OmniaScience

Journal of Technology and Science Education

JOTSE, 2022 – 12(3): 578-595 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349

https://doi.org/10.3926/jotse.1694

INCREASE IN ACADEMIC PERFORMANCE DUE TO THE APPLICATION OF COOPERATIVE LEARNING STRATEGIES: A CASE IN CONSTRUCTION ENGINEERING

Elena Cano-García[1], Óscar Rojas-Cazaluade[2]

[1]Universitat de Barcelona (Spain)

[2]Universidad Católica del Norte (Chile)

ecano@ub.edu, orojas@ucn.cl

Received April 2022

Accepted May 2022

Abstract

Cooperative learning has positive effects on student motivation, participation, and performance. Following the methodology's principles, an intervention was designed to be implemented online during confinement in a university subject called Transport Infrastructure (n=40). The data collected shows that the operation of cooperative learning in online environments has the same benefits in improving satisfaction, learning pace, and performance. These findings have implications for future instructional designs in hybrid or online modalities.

The cooperative work teaching and learning methodology, if effective, will involve the conscious and sustained effort of a small group of students toward a pre-established goal, where each of its components assumes roles and coordinates their actions to achieve said purpose. In addition, the articulation of their resources-capabilities, the interaction generated between the members during the process, and the

preliminary results obtained, promote a greater commitment-responsibility for their work and interdependence and support among their peers, raising the threshold between individual and group.

The article allows the effects of this didactic proposal on four elements: the participation rate, the improvement of the learning pace, the increase in academic performance, and the participants' satisfaction. The results are an increase of 0.5 points in qualifications, 17% in approval rate, and 85% in learning compared to the minimum required (80%). These results, together with the participation and satisfaction rates, lead to considering the extension of the proposal to other teaching modules and subjects.

Keywords – Cooperative learning, motivation, active methodologies.

To cite this article:

Cano-García, E., & Rojas-Cazaluade, O. (2022). Increase in academic performance due to the application of cooperative learning strategies: A case in construction engineering. *Journal of Technology and Science Education,* 12(3), 578-595. https://doi.org/10.3926/jotse.1694

----

1. Introduction

Adopting a competence-based educational approach enriches to the extent that it involves integrating and mobilizing different types of learning (knowledge, skills, and attitudes) to face situations and problems in specific contexts (Cano, 2019; Villa-Sánchez, 2020). Furthermore, this approach makes it possible to self-regulate and direct one's learning and continuous learning throughout life (Ye-Lin, Prats-Boluda, García-Casado, Guijarro-Estelles, & Martínez-de-Juan, 2019), where the graduates have training for economic globalization and market demands, innovation, and competitiveness. Also, they become participatory citizens in a fairer and more equitable society (Díaz-Barriga-Arceo, 2019).

Therefore, universities must have a more significant commitment to practical training and the need to set up training processes in which professional practice is revalued, integrating the knowledge and skills of the field of knowledge with reflective and ethical attitudes that come closer to said graduate model. Therefore, the teacher should try to encourage students to adopt critical, analytical thinking, understand the knowledge of the subject under study, to develop various transversal competencies (effective communication, teamwork, and leadership, among others.

In this sense, the teaching-learning processes that promote the development of competencies are linked to active, authentic, and situated methodologies (Halbaut, García & Aróztegui, 2015; Leiva-Reyes, Gutiérrez-Jiménez, Vásquez-Rojas, Chávez-Lezama & Reynosa-Navarro, 2020). Therefore, the problems, the projects, the cases, the simulations, or the practices are, among others, proposals that can allow the development of competencies and align with the CDIO Initiative implemented in all the engineering programs of the Universidad Católica del Norte (UCN) in Chile.

The CDIO initiative (2010), Conceive-Design-Implement-Operate, in a cooperative environment was born at MIT and the Swedish universities of Chalmers, Linkoping, and Royal Institute of Technology (KTH). More than 120 schools worldwide are currently participating. In the CDIO framework (MIT, 2010), learning the fundamental bases and the advanced disciplinary contents of engineering is promoted in an environment with explicit references to the professional practice of engineering as an adequate context for its learning. One of the critical strategies to do this is cooperative learning.

Cooperative Learning is a learning methodology based on teamwork, including various techniques (Azorín, 2018). Gilles (2007) defines it as a pedagogical practice involving the work of students in small groups who guide their actions towards fulfilling pre-established goals. Thus, effective cooperative work involves the conscious and sustained effort of a group and its members toward a known goal, where each of its constituent parts assumes roles and coordinates their actions to achieve said purpose. Furthermore, the articulation of their resources-capabilities, the interaction that is naturally generated between members during the process, and the preliminary results that are obtained, promote a greater commitment-responsibility for their work and interdependence - support towards the requirements of others (Johnson & Johnson, 2009).

As has been pointed out, students are expected to work in an articulated and interdependent manner to achieve a common goal through cooperative work. This teaching-learning methodology teaches its participants to receive and give help, listen to their teammates' ideas and perspectives, and develop skills for conflict resolution and the democratic achievement of consensus. To foster an educational environment that provides opportunities for learning and development of knowledge, experiences, and skills for each of its participants, it is required that the pedagogical activities be carried out in small groups with a heterogeneous and diverse composition (Gilles, 2007) and randomly selected (Johnson, Johnson & Holubec, 1994). For Lou, Abrami, Spence, Poulsen, Chambers and d'Apollonia (1996, as cited in Gilles, 2007: page 51), better learning results are achieved by forming work teams of 3-4 students compared to those of 5 to 7 students. Gilles (2016) indicates that creating small groups would give its members a more significant opportunity to develop their interpersonal competencies and receive effective feedback. This situation allows greater traceability of their personal and collective actions in processes that are part of a global task (Cohen, 1994; Shachar & Sharan, 1994; Johnson & Johnson, 2009).

Cooperative Learning significantly affects all students' performance (Porras & Arias-Trujillo, 2016). In particular, those students with lower academic performance records achieve notable progress (Huang, Shih & Lai, 2011), perhaps due to the competition generated among peers or because they are more likely to benefit directly from knowledge exchange activities. On the other hand, Cooperative Learning also has effects on competency development. According to Marquez, Tolosa, Gómez, Izaguirre, Rennola, Bullon et al. (2016), applying teaching-learning and assessment strategies in an innovative environment within the classroom promotes the creation and activates the entrepreneurial competencies of students through the formation of work teams in the development of projects for the obtaining a product. In this way, the group's intelligence is promoted, while the sum of efforts in getting expected results is stimulated.

This type of learning has been especially relevant during COVID-19. In times of pandemic and forced confinement, distance education configures a new way of learning; however, it generates uncertainty where teachers and students are immersed in new scenarios.

On the one hand, some studies highlight the positive effects of confinement due to COVID-19 on continuity in the study and even on performance (González, de la Rubia, Hincz, Comas-López, Subirats, Fort et al., 2020). On the other hand, however, various limitations have been recorded. For example, Abcouwer, Takács and Solymosy (2021) suggest that cooperative online work can be a relevant practice. Their results are conclusive about the benefits of continuous evaluations during the course, which allows for monitoring students' learning trajectories in cooperative processes. Additionally, several authors (Xiomara, 2018; Ye-Lin et al., 2019) think collaboration is a teaching method that uses social interaction to build knowledge. Also, the learning responsibility is on students, who must conceptualize, organize and put ideas into practice in a continuous evaluation process. However, the responsibility of assisting and facilitating the teaching-learning process remains with the teacher. In this sense, Cooperative Learning becomes a particularly relevant strategy in this context (Bestiantono, Agustina & Cheng, 2020).

Cooperative Learning, as has been indicated, has determining effects on motivation and the pace of learning.

Regarding the effects on motivation, it is interesting to point out that one of the fundamental tasks of teachers is to motivate students learning to learn. Gargallo, Pérez, Garcia, Giménez and Portillo (2020) point out that the presence or absence of motivation by students in a subject can be attributed to the student's characteristics and that the student-teacher relationship is also essential, directly affecting motivation.

Ingram and Hathorn (2004, cited by Cenich & Santos, 2006) point out that collaboration consists of three decisive elements: participation, interaction, and synthesis. Participation is essential because collaboration cannot occur within a group unless there is more or less equal participation among its participants. Interaction requires group members to actively respond to each other, making ideas explicit and generating feedback. Finally, the product created by the group must represent a synthesis of the views of all the group members.

The positive effects of participation documented by Xhomara (2018) indicate that it increases achievement motivation, contributes to the improvement of academic results, and directly affects the construction of knowledge, achieving more active and meaningful learning. Furthermore, there is evidence that active strategies such as the flipped classroom increase motivation (Cho, Zhao, Lee, Runshe & Krousgrill, 2021), increase performance, and develop some competencies linked to sustainability (Sandobal Verón, Marín & Barrios, 2021), so its application seems amply justified.

On the other hand, about the effects on the pace of learning, one of the crucial advantages of cooperative work is to increase motivation and interactions between peers so that students collaborate and learn from each other, seeking to balance the pace of learning. I work in an environment of self-improvement, raising the threshold of learning. In this context, rhythm is one of the factors of academic performance associated with the student's physical condition and mental disposition, the task environment, the methodological strategy, and, in any case, the level of motivation. This motivation is not unilateral but becomes bilateral: Teacher-Student, to specifically benefit those students who are left out of the first diagnosis, all the effort is directed at developing strategies that strengthen complex thinking. (Bedoya & Correa, 2007).

In relation to this, González-Pérez, Traver-Martí and García-López (2011: page 192, cited by Azorín, 2018), state that:

> *Cooperation stimulates and demands equal opportunities, where all its components have a relevant role, and each one is recognized as a valuable participant, regardless of gender, ethnic origin, religion, or socioeconomic status. But previously, cooperation is built on equal treatment and dignity, without denying or eliminating differences in abilities, cognitive rhythms, or talents, instead of recognizing them and taking advantage of them pedagogically.*

González-Fernández, García-Ruiz and Ramírez (2015) points out that pedagogical strategies such as cooperative work, peer tutoring, and the use of tools such as Blog, Google Docs/Drive, Google +, Twitter, etc., facilitate reaching evidence and content. However, the process and the final product depend on the group members' participation and organization. For this, it is essential to know how to tune into different rhythms, attitudes, and behaviors, that is, to master a series of social competencies and to understand how to choose the suitable medium to get the information to the other.

2. Methodology, Context, and Data Collection & Analysis

This innovation was carried out in the Construction Engineering career of the Universidad Católica del Norte (UCN) in Chile, during the first semester of 2020 with n=40 students, in the mandatory subject "Transport Infrastructure," with an academic load of 5.0 transferrable credits system (TCS), and more specifically in the "Road Infrastructure" module. The subject's learning outcomes are linked to competencies to be assessed and build transport infrastructure projects.

Relevant characteristics of the construction engineering graduate are effective communication, permeability to change, leadership attitude, and proactivity. It also considers the impact of their professional work in a global, social, economic, and environmental context since the engineering professional must show social responsibility and commitment to the permanent development of the region and the country. In this context, the UCN has a PEI that indicates that the different career programs must migrate towards student training based on competencies and learning outcomes.

Previous studies (Rojas, Jiménez., Lepe & Mercado, 2016) revealed performance and learning pace difficulties. Table 1 shows the values achieved in the years 2018 and 2019 for indicators of module performance, subject performance, approval percentage, and attendance percentage.

Year Course	Module Performance	Performance Subject	% Approval	% Attendance
2018	4.0	4.6	100%	86.0%
2019	4.3	4.6	97.0%	85.0%
Average	4.2	4.6	98.5%	85.5%

Table 1. History of assessment averages, approval, and attendance

Regarding the learning rate, we decide what this measurement be carried out using the ordinary differential equations (ODE). ODE is recurrent in developing engineering science as a mathematical tool for solving common problems. For example, Ruby (1991) describes one of the applications of ODE in fields of engineering sciences. However, in educational sciences, the applications of ODE are scarce. In this context, Rojas et al. (2016) point out that a homogeneous ODE can measure learning rate. In the ODE, the rate of change dy/dt is indeed equal to a constant a (rate of desired learning achievement) minus a term proportional to y (rate of achievement rate learned) in the equation $dy/dt = a - by$. Where

dy/dt is the rate of change of the acquired learning; ***a*** is the constant relative to the total achievement that is added to previous knowledge; ***by*** is a magnitude proportional to ***y*** (amount of learning to be achieved), and ***b*** a magnitude relative to the learning frequency. This equation states that the solution of the equation is increasing. For an initial time t=0, the learning rate ***y*** is equal to zero. Being the root of the differential equation in these conditions: $y = (a/b)(1 - e\text{-}bt)$, being the exponent of the Napierian constant e responsible for the frequency of the learning rhythm. Suppose the curve of satisfactory responses has the shape of an ODE in a steady-state. In that case, the acceptable answers respond to monitorable variables, such as growth rate, learning achievements achieved, amount of learning to be completed, etc.

Applying this equation, Table 2 describes the values reached in the measurement of the learning pacing in 5 moments in 2016, which will allow contrasting with those obtained in the present research.

Learning Rhythm	Weather 1	Weather 2	Weather 3	Weather 4	Weather 5
Course 2016	46%	65%	75%	77%	80%

Table 2. The pace of learning experience 2016

In summary, taking into account the indicators indicated above, it follows that students did not have low attendance, of the order of 85%, and with a pass rate greater than 97%, their academic performance in the module is lower than the performance academic performance of the subject (on a scale of 1 to 7), 4.2 versus 4.6 on average, respectively.

Perhaps the reduced academic performance in the semester is due to the loss of motivation for the subject, the contents taught, and the teaching-learning methodology. Another reason could be the academic load of other topics in the semester, which affects a better academic performance as an individual as a team.

Although the attendance per session in the last years has been high, it is also necessary to promote it, given the difficulty derived from the confinement due to COVID-19. The data available are:

1. Average of 30 sessions of the 2019 subject: 85%
2. Average of 30 sessions of the 2018 subject: 87%
3. Average of 30 sessions of the 2017 subject: 80%
4. Average of 30 sessions of the 2016 subject: 89%

Based on this diagnosis and in the outlined context, the general objective of innovation was established, consisting of increasing the academic performance rate. The specific objectives of the innovation, in turn, would be:

- First, increase the pace of student learning in the school period.
- Increase student participation in face-to-face sessions on the subject.

The intervention is designed to answer the above objectives in two training instances: the chair or traditionally expository sessions and the workshop, linked to collaborative construction sessions. In the first, cooperative learning methodologies are applied compared to the master sessions of previous years. In the second, PBL (Problem-Based Learning) is introduced compared to problem work that has not been systematized until now. In Problem-Based Learning (PBL), students carry out a process of investigation and creation that culminates in answering a question, solving a problem, or creating a product.

The didactic sequences are shown below:

CHAIR

Apply cooperative learning methodologies. Theoretical phase of the Road Infrastructure module:

- Introduce the reading of the case in pairs outside the classroom.
- Create work teams (3 or 4 students).
- Discuss the matter in expert teams - classroom.
- Socialize the subtopics of the case within the team.
- Individual summative assessment.
- Feedback – Kahoot.
- Prepare a presentation of the matter (conceptual map or PowerPoint by the team).
- Presentation of the matter.
- Closing – Feedback.
- Academic assessment Rubric.
- Peer-assessment Rubric.

WORKSHOP

Apply PBL methodology to develop the practical phase of the Road Infrastructure module. The teams develop the project based on five deliverables:

- Development of the project's charter.
- Topographic survey of the project area.
- Geometric, planimetric, and altimetric design of the road project.
- A physical representation of a section of the road project (model).
- Delivery of final report. The written part of the project.
- Final project assessment rubric – Academic.
- Model Peer Assessment.

A teaching innovation was designed with which it was expected to improve the academic performance of the module and the learning pace and if so, replicate it in other modules and subjects. Otherwise, reformulate the innovation. Furthermore, it was expected that with the implementation of teaching innovation, the motivation to want to learn would increase (Huertas, 1997). Research done by Barca-Lozano, Almeida, Porto-Rioboo, Peralbo-Uzquiano and Brenlla-Blanco (2012) points out that motivating teaching skills are relevant when encouraging students, and it has been proven that these have significantly improved learning outcomes.

The aim was to increase the pass rate of the innovative module of the subject, so it is proposed to grant a more active role to the student, making him a participant from the first day the Road Infrastructure module is taught. Regarding determining the learning pace, through a survey, they inquired about their previous knowledge, which will be replicated at different times of the progress of the contents, according to the module schedule. At the end of the module, the students were surveyed to measure their satisfaction level according to teaching innovation and their interest in the module contents.

Hence, this proposal would be easy to transfer to other career subjects, adapting the contents and activities based on the available resources and, above all, the teaching style of each teacher.

From a universe of 40 students: Based on the principles established by the "Scientific Ethics Committee of the Universidad Católica del Norte" regarding the collection of information in research involving human beings, the question was: Do you agree to participate in this study? 100% accepted. Finally, the sample comprises 35% women and 65% men. 97% take it for the first time, and 3% repeat it.

Regarding the data collection, the indicators gathered to respond to the proposed objectives are established in four categories:

1. Academic performance according to qualifications:
   a) Average academic performance of the module.
   b) Average academic performance in the subject.
2. The increased pace of learning:
   a) Student learning pace rate (%).
3. Participation in synchronous sessions
   a) The number of students attending per session.
   b) Module attendance rate (%).
4. Satisfaction level with the implementation of teaching innovation in Road Infrastructure module of Transport Infrastructure subject.

The data collection instruments and sources and the schedule with the actions are detailed in Table 3. In addition, the indicator aligned with the research objectives is made explicit. The data collection instruments, tools, and sources are defined. Finally, the data collection period (during the 2020 semester) and the data analysis time are determined.

Indicator	Data Collection Instruments	Sources	Collection Period	Analysis Term
Number of students participating in the synchronous sessions (in %)	Tongoy or Zoom platform assistance list	Students	Throughout the first half of 2020	Throughout the first half of 2020
Learning Rhythm (in %)	Knowledge questionnaire on topics related to the subject to compare it with the pattern-curve of acquisition rhythm (Socrative)	Students	Five measurements during the first half of 2020	Five measurements during the first half of 2020
Module grade average	Average module grades: Chair: summative evaluations Workshop: Collaborative Works Finals: Weighted averages of chair and workshops	Students	Last day of the module (week 10)	At the end of the module (week 10)
Subject grade point average	Average course grades: Chair: summative evaluations Workshop: Collaborative Works Finals: Weighted averages of chair and workshops	Students	Last day of the course (week 17)	At the end of the semester (week 17)
Satisfaction Perception (in %)	Satisfaction and perception of learning and detection of interests. (GoogleForms). https://bit.ly/3aIlgoi	Students	Last day of the module (week 10)	At the end of the module (week 17)

Table 3. Data collection planning, sources, and schedule with actions

For the quantitative analysis of the research data collected to respond to the proposed objectives, the database and statistical software, MS Excel and Statgraphcs, were used. In addition, Socrative and Google Forms applications were performed for the database organization.

1. Academic performance according to qualifications: this work was done on collecting, organizing, and analyzing data with the Socrative application and MS Excel software.

2. Increased learning pace: work was done on data collection, organization, and analysis with Socrative, MS Excel, and Statgraphics software.
3. Participation in the synchronous sessions: this work was done on collecting, organizing, and analyzing data with the Zoom database and MS Excel.
4. Satisfaction with the implementation of teaching innovation in Road Infrastructure module of Transport Infrastructure subject: this work was done on data collection, organization, and analysis with the Google Forms application and MS Excel.

3. Results

The results seem to show the benefits of applying active techniques on performance and participation/motivation. Moreover, these results are shown comparatively concerning previous editions.

3.1. Participation Improvement

This section records the data collected during the development of the implementation of the teaching innovation. The average of 30 sessions of the 2020 subject was 94%, exceeding the data of the previous diagnosis by nine average percentage points.

Increase student participation in face-to-face sessions on the subject. This objective was measured by registering attendance to the synchronous virtual classes of the "www.tongoy.ucn.cl" platform. It is also possible to evidence attendance through the participation of students in cooperative work teams. In addition, the data can be collected from the statistical report of the Zoom platform, used for virtual online classes.

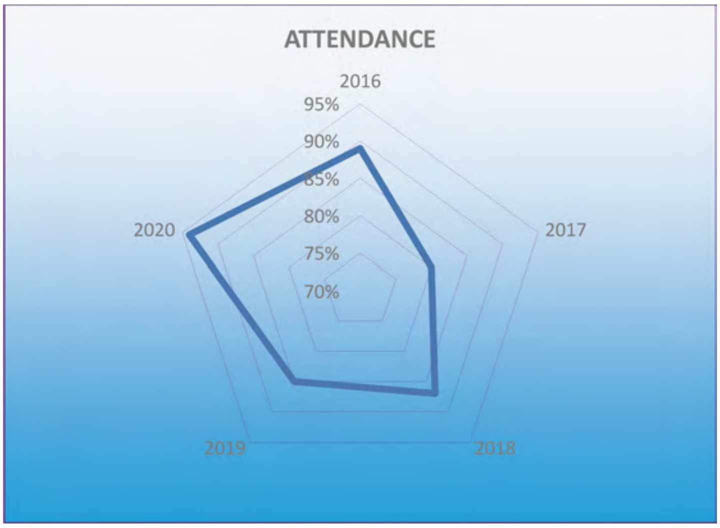

Figure 1. Comparative assistance period 2016 to 2020. Own source

It could be noted that despite the students being confined due to health restrictions due to COVID-19 and the sessions implemented for virtual synchronous classes were at 08:10 in the morning, the attendance rate increased by an average of 9 percentage points

3.2. The Pace of Learning Increases

To the learning pace to be stated, surveys with 20 multiple-choice questions were taken five times during the development of the Road Infrastructure module. The evaluative average of each survey is indicated in Table 4 and corresponds to an average of 38 surveys from 40 students.

Based on the values obtained in each "Average-Good" assessment period, Table 5 was developed, which shows the rate achieved in each assessment period. The pace is calculated by dividing "Average-Good" by the total number of survey questions (20).

Survey dates	Period		Average Good (pts.)
	Days	Week	
28-Apr-20	1	1	12.13
29-May-20	30	4	14.37
26-Jun-20	60	8	16.06
24-Jul-20	90	12	16.69
26-Aug-20	120	17	16.95

Table 4. Average-Good. Own source

Survey Dates	Period's		Average Good (pts.)	Rhythm
	Days	Week		
28-Apr-20	1	1	12.13	61%
29-May-20	30	4	14,37	72%
26-Jun-20	60	8	16.06	80%
24-Jul-20	90	12	16.69	83%
26-Aug-20	120	17	16.95	85%

Table 5. Measurement schedule of the series of surveys – Own source

Using the averages of the five series of surveys, using the Statgraphics Centurion XVI software, version 16.1.03, a simple regression was performed, obtaining the following results for the dependent variables: Average-Good and independent: Deadline-Days.

The applied model is Log-X: $Y = a + b*\ln(X)$

Parameter	Estimated Least Squares	Standard Error	Statistic - T	P-value
Intercept	11.8939	0.584615	20.3448	0.0003
Pending	0.99808	0.154597	6.456	0.0075

Table 6. ANOVA analysis statistics – Source Statgrafics Centurion XVI

Source	Sum Squares	df	Middle Square	F-reason	P-value
Model	15.1092	1	15.1092	41.68	0.0075
Residue	1.08751	3	0.362505		
Total (Corr.)	16.1967	4			

Table 7. Statistical analysis of variance - Source Statgrafics Centurion XVI

- Correlation Coefficient = 0.965845
- R-squared = 93.28%
- R-squared (adjusted for df) = 91.05%
- Standard error of the est. = 0.602084
- Mean absolute error = 0.367417

The output shows the results of fitting a log-X model to describe the relationship between Average-Good and Deadline-Days. The equation of the fitted model is:

Average-Good = 11.8939 + 0.99808*ln(Term-Days)

Since the P-value in the ANOVA table (Table 6) is less than 0.05, there is a statistically significant relationship between Average-Good and Deadline-Days with a confidence level of 95.0%.

The R-Squared statistic indicates that the fitted model explains 93.2856% of the variability in Average-Good after transforming to a Y/(1-Y) scale to linearize the model.

The correlation coefficient derived from the analysis in Table 7 equals 0.965845, indicating a relatively strong relationship between the variables. The estimate's standard error shows that the residuals' standard deviation is 0.602084. This value can be used to build prediction limits for new observations.

The figure of the logarithmic model is as follows.

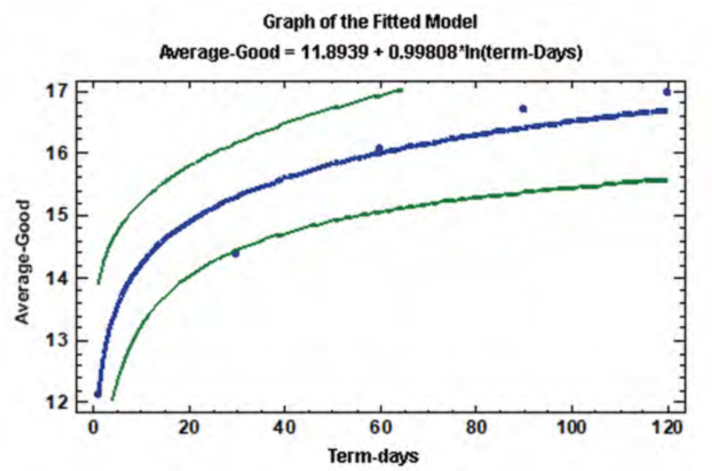

Figure 2. Adjusted Model. Font Statgrafics Centurion XVI Centurion

As long as the characteristic curve of expected achievements versus time shows similarity with an ordinary differential equation (ODE), the transition period is the minimum expected knowledge.

From a simple and comparative analysis concerning a similar measurement of 2016, from the following table, it is inferred that the learning pace varied positively by five percentage points from 2016.

Learning Pace	**Measure 1**	**Measure 2**	**Measure 3**	**Measure 4**	**Measure 5**
Class 2016	46%	65%	75%	77%	80%
Class 2020	61%	72%	80%	83%	85%

Table 8. Comparison of the learning pace periods 2016 and 2020

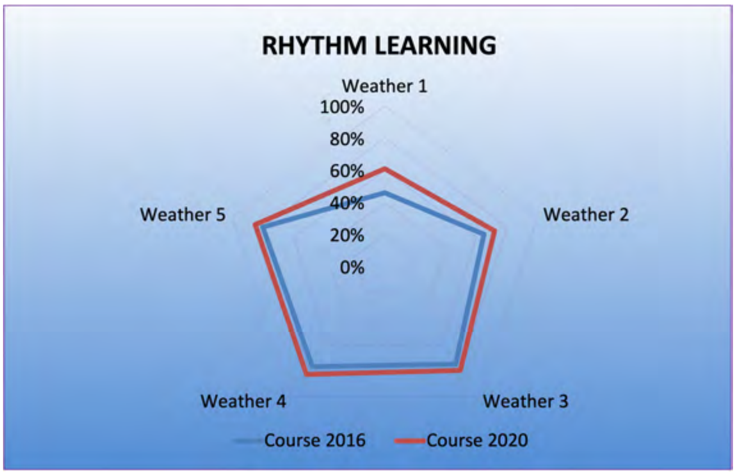

Figure 3. Comparative learning rate period 2016 and 2020

The graph obtained from the previous table clearly shows that the learning rate's growth was sustained over time. Regarding the considerable difference in the first measurement, this difference is because the learning of the previous subjects has been contextualized and the teaching innovation implemented.

3.3. Academic Achievement Improvement

The general objective of the proposed research was "Increase the academic performance rate of students," which was measured by the average grades of the Road Infrastructure module and the subject. In addition, this was complemented by the approval percentage of the subject. The results shown in the following graphs demonstrate that the stated objective was achieved.

The average grade of the module - subject was taken to assess the performance.

i. Average partial assessment quiz Nº1: 1 of 4 of the subjects – 15% each
ii. Average of 5 cooperative workshops: 5 of 10 workshops – 40% final average
iii. Average of a field job: 1 of 2 jobs – 50% each

Year	2016	2017	2018	2019	2020
Subject	4.4	4.6	4.6	4.6	5.0
Module	3.9	4.4	4.2	4.4	4.9

Table 9. Average Notes

Percentage of approval module - subject

i. Average four partial assessment quiz: 36% final grade weighting
ii. Average ten cooperative workshops: 24% final grade weighting
iii. Average two fieldwork: 40% final grade weighting 40%

Year	2016	2017	2018	2019	2020
Module	45%	78%	72%	80%	100%
Course	93%	100%	100%	97%	100%

Table 10. Approval percentage

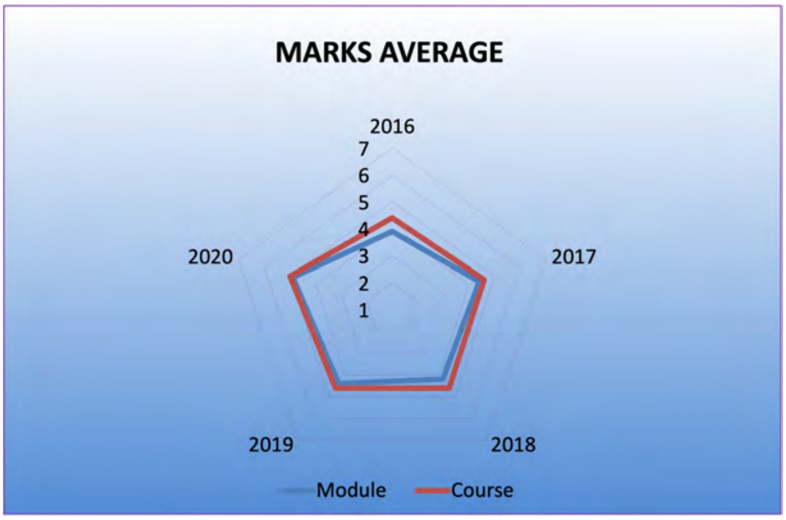

Figure 4. Comparison of average grades for the module and the subject

It is important to note that timidly since 2016, active pedagogical activities have been implemented. Thus, constant growth over time can be seen from the teaching innovation implementation in 2020. The average mark of the module reached 4.9 and the subject 5.0, in contrast to the previous year, where the averages were 4.4 and 4.6, respectively.

Meanwhile, regarding the approval rate, this increased in the Road Infrastructure module from 80% to 100%, a significant increase since it is the module where the teaching innovation was applied. Regarding the subject's approval, it increased from 97% to 100%, which is evidenced in Figure 5.

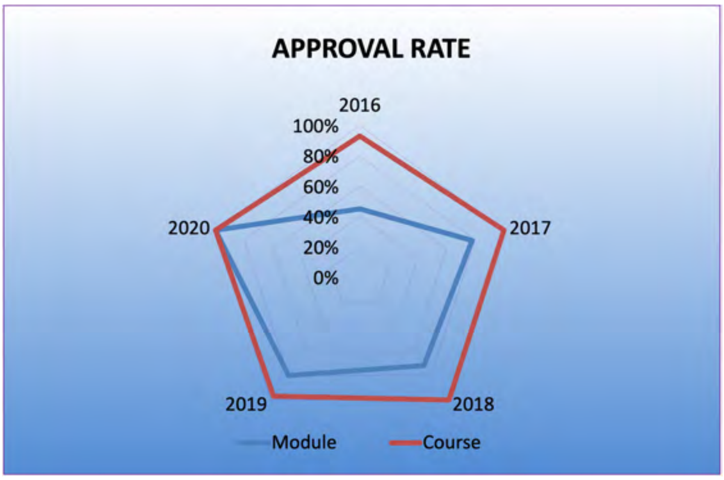

Figure 5. Comparative percentage of passing the module and the subject

3.4. Level of Satisfaction with the Proposal

Finally, the perception of satisfaction is addressed. The satisfaction survey was constructed based on a psychometric scale (Likert scale) and a satisfaction scale of Customer Satisfaction Score (CSAT) type. Despite their advantages, one of the drawbacks of CSAT-type satisfaction surveys is that they require a certain degree of involvement on the part of the respondents, an effort they are not always willing to invest in. In such a situation, it is difficult to obtain more reliable answers. It is crucial if we consider that, frequently, the dissatisfied students are those who wish to express their point of view. However, one of the advantages of online and real-time a captive universe of CSAT surveys is to reach conclusions by assessing the satisfaction level immediately. Since this research case, students have had more than ten weeks out of 17 in the semester to mature and evaluate the teaching innovation implemented in the Road Infrastructure module. The measurement of the degree of satisfaction, by itself, is not effective in giving an overview of the students' experience. Therefore, using it in conjunction with other measurement models is recommended to obtain a more meaningful analysis. In this case, it was used linked to a Likert survey. Remarkable results were obtained from this survey that explains satisfaction levels with variables such as management, teaching, methodology, assessment, and others of the implemented teaching innovation. Only those related to the method are rescued below.

Assessment Aspects: Regarding the assessment issues of the activities implemented in teaching innovation, the following statements were established in the satisfaction survey:

- There was clarity regarding the criteria with which I was assessed.
- Through a rubric, I promptly informed how the activity would be evaluated.
- At the end of each activity and assessment task, feedback was given.
- The practical activities were self-assessed, peer-assessed, and assessed by teachers.
- The assessment of the subject is consistent with the stated learning outcomes.

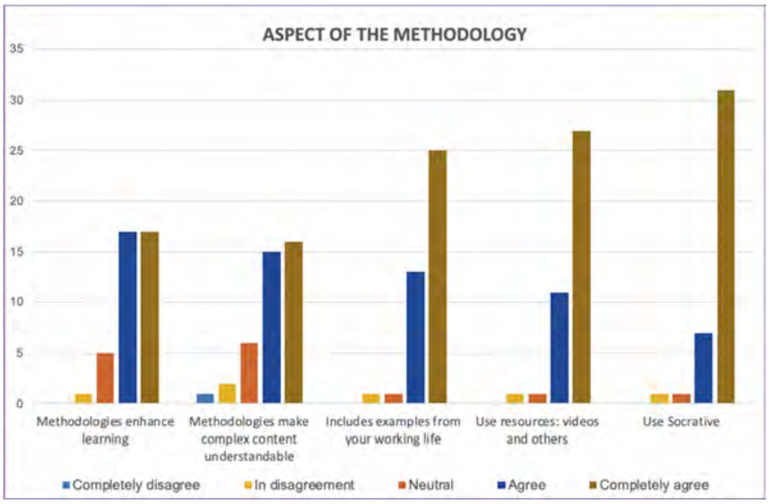

Figure 6. Degree of agreement or disagreement regarding methodology

Regarding the overall satisfaction with the experience of implementing teaching innovation, a very high rate is shown, as seen in Figure 7. We should note that no students expressed dissatisfaction with the implementation; however, 12.5% of the students said they were indifferent to the implementation. Necessary is the support of 87.5% of the students who expressed satisfaction with implementing teaching innovation in the Road Infrastructure module.

Figure 7. Degree of student satisfaction regarding teaching innovation. Own source

4. Conclusions

The conclusions are established based on the analysis of the results collected from the implementation of teaching innovation in Transport Infrastructure subject of the Construction Engineering career at the Universidad Católica del Norte.

Establish that the schedule defined in the innovation proposal was reorganized due to the general planning modification of the subject in response to the social outbreak and later to the COVID-19 pandemic effects. The initial schedule was established to implement the module in ten weeks, and both a theoretical and an experimental stage continued. However, the experimental stage had to move over time and increase the partial times, concluding the implementation in seventeen weeks.

The results achieved are explained from the perspective of the proposed general and specific objectives.

The general objective of the research sought to "Increase the academic performance rate of students," that is, raise the average grades, both in the Road Infrastructure module, in which the innovation was implemented, and in the subject, Transportation Infrastructure. In addition, increase the percentage of the module and subject approval. In this sense, the module reached an average of 4.9 and the subject of 5.0. In contrast, the previous year's averages were 4.4 and 4.6, respectively. Furthermore, the approval rate increased in the Road Infrastructure module from 80% to 100% and in the subject from 97% to 100%.

About specific objective 1 (Increase the learning rate of students during the school period), it should be remembered that the scenario corresponds to the road infrastructure module of the Transportation Infrastructure subject of the Construction Engineering career. Therefore, the objective universe corresponds to 40 students who answered a series of five samples applied for 120 days. From the analysis of the statistics and consolidated results of the samples detailed in Tables 4 to 7, Average-Good versus Time-Days, for an initial time $t0 = 0$, corresponding to the first measurement, the curve shows a knowledge prior learning of 61%, which indicates that the student brings prior learning. This result is explained by the existence of a better connection between programs of previous subjects.

Around the eighth week, the knowledge acquired is around 80%, which is the minimum expected for implementing teaching innovation. Meanwhile, beyond the seventeenth week, the characteristic curve of expected achievements versus time is transient (it remains constant for the project), with the student reaching 85% of learning.

About the statistical analysis of the adjusted model: Average-Good = 11.8939 + 0.99808*ln(Term-Days). It is concluded that the P-Value statistic of less than 0.05 explains a statistically significant relationship between Average-Good and Deadline-Days for a confidence level of 95.0%. In addition, the R2 statistic of 93.29% reflects the model's goodness of fit and that the statistical correlation coefficient equal to 0.965845 expresses a relatively strong positive relationship between the variables.

The comparative analysis concerning a similar measurement in 2016 inferred that the pace of learning varied positively by five percentage points in 2020 compared to 2016.

As a final result, we can conclude by utilizing an adjusted model of an ordinary differential equation. The model can monitor during the development of a module and subject the progress in time of the students' learning and accelerate with other active methodologies or with a combination of these student learning, as pointed out by Rojas et al. (2016).

Concerning specific objective 2 (Increase student participation in face-to-face sessions on the subject), it should be noted that this objective was essential and relevant since, as a result of the COVID-19 pandemic, the country entered total and partial confinement phases, depending on the contagious degree in the cities. Therefore, the preceding, the university planned the academic year remotely, taking all classes synchronously and asynchronously, virtually, respecting class schedules to avoid overlapping classes and other possible conflicts. In this sense, it should be noted that the students were confined to health restrictions due to COVID-19. Therefore, the sessions implemented for the virtual synchronous classes were established at 08:10 in the morning. As a result, attendance increased on average by nine percentage points from previous years, perhaps due to the convenience of being able to attend sessions from their homes, even though certain studies consider that students attribute less efficiency to online modalities (Butnaru, Nită, Anichiti & Brînză, 2021).

Finally, regarding the perception of student satisfaction regarding the implementation of teaching innovation, three statements can be established by way of conclusion:

In the first place, regarding the Management of the Module, the Teacher Aspects, the Methodological Aspects, and the Evaluative Aspects, the students, for the sum of the statements "Agree and Completely agree," on average, equal to or exceed 90%, powerful weighting that satisfies the teaching expectations of the research. On the other hand, regarding the Degree of Satisfaction with the Implementation of Teaching Innovations, the results show that 87.5% of the assessed students the teaching innovation implemented by the teacher with scores ranging from 7 to 10 points.

As a whole, the results show the benefits of cooperative learning methodologies in online environments in engineering due to their effect on participation, the pace of learning, and, consequently, performance. The outcomes derived from the workshops are similar to those reported by Lindín (2021), who once narrated cases in which digital technology was used to promote active learning and generate student-centered educational practices. It allows students to practice the digital information skills necessary for the work content of the subject and makes the student responsible for their learning. This learning will only be achieved collaboratively, providing valuable knowledge to the class group. The publication also establishes that the transformation of the theoretical classes and other virtual activities has favored the virtual communication of the flipped classroom model. The interaction with the students has been superior, an aspect reflected in the 2020/2021 academic year. This pattern is similar to what happened in the virtual collaborative workshops for the face-to-face innovation workshops in this study.

The study has some limitations, such as the fact that it is limited to one unit of the syllabus or the size of the group of students, which could decrease the effect as it becomes a more generalized experience. Despite this, the implications for teaching practice in online or hybrid environments seem clear: the application of active methodologies has positive effects, especially in this type of environment.

Based on these results, future studies and analyzes could complement teaching innovation, especially regarding the learning pace. Since these data could be used not only in a productive way by the teacher but also for a formative evaluation, in which the student makes his decisions, thus favoring the self-regulation of learning (Kim, Yoon, Jo & Branch, 2018) and further contributing to the development of the competences of university students.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning the research.

Funding

The authors received no financial support for the research, authorship, and publication of this article but the active learning methodologies applied were designed, implemented, and evaluated within the innovative teaching project funded by CORFO.

References

Abcouwer, T., Takács, E., & Solymosy, J. (2021). Fine-tuning the Evaluation Focus in the University Cooperative Learning Model in Relation to the Pandemic. *Communications of the Association for Information Systems,* 48, 196-204. https://doi.org/10.17705/1CAIS.04825

Azorín, C. (2018). El método de aprendizaje cooperativo y su aplicación en las aulas. *Perfiles educativos,* 40(161), 181-194. Available at: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-26982018000300181 https://doi.org/10.22201/iisue.24486167e.2018.161.58622

Barca-Lozano, A., Almeida, L.S., Porto-Rioboo, A.M., Peralbo-Uzquiano, M., & Brenlla-Blanco, J.C. (2012). Motivación escolar y rendimiento: impacto de metas académicas, de estrategias de aprendizaje y autoeficacia. *Anales de psicología,* 28(3), 848-859. https://doi.org/10.6018/analesps.28.3.156101

Bedoya, G., & Correa, H. (2007). Ritmos de aprendizaje. *Colegio Oficial José Antonio Galán*. Available at: https://bit.ly/3psPR1p

Bestiantono, D.S., Agustina, P.Z.R., & Cheng, T.H. (2020). How Students' Perspectives about Online Learning Amid the COVID-19 Pandemic? *Studies in Learning and Teaching*, 1(3), 133-139. https://doi.org/10.46627/silet.v1i3.46

Butnaru, G.I., Nită, V., Anichiti, A., & Brînză, G. (2021). The Effectiveness of Online Education during Covid 19 Pandemic—A Comparative Analysis between the Perceptions of Academic Students and High School Students from Romania. *Sustainability,* 13, 5311. https://doi.org/10.3390/su13095311

Cano, E. (2019). Presentación del monográfico: Evaluación por Competencias en la Educación Superior: Buenas Prácticas ante los Actuales Retos. *Revista Iberoamericana de Evaluación Educativa,* 12(2), 5-8. Available at: https://revistas.uam.es/index.php/riee/issue/view/931 https://doi.org/10.15366/riee2019.12.2.003

Cenich, G., & Santos, G. (2006). Aprendizaje Colaborativo Online: Indagación de las Estrategias de Funcionamiento. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología,* 1. Available at: https://bit.ly/2Ob5ZVz

Cho, H.J., Zhao, K., Lee, C.R., Runshe, D., & Krousgrill, C. (2021). Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance. *IJ STEM Ed,* 8, 46. https://doi.org/10.1186/s40594-021-00302-2

Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research,* 64, 1-35. https://doi.org/10.3102/00346543064001001

Díaz-Barriga-Arceo, F. (2019). Evaluación de Competencias en Educación Superior: Experiencias en el Contexto Mexicano. *Revista Iberoamericana de Evaluación Educativa,* 12(2), 49. https://doi.org/10.15366/riee2019.12.2.003

Gargallo, B., Pérez, C., Garcia, F.J., Giménez, J.A., & Portillo, N. (2020). La competencia aprender a aprender en la universidad: propuesta de modelo teórico. *Educación XX1*, 23(1), 19-44. https://doi.org/10.5944/educXX1.23367

Gilles, R. (2007). *Cooperative learning: Integrating Theory and Practice*. SAGE Publications, Inc. https://doi.org/10.4135/9781483329598

Gilles, R. (2016). Cooperative Learning: Review of Research and Practice. *Australian Journal of Teacher Education,* 41(3). https://doi.org/10.14221/ajte.2016v41n3.3

González, T., de la Rubia, M.A., Hincz, K.P., Comas-López, M., Subirats, L., Fort, S. et al. (2020) Influence of COVID-19 confinement on students' performance in higher education. *PLoS ONE,* 15(10), e0239490. https://doi.org/10.1371/journal.pone.0239490

González-Fernández, N., García-Ruiz, R., & Ramírez, A. (2015). Aprendizaje cooperativo y tutoría entre iguales en entornos virtuales universitarios. *Estudios pedagógicos,* 41(1), 111-124. https://doi.org/10.4067/S0718-07052015000100007

González-Pérez, V., Traver-Martí, J.A., & García-López, R. (2011). El aprendizaje cooperativo desde una perspectiva ética. *ESE: Estudios Sobre Educación,* 21, 181-197.

Halbaut, L., García, E., & Aróztegui, M. (2015). Metodologías para el Desarrollo de Competencias. En Londoño, G., & Cano, E. (Eds.), *Formación y Evaluación por Competencias en Educación Superior por competencias* (67-89). Ediciones Unisalle.

Huang, H.C., Shih, S.G., & Lai, W.C. (2011). Cooperative Learning in Engineering Education: a Game Theory-Based Approach. *International Journal of Engineering Education,* 27, 875-884.

Huerta, J.A. (1997). *Motivación. Querer Aprender.* Aique.

Ingram, A., & Hathorn, L. (2004). Methods for Analyzing Collaboration in Online Communications. In Roberts, T. (Ed.), *Online Collaborative Learning: Theory and Practice* (215-241). Idea Group Inc., USA. https://doi.org/10.4018/978-1-59140-174-2.ch010

Johnson, D., & Johnson, R. (2009). An educational Psychology Success Story: Social Interdependence *Theory and Cooperative Learning. Educational Researcher,* 38(5), 365-379. https://doi.org/10.3102/0013189X09339057

Johnson, D., Johnson, R., & Holubec, E. (1994). *El aprendizaje cooperativo en aula.* Editorial Paidós.

Kim, D., Yoon, M., Jo, I.H., & Branch, R.M. (2018). Learning analytics to support self-regulated learning in asynchronous online courses: A case study at a women's university in South Korea. *Computers and Education,* 127, 233-251. https://doi.org/10.1016/j.compedu.2018.08.023

Leiva-Reyes, K.A., Gutiérrez-Jiménez, A.E., Vásquez-Rojas, C.P., Chávez-Lezama, S.E., & Reynosa-Navarro, E. (2020). Aprendizaje colaborativo en línea y aprendizaje autónomo en la educación a distancia. *Revista Científica, Cultura, Comunicación y Desarrollo,* 5(3), 95-100.

Lindín, C. (Coord.) (2021). El valor de las tecnologías digitales en la mejora de la Educación Superior. *Cuaderno de Docencia Universitaria 45.* Universidad de Barcelona. Available at: http://diposit.ub.edu/dspace/bitstream/2445/181952/1/16445-CDU-45.pdf

Lou, Y., Abrami, P.C., Spence, J.C., Poulsen, C., Chambers, B., & d'Apollonia, S. (1996). Agrupación dentro de la clase: un metanálisis. *Revisión de la investigación educativa,* 66(4), 423-458. https://doi.org/10.3102/00346543066004423

Márquez, R., Tolosa, L., Gómez, R., Izaguirre, C., Rennola, L., Bullon, J. et al. (2016). Reproducción de un ambiente de innovación en el salón de clase. Una estrategia para promover la creatividad en la educación en Ingeniería Química. *Educación Química,* 27, 249-256. https://doi.org/10.1016/j.eq.2016.07.001

MIT (2010). *Estándares CDIO v. 2.0.* Massachusetts Institute of Technology. Available at: https://bit.ly/3ayD4SO (Accessed: December 2019).

Porras, R., & Arias-Trujillo, J. (2016). El aprendizaje cooperativo como metodología para estudiar las propiedades mecánicas de los materiales en la Ingeniería Civil. *REDU Universitaria,* 14(2) 37-55. https://doi.org/10.4995/redu.2016.5677

Rojas, O., Jiménez, W., Lepe, C., & Mercado, J. (2016). Innovación en Comprensión del Ritmo de Aprendizaje asignatura de Ingeniería por Modelo Matemático. *XXIX Congreso SOCHEDI Universidad de la Frontera.* Temuco, Chile. Available at: https://bit.ly/3jopq8T

Ruby, L. (1991). If you understand leaky bucket, you understand a lot of physics. *The Physics Teacher,* 29(1), 44-46. https://doi.org/10.1119/1.2343203

Sandobal Verón, V.C., Marín, M.B., & Barrios, T.H. (2021). El aula invertida como estrategia didáctica para la generación de competencias: Una revisión sistemática. *RIED. Revista Iberoamericana de Educación a Distancia*, 24(2), 285-308. https://doi.org/10.5944/ried.24.2.29027

Shachar, H., & Sharan, S. (1994). Talking, relating, and achieving: Effects of cooperative learning and whole-class instruction. *Cognition and Instruction,* 12, 313-353. https://doi.org/10.1207/s1532690xci1204_2

Villa-Sánchez, A. (2020). Aprendizaje Basado en Competencias: desarrollo e implantación en el ámbito universitario learning: development and implementation in the university field Introducción. *REDU Revista de Docencia Universitaria*, 18(1), 19-46. Available at: https://dialnet.unirioja.es/descarga/articulo/7476033.pdf https://doi.org/10.4995/redu.2020.13015

Xhomara, N. (2018). The role of students' engagement, knowledge construction approaches, and achievement motivation on increasing of active learning. *European Journal of Education Studies,* 5(5), 189-204.

Ye-Lin, Y., Prats-Boluda, G., García-Casado, J., Guijarro-Estelles, E., & Martínez-de-Juan, J.L. (2019). Diseño, aplicación y valoración de actividades destinadas al trabajo y evaluación de múltiples competencias transversales en grupos numerosos de máster en ingeniería, empleando el aprendizaje basado en proyectos. *Educatio Siglo XXI*, 37(3), 133-162. https://doi.org/10.6018/educatio.399201

Published by OmniaScience (www.omniascience.com)

Journal of Technology and Science Education, 2022 (www.jotse.org)