		
Total School	819	147	966		
% Participation	59.2	65.3	60.1		

Table 1. Distribution of students who answered the questionnaire (i.e. freshmen and upperclassmen), compared with the entirety of students in the School of Engineering.

For a first analysis we separated the participants into three groups: freshmen (198), upperclassmen who had participated in at least one active methodology course (210) and upperclassmen who had not had active methodology courses (173). Upon comparing the selections for an ideal class in these three groups we found that the principal difference is produced in the "participatory" attribute, such as shown in Figure 5. This is the most chosen attribute by upperclassmen in both groups, while for freshmen it is the third, being out chosen by "dynamic" and "necessary".

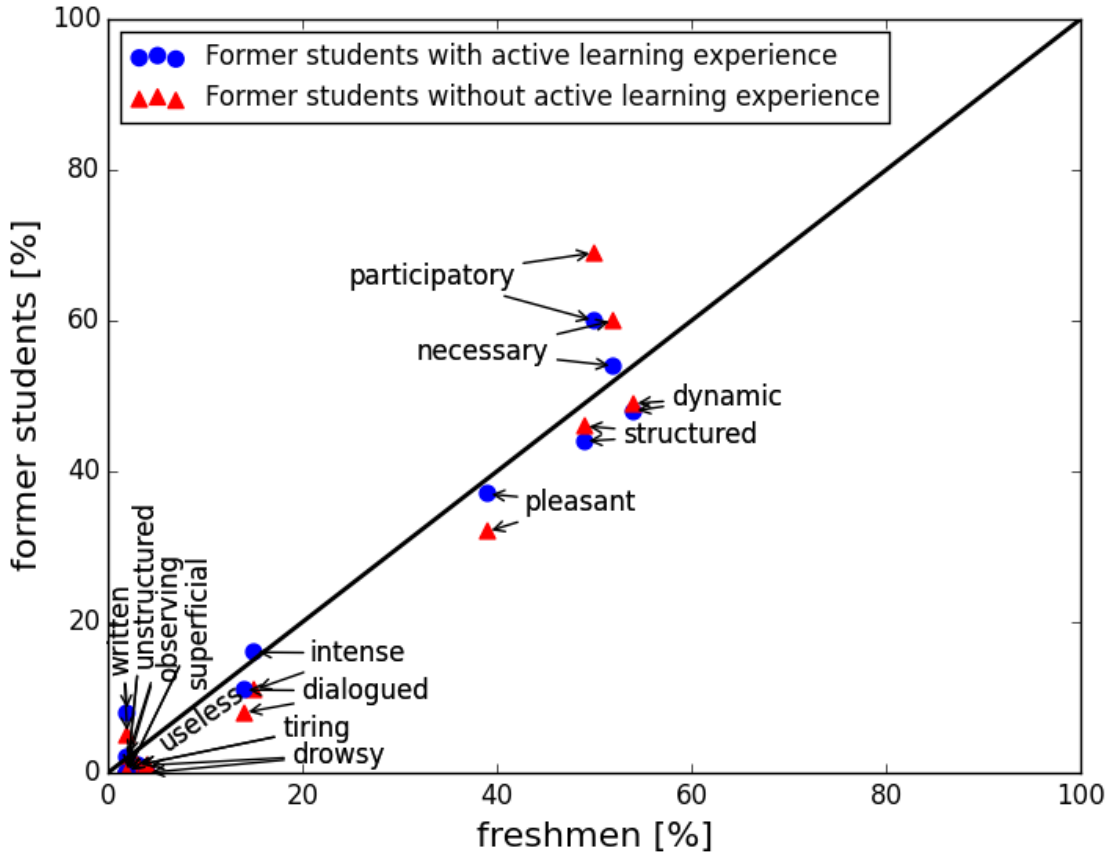

Figure 5. Selection of attributes by freshmen compared to that of former students with active learning experience (blue circle) and without such experience (red triangle).

Next, we separated the students who had taken only one course with an active learning methodology in order to evaluate if any of them had had a distinct influence on the students' opinion. In this way, the sample considers 79 students who had only taken Introduction to Programming with an active learning methodology, 44 who had only taken the course Relational Databases and 16 who had only taken Linear Algebra.

Figure 6 shows the results for the ideal class of these three groups. Although differences appear in various attributes, such as "necessary" and "participatory", there is a particular difference that attracts attention, which is produced in the attribute "structured", where 63% of the students who had only participated in the course Linear Algebra chose it, while for the other courses this did not exceed 50%. The Linear Algebra course was only given under the active learning methodology during second semester 2013, and was taught by professors without experience in these types of methodologies and without adequate support by the School. As is shown in the low course evaluation in Table 2, the students' experience was not satisfactory.

Semester	Introduction to Programming	Relational Databases	Linear Algebra
2012-II	5.99, 6.31, 6.44	6.22	5.45, 5.79
2013-I	6.52, 6.54	5.91	6.23, 6.37
2013-II	6.2, 6.46, 6.6	5.97	4.3, 5.59

Table 2. Evolution of students' assessment of professors in the observed course, in a 1-7 scale. The amount of grades in each cell indicates the number of different sections in the corresponding semester. The cells with a grey background identify the semester in which the course was given with an active learning methodology.

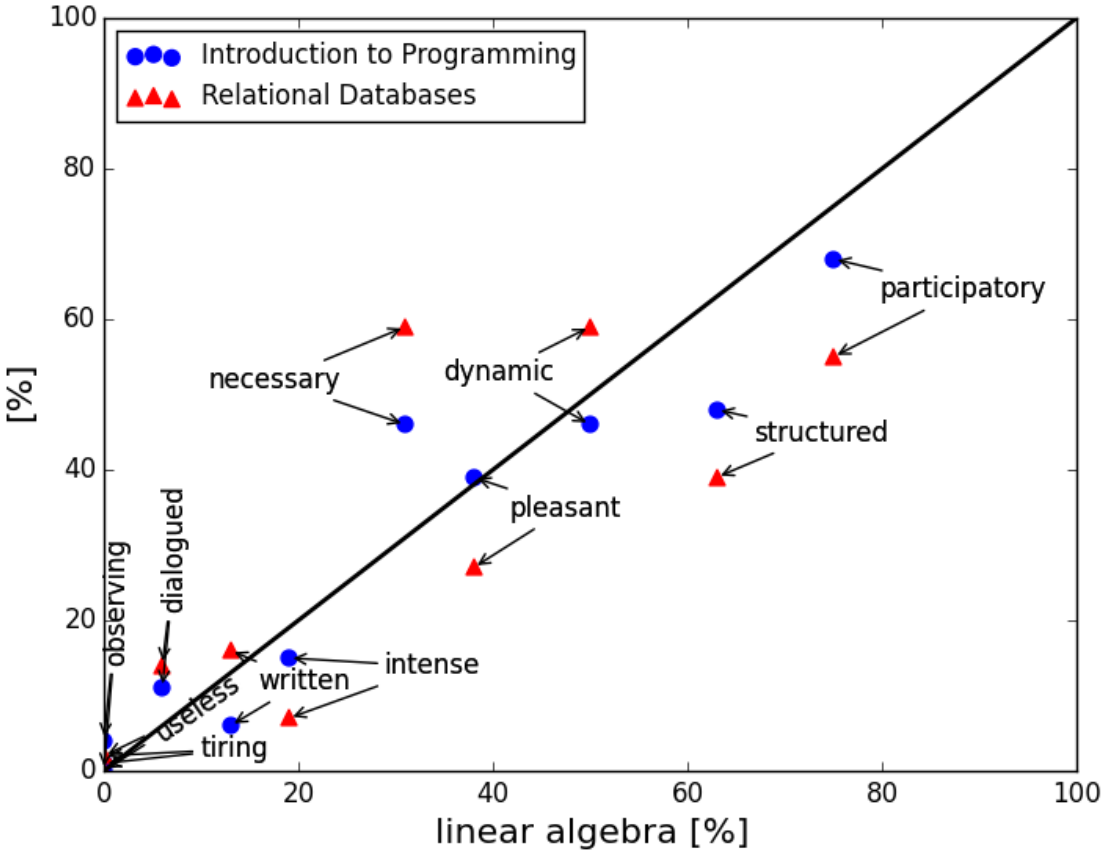

Figure 6. Selection of attributes made by students who have only taken the Linear Algebra course, compared to students who have only taken Introduction to Programming or Relational Databases. Note that students who took Linear Algebra did not select the attributes unstructured, drowsy and superficial.

Discussion and conclusions

In both studies we can appreciate the relation between the students' opinion and their experience with courses with active learning methodologies. Thus, in the first study we see how experience in a course with active learning makes students value participation more as a relevant characteristic in a good class. In turn, in the second study, we see that those students who had a recent experience in a poorly evaluated course selected the attribute "structured" as relevant, possibly as a consequence of that experience.

Table 3 shows a compilation of the selection results for the ideal class both for the first study as well as for the second study. Although the attributes added in the second study provoke differences in the quantities, it can be appreciated that there is a similarity in the differences between the pre and post questionnaire of the first study and the survey of the freshmen and upperclassmen of the second study. In particular, it is possible to appreciate that in both cases the selection of the attribute "participative" increase for the description of the ideal class. In this sense, the results of the pre-survey of the first study are comparable in context to the freshmen, in the sense that both have not had previous experience in active learning courses. On the other

hand, the results of the post survey in the first study are similar to the upperclassmen in the second study since in both cases there were recent experiences in courses with an active learning methodology, or at least, recent experiences with this methodology in a close context.

Attribute	1st Study – Pre (%)	1st Study – Post (%)	2nd Study – Freshmen (%)	2nd Study – Former (%)
Tiring	2	0	3	1.3
Pleasant	57.1	51.8	39.4	35
Unstructured	0	0	1.5	0
Dynamic	79.6	75	53.5	48
Written	12.2	3.8	1.5	6.5
Intense	12.2	10.7	15.2	13.8
Useless	0	3.6	2	0.3
Necessary	61.2	62.5	52	56
Observing	4.1	0	2	1.3
Participatory	40.8	67.9	50.6	64
Revealing	18.4	14.3		
Drowsy	0	0	3.5	0.5
Superficial	0	0	2	0
Dialogued			14.1	9.7
Structured			49.5	44.9

Table 3. Summary of students' attribute selection in their characterization of the ideal class in both studies.

The results allow relating the opinion of the students on learning methodologies with their past experience, both direct as well as their immediate context. Thus, based on these results we can understand that there is an initial resistance by students towards learner-centered teaching methods, but that said resistance could be modified if the application of the change in modification is done adequately. In turn, the results also demonstrate that the constant application of active learning in diverse courses of a School may influence the collective opinion of the students, making future changes easier in courses that still maintain traditional methodologies.

Acknowledgements

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