TOWARDS IMPLEMENTATION OF INNOVATIVE METHODOLOGIES IN CONSTRUCTION ENGINEERING IN CHILE. A CASE STUDY

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Abstract: The demands of society are changing rapidly, which in turn enhances the need to prepare qualified professionals with up-dated skills and competencies. Due to this fact, universities must be able to develop new teaching strategies which should be focused, not only in the curricula, but on teaching methodology. This paper shows an experience, developed for the subject matter of electrical installations within the Construction Engineering degree of the Autonomous University of Chile. The aim is to show a Project-Based Learning model using cooperative as well as collaborative strategies, while taking into ac-count both the particular situation of higher education in Chile and the socio-cultural factors of students. The methodology and tools used for its implementation are described and related to obtained results within the Chilean context. It concludes that this teaching method contributes with learning enhancement in terms of strengthening of technical and transversal competencies, while also resulting in a significant improvement of grades, as well as a marked reduction in the absenteeism rate.

Keywords: project-based learning, cooperative, collaborative, construction engineering, competencies, active learning

1. INTRODUCTION

Since their origins, main objective of engineers has been to contribute to the technological development of society. For this reason engineers must be able to identify and assess needs and then provide tools for solving them. Despite solutions are based on scientific and technological knowledge, some other aspects such as society acceptance, environmental impact, sustainability, economy, innovation or efficiency, must be considered. Thus, engineers must combine not only scientific and technical competencies, but also responsible attitudes, creativity, value prioritization, team work, empathy, leadership, communicative skills, etc. [1].

In Chile, the degree of engineering was offered for first time in the University of Chile in 1944. Since then, the role of Chilean engineers has changed and keeps changing due the rapid trans-formation of the country and

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society [2, 3]. Traditionally, Chilean higher education institutions have tried to face this issue by modifying, incorporating, and/or deleting subject matters but without paying attention to the pedagogical aspects of these decisions. As it was stated by Van der Bergh et al. (2006), higher education engineering must con-sider all requirements of society by incorporating new pedagogical methodologies and not only new curriculum proposals [4]. To our knowledge, in Chile there are still few examples of teaching innovation programs which include some active learning methodologies. In addition, developed strategies are based on foreign models such as Tuning EU (2013) or its Latin American adaptation, called Tuning Latin America (2013). Despite these have been tested in other countries, for a successful implementation in Chile, some particularities must be taken into account [5, 6].

According to Villarroel and Bruna (2014), two key factors may explain why these active learning strategies are still very rare in Chile: the heterogeneity of first year students and teacher pro-files (Sisto 2005) [7, 8]. On one hand, novice students have very different skills and knowledge levels depending on the institution they came from prior to university. This implies difficulties for team formation, workload design or self-learning skills, among others. This can be observed, according to OCDE (2011), by analyzing Chilean PISA test scores (Programme for International Student Assessment) which shows up to 80% of results scattering based on type of previous institution (private or public). In particular, university access scores, categorized by Chilean region and type of institution shows similar tends [9, 10].

On the other hand, a high percentage of teachers who work in higher education also have other jobs, due to labor precarious-ness. As observed by Guzmán-Valenzuela and Barnett (2013), most teachers have short-term contracts, typically part-time, which forces them to work in several institutions at the same time, with relatively poor salaries and work conditions (e.g. absence of paid annual leave). Therefore, they have neither the required time for developing new pedagogical skills nor the work stability for incorporating such methodologies [11].

According to the Chilean National Education Council (CNED, 2014) 56.5 % of the total of higher education students are currently enrolled in universities and the rest in the so called professional institutes (PI). In particular, construction engineering accounts for 2 % of total university students and more than 5 of PI. This trend may be explained by both the shorter duration of the curricula, ranging from 4 to 6 semesters (university ranges from 9 to 12 semesters) and the closer relation between what students learn and their future work tasks. This may also explain why universities enrollment has just increased by 13%, while professional institutes have increased enrollment by 37 % during the last decade [12].

Despite universities offer more subject matters in comparison to professional institutes, students feel that most of these subjects are not directly related to their expected future job pro-file, which is a key factor for increasing desertion rates, but also for the distance between university and society [13]. According to De los Rios et al. (2010), degrees must improve the professional capacities of students, bringing them closer to their future work techniques, but also developing other skills such as behavioral competencies, personal and In-terpersonal skills, creativity and design, implementation and operation, etc. [14]. In other countries, different teaching technics have been developed and tested for decades, mostly in the EU and USA, looking for better learning results (e.g. problem-based learning, project-based learning, cooperative and collaborative learning, etc. [15]. Furthermore, some of these methodologies have been tested together [16, 17], and already included within new education-al structures proposed in many countries and in all academic levels.

This paper tries to contribute to the implementation of Project-Based Learning (PBL), along with the cooperative and collaborative learning (CC) in the construction engineering degree. The previous model, or the so called “traditional” and PBL+CC are compared and related to competencies and skills developed by students. The PBL+CC method is later explained in detail. Finally, results are shown based on the obtained academic scores, attendance percentage during the course and the answers from an ad-hoc survey.

2. CONTEXT OF STUDY AND THEORETICAL FOUNDA-TION: TRADITIONAL METHODOLOGY

PBL+CC has been implemented for the electrical installations course within the curriculum of construction engineering. This degree has been designed with the objective of students to graduate with two types of competencies, those related to the knowledge of basic sciences and the ones that involve professional tasks such as formulation, supervision, development and evaluation of complex construction projects.

Nevertheless, each subject matter is structured depending on the teacher in charge. Each lecturer has different pedagogical tools to teach and evaluate the specific educational objectives, but in general all subject matters are developed in a similar way. That is, they are based on expositive lecture classes and a final exam for assigning grades to students. Particularly, the electrical installations course is programmed on the fifth semester (out of 9). It is developed during 31 sessions and each one takes one hour and a half. During each session, the teacher explains theoretical concepts by using slides. Additionally, several problems are proposed and solved by the teacher in a blackboard. Finally, in order to evaluate the learning outcomes, students face a final exam that takes one hour and a half, which is based on blooms taxonomy. The grading scale used is in accordance with the standard Chilean grades which range from 1 to 7. In this scale 4 is the minimum score for passing the course.

The subject program consists of the concepts shown in Table 1. This content aims to “allow the student to know the theoretical core concepts of electricity and its applications, as well as interpreting and executing simple electrical projects in the context of residential, tertiary and industrial building construction”. The subject program is focused on obtaining the so called “specific technical competencies” (STCs) stated by Maritza et Al. (2014) and it only mentions the so called “professional competencies” but neither their definition nor implementation strategies are shown for achieving these objectives [18].

Table 1. Themes included b the traditional subject program.

Theoretical concepts	Ohm’s Law and Joule’s Effect; DC and AC; Resolution of single-phase circuits; Resolution of three-phase circuits.
Lighting Systems	Lighting installation calculation and design: Street, interior and sport lighting.
Electric wires	Types of wires; Constructive elements; Section calculation; Voltage drop, maximum current, losses.
Electrical protection	Types of protection against direct and indirect contacts. Protection against overloads and short circuits, switch; design and selection.
Grounding outlets	Types of grounding; Electric parameter calculation and design.

Also, due to the fact that the final exam is designed based only on the cognitive domain of Blooms taxonomy, it can be concluded that only STCs are evaluated. In accordance with the classification of the dimension of knowledge stated by Bloom and his colleagues, it can be determined that only two categories of the knowledge dimension: the factual (KD1) and the conceptual (KD2), along with the first four categories of the cognitive process dimension: remember (CPD1), understand (CPD2), apply (CPD3) and analyze (CPD4) are considered. Therefore it cannot be affirmed that the program does incorporate neither the Procedural Knowledge (KD3), nor last stages of cognitive process dimension (evaluate (CPD5), create (CPD6) and apply (CPD7)), nor the affective domain (AD) (motivation, social behavior, values, appreciation), nor the so called transversal competencies, such as instrumental, personal or systemic, which can be included within the psychomotor domain (PD).

3. CONTEXT OF STUDY AND TEORETICAL FOUNDATION: PBL+CC METHOD-OLGY

PBL can be defined as a model for teaching complex problem-solving (Prince and Felder, 2006) which consists on an open-ended task from a client posed to students [19]. From this point of view, students create proposals, obtain approval for their work schedule, objectives and budget [17]. In the PBL+CC phase, students identify what they need to know, learn and teach to each other, then return to the project and complete the work schedule. PBL+CC empowers students to share more activities and responsibilities in learning, when compared to the traditional method, where the teacher is who assumes most of these tasks.

Despite PBL definition seems similar to the so called problem-based learning, one main difference must be highlighted, which is that in PBL, problems are chosen by students. It must be mentioned that in this case, projects contain some problems designated by the teacher, such as those related to voltage drops, electrical protection devices and standards. However, these must be discovered by students within the project analysis. Also, other issues must be considered and chosen by them such as power factor enhancement, energy loss reduction, lighting efficiency design, etc.

The aim of this PBL+CC method is to extend the cognitive domain and to add some aspects from the affective domain, which in Chile is usually named as transversal competencies. Table 2 shows the traditional learning targets, (where only technical issues are considered), and these along with the aforementioned transversal competencies which are considered within the PBL+CC method. Both are related to different categories of the classification in accordance with Blooms taxonomy.

Table 2. Activities and responsibilities (PBL+CC and traditional learning method).

CASE	LEARNING OBJECTIVES	BLOOM´s DOMAINS
Traditional Expositive sessions	(0) Solve problems related to the theoretical content.	KD1, KD2, CPD1, CPD2, CPD3, CPD4.
PBL+CC	(0) Solve problems related to the theoretical content.	KD1, KD2, CPD1, CPD2, CPD3, CPD4.
	(1) Capacity for abstraction, synthesis and analysis.	KD1, KD2, CPD4.
	(2) Ability to search, process and analyze information from several sources.	CPD4, KD3
	(3) Ability to organize work based on planning.	KD3
	(4) Teamwork and interpersonal relations skills	AD
	(5) Ability to motivate the team for common targets consecution	AD
	(6) Decision-making ability	CPD5
	(7) Creativity	CPD6
	(8) Ability to formulate & manage projects.	AD and meta-cognitive knowledge
	(9) Verbal and written communication	AD and meta-cognitive knowledge
	(10) Ability to apply the knowledge in real context	CPD7 and meta-cognitive knowledge

Students received real projects which have already been developed and executed by teachers. Each project includes the same number of technical errors (i.e. excessive voltage drops, inefficient electrical protections, materials not allowed by law, etc.). These errors must be discovered and solved by students during the project analysis. Before the project can be analyzed, students should achieve the first three stages of the cognitive process dimension, which are related to the factual and conceptual knowledge dimension (to remember, to understand, and to apply). At this point students are capable to analyze the project in order to find the aforementioned errors, but in addition they have learned how is the search process, by analyzing and processing information from different sources. Since the information is not given directly by teacher, students must research and find what they need to learn. This implies that they recognize searching tools (library, websites, interviews with experts, etc.) and learn how to use these for achieving their self-set targets. Like this, students learn in an autonomous way and the teacher only checks whether this knowledge is correct and does not miss some topics. From this point of view it can be concluded that learning objectives numbered (0), (1) and (2) are covered (Table 2).

Teams must plan their workload and divide it between members of the group during the duration of the course in an autonomous way. Two dates are set up by the teacher where students must present a brief report. These must contain the performed work up to date and discuss about the differences between the original plan and the real planning developed. The last week they must present the final report, which is the rewritten project that was assigned to them originally. The final grade is assigned per team and it depends on every team member. This is, every team member achieves the same grade, but this may be defined by the work evaluation of another team member. From this point of view the procedural knowledge, as well as the affective domain are incorporated. Thus students attentively listen to each other, participate in discussions, propose actions based on knowledge, accept rules and accept them as their own, since everyone is responsible for the grade of the whole team. This process allows establishing learning outcomes (3), (4) and (5) (Table 2).

Projects also had a certain number of items which could be clearly improved upon depending on economic and environmental parameters (i.e. oversized sections of cable, poorly designed routes, size of ground grids that may be reduced, etc.). All of these issues should be proposed and solved by students. Thus, from this point of view, learning objectives (6) and (7) (Table 2) are included, and students are also empowered by sharing the responsibility of selecting problems.

Finally, the original project must be reformulated and presented to other groups. Therefore, a good command in verbal and written communication is required in order to share to other teams what they have done and how they have achieved it along the time of the project. At this point students have went through each step that represents a real job in the field of electrical installations for building construction. Therefore, learning objectives (8), (9) and (Table 2) are achieved.

4. METHODOLOGICAL DETAILS AND PBL+CC IMPLE-MENTATION

According to Pucher and Lehner, (2011) and Ruiz-Gallardo et al., (2011), four key factors must be taken into account in order to provide an optimal implementation of active learning tools and, in particular, for PBL [20, 21]:
i) Motivation of students for both subject matter and active learning methodology.
ii) Previous knowledge of students, in particular regarding to project management and team work, but also mathematics and reading comprehension.
iii) Work experience of the teacher and her/his empathy with students.
iv) Working load manageable by students.

All items were carefully addressed and methodology was deeply explained to the faculty academic authorities. However, a risk was detected, concerning the heterogeneity of students (which is not considered by the cited papers). Particularly, this course has about 40% of students that come from public schools, and 60% from private schools. The average university access score was 525.8 points out of 850, but these marks ranged from 450 to 681 with a standard deviation (SD) of 42.5. Furthermore, the educational vulnerability index (IVE) which measures the socio-economic status of the students (from 0 to 100) was taken into account. This index is calculated based on the household in-comes of students, and for this course IVE varies from 35.7 to 95.1 with an average of 64.6 (SD 11.9). Despite this important heterogeneity, after taking into account the satisfactory results reported by other similar Latin American countries such as Argentina [22] or Brazil [23] the academic authorities agreed to the implementation of this PBL+CC.

However, PBL+CC method was not considered within the original academic plan and therefore students had the right to refuse it or, even worse, to drop the course. Despite the PBL+CC method might contribute to decrease the percentage of desertion [24], some authors indicate that not all students have been enthusiastic about PBL and many of them still prefer traditional teaching and assessment methods, in which they play a more passive role in the learning process [25, 26]. Thus, the traditional method was also programmed by using another timetable for those students who did not agree to work with PBL+CC.

Traditional method was developed in the same way as it has been previously explained. This is, 31 expositive lectures sessions, where theoretical concepts and practical exercises are developed by teacher while students pay attention. Finally, students have an exam for achieving their final grades for the course. This exam contains questions and exercises based on Bloom's taxonomy, thus learning results (Table 2) are evaluated with the aforementioned levels of knowledge [27].

On the other hand, for those students who opted for the PBL+CC methodology, this was deeply explained in the first session and some successful examples were shown and dis-cussed. Then, at this stage, the motivation and acceptance of students were reinforced with the so called driving question, since both are key factors for satisfactory development of PBL+CC, as well as for achieving better learning results [28, 29]. The "driving question" was not a single question but an open discussion: "Are we able to correct and/or improving a project carried out by professionals?; can we improve real projects in areas such as economy, environmental impact, supply security or protection of users?; are we ready for facing a real job?; can we work by our-selves without guiding?; what we should know to make these improvements?".

Once students had fully understood the PBL+CC methodology and were in agreement with it, details for its implementation in this specific course were described. First they must change their minds since traditional sessions would be substituted by a common space where each group would be advised and guided but expositive lectures would be removed.

In spite of Spoelstra et al. (2015) suggesting that team work efficiency may be improved by selecting team members in relation to some algorithm application, in this particular case, groups were randomly formed without considering gender, friendship, previous institution, etc. [30]. There were two reasons to support this decision. On one hand, by this way nobody could complain about teacher´s decision because it was a probabilistic method and thus the acceptance of the student of the PBL+CC method would not weaken. On the other hand, students tend to self-select group members who are most like themselves. How-ever in most cases in Chile this is sadly conditioned by the social status. Chile is the OECD member that shows the highest social and economic differences according to the Gini index [31]. Furthermore, as it has been stated, the previous knowledge of students is directly related to this status. Hence, by using this random selection method, the integration between social and cultural statements may be encouraged without increasing the resistance of students [32].

When teams were formed, each group was self-organized. Team members must establish roles for each one through an adequate discussion in order to state who is in charge of what PBL+CC task and how these will be related to other members. After-wards, each group received an original electrical facilities project (i.e. Hospital, Factory, Hotel, Residential Building, etc.). Each project had been previously analyzed and checked in depth to ensure same difficulty and workload involved. These projects were assigned randomly to each group. Then, a work plan must be elaborated by each team and presented to the teacher on the first PBL+CC session. It must be noted that the group self-organization and its work plan were not defined by the teacher, with the objective of increasing both technical and transversal competencies such as consensual decision-making, dialogue, empathy, discussion, conflict resolution skills, and workload assessment and distribution, among others [23]. In addition, a work plan is required in the first session expecting that this schedule should be wrong and students realize at the end what they had supposed the work to be easier and it turned out to be harder or viceversa. Finally, the overall grading system was calculated through three different items which would be evaluated as it is shown in Table 3.

Table 3. Students' overall grade assignment system.

Aspects for evaluating		**Contribution to the students´ overall grade**
CONTINUOUS EVALUATION		30 %
Classroom observations	40 %	
Partial report 1	30 %	
Partial report 2	30 %	
PROJECT PRESENTATION		30 % (75 % assigned by professor) (25 % assigned by other students)
PROJECT QUALITY		40 %
TOTAL		**100 %**

For each item the corresponding grade was assigned based on a detailed rubric. With the aim of strengthen positive interdependency between members of the team, an active participation strategy was designed in accordance with Ghaith et al. (2007). Each session, the teacher randomly selects a member from each group. This student must be able to explain any aspects related to their project and not only his/her tasks. Therefore students must share their individual work with the other members, making the cooperative and collaborative competencies possible. This way, each member of the team achieved the same grade as the others [33].

Two types of control points were designed for the continuous work evaluation: weekly monitoring and delivering partial re-ports. On the one hand, every session, a member of the group was asked about the work that was performed during the previous week and also about how this was related to the initial plan. On the other hand, partial reports were delivered on two dates. Deadlines were programmed on session 10th and 20th. Every partial report had to include: the record of the weekly summaries from the beginning of the project, the work developed by each member and its correspondence with the original plan. When a report contains all information, the group achieves 7 points, otherwise all members achieve 1 point. It must be mentioned that all the members of the group would have the same mark, as it was aforementioned. This causes interdependency to be reinforced.

Students work in an autonomous way and the teacher provides the needed triggering factor for focusing them on key topics or correct some theoretical concepts. Despite Cheung and Vogel (2013) have shown some e-tools that might be considered as appropriated for continuous evaluation in collaborative and cooperative environments, the current situation in Chile does not allow to introduce such e-tools at this point [34]. According to the Chilean Telecommunications Subsecretariat [35] only 47% of households in the Region have access to internet connection and only 4.2% of those have are broadband Internet access.

5. RESULTS AND DISCUSSION

As it has been aforementioned, the success of PBL+CC requires the support of students. Hence, after the discussion around the so called “driving question”, students voted for approving or rejecting the implementation of the PBL+CC methodology in the present course. The outcome was that 30 out of 36 students agreed on the PBL+CC implementation. The other 6 were not in the classroom at that time.

On the first session, teams were formed by selecting members randomly, as it was explained, thus 9 groups with 4 members were defined. Then, members of the group discussed in order to self-organize their roles, assignments, plan, objectives, etc. This was the most troublesome stage, from the point of view of the reaction of the students.

At the project-planning stage (2nd session), there were 8 students who expressed their wish not to proceed with the PBL+CC. They did not complain about assigned roles, plans or leadership. They exposed that the main reason was the incompatibility with other members. At this point, bibliography shows some techniques which might have avoided such situations [30, 34, 36]. Nevertheless the objective was both to promote integration and preparing students for future work environments where many different personal behaviors might interact. Despite teacher effort to get them on board, only two students were reincorporated to their original teams. Thus 4 groups had 3 members, 1 group was formed by only 2 members and 4 groups remained complete with their 4 original members. Finally, the teacher opted for reducing the number of teams by in-creasing the number of members per team.

The students from those groups that were incomplete were randomly re-assigned, resulting 6 teams with 5 members. The other 6 students opted for following the traditional expositive methodology. It must be said that 4 of these six students were never at classroom and other 2 had less than 40% of attendance. This indicates that these students had very low motivation for the subject matter.

Afterwards, no further problems can be reported. All the students accepted their role inside the team and the work was observed to be increasingly cohesive and cooperative during the sessions. Until the deadline of project presentation, the same routine took place in PBL+CC sessions. The teacher took an average of 15 minutes per team. During this time, students were guided by the teacher who also checked their work and planning. Students showed motivation and an increasingly cooperative and collaborative behavior. Also, every session, all of them were able to answer questions from the teacher.

This assessment method allowed evaluating the affective domain of learning, since without an adequate participation and integration within the team it was not possible to achieve good grades. In the case of the traditional method, affective learning cannot be evaluated since there is no assessment method designed for this domain.

Figure 1 shows attendance distribution of the students during PBL+CC. When a student was absent, this was justified by medical certificates and special familiar issues. Compared to previous courses (non PBL+CC), attendance distribution showed significant improvement (Fig. 2). This is explained by motivation but also because of the interdependency between members of the group since their marks depended on both the attendance of other members as well as their work [37].

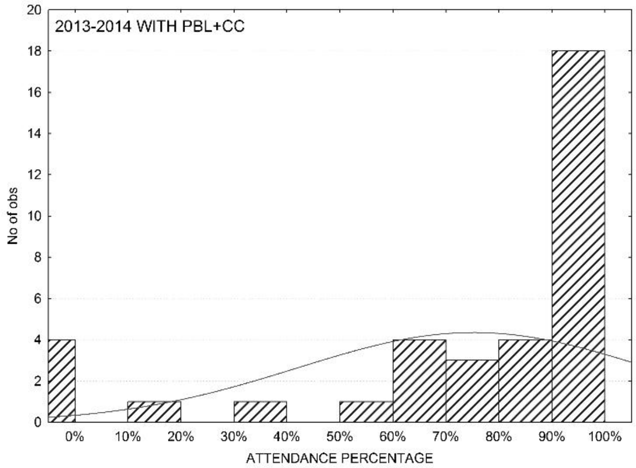

Fig. 1. Percentage of students attending to the PBL+CC sessions distribution.

The four cases shown in Figure 1, which correspond to 0% of attendance, represent those students which refused the PBL+CC methodology from the beginning, but also never were in the traditional expositive lecturers. The other two students who kept the traditional methodology participated less than 40%. Despite the timetable of traditional sessions was defined in agreement with the students in order to increase their attendance, they did not participate adequately. These students showed very low interest and motivation. When they were asked about the causes or troubles they had attending classes, they mainly stated that these were based on the economic situation of their family and they took advantage of any occasion to work that presented itself to them, even during class hours. If we observe the last year attendance percentage (Fig. 2), it can be concluded that there is an increase in terms of average attendance. Statistically, a p-level of 0.000783 is calculated due the non-parametric analysis for a comparison between the two variables (course with PBL+CC and without PBL+CC), there-fore the hypothesis is accepted that there is a significant difference between the two methods.

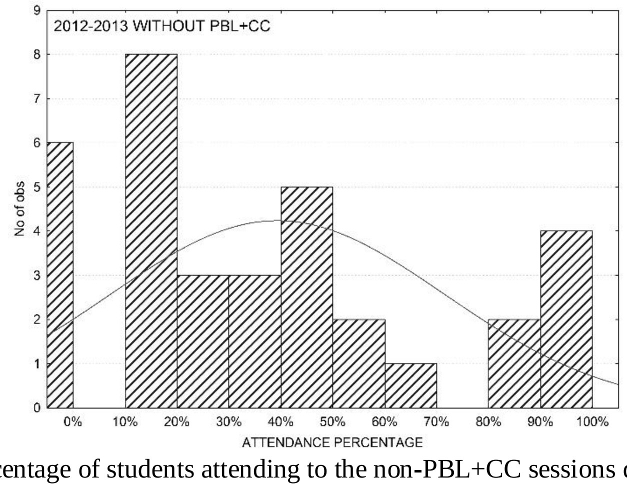

Fig. 2. Percentage of students attending to the non-PBL+CC sessions distribution.

Projects were presented during the last two weeks and each one took a maximum of 20 minutes. The procedure was as it follows: one member was randomly chosen to develop oral presentation. After the project exposition, several questions were asked by teacher and by other students to all team members. This strengthened the positive interdependence since all team members must know about the work done by the others. The assessment of the presentation was performed according to a rubric which was also provided to students so they could evaluate their classmates, assuming the role of “experts”. This grade contributed 25% to the overall presentation assessment. In addition, the affective and the knowledge domain are contemplated when evaluating the structure of the project, the argumentation, technical vocabulary or technical answers, among others.

Once all presentations were finished, final reports were collected and evaluated. Thus evaluation of cognitive process and knowledge dimension in each of its levels was carried out.

For those students who did not follow the PBL+CC, a final exam was used. This consisted on a 10 questions test, along with two development problems. The survey asked about standards, technical equations and electrical devices, among others. This way the levels of “remembering” and “understanding” of the cognitive process, as well as the factual knowledge of the knowledge dimension were evaluated.

Grades distribution obtained by PBL+CC methodology show conclusive results on the improvement of grades, which are founded by a p-level of 0.00001 obtained from the non-parametric analysis. Figure 3 shows students’ marks that were obtained within PBL+CC and also contains the ones obtained by the 6 students who did not follow the PBL+CC on this 2013-2014 course. As it can be seen in Figure 3, three of them did not pass the exam since they achieved less than four points. These three students were never in classroom. That is, they dropped out the course.

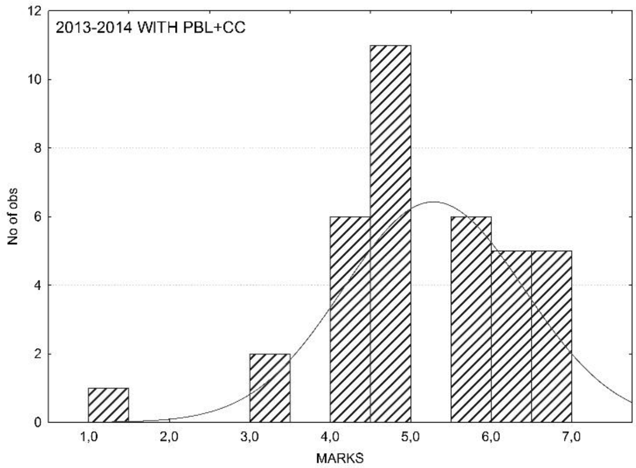

Fig. 3. Distribution of grades obtained by students with the PBL+CC method (2013-2014 Course).

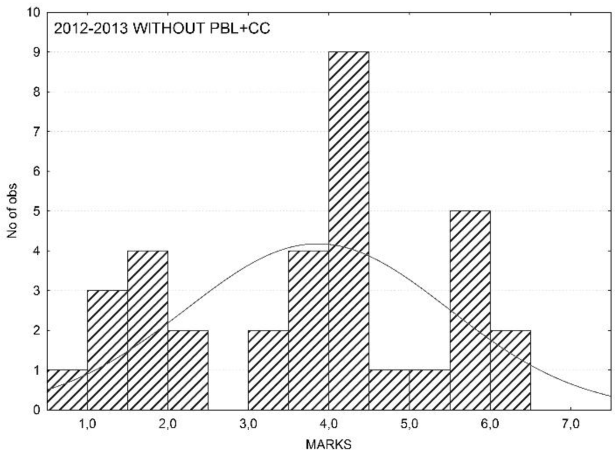

Fig. 4. Distribution of grades obtained by students without the PBL+CC method (2012-2013 Course).

Compared to previous course the grade average was improved (Fig. 4) and SD was reduced, which is in accordance with previous authors [38, 39]. This SD reduction is highly influenced due to same grades being assigned to all team members. It should be also noted that all PBL+CC students had grades higher than 4, so passed the course.

Table 4 shows the corresponding grade statistics grouped by students who enrolled in PBL+CC, those who refused this method and grades obtained in previous course. Despite the number of students being low, it can be observed how grade statistics, obtained in the previous course, are similar to those achieved by those students who were not enrolled in PBL+CC.

Table 4. Marks statistics grouped by type of methodology and course.

Course	Valid N	Mean	Median	Min.	Max.	SD
2013-2014 PBL+CC	30	5.53	5.50	4.50	6.70	0.79
2013-2014 non-PBL+CC	6	3.90	3.80	1.50	6.0	1.55
2012-2013 Traditional	34	3.84	4.10	1.00	6.50	1.62

In the last session, students shared their perceptions and dis-cussed about PBL+CC methodology. Their overall perception was that the PBL+CC had provided some skills to face a future job but some of them were not sure about which ones. This is, they did not identify which level of the learning domain they achieved. In addition, they expressed that the workload was harder than they had assumed to be at the beginning of the project. In order to know better the perceptions of students, they were requested to fill out a basic five questions survey related to their experience, similar to those proposed by Rodriguez-Sandoval and Cortés-Rosdriguez [40].

Table 5 shows both questions and answers. Most of the students felt the workload was higher than the one involved in the traditional method (question Q1), which is in accordance with other authors [25, 41]. However, it is possible to infer that this perception was caused due to the fact that students took responsibility for their own learning. Despite the teacher picked some problems with the aim of focusing in the main topics to cover, as it has been stated above, students did choose several other issues. In addition, the motivation of students produced an increase in these self-picked issues. Thus, they required to invest more time and because of that they felt an increase on the overall workload. Furthermore, time spent searching data is part of this workload. Question Q2 asked for this topic and most of students (>86 %) considered this as high or moderate (question Q2). It is suggested that these difficulties are based on the low percentage of households with high speed internet connection. It has been observed also that information screening skills had to be improved in previous courses since nowadays there is so much information available.

Coordination, which involves the assignment of roles, team discussions, decision making, etc. (question Q3) has been stated as difficult by almost all of them (>83 %). This is explained due to the fact that these students had never faced this procedure of grade interdependency in any previous courses and this meant an important change of perspective.

Table 5. Results from the PBL+CC assessment survey, performed by students.

Q1	How would you rate the workload from the PBL+CC method compared to traditional methodologies?	Higher (24)	Equal (6)	Less (0)
Q2	What level of difficulty do you assign to seek and address the information?	High (12)	Average (14)	Low (4)
Q3	What level of difficulty do you assign to coordinate with your classmates?	High (15)	Moderate (10)	Low (5)
Q4	Do you think this method has enabled you to improve your skills regarding the work environment?	A lot (11)	Quite (9)	Not at all (10)
Q5	Would you recommend the implementation of the methodology in other classes you take or have taken?	Highly (21)	Some (5)	Never (4)

Other authors [42] have high-lighted that students considered PBL as an effective method for increasing professional competencies but here it is not clear. PBL methodology, along with use of rubrics and the group grading assignment system, have provided students with very useful experiences related to creativity, negotiation skills, time management, communication and presentation among others, how-ever they have not felt these. Thus it can be concluded that question Q4 must be rewritten for the next survey in order to be more specific. Therefore this question should be divided into competencies which were supposedly reinforced by the PBL+CC methodology in order to identify the correlation with the perceptions of students in a better way.

Finally, a high percentage of students (81.3 %) would recommend this methodology for other courses (question Q5), which means students enjoyed this methodology in general, which agrees with the bibliography on the matter [43].

6. CONCLUSIONS

This paper shows the design, implementation and development of a project-based learning with a collaborative and cooperative methodology in the subject of electrical installations within the construction engineering degree. This methodology has enabled the development of transversal competencies in students, in particular those related to organization, planning, autonomous learning and interpersonal relations skills. In addition, the showed PBL+CC enables a continuous evaluation of work and his/her learning progress, which is self-performed by the student. All of this is consistent with tminee targets proposed by Tuning for Latin America reports.

Chilean society characteristics highly influence on the development of active learning methodologies. The difference between the behaviors of students, but also between cultural-economic levels, does not allow to implement some techniques easily, particularly those related to team formation and use of e-tools which might improve results. In spite of this, it is clear that the PBL+CC method has improved the attendance and grades of students when compared to the previous course (2012-2013), where this method was not implemented.

It should be noted that PBL+CC has been very well received by students who stated they would recommend those pedagogical methodologies to be extended to other subjects. However, there is a long road ahead of us to change their perception about team work and self-evaluation. Therefore, it is suggested to modify the ending survey by incorporating questions about how this method has increased their transversal competencies and social skills. Also hand workload, which is always a concern in these active learning methods, should be investigated in order to use some teaching tools which allow teachers to limit it but without reducing the autonomous learning process of the student.

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