



USE OF THE FLIPPED CLASSROOM TO DESIGN CREATIVE AND ACTIVE ACTIVITIES IN THE FIELD OF COMPUTER SCIENCE

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Abstract. The objective of this quantitative research is to analyze the impact of the flipped classroom in the educational process on computer science considering data science and machine learning. This study proposes the consultation of *YouTube* videos (before class), collaborative work through *MySQL* software (during class) and individual work through *MySQL* software (after class) in the database subject. The results of machine learning (linear regression) indicate that school activities before, during and after the class positively influence the assimilation of knowledge and development of skills on the administration of the database. Likewise, data science identifies 6 predictive models on the use of the flipped classroom in the educational process by means of the decision tree technique. Finally, the flipped classroom improves the teaching-learning conditions through the performance of creative and active activities.

Keywords: data science, educational process, flipped classroom, higher education, machine learning, teaching-learning.

Introduction

The use of information and communications technologies (ICTs) in the field of education is causing the creation of new pedagogical models for teaching and learning (Salas-Rueda, 2015; Yelamarthi & Drake, 2015). For example, the flipped classroom promotes the realization of school activities inside and outside the classroom through technological tools and digital resources (Schneider & Blikstein, 2016; Shen, 2018).

Educational innovation includes the transformation of students into active agents through the use of ICTs (Chiecher & Melgar, 2018; Kang & Es, 2019). Advances in technology facilitate the creation of school activities focused on students (Beisiegel, Mitchell, & Hill, 2018). In particular, digital tools allow the communication, use and dissemination of information on the Internet (Ramírez Mera & Barragán López, 2018).

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Nowadays, teachers use the flipped classroom to increase academic performance and motivate students during the teaching-learning process (Burke & Fedorek, 2017; Maciejewski, 2016). The advantages of this pedagogical model are related to the realization of creative and active activities in the classroom and the personalization of learning (Kim et al., 2014).

The flipped classroom proposes the revision of audiovisual contents before the face-to-face session with the purpose of using the time of the class in the development of creative and active activities (Mason, Rutar Shuman, & Cook, 2013; Shen, 2018).

In the 21st century, students demand new pedagogical and technological strategies that facilitate the assimilation of knowledge and development of skills. Thus, this research proposes the consultation of *YouTube* videos (before class), collaborative work through *MySQL* software (during class) and individual work through *MySQL* software (after class) in the database subject with the purpose of improving the teaching-learning conditions.

This quantitative study analyzes the use of the flipped classroom in the educational process on computer science considering data science and machine learning. Therefore, the research questions are:

- What is the impact of the flipped classroom in the educational process on the administration of the database considering the use of *YouTube* videos and *MySQL* software?
- What are the predictive models on the use of the flipped classroom in the educational process on the administration of the database?

Machine learning allows identifying the linear regression through the training section (50%, 60% and 70% of the sample) to evaluate the impact of the flipped classroom in the educational process. Likewise, the evaluation section (50%, 40% and 30% of the sample) allows knowing the accuracy of the linear regression.

On the other hand, data science allows establishing the predictive conditions between the flipped classroom and educational process (assimilation of knowledge and development of skills on the administration of the database) by means of the decision tree technique.

1. Flipped classroom

Nowadays, technology is modifying the form of access, use and processing of information in the educational field (Hevia-Artime & Fueyo-Gutiérrez, 2018; Salas-Rueda, Jesús Vázquez Estupiñán, & Lugo-García, 2016). In particular, ICTs allow the construction of educational spaces that facilitate the interaction between the contents of the courses and students (Eschenbrenner & Fui-Hoon Nah, 2019; Yelamarthi & Drake, 2015).

The flipped classroom promotes the use of various multimedia resources (*e.g.*, videos and digital readings) before class to facilitate the assimilation of knowledge (Burke & Fedorek, 2017; Kim & Ahn, 2018). In fact, the technology allows personalized learning because students consult the audiovisual content of the courses at any time and place (Mason et al., 2013).

Teachers can modify the teaching-learning conditions through the flipped classroom because this pedagogical model allows the creation of dynamic, creative and active activities (Cohen et al., 2016; Maciejewski, 2016). For example, students make presentations and discuss the topics of the courses in the classroom (Dommert, 2018).

Several authors (e.g., Mason et al., 2013; Maciejewski, 2016; Salinas Martínez et al., 2015; Shen, 2018) have incorporated the flipped classroom in school activities and educational practices.

Jing Shen (2018) proposes the revision of the digital presentations in the house and realization of debates in the face-to-face session with the purpose of improving the teaching-learning process on the search of information in Internet. In the same way, Cohen et al. (2016) used the flipped classroom to facilitate the assimilation of knowledge about the use of digital resources. Even, Dommett (2018) incorporated digital readings and videos into school activities for developing students' skills.

In the field of mathematics, Salinas Martínez et al. (2015) propose the use of videos and massive open online course (MOOC) before the face-to-face session and collaborative work in the classroom. In the same way, Madrid García et al. (2018) incorporated the flipped classroom in the field of mathematics through the consultation of audiovisual materials and digital readings.

The results of the flipped classroom in the engineering courses are the improvement of the academic performance of the students and realization of the active activities in the classroom (Mason et al., 2013). In the same way, the use of digital readings before the face-to-face session and the collaborative work in the classroom improved the educational process on electronics (Kim et al., 2014).

Maciejewski (2016) proposes the consultation of videos and realization of online assessments to facilitate the assimilation of knowledge and development of skills in mathematics. Even, Yelamarthi and Drake (2015) point out that the flipped classroom increases the motivation of students during the educational process related to digital circuits.

The media and technological devices have a significant influence on the development of competences (Bonilla-del-Río, Diego-Mantecón, Lena-Acebo, 2018; Law Schuetz, Biancarosa, & Goode, 2018). In particular, the flipped classroom is a pedagogical and technological model that favors the active role of the student during the teaching-learning process (Cohen et al., 2016; Kim & Ahn, 2018).

2. Method

This quantitative research analyzes the impact of the flipped classroom in the educational process on computer science considering data science and machine learning. The sample consists of 31 students from the Bachelor of Computer Science (25 men and 6 women) who took the database subject in a Mexican university during the 2015 school year. This degree is taught in the executive mode, therefore, the students study and work. The average age of the participants is 26.64 years.

2.1. Procedure

The procedure began with the organization of 5 laboratory practices on the administration of the database considering the flipped classroom (see Table 1). *MySQL* software allows consulting, updating, storing and deleting the information in the database.

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

No.	Topic	Before class	During class	After class
1	Creation of the table	Check <i>YouTube</i> videos about the creation of the table in the database	Use <i>MySQL</i> software with your partner to create tables about products and customers	Use <i>MySQL</i> software individually to create tables about suppliers and branch offices
2	Storage of information	Check <i>YouTube</i> videos about the storage of information in the database	Use <i>MySQL</i> software with your partner to store the information of the tables (products and customers)	Use <i>MySQL</i> software individually to store the information in the tables (suppliers and branch offices)
3	Query of information	Check <i>YouTube</i> videos about the query of information in the database	Use <i>MySQL</i> software with your partner to consult the information of the tables (products and customers)	Use <i>MySQL</i> software individually to consult the information of the tables (suppliers and branch offices)
4	Update of information	Check <i>YouTube</i> videos about the update of information in the database	Use <i>MySQL</i> software with your partner to update the information in the tables (products and customers)	Use <i>MySQL</i> software individually to update the information in the tables (suppliers and branch offices)
5	Elimination of information	Check <i>YouTube</i> videos about the elimination of information in the database	Use <i>MySQL</i> software with your partner to remove the information from the tables (products and customers)	Use <i>MySQL</i> software individually to remove the information from the tables (suppliers and branch offices)

The hypotheses about the consultation of the *YouTube* videos (before the class) and development of competences are:

- Hypothesis 1 (H1): The consultation of *YouTube* videos (before the class) positively influences the assimilation of knowledge about the administration of the database;
- Hypothesis 2 (H2): The consultation of *YouTube* videos (before the class) positively influences the development of skills about the administration of the database.

The hypotheses about the use of *MySQL* software for collaborative work (during the class) and development of competences are:

- Hypothesis 3 (H3): The use of *MySQL* software for collaborative work (during the class) positively influences the assimilation of knowledge about the administration of the database;
- Hypothesis 4 (H4): The use of *MySQL* software for collaborative work (during the class) positively influences the development of skills about the administration of the database.

The hypotheses about the use of *MySQL* software for individual work (after class) and development of competences are:

- Hypothesis 5 (H5): The use of *MySQL* software for individual work (after class) positively influences the assimilation of knowledge about the administration of the database;

- Hypothesis 6 (H6): The use of *MySQL* software for individual work (after class) positively influences the development of skills about the administration of the database.

On the other hand, the predictive models on the use of the flipped classroom in the educational process of computing are:

- 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 *MySQL* software for collaborative work (during class) and knowledge assimilation;
- Predictive model 4 (PM4) on the use of *MySQL* software for collaborative work (during the class) and development of skills;
- Predictive model 5 (PM5) on the use of *MySQL* software for individual work (after class) and knowledge assimilation;
- Predictive model 6 (PM6) on the use of *MySQL* software for individual work (after class) and development of skills.

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.

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 <i>YouTube</i> 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 <i>MySQL</i> 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 <i>MySQL</i> 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%
		Development 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

Below are the results on the impact of the flipped classroom in the educational process on computer science considering data science and machine learning.

The flipped classroom facilitates too much (n = 20, 64.52%), much (n = 8, 25.81%) and little (n = 3, 9.68%) the assimilation of knowledge about the administration of the database. Also, the flipped classroom facilitates too much (n = 20, 64.52%), much (n = 9, 29.03%) and little (n = 2, 6.45%) the development of skills about the administration of the database.

3.1. Before the class

The consultation of *YouTube* videos facilitates too much (n = 15, 48.39%), much (n = 14, 45.16%) and little (n = 2, 6.45%) the educational process (see Table 2). The results of machine learning (linear regression) with 50% (0.583), 60% (0.640) and 70% (0.621) of training indicate that H1 is accepted. Therefore, the consultation of *YouTube* videos (before the class) positively influences the assimilation of knowledge about the administration of the database. Likewise, the results of machine learning with 50% (0.749), 60% (0.710) and 70% (0.619) of training indicate that H2 is accepted. Therefore, the consultation of *YouTube* videos (before the class) positively influences the development of skills about the administration of the database (see Table 3).

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

Hypothesis	Training	Linear regression	Conclusion	Square error
Hypothesis 1: Videos <i>YouTube</i> → 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 <i>YouTube</i> → 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

The PM1 on the flipped classroom presents 7 conditions with the accuracy of 80.65% (see Figure 1). For example, if the student considers that the consultation of *YouTube* videos facilitates too much the educational process and has an age > 24.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database. On the other hand, if the student considers that the consultation of *YouTube* videos facilitates much the educational process and has an age > 31.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

Table 4 shows the conditions of the PM1 on the flipped classroom. For example, if the student considers that the consultation of *YouTube* videos facilitates too much the educational process and has an age ≤ 23.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

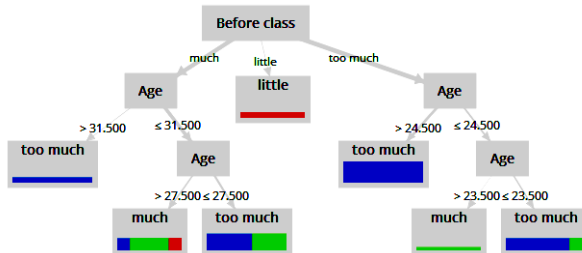


Figure 1. Predictive model 1 on the flipped classroom (source: created by author)

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

No.	Videos <i>YouTube</i> → 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

The PM2 on the flipped classroom presents 7 conditions with the accuracy of 80.65% (see Figure 2). For example, if the student considers that the consultation of *YouTube* videos facilitates too much the educational process and has an age > 26.5 years then the flipped classroom facilitates too much the development of skills about the administration of the database.

On the other hand, if the student considers that the consultation of *YouTube* videos facilitates much the educational process and has an age ≤ 23 years then the flipped classroom facilitates too much the development of skills about the administration of the database.

Table 5 shows the conditions of the PM2 on the flipped classroom. For example, if the student considers that the consultation of *YouTube* videos facilitates too much the educational process and has an age ≤ 25.5 years then the flipped classroom facilitates too much the development of skills about the administration of the database.

3.2. During the class

The use of *MySQL* software for collaborative work facilitates too much (n = 19, 61.29%), much (n = 10, 32.26%) and little (n = 2, 6.45%) the educational process (see Table 2). The results of machine learning with 50% (0.632), 60% (0.532) and 70% (0.576) of training indicate that H3 is accepted. Therefore, the use of *MySQL* software for collaborative work (during the class) positively influences the assimilation of knowledge about the administration of the database. Also, the results of machine learning with 50% (0.517), 60% (0.475) and 70% (0.435) of training indicate that H4 is accepted. Therefore, the use of *MySQL* software for collaborative work (during the class) positively influences the development of skills (see Table 6).

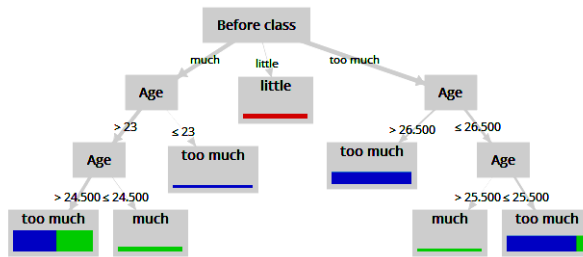


Figure 2. Predictive model 2 on the flipped classroom (source: created by author)

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

No.	Videos <i>YouTube</i> → 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

The PM3 on the flipped classroom presents 9 conditions with the accuracy of 80.65% (see Figure 3). 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 assimilation of knowledge about the administration of the database. On the other hand, if the student considers that the use of MySQL software for collaborative work facilitates much the educational process, is a man and has an age > 28.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

Table 7 shows the conditions of the PM3 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 ≤ 27.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

The PM4 on the flipped classroom presents 9 conditions with the accuracy of 87.10% (see Figure 4). 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 > 32.5 years then the flipped classroom facilitates much the development of skills about the administration of the database. On the other hand, if the student considers that the use of MySQL software for collaborative work facilitates much the educational process and is a woman then the flipped classroom facilitates much the development of skills about the administration of the database.

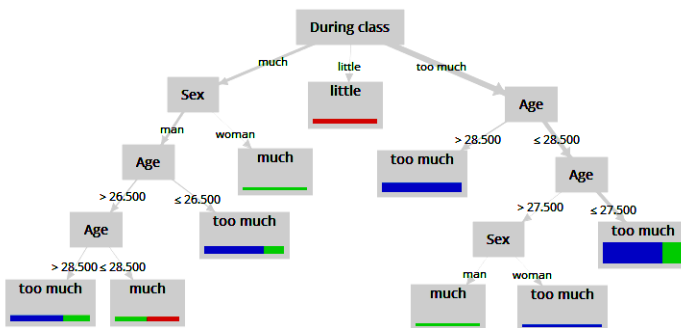


Figure 3. Predictive model 3 on the flipped classroom (source: created by author)

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

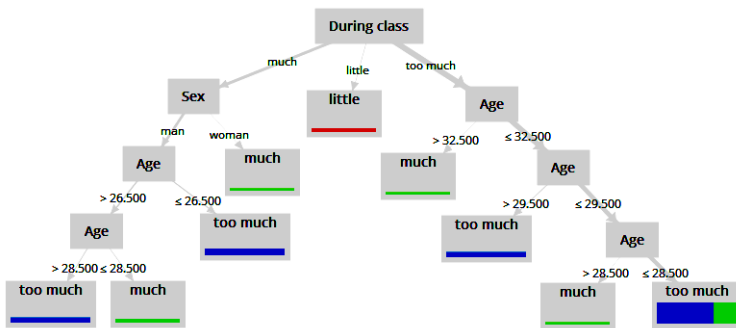


Figure 4. Predictive model 4 on the flipped classroom (source: created by author)

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

3.3. After the class

The use of MySQL software for individual work facilitates too much (n = 18, 58.06%), much (n = 9, 29.03%) and little (n = 4, 12.90%) the educational process (see Table 2). The results of machine learning with 50% (0.271), 60% (0.289) and 70% (0.399) of training indicate that H5 is accepted. Therefore, the use of MySQL software for individual work (after class) positively influences the assimilation of knowledge about the administration of the database. Likewise, the results of machine learning with 50% (0.857), 60% (0.645) and 70% (0.661) of training indicate that H6 is accepted. Therefore, the use of MySQL software for individual work (after class) positively influences the development of skills about the administration of the database (see Table 9).

The PM5 on the flipped classroom presents 6 conditions with the accuracy of 70.97% (see Figure 5). For example, if the student considers that the use of MySQL software for individual work facilitates too much the educational process and has an age ≤ 26.5 years then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

On the other hand, if the student considers that the use of MySQL software for individual work facilitates little the educational process and is a woman then the flipped classroom facilitates little the assimilation of knowledge about the administration of the database.

Table 10 shows the conditions of the PM5 on the flipped classroom. For example, if the student considers that the use of MySQL software for individual work facilitates much the educational process then the flipped classroom facilitates too much the assimilation of knowledge about the administration of the database.

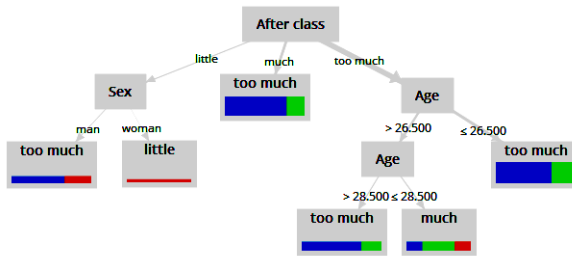


Figure 5. Predictive model 5 on the flipped classroom (source: created by author)

Table 9. Use of MySQL software after the class (source: created by author)

Hypothesis	Training	Linear regression	Conclusion	Square error
Hypothesis 5: MySQL software → assimilation of knowledge	50%	$y = 0.271x + 0.854$	Accepted: 0.271	0.653
	60%	$y = 0.289x + 0.105$	Accepted: 0.289	0.659
	70%	$y = 0.399x + 0.750$	Accepted: 0.399	0.562
Hypothesis 6: MySQL software → development of skills	50%	$y = 0.857x + 0.380$	Accepted: 0.857	0.662
	60%	$y = 0.645x + 0.451$	Accepted: 0.645	0.410
	70%	$y = 0.661x + 0.923$	Accepted: 0.661	0.417

The PM6 on the flipped classroom presents 8 conditions with the accuracy of 77.42% (see Figure 6). For example, if the student considers that the use of MySQL software for individual work facilitates too much the educational process and has an age > 29.5 years then the flipped classroom facilitates too much the development of skills about the administration of the database. On the other hand, if the student considers that the use of MySQL software for individual work facilitates little the educational process and is a woman then the flipped classroom facilitates little the development of skills about the administration of the database.

Table 11 shows the conditions of the PM6 on the flipped classroom. For example, if the student considers that the use of MySQL software for individual work facilitates too much the educational process and has an age ≤ 26.5 years then the flipped classroom facilitates too much the development of skills about the administration of the database.

Table 10. Conditions of the predictive model 5 (source: created by author)

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

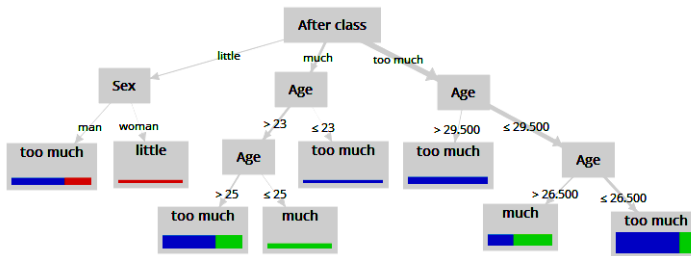


Figure 6. Predictive model 6 on the flipped classroom (source: created by author)

Table 11. Conditions of the predictive model 6 (source: created by author)

No.	MySQL software → educational process	Sex	Age	Flipped classroom → development of skills
1	Little	Man	-	Too much
2	Little	Woman	-	Little
3	Much	-	> 25 years	Too much
4	Much	-	≤ 25 years	Much
5	Much	-	≤ 23 years	Too much
6	Too much	-	> 29.5 years	Too much
7	Too much	-	≤ 29.5 & > 26.5 years	Much
8	Too much	-	≤ 26.5 years	Too much

4. Discussion

The flipped classroom is modifying the behavior of students during the teaching-learning process (Kim & Ahn, 2018; Maciejewski, 2016). In particular, this quantitative research proposes the consultation of *YouTube* videos (before class), collaborative work through *MySQL* software (during class) and individual work through *MySQL* software (after class) in the database subject.

Most of the students think that the flipped classroom facilitates too much the assimilation of knowledge ($n = 20$, 64.52%) and development of skills ($n = 20$, 64.52%) about the administration of the database.

4.1. Before the class

The flipped classroom allows innovating school activities through the incorporation of ICTs (Kim & Ahn, 2018; Yelamarthi & Drake, 2015). For example, the consultation of videos before the class favors the active role of the student during the educational process (Burke & Fedorek, 2017).

Most of the students ($n = 15$, 48.39%) think that the consultation of *YouTube* videos facilitates too much the educational process. Also, the result of the linear regression for H1 is greater than 0.580, therefore, the consultation of *YouTube* videos (before the class) positively influences the assimilation of knowledge about the administration of the database. The PM1 on the flipped classroom presents 7 conditions with the accuracy of 80.65%.

Also, the result of the linear regression for H2 is greater than 0.610, therefore, the consultation of *YouTube* videos (before the class) positively influences the development of skills about the administration of the database. The PM2 on the flipped classroom presents 7 conditions with the accuracy of 80.65%.

4.2. During the class

This research shares the ideas of various authors (e.g., Maciejewski, 2016; Mason et al., 2013) about the importance of the flipped classroom for the development of competences.

Most of the students ($n = 19$, 61.29%) think that the use of *MySQL* software for collaborative work facilitates too much the educational process. Also, the result of the linear regression for H3 is greater than 0.530, therefore, the use of *MySQL* software for collaborative work (during the class) positively influences the assimilation of knowledge about the administration of the database. The PM3 on the flipped classroom presents 9 conditions with the accuracy of 80.65%.

Also, the result of the linear regression for H4 is greater than 0.430, therefore, the use of *MySQL* software for collaborative work (during the class) positively influences the development of skills about the administration of the database. The PM4 on the flipped classroom presents 9 conditions with the accuracy of 87.10%.

4.3. After the class

Nowadays, teachers use the flipped classroom to facilitate the assimilation of knowledge and development of skills of students (Maciejewski, 2016; Schneider & Blikstein, 2016).

Most of the students ($n = 18$, 58.06%) think that the use of *MySQL* software for individual work facilitates too much the educational process. Also, the result of the linear regression for H5 is greater than 0.270, therefore, the use of *MySQL* software for individual work (after class) positively influences the assimilation of knowledge about the administration of the database. The PM5 on the flipped classroom presents 6 conditions with the accuracy of 70.97%.

Also, the result of the linear regression for H6 is greater than 0.640, therefore, the use of *MySQL* software for individual work (after class) positively influences the development of skills about the administration of the database. The PM6 on the flipped classroom presents 8 conditions with the accuracy of 77.42%.

This research shares the ideas of various authors (e.g., Etchegaray Centeno et al., 2018; Eschenbrenner & Fui-Hoon Nah, 2019) on the fundamental role of ICTs to meet the demands and needs of students. Finally, the flipped classroom is a pedagogical model that modifies the functions of teachers and the role of students during the educational process through technological tools (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 consulted *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 because teachers can organize creative activities that facilitate the learning process. The limitations 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 activities inside and outside the classroom.

The implications of this research are the use of the flipped classroom in various educational 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 teachers and students during the educational process. For example, the flipped classroom facilitates the construction of creative and active educational experiences.

Author contributions

The flipped classroom improves the teaching-learning conditions through the performance of creative and active activities. This study proposes the consultation of *YouTube* videos (before class), collaborative work through *MySQL* software (during class) and individual work through *MySQL* software (after class) in the database subject.

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ATVIRKŠTINIO MOKYMOSI PANAUDOJIMAS MODELIUOJANT KŪRYBINĘ IR AKTYVIAJĄ VEIKLĄ KOMPIUTERIŲ MOKSLO SRITYJE

Ricardo Adán SALAS RUEDA

Santrauka

Šio kiekybinio tyrimo tikslas – išanalizuoti atvirkštinio mokymosi poveikį kompiuterių mokslui ugdymo proceso metu, remiantis duomenų mokslu ir mašininu mokymusi. Šiame tyrime duomenų bazėje siūloma pasitelkti *YouTube* vaizdo įrašus (iki mokymosi proceso), bendradarbiavimu grindžiamą veiklą, naudojantis *MySQL* programine įranga (mokymosi proceso metu) ir individualią veiklą, taikant *MySQL* programinę įrangą (pasibaigus mokymosi procesui). Mašininio mokymosi rezultatai (linijinė regresija) rodo, kad mokyklinė veikla iki mokymosi proceso, jo metu ir jam pasibaigus daro teigiamą įtaką žinių įsisavinimui bei duomenų bazės administravimo įgūdžių tobulinimui. Panašiai ir duomenų mokslo atveju, remiantis sprendimų medžio metodu, ugdymo proceso metu pasitelkus atvirkštinį mokymąsi, nustatomi 6 prognostiniai modeliai. Galiausiai atvirkštinis mokymasis, taikant kūrybinę ir aktyviąją veiklą, pagerina mokymo–mokymosi sąlygas.

Reikšminiai žodžiai: duomenų mokslas, ugdymo procesas, atvirkštinis mokymasis, aukštasis išsilavinimas, mašininis mokymasis, mokymas–mokymasis.