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Building creative and active computer science lessons using the flipped classroom approach

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Abstract. This quantitative study aims to examine how the flipped classroom approach to teaching computer science, with an eye on data science and machine learning, affects student learning outcomes. Based on the findings of this research, it is recommended that students studying databases use YouTube videos as a pre-class resource, work together using MySQL software during class, and complete their own MySQL-based assignments outside of class. Machine learning (linear regression) findings show that extracurricular activities before, during, and after school help students learn and grow in their knowledge and ability to manage databases. Similarly, using a decision-tree based approach, data scientists have identified six prediction models for implementing the flipped classroom. Last but not least, the flipped classroom enhances the teaching-learning environment by having students engage in more imaginative and physical forms of instruction.

Keywords: STEM (Science, Technology, Engineering, Mathematics), HE (Higher Education), ML (Machine Learning), TL (Teaching and Learning).

Introduction

New pedagogical models for instruction and learning are being developed thanks to the widespread use of ICTs in the academic community (Salas-Rueda, 2015; Yelamarthi & Drake, 2015). The flipped classroom is one approach that encourages the use of technology and online resources to bring about learning both in and out of the classroom (Schneider & Blikstein, 2016; Shen, 2018).

The use of information and communication technologies (ICTs) in the classroom has allowed students to be more engaged in their own learning (Chiecher & Melgar, 2018; Kang & Es, 2019). The development of student-centered projects in the classroom has been facilitated by technological developments (Beisiegel, Mitchell, & Hill, 2018). In particular, the employment of digital technologies facilitates online communication, application, and distribution of data (Ramrez Mera & Barragán López, 2018).

The flipped classroom is a strategy used by today's educators to boost student achievement and maintain their interest and engagement throughout the course of instruction (Burke & Fedorek, 2017; Maciejew- ski, 2016). These benefits stem from the model's emphasis on student agency and active participation in the classroom, as well as its ability to be tailored to each individual's needs (Kim et al., 2014).

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To better use class time for the creation of creative and energetic activities, the flipped classroom recommends reviewing audiovisual materials before the face-to-face session (Mason, Rutar Shuman, & Cook, 2013; Shen, 2018).

Young people in the twenty-first century want their educators to use cutting-edge methods of teaching and learning to better equip them with the information and abilities they'll need to succeed in the modern world. As a result, this study proposes, with the hope of bettering teaching and learning, that students in the database subject watch YouTube videos before class, work together using the MySQL software during class, and complete their own individual projects using the MySQL software after class.

Taking into account data science and machine learning, this quantitative research examines the flipped classroom's impact on CS education. The utilization of online resources like YouTube videos and MySQL software in the classroom raises the following research questions: - How does the flipped classroom model affect database administration?

If the flipped classroom method is used to teach data management, what kinds of predictive models might we expect to see?

With the use of machine learning, we can determine the linear regression by using the training section (composed of 50%, 60%, and 70% of the sample) to assess the efficacy of the flipped classroom. Like the training portion, the assessment section (with 50%, 40%, and 30% of the sample) reveals the linear regression's precision.

Contrarily, data science enables the establishment of prediction circumstances between the flipped classroom and the educational process (knowledge absorption and skill development in database administration) by means of the decision tree method..

1. Flipped classroom

Hevia-Artime, Fueyo-Gutiérrez, & Salas-Rueda, Jess Vázquez Estupián, & Lugo-Garca (2018), as well as Salas-Rueda, Jess Vázquez Estupián & Lugo-Garca (2016), all point to the ways in which modern technology is altering the educational landscape. In particular, ICTs enable the development of pedagogical spaces that improve students' engagement with course materials (Eschenbrenner & Fui-Hoon Nah, 2019; Yelamarthi & Drake, 2015).

Students in a flipped classroom are encouraged to utilize digital texts and videos in advance of class to help them prepare for the material (Burke & Fedorek, 2017; Kim & Ahn, 2018). As a matter of fact, students may access the video and audio materials for their classes whenever and wherever they choose thanks to the convenience offered by modern technology, allowing for truly individualized instruction (Mason et al., 2013).

The flipped classroom is an innovative pedagogical concept that gives educators the freedom to develop engaging, student-centered, and collaborative projects that improve the quality of instruction and learning in the classroom (Cohen et al., 2016; Maciejewski, 2016). For instance, classroom discussions and student presentations are common ways that students engage with course material (Dommett, 2018).

Many researchers and educators have adopted the flipped classroom model (e.g.,

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Mason et al., 2013; Maciejewski, 2016; Salinas Martnez et al., 2015; Shen, 2018).

With the goal of enhancing the teaching-learning process about Internet research, Jing Shen (2018) suggests revising digital presentations in the home and re- alizing discussions in the face-to-face session. Similar to how Cohen et al. (2016) utilized the flipped classroom to help students learn how to use digital resources, this study also employed a flipped approach to teaching and learning. Even Dommett (2018) used online books and videos in class to help pupils learn and grow.

To prepare students for in-class discussion and group work in mathematics, Salinas Martnez et al. (2015) suggest using videos and MOOCs. Similarly, Madrid Garca et al. (2018) used the flipped classroom in the area of mathematics via the use of online videos and supplementary texts.

The flipped classroom model has been shown to increase student engagement and boost academic achievement in engineering courses (Mason et al., 2013). Learning about electronics is further enhanced through pre-class digital readings and class collaboration (Kim et al., 2014).

Maciejewski (2016) suggests using video lectures and completing online tests to help students learn and improve their mathematical knowledge and abilities. Students are more engaged in the learning process of digital circuits, as noted by Yelamarthi and Drake (2015), who argue that the flipped classroom model is the way to go.

Bonilla-del-Ro, Diego-Mantecón, & Lena-Acebo (2018) and Law Schuetz, Biancaro-sa, & Goode (2018) both find that media and technology have a large impact on how people learn and grow in their skills. The flipped classroom is one such pedagogical and technology strategy that encourages student participation in the teaching and learning process (Cohen et al., 2016; Kim & Ahn, 2018).

2. Method

This study provides a quantitative evaluation of the flipped classroom's effect on CS education with data science and ML in mind. Thirty-one students (25 male and 6 female) from a Bachelor of Computer Science program at a Mexican institution who took the database course in 2015 make up the sample. Because of the executive format of this program, students are able to balance their academic and professional responsibilities. As a group, the participants had an average age of 26.64.

2.1. Procedure

Methodology kick-started with the planning of 5 hands-on exercises in database management, utilizing the flipped classroom as a guiding principle (see Table 1). MySQL is a database management system that facilitates access, modification, storage, and deletion of data.

Table 1. Laboratory practices (source: created by author)

No.	Topic	Before class	During class	After class
1	Creation of the table	Check *YouTube* videos about the creation of the table in the database	Use *MySQL* software with your partner to create tables about products and customers	Use *MySQL* software individually to create tables about suppliers and branch offices
2	Storage of information	Check *YouTube* videos about the storage of information in the database	Use *MySQL* software with your partner to store the information of the tables (products and customers)	Use *MySQL* software individually to store the information in the tables (suppliers and branch offices)
3	Query of information	Check *YouTube* videos about the query of information in the database	Use *MySQL* software with your partner to consult the information of the tables (products and customers)	Use *MySQL* software individually to consult the information of the tables (suppliers and branch offices)

4	Update of information	Check *YouTube* videos about the update of information in the database	Use *MySQL* software with your partner to update the information in the tables (products and customers)	Use *MySQL* software individually to update the information in the tables (suppliers and branch offices)
5	Elimination of information	Check *YouTube* videos about the elimination of information in the database	Use *MySQL* software with your partner to remove the information from the tables (products and customers)	Use *MySQL* software individually to remove the information from the tables (suppliers and branch offices)

The following are some assumptions about the relationship between viewing YouTube videos in advance of a class and skill acquisition: - Hypothesis 1 (H1): Viewing instructional videos on YouTube prior to a database management class has been shown to improve students' retention of course material;

- Hypothesis 2 (H2): Viewing relevant YouTube videos prior to a class session has a constructive effect on learning database administration abilities.

The following are some of the theories about the usage of MySQL software for group projects (during class time) and skill acquisition:

It is hypothesized that students will learn more and gain more experience with database administration if they use MySQL software for group projects in class; similarly, it is hypothesized that students will learn more and gain more experience with database administration if they use MySQL software for group projects in class (H4).

The following are some of the assumptions made concerning students' independent work with MySQL software (during class time) and skill development:

- Hypothesis 5 (H5): Using MySQL software for independent study (outside of class) positively affects the learning of database management;

- Hypothesis 6 (H6): Using MySQL software for independent study (outside of class) positively promotes the growth of expertise in database management.

Predictive models on the use of the flipped classroom in computing education are as follows: - Predictive model 1 (PM1) on the consultation of YouTube videos (before the class) and assimilation of knowledge; - Predictive model 2 (PM2) on the consultation of YouTube videos (before the class) and development of skills; - Predictive model 3 (PM3) on the use of the MySQL software for collaborative work (during the class) and assimilation of knowledge.

2.2. Analysis of data

The *RapidMiner* tool allows the calculation of machine learning (linear regression) with 50% (n = 15), 60% (n = 18) and 70% (n = 21) of training to evaluate the research hypothesis. In addition, the *RapidMiner* tool allows the construction of predictive models on the use of the flipped classroom by means of the decision tree technique.

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2.3. Data collection

Table 2 shows the measurement instrument (questionnaire) used to collect the information.

Table 2. Questionnaire (source: created by author)

No.	Variable	Dimension	Question	Answer	n	%
1	Student profile	Sex	1. Indicate your sex	Man	25	80.65%
				Woman	6	19.35%
		Age	2. Indicate your age	20 years	0	0.00%
				21 years	0	0.00%
				22 years	3	9.68%
				23 years	3	9.68%
				24 years	3	9.68%
				25 years	5	16.13%
				26 years	2	6.45%
				27 years	2	6.45%
				28 years	4	12.90%
				29 years	3	9.68%
				> 29 years	6	19.35%

End of Table 2

No.	Variable	Dimension	Question	Answer	n	%
2	Flipped classroom	Before the class	3. The consultation of *YouTube* videos facilitates the educational process	Too much (1)	15	48.39%
				Much (2)	14	45.16%
				Little (3)	2	6.45%
		During the class	4. The use of *MySQL* software for collaborative work facilitates the educational process	Too much (1)	19	61.29%
				Much (2)	10	32.26%
				Little (3)	2	6.45%
		After the class	5. The use of *MySQL* software for individual work facilitates the educational process	Too much (1)	18	58.06%
				Much (2)	9	29.03%
				Little (3)	4	12.90%
3	Educational process	Assimilation of knowledge	6. The flipped classroom facilitates the assimilation of knowledge about the administration of the database	Too much (1)	20	64.52%
				Much (2)	8	25.81%
				Little (3)	3	9.68%
		Develop-ment of skills	7. The flipped classroom facilitates the development of skills about the administration of the database	Too much (1)	20	64.52%
				Much (2)	9	29.03%
				Little (3)	2	6.45%

3. Results

Considering data science and machine learning, the following are the findings from an investigation of the effects of the flipped classroom on computer science education.

Some students (n = 20; 64.52 percent), some (n = 8; 25.81 percent), and a few (n = 3; 9.68 percent) find that the flipped classroom model is an effective means of learning database administration. Furthermore, the development of database administration abilities is facilitated too much (n = 20, 64.52%), much (n = 9, 29.03%), and little (n = 2, 6.45%) using the flipped classroom.

3.1. Before the class

Too much (n = 15, 48.39%), considerably (n = 14, 45.16%), and little (n = 2, 6.45%) of the student body agree that consulting YouTube videos helps in the educational process (see Table 2). Machine learning (linear regression) experiments using 50% (0.583), 60% (0.640), and 70% (0.621) training data points to H1 being approved. Watching relevant videos on YouTube before class helps students retain more information about database management. Similarly, H2 may be approved based on the machine learning outcomes at 50% (0.749), 60% (0.710), and 70% (0.619) of training. Therefore, watching movies on YouTube (before class) helps students learn more about database management (see Table

Table 3. Use of *YouTube* videos before the class (source: created by author)

Hypothesis	Training	Linear regression	Conclusion	Square error
Hypothesis 1: Videos *YouTube* → assimilation of knowledge	50%	y = 0.583x + 0.437	Accepted: 0.583	0.353
	60%	y = 0.640x + 0.390	Accepted: 0.640	0.396
	70%	y = 0.621x + 0.402	Accepted: 0.621	0.476
Hypothesis 2: Videos *YouTube* → development of skills	50%	y = 0.749x + 0.312	Accepted: 0.749	0.300
	60%	y = 0.710x + 0.335	Accepted: 0.710	0.301
	70%	y = 0.619x + 0.417	Accepted: 0.619	0.286

Seven conditions are presented on the PM1 for the flipped classroom, and its accuracy is 80.65 percent (see Figure 1). If a student is older than 24.5 and thinks that watching tutorial videos on YouTube makes learning too easy, then they may find that the flipped classroom model doesn't provide them enough of a challenge when it comes to absorbing information about database management. However, if a student is above the age of 31.5 and finds that watching instructional videos on YouTube greatly simplifies the learning process, then the flipped classroom may be too easy for him or her to absorb the material necessary to manage a database.

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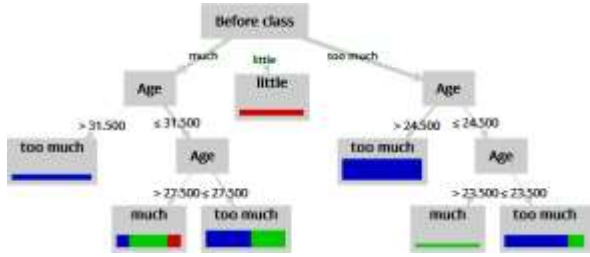

The PM1 flipped classroom circumstances are shown in Table 4. If a student is under the age of 23.5 and thinks that watching videos on YouTube makes the learning process too easy, then the flipped classroom isn't the best way for them to learn about database management.

Figure 1. Predictive model 1 on the flipped classroom (source: created by author)

Table 4. Conditions of the predictive model 1 (source: created by author)

No.	Videos *YouTube* → educational process	Sex	Age	Flipped classroom → assimilation of knowledge
1	Much	–	> 31.5 years	Too much
2	Much	–	≤ 31.5 & > 27.5 years	Much
3	Much	–	≤ 27.5 years	Too much
4	Little	–	–	Little
5	Too much	–	> 24.5 years	Too much
6	Too much	–	≤ 24.5 & > 23.5 years	Much
7	Too much	–	≤ 23.5 years	Too much

At least eighty-six percent of the time, the PM2 on the flipped classroom shows seven circumstances (see Figure 2). If a student is above the age of 26.5 and thinks that watching videos on YouTube is too helpful in their studies, then the flipped classroom is probably not the best environment in which to learn how to manage a database.

However, if a student is under the age of 23 and believes that watching videos on YouTube is an effective way to learn, then the flipped classroom may be too easy for them to use in terms of learning how to manage a database.

As can be seen in Table 5, the PM2 circumstances in the flipped classroom. If a student is under the age of 25.5 and thinks that watching videos on YouTube makes the learning process too easy, then the flipped classroom isn't the best way for them to learn database management.

3.2.1 While in lecture

Too much (n = 19, 61.29 %), considerable (n = 10, 32.26 %), and little (n = 2, 6.4 %) of the student body report that using MySQL software for collaborative work improves their academic experience (see Table 2). Machine learning results at 50% (0.632), 60% (0.532), and 70% (0.576) of training all point to H3 being accepted. This means that engaging in group projects (during class) using MySQL as a database management system aids in the retention of information. Machine learning experiments using 50% (0.517), 60% (0.475), and 70% (0.435) of available training data all support accepting H4. Consequently, the collaborative work done in class using MySQL software has a favorable effect on the students' skill development (see Table 6).

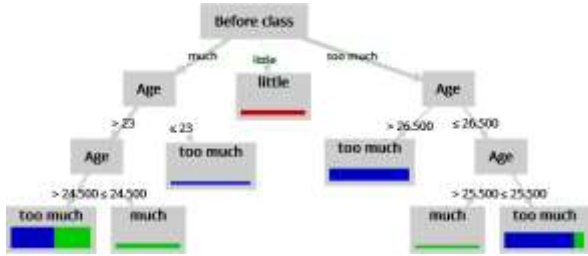

Figure 2. Predictive model 2 on the flipped classroom (source: created by author)

Table 5. Conditions of the predictive model 2 (source: created by author)

No.	Videos *YouTube* → educational process	Sex	Age	Flipped classroom → development of skills
1	Much	–	> 24.5 years	Too much
2	Much	–	≤ 24.5 & > 23 years	Much
3	Much	–	≤ 23 years	Too much
4	Little	–	–	Little
5	Too much	–	> 26.5 years	Too much
6	Too much	–	≤ 26.5 & > 25.5 years	Much
7	Too much	–	≤ 25.5 years	Too much

Table 6.Use of *MySQL* software during the class (source: created by author)

Hypothesis	Training	Linear regression	Conclusion	Square error
Hypothesis 3: *MySQL* software → assimilation of knowledge	50%	y = 0.632x + 0.482	Accepted: 0.632	0.364
	60%	y = 0.532x + 0.639	Accepted: 0.532	0.355
	70%	y = 0.576x + 0.478	Accepted: 0.576	0.446
Hypothesis 4: *MySQL* software → development of skills	50%	y = 0.517x + 0.758	Accepted: 0.517	0.342
	60%	y = 0.475x + 0.770	Accepted: 0.475	0.349
	70%	y = 0.435x + 0.769	Accepted: 0.435	0.396

70% y = 0.435x + 0.769 0.435% of people found this acceptable.

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Flipped classroom PM3 gives 9 conditions with an 80% confidence level (see Figure 3). If a student is older than 28.5 and thinks that the usage of MySQL software for group projects simplifies the learning process too much, then the flipped classroom is probably not the best environment in which to absorb information about database management. However, if a student is male, above the age of 28.5, and believes that using MySQL software for group projects improves their education, then the flipped classroom may be too helpful in his pursuit of database management skills.

The PM3 conditions for the flipped classroom are shown in Table 7. If a student is under the age of 27 and thinks that using MySQL software for group projects makes learning too easy, then the flipped classroom is probably not the best way for them to learn about database management.

The PM4 used in the reversed classroom displays 9 conditions with an accuracy of 87.10%. (see Figure 4). If a student is above the age of 32.5 and thinks that using MySQL software for group projects makes the learning process too easy, then the flipped classroom is a great way to help them learn more about database administration. If, on the other hand, a female student believes that the usage of MySQL software for collaborative work really improves the educational process, then she will benefit much from the flipped classroom in terms of learning database administration.

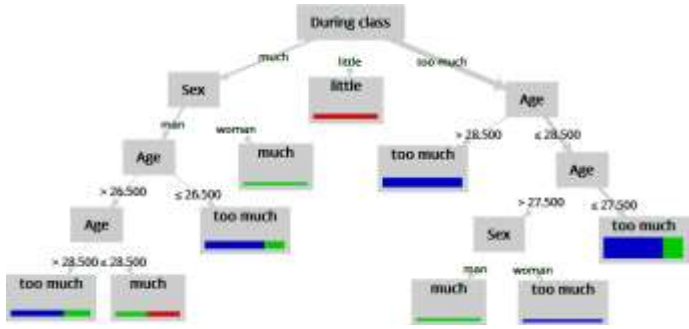

Figure 3. Predictive model 3 on the flipped classroom (source: created by author)

Table 8 shows the conditions of the PM4 on the flipped classroom. For example, if the student considers that the use of *MySQL* software for collaborative work facilitates too much the educational process and has an age ≤ 28.5 years then the flipped classroom facilitates too much the development of skills about the administration of the database.

Table 7. Conditions of the predictive model 3 (source: created by author)

No.	*MySQL* software → educational process	Sex	Age	Flipped classroom → assimilation of knowledge
1	Much	Man	> 28.5 years	Too much
2	Much	Man	≤ 28.5 & > 26.5 years	Much
3	Much	Man	≤ 26.5 years	Too much
4	Much	Woman	–	Much
5	Little	–	–	Little
6	Too much	–	> 28.5 years	Too much
7	Too much	Man	≤ 28.5 & > 27.5 years	Much
8	Too much	Woman	≤ 28.5 & > 27.5 years	Too much

9	Too much	–	≤ 27.5 years	Too much

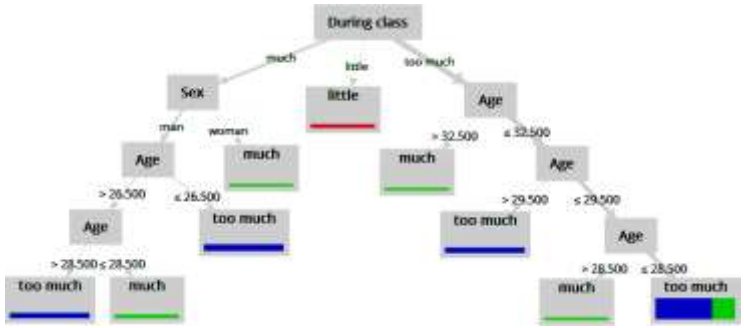

Figure 4. Predictive model 4 on the flipped classroom (source: created by author)

Table 8. Conditions of the predictive model 4 (source: created by author)

No.	*MySQL* software → educational process	Sex	Age	Flipped classroom → development of skills
1	Much	Man	> 28.5 years	Too much
2	Much	Man	≤ 28.5 & > 26.5 years	Much
3	Much	Man	≤ 26.5 years	Too much
4	Much	Woman	–	Much
5	Little	–	–	Little
6	Too much	–	> 32.5 years	Much
7	Too much	–	≤ 32.5 & > 29.5 years	Too much
8	Too much	–	≤ 29.5 & > 28.5 years	Much
9	Too much		≤ 28.5 years	Too much

4. Discussion

Students' actions during class time are changing because of the flipped classroom model (Kim & Ahn, 2018; Maciejewski, 2016). In the case of databases, this quantitative study specifically proposes that students check YouTube videos before class, work together using MySQL software during class, and then work on their own using MySQL software after class.

Most students (n = 20, or 64.52%) agree that the flipped classroom makes it easier to learn and apply skills related to database management.

Before the first class: 4.1.

In the flipped classroom, students and teachers work together to create new and exciting ways to learn using digital technologies (Kim & Ahn, 2018; Yelamarthi & Drake, 2015). In the classroom, for instance, students benefit from taking an active part when they watch films before class (Burke & Fedorek, 2017).

Nearly half of the students (n = 15; 48.39%) agree that watching instructional videos on YouTube is helpful, maybe even essential, to their studies. Additionally, the linear regression result for H1 is better than 0.580, suggesting that watching videos on YouTube (before to class) aids in the retention of information about database management. Seven conditions are presented by PM1 in the flipped classroom, and an accuracy of 80.65 percent is achieved.

Furthermore, the linear regression result for H2 is larger than 0.610, suggesting that watching videos on YouTube (before class) has a good effect on learning how to manage a database. Flipped classroom PM2 provides 7 conditions with an

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accuracy of 80.65 percent.

4.2.1 While in Lecture

This study concurs with previous ones in emphasizing the value of the flipped classroom for skill acquisition (see, for example, Maciejewski (2016) and Mason et al. (2013)).

Sixty-two percent of students (n = 19) agree that using MySQL software for collaborative work makes learning too easy. The linear regression for H3 is larger than 0.530, meaning students' usage of MySQL for group projects in class has a beneficial effect on their learning of database management. With a tally of 9 circumstances, the PM3 on the flipped classroom achieves an accuracy of 80.65 percent.

Furthermore, the linear regression result for H4 is larger than 0.430, suggesting that using MySQL software for group projects (during class) significantly promotes the growth of expertise in database management. In a flipped classroom setting, PM4 provides 9 conditions with an accuracy of 87.10 percent.

4.3 After class, today's educators employ the flipped classroom to aid students in retaining information and acquiring new abilities (Maciejewski, 2016; Schneider & Blikstein, 2016).

MySQL software for independent study is seen as too helpful by the majority of students (n = 18, 58.06%). Furthermore, the linear regression result for H5 is larger than 0.270, suggesting that using MySQL software for independent study (outside of class) aids in the acquisition of database administration skills. Six conditions are presented by the PM5 in the flipped classroom, with an accuracy of 70.97 percent. Furthermore, the linear regression result for H6 is larger than 0.640, suggesting that working with MySQL software outside of class has a good effect on students' learning of database management. There are 8 different scenarios presented by the PM6 in the flipped classroom, and it has an accuracy of 77.42%.

Many writers' perspectives on the importance of information and communication technologies (ICTs) in catering to students' demands and requirements are reflected in this study. Finally, the flipped classroom is a pedagogical concept that uses technology to switch up the traditional roles of instructor and student (Kim et al., 2014; Yelamarthi & Drake, 2015).

Conclusions

In the 21st century, the flipped classroom is transforming the organization of courses and realization of activities inside and outside the classroom. Before the class, the students con- sulted *YouTube* videos in order to facilitate the assimilation of knowledge and development of skills about the creation of the table and the storage, query, update and elimination of information in the database. In addition, *MySQL* software allows building new educational experiences collaboratively during the class and individually after the class.

This research recommends the use of the flipped classroom in the educational field be- cause teachers can organize creative activities that facilitate the learning process. The limita-tions of this study are the use of *YouTube* videos and *MySQL* software during the educational process of computing. Therefore, future research may analyze the use of social networks, online assessments, digital presentations and Web applications during the realization of ac- tivities inside and outside the classroom.

The implications of this research are the use of the flipped classroom in various educa- tional areas such as administration, medicine, marketing and law in order to develop the skills of the students and facilitate the assimilation of knowledge.

Finally, technological advances are changing the functions, activities and roles of teachersand students during the educational process. For example, the flipped classroom facilitates the construction of creative and active educational experiences.

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