Teaching Mathematics using Active Learning: Teachers’ Preparation in Chile

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Teachers’ preparation in Chile

Abstract

The effectiveness of active learning has been demonstrated in many studies conducted across 
multiple disciplines, levels, countries, and backgrounds. Nevertheless, few of those published 
have focused on teaching mathematics with active learning methodologies. In particular, even 
though Latin American universities have an increased interest in student-centered 
methodologies, there are not enough documented experiences of Spanish-speaking universities 
using active learning methodologies. This work reports a unique experience with a group of 
instructors teaching mathematics using active learning in a private university in Chile. 
In that scenario, twelve instructors of the Engineering School received professional development 
training on both active learning and collaborative methodologies with the aim of enabling them 
to modify the way they prepare their classes and interact with students in the classrooms. These 
instructors taught basic math courses for engineering students under the supervision of two 
coordinators that also participated in this study. 
The development training started with an introductory workshop focused on raising awareness 
among the participants about the importance and the need for a change of paradigm in classroom 
practice. Then, the instructors participated on follow-up sessions, class observations and 
feedback sessions. They received guidance on the design of pedagogical material that could 
foster students’ engagement in their own learning. In the first semester of implementation of this 
experience, over 1300 students from the first and second years of the engineering program 
enrolled on the selected courses. 
In this paper, we present a description of the instructors’ training methodology, the follow-up 
during the semester, instructors’ perspectives at the end of the semester measured by an 
terview, as well as students’ performance in terms of passing ratio, their perception of the 
pedagogical approach and about their own learning. 
Among other results, some courses showed an improvement in the percentage of passing grades 
compared to a preceding year and an increased percentage of students not dropping out of the 
courses. However, in some other courses the results showed that more improvement is needed. 
Evidence was found about some factors that may affect the success of the implementation of 
innovation in class. Instructors’ previous preparation and perception of their own teaching 
appears to be an important factor, as well as the way students’ perceived their interaction with 
knowledge and their responsibility to the act of constructing that knowledge on their own. These 
results were encouraging to continue working with a professional development program for 
faculties for this Engineering School to transform their teaching practices.

Background

This work reports a unique experience in Chile in which the Department of Mathematics of the 
School of Exact Sciences agreed to collaborate with the School of Engineering to implement 
active learning strategies in all the mathematics courses offered to engineering students at one
particular campus. At the university in which this study took place, mathematics courses are taught with a number of parallel sections, each of them with about 40 students and different instructors. Each of the courses has a coordinator who makes sure that all instructors are teaching the course at the same pace. All sections of a particular mathematics course cover the same topics every week. Moreover, the course coordinator designs all summative partial and final exams for all sections. The five mathematic courses that were considered for this study have a very long list of topics (syllabus) to cover and evaluate. Even in a traditional lecturing style not all topics are fully covered by the teacher; some topics are just mentioned and left for the student to go over the material or to do exercises by themselves.

Before this study, the main teaching strategy in all mathematics courses was a traditional approach. For this paper, traditional teaching means the main actor is the teacher by lecturing most of the sessions with minimal or no participation from the students, and with a heavy use of chalk and blackboard by the teacher. In a traditional class, the instructor explains the topic, solves some exercises, and asks students to solve some others. Then, homework is assigned with similar exercises. In summary, it is a teaching strategy based on information transmission with minimal instructor-student interaction and even less student-student interaction.

Active learning definitions emphasize the role of students to engage in their own learning process by working in course-related activities and participating in group discussions rather than passively listening to the instructor. Active learning seeks to have all students actively engage in higher-order thinking, such as synthesizing, analyzing, and evaluating information, which often occurs in a collaborative classroom environment. For this paper, authors consider active learning as a student-centered classroom (as defined above) and traditional practices as a teacher-centered classroom. Moreover, authors are not against traditional teaching, but they consider that the use of lecturing should be kept to a minimum to allow students participation and to foster their construction of knowledge.

Evidence of the fact that students who actively engage with course material will end up retaining it for much longer than they would have otherwise, and they will be better able to apply their knowledge broadly, has been accumulating for decades. Previous research shows that active learning is effective in many disciplines. However, not as many previous research experiences have been published focusing on teaching mathematics with an active learning methodology. In particular, fewer documented experiences of Spanish-speaking universities are available even though lately those universities have an increased interest in student-centered methodologies.

Active learning in mathematics is a very important topic. The *Notice of the American Mathematical Society* has recently published an article that provides a definition of active learning, gives some examples of active learning techniques and environments, and addresses some common questions regarding active learning, such as: How will students learn the mathematics if we do not clearly tell them everything about it? What if I can’t cover the same amount of material? How do I know if I’m doing a good job with my teaching? I didn’t need active learning, why do my students? This AMS publication calls on everyone involved in
graduate education to raise awareness on the importance of knowing and implementing active learning strategies.

Huet e Silva, Pacheco & Tavares\textsuperscript{10} found that both the curriculum organization of a course and the teaching strategies positively correlate to students’ failure and dropout rate in a first-year undergraduate programming course at the University of Aveiro, Portugal. Another study\textsuperscript{6} presented a systematic approach to active learning in the classroom that consists of four dimensions: context setting, class preparation, class delivery and continuous improvement. That study\textsuperscript{6} emphasized that all dimensions are connected in the sense that one has impact on the others, either positive or negative depending on whether the actions taken strengthen or weaken that particular dimension.

**Methodology**

Twelve instructors participated in this project. The instructors did not have any experience in student-centered educational strategies. They gave lectures using the blackboard to present content to students and solve exercises. They were assigned to participate in the project of learning and implementing different strategies, that is, there was no selection recruitment process. This paper reports the actions and results of one semester of training and implementing (Figure 1).

![Figure 1. Elements involved in the training process towards a shift into the active learning paradigm.](image)

**Prior to the first day of class**

The twelve instructors received professional development (PD) training on active learning and collaborative methodologies in a two-day long workshop that would enable them to implement it in their classrooms. The two PD facilitators had extensive experience in active learning both in teaching engineering and mathematics courses for undergrads and in professional development for university instructors. The objective of this workshop was three-fold:

a) To gather data to know the instructors’ initial beliefs about teaching\textsuperscript{11}.

b) To introduce instructors to constructivism and active learning as a methodology that can be used in mathematics. That is, making participants aware that traditional teaching often
does not foster learning and that a student-centered teaching strategy has a better chance to be successful.

c) To train instructors in specific active learning and collaborative learning strategies which were used by the workshop’s instructors to introduce the content.

This workshop took place two weeks before the semester started; the following weeks, participants worked in groups to design activities for at least the first month of the course. There were two more meetings, one per week, in which participants received feedback on their designs. Figure 2 shows the complete training cycle that occurred during the entire semester and indicates the parts implemented prior to the first day of class (text in black) and the ones that took place during the semester (text in green).

The PD process (Figure 2) is called a cycle because it consists of a few elements that are repeated\textsuperscript{11}. The description of each element is taken from Ho et al (2001, p.147)\textsuperscript{12}:

- **Self-reflections**: Instructors “undergo self-reflection and clarify personal conceptions.” In this study, all three reflections occurred prior to the first day of class.
- **Exposures**: Workshop facilitators “provide a direction and a model for improvement.” Exposure 1 and Exposure 2 occurred prior to the first day of class, whereas Exposure 3 occurred during the semester.
- **Confrontations**: Instructors “are brought to realize possible inadequacies in their existing conceptions and/or teaching practices and thus create an awareness for the need to change.” This is a critical moment in the PD workshop since instructors realize that there is a conflict or some incongruences in their practice.
- **Commitment building**: Workshop facilitators “encourage instructors to engage in changes and development.” This commitment occurred during an individual interview with each instructor at the end of the semester.
Exposure 3 consisted in a series of meetings that took place during the semester. The format of these meetings varied: they were tailored to accommodate the instructors’ needs for the particular strategy each course was implementing.

Instructors requested literature to go over some of the ideas discussed in the workshop. The facilitators gave them a set or optional reading materials\textsuperscript{1,2,3,13,14,15,16,17,18}. Most of the materials were written in Spanish, since the instructors had mentioned that even though they understood English, they read faster in their native language.

\textit{Instructors and mathematics courses}

The participants were divided into five groups (one group for each course) who worked on each course they were teaching. Table I presents a relationship of the 12 instructors who participated in this project and the mathematics course and number of sections that each of them taught.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
Course & Instructor & Number of sections \\
\hline
Pre-Calculus (PC) & Instructor A & 4 \\
Pre-Calculus (PC) & Instructor B & 4 \\
Pre-Calculus (PC) & Instructor C & 1 \\
Differential Calculus (DC) & Coordinator 1 & 1 \\
Differential Calculus (DC) & Instructor D & 4 \\
Differential Calculus (DC) & Instructor E & 3 \\
Differential Calculus (DC) & Instructor C & 1 \\
Differential Calculus (DC) & Instructor F & 1 \\
Integral Calculus and Probability (IP) & Instructor C & 2 \\
Integral Calculus and Probability (IP) & Instructor F & 2 \\
Integral Calculus (IC) & Coordinator 2 & 1 \\
Integral Calculus (IC) & Instructor G & 3 \\
Integral Calculus (IC) & Instructor H & 2 \\
Differential Equations (DE) & Coordinator 2 & 1 \\
Differential Equations (DE) & Instructor G & 3 \\
Differential Equations (DE) & Instructor H & 2 \\
Differential Equations (DE) & Instructor I & 1 \\
Differential Equations (DE) & Instructor J & 1 \\
\hline
\end{tabular}
\caption{Relationship between the courses and sections taught by each instructor.}
\end{table}

There were 12 instructors in total teaching five courses. Two of the instructors worked as coordinators as well. Coordinator 1 was in charge of Pre-Calculus (PC), Differential Calculus (DC) and Integral Calculus and Probability (IP). Coordinator 2 was in charge of Integral Calculus (IC) and Differential Equations (DE). The number of sections per instructor varies from 1 to 6 sections, the regular academic teaching load is 4 sections. Each section had between 30 and 60 students each.

\textit{Students}
During the semester, 1399 students participated in this project. Table II shows the number of students in each course.

Since this was the first time student-centered methodologies had been implemented in mathematics courses at the university, we can assume that this was the students’ first time participating in a class like this, at least in mathematics courses. The experience of students was assessed by class observations, sessions with instructors during the semester and interviews conducted by instructors at the end of the semester. There was a survey at the end of the semester; however, since the survey was implemented once the semester had concluded and by inviting students via email, the turnout was very low.

Table II. Number of students for each course.

<table>
<thead>
<tr>
<th>Course</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Calculus (PC)</td>
<td>307</td>
</tr>
<tr>
<td>Differential Calculus (DC)</td>
<td>431</td>
</tr>
<tr>
<td>Integral Calculus and Probability (IP)</td>
<td>162</td>
</tr>
<tr>
<td>Integral Calculus (IC)</td>
<td>185</td>
</tr>
<tr>
<td>Differential Equations (DE)</td>
<td>314</td>
</tr>
<tr>
<td>Total</td>
<td>1399</td>
</tr>
</tbody>
</table>

Monitoring and feedback

During the semester, the instructors worked in groups designing material and activities used in the course. Each of the coordinators worked very closely with the instructors. In addition, the two PD instructors kept in contact with the instructors who participated in the PD and coordinators with the next actions:

- Regular meetings with the coordinators for feedback on actions and materials. In these meetings, coordinators presented the materials the instructors had designed. The feedback focused on the pedagogical aspects of the material as well as on their mathematical content.
- Meetings with instructors in which they presented part of the designed materials and commented on the experiences inside the classroom. In this session, each team presented part of the designed materials and the way they were taught. In the feedback, not only the members of the Unit actively participated, the coordinators and the instructors from the other courses participated as well.
- Individual class observation of instructors and a feedback session. The observation was non-participant with a protocol that observed: the way the instructor structured the activity, the way students worked collaboratively, instructor-groups/students interaction, students’ interaction within groups, and in general the attitude of the instructor and students in class. There were two types of feedback sessions with instructors: group and individual sessions. In both sessions, the member of the Unit commented on the results of the observation focusing on giving feedback to improve the way the class was implemented.
In-class activities

The methodology of mathematics courses fostered active involvement of the student in the learning process, through previous readings of the different topics to be addressed and the assignment of problems that must be discussed in the classroom, encouraging collaborative learning and teamwork. The class used a methodology that favors the adequate mastery of the mathematical concepts and the development of both thinking skills and problem solving skills. It also allowed the incorporation of the use of computational technology in the mathematics curriculum to facilitate the processes of understanding and representation of the subjects treated, and to enhance the development of cognitive abilities.

An instructional strategy used in the courses was Peer Instruction\(^\text{19, 20, 21}\) in which, instead of instructors presenting the content in class, students had to do some activities previous to the class and actively participate during the class by answering conceptual questions. Each week, as a preliminary activity, students were given the task of having to review some material related to the contents of the course, with the intention that the student review some applications covered in the week. At the beginning of the class, the instructor gave an overview of the reading materials the students had already reviewed, going into the main aspects of the material. Then, the instructor followed that with Peer Instruction, in which conceptual questions were presented to students, following the next steps for each question:

- A conceptual question is posted to students.
- Students choose the answer individually.
- If the correct answer is chosen by between 30% and 70% of students, they have to discuss it in pairs trying to convince the peer that they are right.
- After the discussion, students answer the question individually again and feedback from instructor is given.
- If the correct answer percentage is less than 30% the first time students answer the question, then the instructor reviews the concept.
- If the correct answer percentage is greater than 70% the first time students answer the question, then the instructor closes off that particular topic and moves on to the next question.

After some peer questions, the instructor poses a more complicated exercise in which students have to apply the concepts covered in the class. The exercise is typically a physical context problem instead of an abstract mathematical problem. Students solve the problem in groups but have to discuss the solution in class with other groups.

Evaluation

As a measure of effectiveness in teaching, we compare students’ performance in the courses were active learning was implemented to the performance of the previous year in the same
courses, which were taught using traditional methods. In particular, we focus on the percentage of students who obtain a passing final grade (at least 4 over 7) in the courses of interest. The two coordinators designed the summative partial and final exams for the semester with the objective of maintaining the structure, level and contents of equivalent exams of previous years. One of the institutionally assigned tasks of the Department of Mathematics’ coordinator is to assure the equity of the evaluation methods through the semesters. Since the coordinators have been in that position for at least two years and have been math instructors at this university for several years, we are confident that they know the material as well as the structures of the exams. Therefore, for this study we consider comparable the final grades of a course to those of the same course a year before. The same kind of tests were conducted in all courses and semesters compared. There were three tests during the semester. All sections of a course took the tests on the same day. The tests had the following structure:

- 25% of the evaluation: Conceptual questions.
- 25% of the evaluation: Multiple choice questions, in which the student develops an exercise in a guided way through the alternatives available in each question.
- 50% of the evaluation: Problem solving, in which the student develops clearly application exercises that involve the subject to be evaluated.

Compared courses used the same evaluation process, that is, weighted activities were similar.

Students’ survey

At the end of the semester, after the last day of class and before the final exam, students were invited to answer an online survey regarding the course. Instructors sent the invitation by e-mail from the course’ learning management system. The survey consisted on adapted questions from [22].

The objective of the survey was twofold: first, to evaluate, in the perspective of students, what kind of pedagogical environment took place; second, to analyze how students perceived the experience in terms of their learning. Gaffney, Gaffney and Beichner [22] designed the Pedagogical Expectancy Violation Assessment (PEVA) with the objective of assessing the expectations and experiences of the students in the classroom, which in their case was a Student-Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) classroom experience [22,23]. In their study, students took the survey before, during, and after the period of the class to observe differences between their expectations and experiences at different stages. In our case, we used an adapted survey at the end of the period to analyze the students’ experience.

To evaluate what kind of pedagogical environment took place, we used 11 Likert scale statements from PEVA with seven options. We did not use all PEVA items, since some of them did not apply to these courses, like having Teaching Assistants or the use of computer programming. Table III describes the scale, the statements and the corresponding item from PEVA.
Table III. The survey given that evaluates the type of methodology that took place in the class. The Likert scale was: 1 (Very infrequently) – 2 – 3 – 4 – 5 – 6 – 7 (Very frequently)

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement: Indicate how often you experienced the following in this math class, using the following scale:</th>
<th>Statement as it appeared in the survey: Indica con qué frecuencia experimentaste en tu curso de matemáticas lo siguiente, usando la siguiente escala:</th>
<th>Item in PEVA Part 2 Survey 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Sessions in which the instructor presents most of the time</td>
<td>Clases en las que el profesor presenta la mayor parte del tiempo</td>
<td>Item 1</td>
</tr>
<tr>
<td>P2</td>
<td>Collaborative group discussions</td>
<td>Discusión colaborativa en grupos</td>
<td>Item 3</td>
</tr>
<tr>
<td>P3</td>
<td>Doing required reading</td>
<td>Hacer lecturas obligatorias</td>
<td>Item 5</td>
</tr>
<tr>
<td>P4</td>
<td>Classroom with work-tables and teacher in front</td>
<td>Salón de clases con pupitres y profesor al frente</td>
<td>Item 6</td>
</tr>
<tr>
<td>P5</td>
<td>Missed classes would be harmful to my learning</td>
<td>Que faltar a clases afectara mi aprendizaje</td>
<td>Item 8</td>
</tr>
<tr>
<td>P6</td>
<td>To memorize equations and/or formulas</td>
<td>Memorizar ecuaciones y/o fórmulas</td>
<td>Item 9</td>
</tr>
<tr>
<td>P7</td>
<td>To interact with my instructor during class time</td>
<td>Interactuar con mi profesor en el salón</td>
<td>Item 10</td>
</tr>
<tr>
<td>P8</td>
<td>To interact with my peers during class time</td>
<td>Interactuar con mis compañeros en el salón</td>
<td>Item 12</td>
</tr>
<tr>
<td>P9</td>
<td>To present my work to the entire class</td>
<td>Presentar mi trabajo a todos durante la clase</td>
<td>Item 13</td>
</tr>
<tr>
<td>P10</td>
<td>To discuss my work with classmates during class time</td>
<td>Discutir mi trabajo con compañeros durante la clase</td>
<td>Item 14</td>
</tr>
<tr>
<td>P11</td>
<td>To discuss my work with my instructor during class time</td>
<td>Discutir mi trabajo con mi profesor(a) durante la clase</td>
<td>Item 15</td>
</tr>
</tbody>
</table>

To analyze how students perceived the experience in terms of their learning, we used six statements from PEVA Part 4 Survey 3. The statements were adapted to the type of course we had. Table IV describes the scale, the statements and the corresponding item from PEVA.

Table IV. The survey given that evaluates the learning perception of students of the course. The Likert Scale was: 1 (Strongly disagree) – 2 – 3 – 4 – 5 – 6 – 7 (Strongly agree)

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement: Please indicate the extent to which you agree with the following statements:</th>
<th>Statement as it appeared in the survey: Indica si estás de acuerdo en las siguientes frases:</th>
<th>Item in PEVA Part 4 Survey 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>The methodology used in the math class is a useful style of teaching and learning</td>
<td>La metodología de la clase de matemáticas es un estilo útil de enseñanza y aprendizaje</td>
<td>Item 1</td>
</tr>
<tr>
<td>A2</td>
<td>I would have learned mathematics better in a more traditional setting</td>
<td>Yo habría aprendido mejor matemáticas en una clase más tradicional</td>
<td>Item 2</td>
</tr>
<tr>
<td>A3</td>
<td>The methodology used in the math class is inappropriate for college classes</td>
<td>La metodología de la clase de matemáticas es inapropiada para clases universitarias</td>
<td>Item 3</td>
</tr>
<tr>
<td>A4</td>
<td>The style of this course helped me learn mathematics</td>
<td>El estilo de este curso me ayudó a aprender matemáticas</td>
<td>Item 4</td>
</tr>
<tr>
<td>A5</td>
<td>Courses in other departments should use the methodology used in the math class</td>
<td>Cursos de otros departamentos deberían usar la metodología de la clase de matemáticas</td>
<td>Item 5</td>
</tr>
</tbody>
</table>
**Final interview to instructors**

At the end of the semester, the members of the Unit interviewed instructors with the objective of gauging the degree of change in their teaching beliefs and their perspective of their teaching for the future. The protocol of the interview included two questions that will be discussed in the following sections.

1. In your perspective, what has changed in your teaching practice from last semester to this semester? You can address aspects about your role as a teacher, your students, your work group and your coordinator.

2. From your perspective, how do you see yourself in the near future regarding your teaching practice? You can address aspects about your role as a teacher, your students, your work group in coordination and your coordinator.

With the first question, we wanted to understand the instructor’s perspective about what, if anything, had changed in their classrooms compared to previous semesters. It was important to ask them the question taking into account all the entities involved; how did they, as teachers, changed, which was their perception of the way students changed, how had their relationship with other instructors as part of a coordinated group changed, and how different was their interaction with the coordinator. The aim was to inquire about a self-reflection of what they did in class and how their role in the classroom, the interactions with their students, with their peers and with the coordinator had changed. Of particular importance was to find out how did they perceive their students’ attitude and motivation, since this was the first time that instructional changes had been introduced in mathematics classes. We were expecting that some of the students might not feel comfortable experiencing these teaching changes. We had the observations conducted in each class. However, we wanted to know the instructor’s perspective on students’ participation.

Since one of the objectives of the project was to build a community, it was important for them to reflect on their work group teaching the same course and the role of the coordinator. We wanted for instructors to tell us whether or not there was more or less interaction among peers and their coordinator, and inquire about the value of this change or lack thereof.

The second question was made to see whether the experience of the semester was something they wanted to continue in the future. Again, the question referred to instructors themselves, students, the work group teaching the same subject and the coordinator. There were some other questions in the interview; however, we wanted to focus on these two for the purpose of this paper.

**Results**

We have divided results into those from students and those from instructors. In the students’ section, we present the final grades of students taking the five courses in this study and compare them to the results of students taking the same courses in a previous semester. In the instructors’ section, we present results from the observations and the interview at the end of the semester.
Students’ results

We analyzed the final grades of the students from the five courses in the study. As mentioned before, the failing rate for math courses in this university is high. In the semester in which this study took place, there were some sessions of the first three courses (PC, DC and IP), that had instructors who were not in this study. However, the number of students in those sessions was too small to make comparisons. We decided to compare the results to those from a previous semester. To have a similar, comparable amount of students, we used the data from students who took the courses exactly a year before (the second semester of the year). Table V presents the percentage of students passing the course from both semesters.

*Table V.* Number of students for each course and the percentage of them passing the course. The first two columns are the students’ results from instructors who participated in the study. The last two columns are the students’ results from instructors who were teaching the courses in a previous year. Most of the instructors were the same in both semesters. In Chile, the passing grade is 4.0 out of 7.0. The percentage next to the number of students for each course in this study represents the proportion of the students who answered the final survey.

<table>
<thead>
<tr>
<th>Course</th>
<th>Students from instructors in this study</th>
<th>Students from instructors of a previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students</td>
<td>Percentage of students passing the course</td>
</tr>
<tr>
<td>Pre-Calculus (PC)</td>
<td>307</td>
<td>30%</td>
</tr>
<tr>
<td>Differential Calculus (DC)</td>
<td>431</td>
<td>52%</td>
</tr>
<tr>
<td>Integral Calculus and Probability (IP)</td>
<td>162</td>
<td>72%</td>
</tr>
<tr>
<td>Integral Calculus (IC)</td>
<td>185</td>
<td>53%</td>
</tr>
<tr>
<td>Differential Equations (DE)</td>
<td>314</td>
<td>54%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1399</strong></td>
<td><strong>50%</strong></td>
</tr>
</tbody>
</table>

The table shows that there was an improvement in some of the courses. For example, for DE and IC, the percentage of students passing the course increased from 36% and 29% to 54% and 53%, respectively. However, there were some other courses in which there was not an improvement (e.g. DC had 53% and then 52%) and a course (PC) in which there was a decline in students passing rate. It seems that the training and follow-up process for some instructors was not the same as for others.

In the case of PC there were three instructors (see Table I). Instructor A and instructor B had four sections each so that they taught eight out of nine sections. In particular, students from instructor A had a very low passing rate (16%). Students from instructor B had a better passing grade but still low (38%). Both instructors taught in the previous year having slightly better results; however, they had fewer sections.

The best results were obtained in DE and IC courses. In both cases, the majority of students were taking courses with instructors G and H and Coordinator 2. In the case of IC, they were the only instructors, and in the case of DE, they had six out of eight sections.
The survey conducted at the end of the semester represents results from the pedagogical approach that students perceived of the course and the students’ perception of their own learning. The survey, however, was completed by 20% of students, a small number of the total number of students in the courses. On the positive side, students answered the survey uniformly across the type of course and instructor of the course. It seems that sending an invitation by email was not a good approach to get students’ opinions. On the other hand, we wanted to have an honest opinion and having done in the classroom was definitely a way to have a greater number of students participating, but they could have felt pressure in the type of answers they would give to the survey.

In order to analyze the results, we grouped the Likert options in three parts:

a) Levels 1, 2 and 3 as low (infrequently for the methodology part of the survey and disagree for the learning perception of the survey).

b) Level 4 as neutral (sometimes for the methodology part of the survey and neutral for the learning perception of the survey).

c) Levels 5, 6 and 7 as high (frequently for the methodology part of the survey and agree for the learning perception of the survey).

A summary of the results for the 11 statements of the methodology approach for the five courses is presented in Table VI. The percentage shown is from students who answered the survey.

Table VI shows that there were acceptable results. Students perceived that there were collaborative group discussions (P2) with 72.6% of them saying that it was frequently and only 13.1% of them saying that it was infrequently. Two directly related statements, which had good results, were those that examined the interaction with the instructor (P7) and with peers (P8). For P7, 80.2% of students thought that was frequently and 10.8% that was infrequently. For P8, the results were similar (79.9% and 10.8%, respectively). Another statement with acceptable results was P5, in which 68.7% of students think that missing the class would be harmful for their learning. This statement is a measure of the extent to which students think the class is helping them to learn.

However, there were some unsatisfactory results as well, and a few disappointing results too. It is disappointing that 73.0% of students think that most of the time instructors were the only ones to present the material (P1). Another disappointing result was P9, which describes the frequency in which students present their work before the entire class. It is probably important to emphasize the importance of the students’ role on explaining their work to reflect in their own understanding.

There were also differences among courses, some of them significant. Statement P3 (Doing required reading) was infrequently for 9.7% of IC course. However, the same statement was infrequently for 48.2% of the PC course. It seems that instructors of PC course did not follow the coordinator’s instruction regarding reading assignments for the course. Statement P5 (Missing classes would be harmful to my learning) was frequent for 80.6% of students of IC course. However, only 58.9% of students of PC students taught it was frequent. In the interaction of students with instructor and peers (P7 and P8) there were some differences too. The rate of
students thinking that the interaction with instructors was frequent ranged from 63.6% of DC course to 89.5% of students in the DE course.

Table VI. Eleven statements that evaluate the type of methodology in the class according to students of the five courses. Highest percentages are marked in bold for each course.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Frequency</th>
<th>All courses</th>
<th>PC</th>
<th>DC</th>
<th>IP</th>
<th>IC</th>
<th>DE</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1. Sessions in which the instructor presents most of the time</td>
<td>Infrequently</td>
<td>14.7%</td>
<td>16.1%</td>
<td>13.6%</td>
<td>27.3%</td>
<td>9.7%</td>
<td>11.6%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>12.4%</td>
<td>7.1%</td>
<td>11.4%</td>
<td>12.1%</td>
<td>16.1%</td>
<td>14.7%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>73.0%</strong></td>
<td><strong>76.8%</strong></td>
<td><strong>75.0%</strong></td>
<td><strong>60.6%</strong></td>
<td><strong>74.2%</strong></td>
<td><strong>73.7%</strong></td>
</tr>
<tr>
<td>P2. Collaborative group discussions</td>
<td>Infrequently</td>
<td>13.1%</td>
<td>16.1%</td>
<td>11.4%</td>
<td>6.1%</td>
<td>16.1%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>14.3%</td>
<td>21.4%</td>
<td>11.4%</td>
<td>9.1%</td>
<td>12.9%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>72.6%</strong></td>
<td><strong>62.5%</strong></td>
<td><strong>77.3%</strong></td>
<td><strong>84.8%</strong></td>
<td><strong>71.0%</strong></td>
<td><strong>72.6%</strong></td>
</tr>
<tr>
<td>P3. Doing required reading</td>
<td>Infrequently</td>
<td>24.7%</td>
<td>16.1%</td>
<td>11.4%</td>
<td>6.1%</td>
<td>16.1%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>14.3%</td>
<td>21.4%</td>
<td>11.4%</td>
<td>9.1%</td>
<td>12.9%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>72.6%</strong></td>
<td><strong>62.5%</strong></td>
<td><strong>77.3%</strong></td>
<td><strong>84.8%</strong></td>
<td><strong>71.0%</strong></td>
<td><strong>72.6%</strong></td>
</tr>
<tr>
<td>P4. Classroom with work-tables and teacher in front</td>
<td>Infrequently</td>
<td>16.2%</td>
<td>14.3%</td>
<td>18.2%</td>
<td>24.2%</td>
<td>16.1%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>15.1%</td>
<td>26.8%</td>
<td>22.7%</td>
<td>12.1%</td>
<td>3.2%</td>
<td>9.5%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>68.7%</strong></td>
<td><strong>58.9%</strong></td>
<td><strong>59.1%</strong></td>
<td><strong>63.6%</strong></td>
<td><strong>80.6%</strong></td>
<td><strong>76.8%</strong></td>
</tr>
<tr>
<td>P5. Missed classes would be harmful to my learning</td>
<td>Infrequently</td>
<td>16.6%</td>
<td>14.3%</td>
<td>18.2%</td>
<td>24.2%</td>
<td>16.1%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>22.4%</td>
<td>30.4%</td>
<td>25.0%</td>
<td>12.1%</td>
<td>3.0%</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>61.0%</strong></td>
<td><strong>55.4%</strong></td>
<td><strong>56.8%</strong></td>
<td><strong>63.6%</strong></td>
<td><strong>58.1%</strong></td>
<td><strong>66.3%</strong></td>
</tr>
<tr>
<td>P6. To memorize equations and/or formulas</td>
<td>Infrequently</td>
<td>10.8%</td>
<td>14.3%</td>
<td>20.5%</td>
<td>9.1%</td>
<td>6.5%</td>
<td>6.3%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>8.9%</td>
<td>12.5%</td>
<td>15.9%</td>
<td>9.1%</td>
<td>6.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>80.3%</strong></td>
<td><strong>73.2%</strong></td>
<td><strong>63.6%</strong></td>
<td><strong>81.8%</strong></td>
<td><strong>87.1%</strong></td>
<td><strong>89.5%</strong></td>
</tr>
<tr>
<td>P7. To interact with my instructor during class time</td>
<td>Infrequently</td>
<td>10.8%</td>
<td>17.9%</td>
<td>11.4%</td>
<td>9.1%</td>
<td>6.5%</td>
<td>8.4%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>9.3%</td>
<td>14.3%</td>
<td>11.4%</td>
<td>3.0%</td>
<td>3.2%</td>
<td>9.5%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>79.9%</strong></td>
<td><strong>67.9%</strong></td>
<td><strong>77.3%</strong></td>
<td><strong>87.9%</strong></td>
<td><strong>90.3%</strong></td>
<td><strong>82.1%</strong></td>
</tr>
<tr>
<td>P8. To interact with my peers during class time</td>
<td>Infrequently</td>
<td>18.9%</td>
<td>19.6%</td>
<td>15.9%</td>
<td>12.1%</td>
<td>29.0%</td>
<td>18.9%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>20.5%</td>
<td>16.1%</td>
<td>27.3%</td>
<td>21.2%</td>
<td>12.9%</td>
<td>22.1%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>62.9%</strong></td>
<td><strong>57.1%</strong></td>
<td><strong>70.5%</strong></td>
<td><strong>66.7%</strong></td>
<td><strong>58.1%</strong></td>
<td><strong>63.2%</strong></td>
</tr>
<tr>
<td>P9. To present my work to the entire class</td>
<td>Infrequently</td>
<td>22.4%</td>
<td>26.8%</td>
<td>22.7%</td>
<td>18.2%</td>
<td>25.8%</td>
<td>20.0%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>14.7%</td>
<td>16.1%</td>
<td>6.8%</td>
<td>15.2%</td>
<td>16.1%</td>
<td>16.8%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>62.9%</strong></td>
<td><strong>57.1%</strong></td>
<td><strong>70.5%</strong></td>
<td><strong>66.7%</strong></td>
<td><strong>58.1%</strong></td>
<td><strong>63.2%</strong></td>
</tr>
<tr>
<td>P10. To discuss my work with classmates during class time</td>
<td>Infrequently</td>
<td>21.6%</td>
<td>25.0%</td>
<td>31.8%</td>
<td>18.2%</td>
<td>19.4%</td>
<td>16.8%</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>15.1%</td>
<td>12.5%</td>
<td>11.4%</td>
<td>15.2%</td>
<td>16.1%</td>
<td>17.9%</td>
</tr>
<tr>
<td></td>
<td>Frequently</td>
<td><strong>63.3%</strong></td>
<td><strong>62.5%</strong></td>
<td><strong>56.8%</strong></td>
<td><strong>66.7%</strong></td>
<td><strong>64.5%</strong></td>
<td><strong>65.3%</strong></td>
</tr>
</tbody>
</table>
In the case of the students’ perception of the course as helping them to learn, Table VII presents the results.

*Table VII.* Six statements that evaluate the learning perception of students of the five courses. Highest percentages are marked in bold for each course, for each item.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Frequency</th>
<th>All courses</th>
<th>PC</th>
<th>DC</th>
<th>IP</th>
<th>IC</th>
<th>DE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. The methodology used in the math class is a useful style of teaching and learning</td>
<td>Disagree</td>
<td>20.1%</td>
<td>28.6%</td>
<td>29.5%</td>
<td>33.3%</td>
<td>6.5%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>8.9%</td>
<td>7.1%</td>
<td>13.6%</td>
<td>15.2%</td>
<td>6.5%</td>
<td>6.3%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td><strong>71.0%</strong></td>
<td><strong>64.3%</strong></td>
<td><strong>56.8%</strong></td>
<td><strong>51.5%</strong></td>
<td><strong>87.1%</strong></td>
<td><strong>83.2%</strong></td>
</tr>
<tr>
<td>A2. I would have learned mathematics better in a more traditional setting</td>
<td>Disagree</td>
<td>56.8%</td>
<td>42.9%</td>
<td>36.4%</td>
<td><strong>45.5%</strong></td>
<td>71.0%</td>
<td>73.7%</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>14.3%</td>
<td>21.4%</td>
<td>11.4%</td>
<td>9.1%</td>
<td>16.1%</td>
<td>12.6%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>29.0%</td>
<td>35.7%</td>
<td><strong>52.3%</strong></td>
<td><strong>45.5%</strong></td>
<td>12.9%</td>
<td>13.7%</td>
</tr>
<tr>
<td>A3. The methodology used in the math class is inappropriate for college classes</td>
<td>Disagree</td>
<td><strong>71.8%</strong></td>
<td><strong>62.5%</strong></td>
<td><strong>47.7%</strong></td>
<td><strong>57.6%</strong></td>
<td><strong>90.3%</strong></td>
<td><strong>87.4%</strong></td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>10.4%</td>
<td>16.1%</td>
<td>13.6%</td>
<td>18.2%</td>
<td>6.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>17.8%</td>
<td>21.4%</td>
<td>38.6%</td>
<td>24.2%</td>
<td>3.2%</td>
<td>8.4%</td>
</tr>
<tr>
<td>A4. The style of this course helped me learn mathematics</td>
<td>Disagree</td>
<td>20.1%</td>
<td>23.2%</td>
<td>38.6%</td>
<td>18.2%</td>
<td>9.7%</td>
<td>13.7%</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>13.1%</td>
<td>16.1%</td>
<td>13.6%</td>
<td>36.4%</td>
<td>6.5%</td>
<td>5.3%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td><strong>66.8%</strong></td>
<td><strong>60.7%</strong></td>
<td><strong>47.7%</strong></td>
<td><strong>45.5%</strong></td>
<td><strong>83.9%</strong></td>
<td><strong>81.1%</strong></td>
</tr>
<tr>
<td>A5. Courses in other departments should use the methodology used in the math class</td>
<td>Disagree</td>
<td>24.7%</td>
<td>28.6%</td>
<td>38.6%</td>
<td><strong>48.5%</strong></td>
<td>9.7%</td>
<td>12.6%</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>11.6%</td>
<td>19.6%</td>
<td>15.9%</td>
<td>6.1%</td>
<td>6.5%</td>
<td>8.4%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td><strong>63.7%</strong></td>
<td><strong>51.8%</strong></td>
<td><strong>45.5%</strong></td>
<td><strong>45.5%</strong></td>
<td><strong>83.9%</strong></td>
<td><strong>78.9%</strong></td>
</tr>
<tr>
<td>A6. The methodology used in the math class is not for me</td>
<td>Disagree</td>
<td><strong>65.3%</strong></td>
<td><strong>53.6%</strong></td>
<td><strong>43.2%</strong></td>
<td><strong>57.6%</strong></td>
<td><strong>90.3%</strong></td>
<td><strong>76.8%</strong></td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>11.2%</td>
<td>14.3%</td>
<td>13.6%</td>
<td>12.1%</td>
<td>3.2%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>23.6%</td>
<td>32.1%</td>
<td><strong>43.2%</strong></td>
<td><strong>30.3%</strong></td>
<td>6.5%</td>
<td>12.6%</td>
</tr>
</tbody>
</table>

Results show that, in general, students answering the survey had a good perception of the math courses. The best results are in statement A1 and A3, since 71.0% of students think that the methodology used is a useful style for teaching and learning. There were 71.8% of students who disagreed with the statement that the methodology is inappropriate for college classes. Other results are not as positive, however. As many as 29.0% of students agreed that they would have learned math better in a traditional course and 23.6% of students agreed that the methodology was not for them.

There were also differences among courses. 87.1% of IC course students agreed that the methodology used is a useful style of teaching and learning (A1) and only 6.5% disagreed. On the contrary, only 51.5% of the IP course students agreed with statement A1 and as many as 33.3% of students of the same course disagreed.

In the case of statement A2, in which students had to agree or disagree with “I would have learned mathematics better in a more traditional setting”, 73.7% of DE course students disagreed
and 13.7% agreed. On the contrary, 36.4% of DC course students disagreed and 52.3% of them agreed.

Statement A5 argues that courses of other departments should use the methodology implemented in the math class. In IC, there were 83.9% of students agreed, while only 9.7% of them disagreed. In the case of students of IP course, only 45.5% of students agreed with the statement and 48.5% disagreed with the statement.

The last statement (A6), in which there is a colloquial statement saying that the methodology used in the math class is not for them, 90.3% of students in the IC course disagreed and only 6.5% of the agreed. On the opposite side, there were 43.5% of students of the DC course who disagreed, and the same proportion, 43.5% of students who agreed.

**Instructors’ results**

Instructors were not familiar with active learning methodologies or collaborative learning at the beginning of the initial workshop. The results of the first survey show that they focus on traditional teaching. Responses to the first question, (What is "teaching" for you?) were:

- Teaching is the tool that allows me to contribute in the formation of a professional and, more importantly, in the education of a human being.
- Deliver content and concepts to students so they can incorporate them into their performance areas.
- It is to contribute ideas, knowledge or experiences to people who do not have them.
- It is the opportunity to contribute to the development and empowerment of knowledge, skills, techniques and tools in a student.
- To teach is to transmit a certain concept, previously determined, organized sequentially.
- It is a process, which must be planned to deliver information and / or knowledge on a subject, and which should facilitate the development of new knowledge.
- It is the delivery of knowledge, rules and contents that can be applied to everyday situations, and to deliver experiences and concrete applications related to the contents seen in classes.
- It is a competence that allows the transmission of conceptual and procedural skills and attitudes that allow students to improve their skills, both attitudinal and procedural, to change their environment.
- Teaching is to transmit clearly and concisely knowledge, so that they are learned correctly in order to be implemented in any situation that requires it.

The set of responses to the initial question is evidence that these instructors have a view of teaching as a delivery of content to students. There are verbs like contribute, deliver and transmit that are common in their answers. We observe also that the role of student is regarded as passive. In some cases, the response does not even mention students; some others mention students only to say that they are the receiving part of the process. A minority of them mentions not the active role in the process, but an active role after the content is assimilated: “incorporate them (concepts) into their performance areas”, “to change their environment” and “so that they can be implemented in any situation that requires it.”
The role of the workshop was to make instructors open to a teaching-learning process in which students should take a more active role, participating in their own learning and in which the role of the instructor goes from being the center of the process to being a guide and placing students in the center of the process. We expected to have a change in the perspective of the instructor and that change to be reflected when instructors teach in the classroom. In the first observation period, a month into the semester, we had contrasting results. Instructor H was an instructor that implemented many of the recommendations in the classroom. He started the session by introducing the objective of the class, he did not spend a long time introducing the topic, he implemented activities during the class in which students worked in groups and he guided students in the solution of the activities. After class, the Unit had a feedback session with that instructor telling him to improve the way he interacted with groups in the classroom and the way in which he fostered interaction among peers.

Contrasting to instructor H was instructor F. Observation took place during the same period. Instructor F had many aspects to improve. The activity was well structured since it was planned before the class. However, the instructor spent a long time explaining the concepts needed for the activity even though reading had been previously assigned. When the activity started, the instructor did not ask students to work in collaborative groups; instead, students worked in pairs or by themselves. There were some students at the back of the classroom who did not participate in the class and the instructor never paid attention to them. The instructor-student interaction was almost individual since the students were not working together. After class, the Unit had a feedback session with the instructor that could lead him to improve the class.

At the end of the semester, the Unit interviewed the instructors as mentioned in the methodology. Among the different questions in the interview, we chose to present the results of the first two questions since those revealed the essence of what we worked with instructors during the semester.

The first question was: “In your perspective, what has changed in your teaching practice from last semester to this semester? You can address aspects about your role as a teacher, your students, your work group and your coordinator.”

In the case of their role as a teacher, some of the instructors’ answers were:

- Now I am on top of the students, activating discussion forums, doing summaries, a lot of time spent, exercise guidelines and controls guidelines, 24/7 working, it was exhausting.
- The commitment of the teachers was a good change, not just getting to class to give a lecture. I tried to convince the students to do a cognitive process in the class.
- I tried to fit in with the parameters we were told. I changed the mentality that the teacher has to cover everything with a lecture. It was not so strange to put them to work as a team, I did not do it always in class but had done so many times.
- As an analogy, before, if the child fell, I picked him up; now if the child falls, I leave him so that he can get up alone, although I was always accompanying the child. I was changing during the semester, which was enriching. What we achieved was to work as a team.
- It was very difficult to start. I have been working in the field for 30 years and this semester was hard for me.
• Yes, there were changes in the work in the classroom. There is more work with them. I make them work in groups.

All instructors agreed that this semester was a major change in the way they taught class. For them was not easy and some of them said so explicitly. Reading their answers, we conclude that they understood that the way the class was implemented was different from what they did before.

In the case of their students, some of the instructors’ answers were:
• Friction, inertia to change, desertion went down, at first there was a resistance to change, the student reacts instantly, and if they do not learn instantly, they become depressed. It reinforces it negatively as an obstacle. You give them everything, all the effort and there are many students that do not take advantage of it. In the end, we were able to overcome the resistance to change.
• Most go slower. Some with a bit of resistance since they do not want to make the effort. They have trouble understanding that they have to work as a team. They were learning.
• In some courses, they have understood it (working in groups, asking their classmates) but in other courses, it has been more difficult.
• Improvements in social relationships were observed. The student had some difficulties at first but began to interact autonomously. The student understood by the end. At first, they asked to return to the traditional way but later understood. At first, they told me that they liked the other methodology. They asked about specific points. They did not read the material and they missed the lectures. Positive: teamwork, interaction, good attitude. The students changed definitely.
• Students are used to lectures. It took a lot of work to get them interested in the new methodology. They do not read the material before class.
• I had a hard time convincing them. They were encouraged to go to the board. Not before.
• They have changed over the course of the semester.
• They work in class; they ask questions in class.

The instructors’ answers were mixed, from enthusiastic instructors who saw a change in their students’ attitudes to instructors who complained about their students.

In the case of their work in teams of instructors, some of the instructors’ answers were:
• Enriching, we all had to participate by supporting each other. Good support and input.
• We have done the work very well, I do the class and the other instructor makes the guides. It didn’t use to be done this way: a class was done by ourselves without collaborating with the rest of the instructors.
• It is now a more active, cordial experience, coordinating workshops and evaluations. We are not isolated professors. We used to work individually.
• In the beginning, there was no accurate communication. I worked alone and later the other instructors joined. We were learning to work as a team. In the past, there was no collegial concept, the teacher was very individualistic and now we designed together and engaged in important discussions. Before, these discussions did not occur. Now the experiences are shared; before, nothing was shared.
• We worked together. Before, we didn’t work in a coordinated or collaborative way.
At first, it was difficult to work with the other instructor, but by the end we were able to make it work. We were able to interact. Before, I did not interact with colleagues.

There is no interaction among instructors in other departments and there is a lot of interaction here in math.

According to instructors’ answers, the interaction among them increased by working together designing, sharing material and discussing the pedagogical approach of the class.

Discussion

The only measure of success in terms of learning that we are presenting is the students passing ratio. In table V we can observe that the percentage of students passing the course in this semester is similar to what was obtained a year before (50% vs 47%). However, there are differences in the courses. A large increase was obtained in IC and DE courses, an increase in IP course, no change in DC course and a decrease in PC course.

The first thing to note is that IC and DE courses are from the same coordination (lead by coordinator 2). Mainly, instructor G, instructor H and coordinator 2 taught these two courses and, individually, their students in their sections obtained a higher passing rate than those from the year before (53%, 59% and 55% respectively). On the contrary, PC course had two instructors with eight out of nine sections and whose students had a low passing rate (16% and 38%).

There could be many reasons for why IC and DE courses were successful and PC was not, in terms of students’ results. One of them is what the students’ survey show. Note that if we compare PC course results to IC and DE courses results, we can observe that in statement P3 (Doing required reading) only 48.2% of PC students said that for their course it was infrequently compared to only 9.7% and 13.7% for IC and DE courses, respectively. Another significant difference was statement P5 (Missed classes would be harmful to my learning). 58.9% of PC students said that for their course that was frequently, compared to 80.6% and 76.8% of IC and DE students, respectively. One of the objectives of an active learning class is to have students actively engaged to take advantage of classroom time. Statement P5 has the goal to measure that.

Another significant difference and of vital importance is statement P8 (To interact with my peers during class time). There, only 67.9% of PC students answered that it happened frequently compared to 90.3% and 82.1% of IC and DE students. In the same way but with less difference was statement P7, which relates to the interaction with instructors. Another related statement with some difference is P2 (Collaborative group discussions) which 62.5% of PC students said was frequent, compared to 71.0% and 72.6% of IC and DE students, respectively. It seems that instructors did not implement the core of the active learning strategy that was promoted in this project, which is collaborative learning, in the same way.

In terms of the six statements that evaluated the learning perception of students, there were also differences between the PC course and IC and DE courses. In all six items the results had a significant difference. An example is statement A2 (I would have learned mathematics better in a more traditional setting). 35.7% of students from the PC course agreed and 42.9% disagreed with the statement. On the other hand, only 12.9% and 13.7% of IC and DE students agreed and
71.0% and 73.7% of IC and DE students disagreed. In the same tendency of results is statement A6 (The methodology used in the math class is not for me). 32.1% of PC students agreed with the statement and 53.6% disagreed. On the opposite side, only 6.5% and 2.6% of IC and DE students agreed and 90.3% and 76.8% of students disagreed with the statement. The perception measured by these two items is important and the differences obtained are very significant. The feeling of students is clear according to the survey: PC students felt they did not learn as much and the final grade results confirmed that.

It is also important to analyze the instructors’ results in the initial survey, the observation session and the final interview to understand the differences between the PC course and the IC and DE courses. Instructors A and B teaching PC started with a very traditional approach of their pedagogical strategy. Instead, instructor G and coordinator 2 had some knowledge regarding a student-centered approach because one of them (coordinator 2) had been trained in university teaching and the other (instructor G) was in a graduate program in education.

Their initial statements were different from one group of instructors to the other. Phrases like “It is the delivery of knowledge, rules, contents, that can be applied to everyday situations, and deliver experiences and concrete applications related to the contents seen in classes” and “Teaching is to transmit clearly and concisely the knowledge, so that they are learned correctly in order to be implemented in any situation that requires it” were answered by PC instructors at the beginning of the workshop regarding the meaning of teaching. On the contrary, IC and DE instructors wrote phrases like: “Teaching is the tool that allows me to contribute in the formation of a professional and, more importantly, in the education of a human being” and “It is the opportunity to contribute to the development and empowerment of knowledge, skills, techniques and tools in a student.” These results clearly differentiate the initial state of the instructors and that might be a factor on students’ learning.

In the semester, all instructors of PC, IC and DE participated in the observation sessions. One of the PC instructors had the largest amount of recommendations since, although the instructor followed the design of the class, the forming of the groups, the interaction with students and the students’ interactions among each other were not optimal. Most of the time, the instructor spent time during the activity answering questions from individual students, making the student-instructor interaction very ineffective. The other PC instructor had better results in the observation. The main problem was with the student-student interaction, as it was not happening. It seems that they were not encouraged to work collaboratively since most students were working in the activities by themselves.

The observation of IC and DE instructors showed that, in general, most of the structure and times dedicated for each activity were acceptable. One of the instructors stood out above the others in the way that he followed all recommendations in the workshop and follow-up meetings. However, the three of them failed to engage students to interact with each other in a productive way. It seems that the instructors need more training on how to foster students’ collaboration and interaction.

During the final interview, there was evidence that PC instructors had reflected on their own teaching but had problems implementing the methodology. The two of them started to blame
students if the results were not what was expected (the interview was individual and it was done before the final exam, so grades were not available). When asked how they see themselves in the near future regarding their teaching practice, they talked more about students than their role as instructors. These results seem to be an evidence that these instructors have a longer way to understand and apply new pedagogical approaches. Overall, the authors consider that the professional development cycle implemented (Figure 2) allowed instructors to reflect upon their practice and motivated them to change their teaching approach.

Conclusions

This work reports a unique experience in Chile in which a group of instructors were taught about active learning in the mathematics classroom. The study reports the training and follow-up of math instructors during a semester. The pedagogical approach was based on active learning and collaborative learning implemented with students. The instructors participated in an initial workshop, follow-up sessions, observations and feedback sessions and a final interview. It was the first time students from this university took a mathematics course in which a student-centered approach was intended as pedagogical strategy. Students’ final grade results were collected and compared to those results from a similar semester the previous year. An online survey that focused in the pedagogical approach and students’ perception on their own learning was implemented at the end of the semester.

In some courses the results were a success; however, in other courses the results indicate that more improvement is needed. During the analysis, we found evidence that there are some factors that may affect the results. The instructors’ previous preparation and perception of their own teaching might be a factor. Nevertheless, the instructors’ level of awareness of the benefits that active learning brings to the class, the increased percentages in passing grades compared to the preceding year and the increased percentage of students not dropping the class encourage us to continue transforming the teaching practices at that university.

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References


