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Implementing Multiple Different Active Learning Techniques In Online Road Geometric Design Courses

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ABSTRACT

Due to its positive results, active learning has spread to most areas of knowledge of Civil Engineering. Many of these studies used only one technique, which is limiting given the diverse learning styles that the students may have. The road geometric design is the area that has been the least explored in Civil engineering. Therefore, the objective of this study is to show the implementation of multiple different active learning techniques in online road geometric design courses. The study shows an iterative implementation of multiple active learning techniques throughout the sequence of the three undergraduate courses in Ecuador. As a result, positive student perception was found from the combination of several active techniques. Each technique, called 'learning moment', was distributed weekly and separated from the others. The students gave the courses an average score between 8.34 to 9.06/10. At each learning moment, there were many positive comments and some easily resolved negative ones. The combination of multiple different active learning techniques, shown in this study, can be used in other courses of Civil Engineering, Engineering, or in similar areas of knowledge.

Key words: active learning; civil engineering; learning environment.

INTRODUCTION

Active learning is any learning activity in which the student participates or interacts actively in their learning process (Bonwell, C., & Eison 1991). Active learning is the opposite of 'traditional' modes of instruction in which students are passive recipients of knowledge. The lecture-style presentations, one of the traditional approach, is no longer welcomed by students (Roehl, Reddy, and Shannon 2013) since they prefer the most innovative learning methods (Subramanian and Kelly 2019). In addition, according to their preference, it also motivates them to reach higher levels of learning (Warren and Padro 2019). This active learning environment allows students to develop skills and abilities they need in their future jobs, especially in the area of Civil Engineering, where they are highly required.

In Civil Engineering courses, several active learning techniques have been employed to get better learning results. Some of these techniques that try to leave behind the lecture-based classes are the flipped classroom model (Cleary 2020) and their variations: peer-assisted flipped classroom (Navin 2021), partially flipped classroom (Warren and Padro 2019), blended learning (Win and Wynn 2015) or gamification (Sailer et al. 2017; González 2018; Huang and Levinson 2012). The main idea of this active model is to engage the student in their learning. This engagement could put the students to learn by themselves: guided exercise supported by ICT (C. G. Oliveira, Macedo, and Oliveira 2018), autolearning with lectures prepared by the students (Garzón-Roca et al. 2018), outcome-based education (Isa et al. 2017). Also, students can learn together with their peers: teamwork learning (Sofroniou and Poutos 2016; Y. García-Ramírez 2020; Antaya et al. 2013; Kunberger and Bondehagen 2008; Y. García-Ramírez 2021), peer-assisted learning (Abushammala 2019b; Van Hattum-Janssen and Loureṇo 2008); active and cooperative learning (Pakpahan 2018; Schneiter 2004; Bandyopadhyay 1999; Kolar et al. 2000; Jacquez et al. 2007). Given the positive results of active learning, those are not the only learning techniques in the civil engineering field.

Some other active techniques involve the student in solving real or fictional problems/projects. It works either individually or collectively. For example, problem-based learning (Scaioni et al. 2020; Miranda et al. 2020), project-based learning (Hossain 2020; Mendes et al. 2019; Picton et al. 2019; Aquere 2017; Chen, Chen, and Gehrig 2013), teaching aids (Dewi et al. 2018), design/build/test in a laboratory (Puleo 2020; Slocum et al. 2018; Li et al. 2018; Beyenal et al. 2009; Kunberger and Bondehagen 2008; Phelps et al. 2008; Mays et al. 2005; Davalos, Moran, and Kodkani 2003), or academic contests (Picton et al. 2019). Also, students can learn by real-world applications: study effects of major natural events (Torlapati et al. 2019), role-play learning (Guerra and Shealy 2018; Maksimova et al. 2017; L. Godoy 2010), experiential learning (Antaya et al. 2013; Miranda et al. 2020), real-world case studies (Wagener and Zappe 2008; Boggs et al. 2004; Kolar et al. 2000; Gross and Dinehart 2015). Exposing the student to these situations would develop their skills: self-learning, collaboration, teamwork, problem-solving, organization, among others. Active learning cannot separate from technology and curriculum; it should use together to enhance learning outcomes.

Students like to use modern technology (Sohrabi and Iraj 2016), and they have internet access on most university campuses and homes (Bergmann and Sams 2014). Some examples of its use are mobile or Moodle system learning (Jiang, Maxwell, and Merchant 2018; Neto, Williams, and Carvalho 2009), interactive video conferencing (Burian et al. 2013), Just-in-Time teaching (Das 2009; Tannous 2005; Kolar et al. 2000), quizzes-based learning (Estes, Welch, and Ressler 2004; Michalaka and Davis 2015; Donohue 2014), virtual laboratory (Budhu 2002; Masala, Biggar, and Geissler 2000; Craddock and Chevalier 2000), virtual simulation environment (García-Macías et al. 2019; L. Godoy 2009; L. A. Godoy 2005; L. Godoy 2010). Not only does the use of technology turn the classroom into active learning, but it must also be part of a curriculum that facilitates learning. The appropriate curriculum allows the student to understand that the subjects are not self-sufficient but are part of more complex training. For example, flexible periods in sequential courses (Gross and Dinehart 2015) is an idea where the subjects are academically connected. Another example es CDIO learning (Conceive, Design, Implement and Operate) (Guan, Millard, and Yang 2008). This CDIO is based on the principle of embedding active learning into engineering education at all levels. Despite the large number of studies that have been carried out in civil engineering, little research has focused on road engineering.

In road engineering, active learning was used in transportation courses (Chen, Chen, and Gehrig 2013; Hossain 2020; Hurwitz et al. 2014; Huang and Levinson 2012; Zhu, Xie, and Levinson 2011), pavement design (Y. García-Ramírez 2019b), road design course (Y. García-Ramírez 2021) and road and geotechnical engineering (Garrido de la Torre et al. 2020). Those courses used team-based learning or problem/project-based learning. In this field, very little has been investigated in geometric road design projects. The geometric design is the most significant element when designing a road. The designer should consider other areas such as topography, geology, traffic, drainage, waterworks, soil movement, environmental impact, pavement design, road safety, among others. Considering its wide knowledge area, students must develop diverse competencies that a single active learning technique may not be enough.

More than one active technique (e.g., flipped classroom, gamification, and problem-based learning) could improve academic results and tackle complex subjects like geometric road design projects. This combination would meet all the learning styles that students have (Y. García-Ramírez 2019a). Some previous research employed these combinations (Purasinghe and Patel 2019; Abushammala 2019a; Yehia and Gunn 2018; Michalaka and Davis 2015; P. Oliveira and Oliveira 2014; Kjolsing and Van Den Einde n.d.; Bielefeldt 2013; Barroso 2010), but not in road geometric design. In this context, the objective of this study was to show the implementation of multiple different active learning techniques in online road geometric design courses. Three undergraduate geometric road design courses were analyzed. All courses belonged to Civil Engineering career at the Universidad Técnica Particular de Loja in Ecuador.

MATERIALS AND METHODS

Participants Selection

The participants in this study were those who enrolled in three undergraduate courses as shown in Table 1. The students were from the civil engineering career in Road Construction I and II of the

Table 1. Detail of the participants in the study.

Group	Course	Number of students	Academic period
A	Road construction I	67 (M:57, W:10)	April-August 2020
B	Road construction II	50 (M: 41, W:9)	October 2020-February 2021
C	Road construction I	98 (M: 69, W:29)	April-August 2021

M: men, W: women
Source: prepared by the author.

Universidad Técnica Particular de Loja in Ecuador. In all courses, students were taught how to design roads geometrically in regular 4-month long. The gender distribution from Table 1 is typical in civil engineering but also other engineering careers. The typical age range of these groups is between 20 to 21 years for regular students, which is after 2 to 3 years of starting their career. All subjects were face-to-face learning, but due to CoViD-19 restrictions, they had to take them remotely using the Zoom platform® and the Virtual Learning Environment (VLE) of the university.

Course General Aspects

Below are the general aspects of the courses:

- The main content of the courses was very similar between them. Students had to learn geometric design skills for rural two-lane roads.
- All writing tasks were checked using the OURIGINAL ® anti-plagiarism system.
- Regarding the tests, they were done online in the VLE. Students could use any physical or digital documents, files, or software (what happens in real life). They didn't need to have their cameras turned on.
- Groups had active learning techniques separated in time. There were no simultaneous tasks during the week, so it had to finish one to start another.
- All academic activities in one week were related to a single topic of geometric road design.
- Courses A, B, and C were in different semesters, so the results from one helped as feedback for the following course. That is, course B has improvements compared to group A, and course C has improvements compared to group B.
- Every week, students, before the synchronous online class, watched a video of a prerecorded lecture shared on YouTube® platform.
- The final grade was calculated like this: weekly practices (10%), weekly oral presentations or infographics (5%), virtual exams (20%), project report (25%), final project presentation (10%), images, questions, or reading controls (10%), and problem-solving sessions (20%). In all cases, an academic rubric was used.

Active Learning Techniques in this Study

Every course had a combination of some the following learning models: the flipped classroom, learning based on comic images/questions, peer-assisted learning, problem-based learning, project-based learning, oral presentation/infographics-based learning, as can be inferred from academic activities in Figure 1. All the activities from Figure 1 had a specific time range during the week; so,

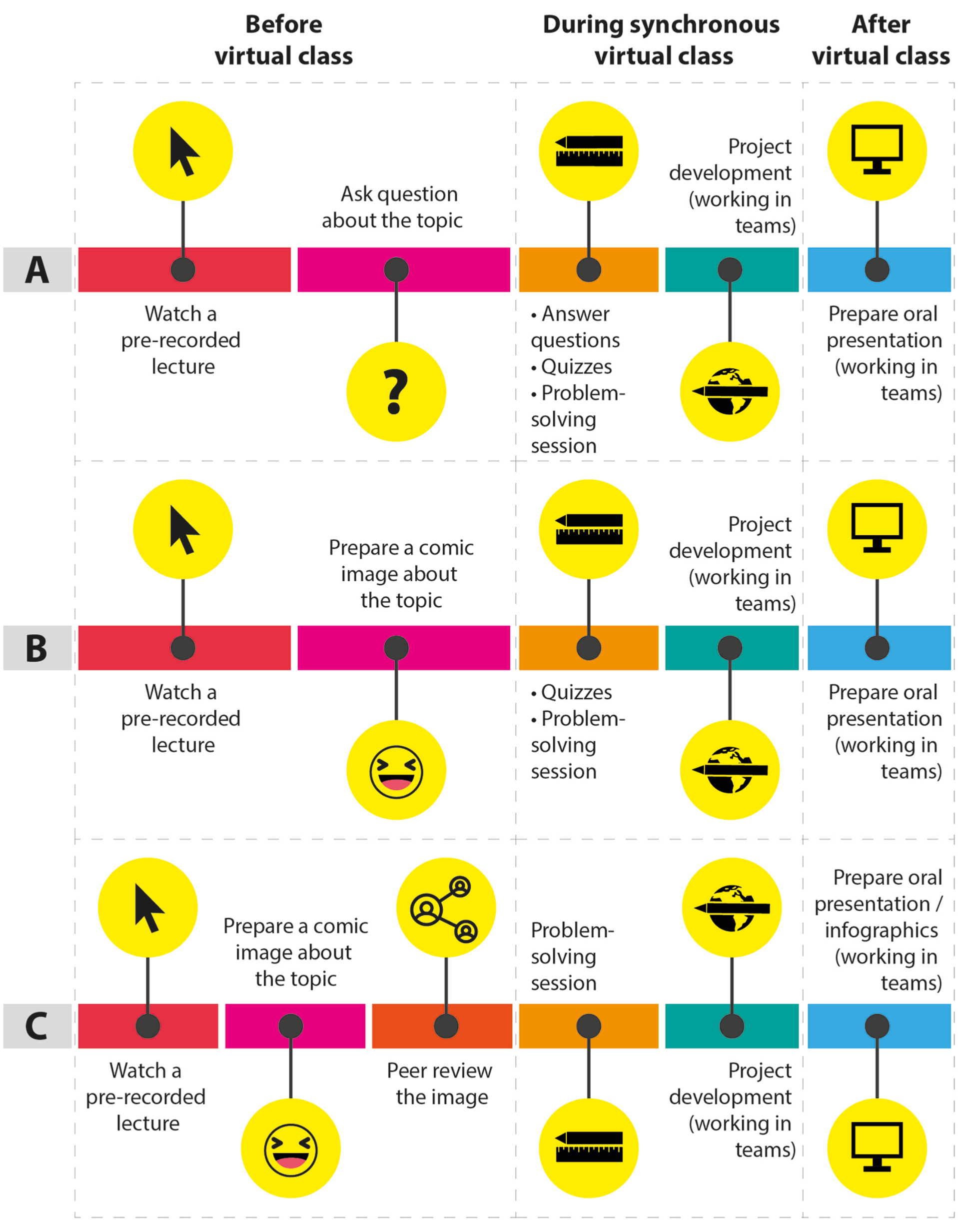

Figure 1. Course academic activities organization.

Table 2. Grades of every academic activity in the groups' study.

Virtual class	Activities	Groups A	Groups B	Groups C
Before	**Ask questions**	a) relationship with the topic (40%), b) integration with other topics (40%), and, c) duplicate questions (20%).	–	–
	Comic image	–	a) knowledge (40%), b) creativity (40%), and, c) quality image (20%).	–
	Peer review	–	–	a) knowledge (40%), b) creativity (40%), and, c) quality image (20%).
During	**Problem solving**	This activity was mainly graded on the basis of the student solving all or part of the problem.		
	Project development	a) in-depth study (40%), b) content-time (30%), c) presentation of the assignment (20%), and d) references (10%).		
After	**Oral presentations**	a) understanding of the topic (30%), b) structure presentation (30%), c) academic material (20%), d) video length (10%), and, e) members in the video (10%).		–
	Infographics	–	a) understanding of the topic (30%), b) structure presentation (30%), c) academic material (20%), d) video length (10%), and, e) members in the video (10%).	a) understanding of the topic (30%), b) use of keywords (30%), c) use of images and choice of format (20%), d) spelling, punctuation, grammar, and writing (10%), and, e) infographic design and creativity (10%).

– Not available

Source: prepared by the author.

two or more activities could not be carried out simultaneously. The grades of every academic activity in the groups' study from Figure 1 are shown in Table 2.

The flipped classroom allows the student to review the topic in advance. In such a way that virtual classes are used in more complex learning tasks. All students had to have internet access at home. They could watch the videos in their own time and replay them as many times as they wanted. This activity was not graded.

The students during the prerecorded lecture could not ask questions, so they could do it before starting the virtual class. The instructor, in group A, started the class by answering the questions or general topics that were asked in the questions. After that, the instructor answered each of the questions on the VLE. So, the rest of the students can see and learn from that answers. The questions were made in a forum, where the students could see the questions of their classmates. They could answer those questions too.

After watching the prerecorded lecture, students from groups B and C made a comic image about the topic. The template image was given by the instructor. The students had to find a funny way to put the academic topic in that template. The idea of this activity was that students transfer the knowledge acquired to another context, but in a funny way. By doing that, they could show that they really understand the topic. And also enjoy and laugh while they learn. Although the use of comic images is not new, for example (Reddy et al. 2020), in civil engineering matters it has been little used. Peer review was an exclusive activity of group C. This task consisted of reviewing the images of two of their classmates before starting the virtual sessions. This activity lasted one day and was carried out before the virtual class.

After comic images/questions, the instructor gave the guidelines for the problem-solving session in the first synchronous online class of 3-hour sessions. The problem was closely related to the prerecorded lecture, image, or question. The instructor explained the problem to solve and the references that would help to solve it. Students were divided into teams using an option on the Zoom platform®. At any time, students could call the instructor to answer questions about the problem. Students were organized in a team by using the Belbin survey results score. This organization was performed based on the previous investigation in the same area of knowledge (Y. García-Ramírez 2021).

The next day, the students had a second synchronous online class of a 2-hour session, where they applied the knowledge acquired so far to a real-world road project. First, the instructor detailed the aspects of the topic to be covered during this virtual practice. Then, students were organized into teams to fulfill the asked elements of the project. In these sessions and thanks to technology, students could interact as a team. The development of the project was carried out by the mandatory requirements to elaborate a highway design to a state entity. During the project, a book was used as a guide (Yasmany García-Ramírez and Russo 2020). Students could request help at any time during the session.

After the virtual class of the project, the students had to elaborate on an oral presentation or an infographic. In both cases, they should show the progress made in the project in the virtual session. It should be noted that in all these tasks, the same topic was being addressed. In the oral presentation, they had to be recorded in a video of no more than 10 minutes. They had to use any digital didactic material for that virtual presentation. Also, all the members had to appear in the video. The video was uploaded and shared via YouTube®. In the infographic, teams synthesize the progress made in the project through images and keywords. It was also was a team activity.

Data Collection and Processing

Data collection came from a survey conducted at the end of the course. It had closed-ended and open-ended questions. The survey, shared through VLE, was anonymous and optional. Those who decided to participate were notified of the academic objective of this instrument. The participants who answered the survey were: 53 (A), 50 (B), and 97 (C). Almost all students participated in each group, so the results were more representative. The description of the survey question for all groups is shown in Table 3. On the surveys, the average value and the confidence interval were also calculated. In the open-ended questions, if at least two people had a similar answer, they grouped. When only one person answered some characteristic, they grouped in the category others.

Table 3. ***Description of the survey questions in groups' study.***

Criteria	All groups (A, B and C)
Course overall value	From 1 to 10, where 1 is the lowest and 10 is the maximum, what is the overall value you would assign to the course?
Self-learning value	From 1 to 10, where 1 is the lowest value and 10 the highest value, how much of the self-learning you did in this course?
General comments	What were your general observations regarding the course: teamwork, project development, class assignments, and exams?

Source: prepared by the author.

RESULTS

Survey Answer

Figure 2 shows the answers to the surveys in every group. In general, a high percentage of interviewees agree with the various activities carried out in the courses. Detailed information on the responses of each group is shown below.

Group A

In group A, 54% considered that they agree with the assignments carried out in synchronous virtual classes. Most of these (72%) did not give information on why it is proper, while 10% said that the appropriate responses from the teacher helped them, and the rest gave varied responses. Of the students who had complaints regarding these academic activities, the main complaint was that the teacher should solve a guided exercise in class and not only places it in the video (73%). Also, some asked that there be no prerecorded classes (10%), and the rest mentioned that class time or assignments submissions should be increased. Besides, 58% agreed with the development of the project. Of these, 26% mentioned the benefits of learning based on a realworld project and

Group	Pre-recorded lectures	Comic images	Peer review images	Virtual class (3 h)	Virtual practice (2 h)	Presentation / infography
A	Not evaluated	Not evaluated	Not evaluated	👍 54% **72%** agree **10%** answers to their questions **18%** others	👍 58% **52%** agree **26%** real and teamwork **12%** learned **10%** others	Not evaluated
A	Not evaluated	Not evaluated	Not evaluated	👎 46% **73%** resolve an example **10%** no video **17%** more time	👎 42% **32%** guide **18%** no teamwork **18%** search **32%** others	Not evaluated
B	👍 90% **50%** teaching **40%** flexible **10%** theory and problems	👍 72% **41%** agree **21%** fun **17%** new way **15%** creativity **6%** innovative	Not evaluated	👍 84% **64%** agree **31%** comple-ment **5%** consistent	👍 92% **51%** agree **39%** real project benefits	👍 78% **64%** agree **15%** oral skill **15%** comple-ment **6%** teamwork
B	👎 10% Volumen up No questions allowed Shorter videos	👎 28% **43%** unfair **21%** their image **21%** hard **15%** desagree	Not evaluated	👎 16% **63%** too much time **37%** more time to complete	👎 8% Too much time Use more software	👎 12% **45%** too much time **36%** desagree **15%** shorter time
C	👍 88% **65%** agree **19%** watch several times **16%** others	👍 91% **66%** agree **11%** creativity **9%** funny **8%** watch **6%** others	👍 77% **84%** agree **8%** outlook **5%** comple-ment **3%** laugh	👍 100% **66%** agree **18%** comple-ment **5%** required **11%** others	👍 94% **71%** agree **18%** real project benefits **11%** others	👍 77% **82%** agree **8%** oral skill **4%** project related **6%** teamwork
C	👎 12% **52%** volumen up **35%** more examples **13%** others	👎 9% Hard Put their comic images	👎 23% **66%** unfair **16%** rubric **9%** grade the instructor **9%** others	👎 0% Nothing to report	👎 6% **40%** choose the teamwork **30%** + time **30%** just teamwork	👎 23% **25%** no teamwork **20%** hard **30%** +time **25%** others

Figure 2. Students' answers result in this study.

the exceptional help they had from their colleagues in the teamwork. Also, 12% said that the project reinforced their self-learning. 10% stated the benefits of gradually advancing in the project according to the topics of the virtual synchronous classes. Likewise, 52% just agreed with the project, so they did not suggest any good characteristics. Those who mentioned some negative aspect about the development of the project (42%), 32% mentioned that more guidance and explanation from the teacher is required, 18% said that not all team members work equitably, and 18% highlighted that they had problems searching for information, especially in the traffic study chapter. The rest (32%)

talked about needing more time to adjust to teamwork, troubleshooting connection problems, or disagree with the anti-plagiarism system.

The principal element in this group was that after watching the prerecorded lecture, students should ask a question about it. Despite the positive intention of this instrument, some aspects should be considered: a) the instructor spent a lot of time answering each question, b) the students did not review the answers of their classmates, c) a lot of questions were repeated, d) some questions were already answered in the prerecorded lecture, and e) some questions were answered with yes/no, so they were very superficial. Considering those aspects, it decided to eliminate this question in the following course and change it to a comic image. This choice freed up virtual class time to focus on the problem-solving session.

Group B

In group B, the students answered for the five learning moments: the videos before the class, the comic image, the 3-hour virtual class, the 2-hour virtual practice, and a weekly presentation. When it comes to the videos, 90% of the respondents agreed with the videos. Of them, 50% considered them didactic, 40% highlighted that they saw the videos at their pace, many times as they desired, and 10% said that it was appropriate to place theory and a guided exercise in the video. The students who disagreed with the videos mentioned that some of them had a low sound. Make shorter videos, they cannot ask the teacher, and it would be best if the guided example is doing during the virtual class. Besides, 72% agreed with the weekly comic images. Of these, 21% highlighted the idea of adapting the technical contents more entertainingly, 17% consider it a fun way to learn, and is part of the current trend. Also, 15% said that it favors creativity and relates theory to the real world, 6% mentioned it as an innovative learning method. And 41% have no observations regarding the images but agree with them. Of those who disagree, 43% suggested improving the rubric to reduce subjectivity, 21% responded that they would like to propose their base images. Also, 21% mentioned that they are hard to create since it must have a relationship between the video and the image, and 15% said that they are unnecessary or it is not a good way to measure knowledge. Furthermore, 84% of those surveyed agree with the activities carried out in the 3-hour synchronous class. Of these students, 64% had no observations, 31% mentioned that the assignments helped to construct their knowledge and allowed them to ask questions to the instructor. And 5% consider that the activities in class are timely and promote teamwork. Of the 16% who complaints about team activities, 63% said they spent a lot of time on tasks, and 37% asked for more time to deliver the assignments. Regarding the virtual practice where they worked on a highway project, 92% agreed with this activity, so around half of those students did not have suggestions for improvement (51%). The rest (39%) highlighted the benefits of the relationship with a real-world project. It integrated the topic of the virtual class, and there was a time to ask questions to the teacher. The rest noticed some other benefits, for example, the gradual progress of the project and the improvements in skills research and teamwork. Those who stated adverse elements regarding the project (8%) mentioned that they spent a lot of time on it and should use more software. Regarding the weekly presentations, 78% of the respondents agreed with this activity. Of these, 64% had no observations, 15% mentioned that presentations helped to improve communication and planning skills, 15% considered that they reinforced what was learned in previous activities, and 6% said that it helped to improve teamwork. Of the 22% who had some observation regarding the weekly presentations, the majority (45%) considered that they used a lot of time in the organization and execution of the task, 36% said they are unnecessary since they can fall into redundancy, and the rest considered that the presentation time should be reduced to less than 10 minutes.

One characteristic of this group was the elaboration of a comic image. The instructor graded it, but some students did not agree with this evaluation. Another element of this group were the reading controls. This instrument was employed to verify that students reviewed the prerecorded lecture. In some cases, students were connecting late or experienced problems with their internet connection, resulting in poor grades. Therefore, it decided to include a peer review to avoid these inconveniences (grading and internet connection). On the other hand, due to the complaints of the weekly oral presentations, a new presentation option was included, which is the infographics. All these updates were available for the next group.

Group C

In group C, 88% agreed with the videos uploaded before the virtual class. Of these, 65% had no observations, 19% said they watched the videos several times and whenever they could. Also, 13% mentioned that the videos allowed them to get into the topic before the synchronous virtual class. And 3% said videos were clear and explanatory. On the other hand, 35% did not agree with the prerecorded lectures, 52% declared that some of the videos have a low sound, 35% mentioned that videos should increase the number of solved exercises. Also, 9% mentioned that they do not like to study in this way. And 4% said that students could not ask the instructor. On the other hand, 91% agreed with the elaboration of images before the synchronous virtual class. Of these, 66% did not have any observations, 11% considered it an attractive way to learn and encouraged creativity. Also, 9% responded it is excellent to turn the course content into a funny way and think in other contexts. Also, 8 % said it is a creative way to “force” students to watch the video before virtual class, and 6% mentioned another answer. The 9% who disagree stated that this task was hard to make because they should cover the whole subject in one image. Regarding the peer review of the image, 77% agreed with this activity. Of these students, 84% had no observations, while 8% said it was a remarkable way to see classmate perspectives. Also, 5% said it complements the content of the video, and 3% said it was a satisfactory way to learn by laughing. On the other hand, 33% who disagree with the peer review mentioned that the lack of experience in grading could have led to receiving unfair grades (66%), that the rubric should improve to reduce subjectivity (16%), images should review by the teacher (9%) and other reasons (9%). Surprisingly, 100% of the respondents agreed with the activities in the synchronous virtual classroom. Of these responses, 66% had no observation of this activity. Besides, 18% mentioned that virtual classes help to understand the video explanations. Also, 5% said that were necessary to explain the topic, 3% mentioned that it allowed to answer doubts, and 8% gave other answers. Also, 94% agreed with the activities of the road project. Of them, 71% had no observations, 18% mentioned the benefits of developing a real-world project and progress it weekly. Also, 7% noticed that the project helped to understand the topic in-depth, and 4% mentioned that it improved teamwork. Of those who disagreed (6%), 40% said it would have been better to have chosen their team members, 30% asked to increase delivery time, and the other 30% said to only deliver the assignment individually, not in teamwork. Additionally, 76% with the weekly presentations and 77% agreed with the weekly infographics. In weekly presentations (in the first half of the semester), 82% had no observations, 8% mentioned that it allows them to develop communication skills, 4% said it was directly related to the project. Another 4% said it also favors teamwork, and 2% gave mixed responses. Of those who had a complaint regarding weekly presentations (24%), 25% stated that there is no teamwork and that not all members work equally. Also, 20% declared that it was difficult to organize due to the virtual model. Besides, 15% mentioned that the delivery time should be increased, and 15% that the presentation time also should be increased (> 10 minutes) since it is not enough to cover all the content. Another 15% wished they had chosen their team. And 10% are not comfortable speaking in public. On the other hand, about weekly infographics (in the second half of the semester), 73% did not have any observations, 13% said that it is a creative way of putting the contents, 9% considered that they improved their synthesis skills and the rest (5%) that favors teamwork. Of the 23% who disagreed, 30% said that there was no teamwork and that 10% would like to choose their team members, 15% suggested an extension in delivery dates, 15% mentioned the difficulty of synthesizing, 15% that the evaluation rubric should improve, and another 15% gave various answers.

In this group, there is a remarkable acceptance of the students to the several active learning techniques. There are some elements to improve; however, they are solvable elements such as volume up the sound of the videos. The factors with less acceptance are peer review and oral presentation/infographic. This trend is because students are not used to grade their classmates' assignments. However, these academic activities are necessary for students to develop skills for the labor world.

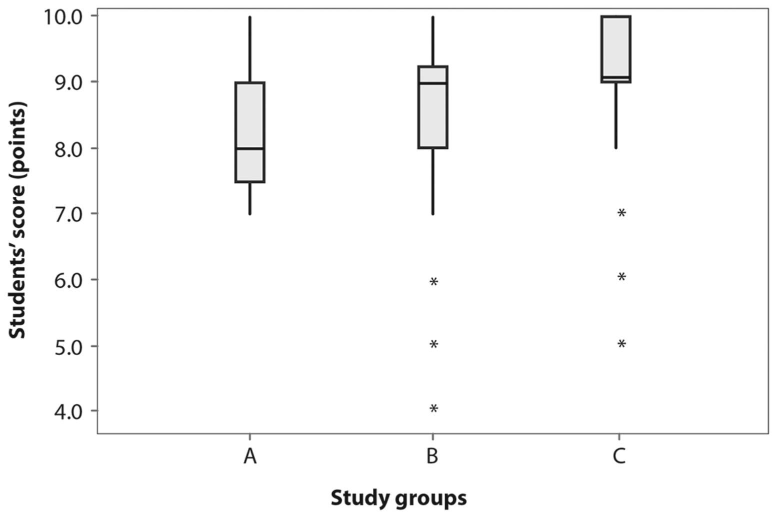

Figure 3. Boxplot of the students' scores of the course for the study groups.

Final Course Rates

Students were also asked to score (from 1 to 10) the whole online course (see Figure 3). It included all the academic activities during the semester. It can infer with high values from Figure 3, that multiple different active learning activities enhance the student's learning experience.

Instructor Comments

Although a deep level of knowledge is difficult to achieve, active techniques increase the probability of achieving it; since students are more involved with their own learning. And the use of several different active techniques would further increase that probability. In addition, this combination allows for covering the diverse learning styles that the students have. With this method, a student will at least learn with a single technique, for example, the problem-solving session, but if they also like the videos, then there is a greater probability that the weekly topic will be learned in-depth. If the student enjoys more than two activities, then the probability of learning increases. Therefore, these techniques must be carefully selected, considering the skills (hard and soft) that the student must develop throughout their career.

On the other hand, even though active techniques were chosen based on the comments of the previous group, it is worth mentioning that their preferences may vary from one group of students to another. That is, one group might like the project development more than the problem-solving. However, the active techniques used in this study are consistent with what happens in the local and national reality. Today's students spend a lot of time on the Internet, especially on content that does not require much attention, such as reading a scientific article. So, videos are a good way for them to consume information. Another way is through comic images. Peer review, oral presentations, and infographics, despite not being to everyone's liking, it is necessary to do those activities, due to the development of critical thinking, oral expression, organization of time, teamwork, etc. Problem-solving is one of the basic aspects of engineering, and the application to a project is to place them in a more realistic environment.

The challenge for instructors is to use one of these active techniques, not only for their complexity but also for the time-consuming. Consequently, including several active techniques in a subject that has been "traditional" is much more challenging, and maybe the results and learning experience can be a negative experience. As a suggestion, those techniques could adapt progressively based on the students' feedback and analyzing their results. For example, one technique could be used in one or two sessions to have more confidence to employ it. In this way, the academic model of the subject is constantly shaped based on local experience.

CONCLUSIONS

The objective of this study was to show the case study implementing multiple different active learning techniques in online road geometric design courses. This research analyzed the student's perception of the three participating groups, and the following conclusions are presented:

> In this scenario, surveys helped to analyze the student's perception of the active methods. In this case, all courses received high scores, which shows notable acceptance by the students. In addition, at each learning moment, there was a higher proportion of students who agreed. Those who disagreed mentioned aspects, which can be easily resolved. Each learning moment sought to develop one or more skills that will be required in the Civil Engineering practice. That is why the learning moments are not randomly selected, but they are the product of a meticulous analysis of the pros and cons of the technique, and its interaction with others.
>
> Despite the positive results, the study does not pretend to be a 'recipe' but shows significant benefits when using several learning moments. This combination is a challenge for the student, which motivates them to keep up with the learning. These moments must be chosen carefully, depending on the skills and abilities that are intended to develop. The study also states that learning should not be improvised and requires that the instructor is adequately prepared, to apply them or adjust them according to the group of students.

This study has limitations. First, the study focused on only one university and only one type of course. Second, the sample size of some groups was small. However, despite these limitations, the study explores the benefits of using multiple different learning techniques. It analyzed road design courses, of which there is very little research. In addition, the next course was an improvement on the previous one. The results of this study can be used to improve learning experience in more courses of civil engineering, engineering, or other similar areas.

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