USE OF FLIPPED CLASSROOM IN THE TEACHING-LEARNING PROCESS ON DESCRIPTIVE STATISTICS

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ABSTRACT

Educational institutions seek to transform the teaching-learning conditions through the use of new pedagogical and technological models. The aim of this quantitative research is to analyze the use of flipped classroom in the teaching-learning process on descriptive statistics through data science. The participants are 49 students who took the Basic Statistics course during the 2017 school year. This study used a single group quasi-experiment to examine the research hypotheses about Flipped classroom. In the Basic Statistics course, the students have difficulties to assimilate the knowledge about mean, mode, median, range and quartiles. Therefore, this research proposes the consultation of YouTube videos before the class, use of the Mathportal application collaboratively during the class and use of the Mathportal application individually after the class. The Mathportal application is a web tool that allows checking the results of the exercises on the mean, mode, median, range and quartiles at any time. The results of machine learning (linear regression) indicate that flipped classroom positively influences the teaching-learning process on descriptive statistics. On the other hand, data science allows the identification of 3 predictive models about the consultation of the YouTube videos and use of the Mathportal application through the decision tree technique. This research recommends the use of the Mathportal application for the teaching-learning process on statistics. Even, this web application can be used in the courses of differential calculus, geometry, algebra and financial mathematics. The implications of this research are the transformation of the educational context through the use of flipped classroom and incorporation of technological tools before, during and after the face-to-face classes. Finally, flipped classroom is a pedagogical model that is transforming the organization and implementation of school activities through the use of technology inside and outside the classroom.

Keywords: Flipped classroom, higher education, data science, machine learning.

INTRODUCTION

Today, technological advances are causing that educational institutions organize and implement new pedagogical models during the planning and implementation of school activities (Colomo-Magana et al., 2021; Li, 2018; Wenming & Erwen, 2018). In particular, the use of flipped classroom is growing at all educational levels (Adam et al., 2017; Awidi & Paynter, 2019; Yang, Sun & Liu, 2017).

Flipped classroom modifies the functions, behaviors and roles of students during the teaching-learning process and facilitates the organization of new school activities inside and outside the classroom (Cabero-Almenara et al., 2021; Goedhart et al., 2019; Jeong, Kim, & Kang, 2018). Before the class, students review digital resources such as audiovisual content, digital readings, presentations and online exams (Awidi & Paynter, 2019; Ozer, Kanbul, & Ozdamli, 2018). In the face-to-face sessions, students acquire a main role in the learning process through the realization of collaborative activities and discussion forums (Liu, 2019; Wittich et al., 2018).

Audiovisual content, educational platforms, web applications and technological tools are used during the implementation of flipped classroom in order to improve the teaching-learning conditions (Bonnes et al., 2017;

Chokshi et al., 2017; Ji & Han, 2019). In fact, this pedagogical model improved the academic performance of students in the courses of chemistry, humanities, medicine and health (Yang, Sun, & Liu, 2017).

Flipped classroom allows that teachers innovate the school activities through the incorporation of Information and Communication Technologies (ICTs) in the activities before, during and after the face-to-face sessions (Akcayir & Akcayir, 2018; Villalba, Castilla, & Redondo, 2018; Zhu & Xie, 2018).

In mathematics and statistics courses, teachers look for new pedagogical and technological models that improve the learning process because students have difficulties to assimilate the knowledge, understand the topics, and develop their skills. For this reason, this quantitative research proposes the use of flipped classroom in the teaching-learning process on descriptive statistics through the consultation of YouTube videos before the class, use of the Mathportal application collaboratively during the class and use of the Mathportal application individually after the class. The research questions are:

- What is the perception of the students about the consultation of the YouTube videos before the face-to-face sessions and use of the Mathportal application during and after the classes about descriptive statistics?
- What are the predictive models about the use of flipped classroom in the teaching-learning process about descriptive statistics?

FLIPPED CLASSROOM

Flipped classroom is a pedagogical model that uses technology to modify the organization and performance of school activities before, during and after the face-to-face sessions (Bonnes et al., 2017; Chokshi et al., 2017; Hughes, 2019). For example, students consult videos and digital readings at home and use technological tools inside and outside the classroom (Cabero-Almenara et al., 2021; Tokmak, Yakin, & Dogusoy, 2019; Tiejun, 2017).

The benefits of flipped classroom are the active role of students, construction of new educational spaces and realization of creative activities during the teaching-learning process through ICTs (He, Holton, & Farkas, 2018; Villalba, Castilla, & Redondo, 2018). In particular, this pedagogical model facilitates the interaction and communication between teachers and students through educational web platforms (Liu, 2019; Wenming & Erwen, 2018). Even, the use of flipped classroom in the educational field improves the academic performance, develops the skills and increases the motivation of students (Akcayir & Akcayir, 2018; Santikarn & Wichadee, 2018; Yu, 2019).

Various authors (e.g., Liu, 2019; Santikarn & Wichadee, 2018; Tiejun, 2017; Wenming & Erwen, 2018) used flipped classroom in order to improve the teaching-learning process and build new educational spaces. In fact, this pedagogical model facilitated the active participation of students in the courses of English Language (Santikarn & Wichadee, 2018; Wenming & Erwen, 2018), History of Modern Design (Tiejun, 2017) and House Architectural Design (Liu, 2019).

In the English Language course, Wenming and Erwen (2018) propose the use of audiovisual content and digital readings before the face-to-face sessions, incorporation of discussion forums in the classroom and realization of activities in the educational platform after the class. Similarly, Santikarn and Wichadee (2018) implemented flipped classroom in the English Language course to improve the academic performance of the students by consulting the videos before the class and holding the discussion forums in the classroom.

Technological advances such as Learning Management System (LMS) allow the performance of the school activities at any time (Annamalai et al., 2021; Bonnes et al., 2017; Tiejun, 2017). In the History of Modern Design course, the Edmodo web platform facilitated the participation of the students before, during and after the face-to-face sessions (Tiejun, 2017). Also, the results of flipped classroom are the increase of the academic performance and active role of students during the learning process (Tiejun, 2017).

Flipped classroom allows that teachers organize new student-centered activities (Adam et al., 2017; Chokshi et al., 2017; Liu, 2019). In the House Architectural Design course, the students acquired an active role by consulting the videos, taking the online questionnaires and using the technological tools inside and outside the classroom (Liu, 2019).

Finally, flipped classroom increases the interaction between the teacher and students, facilitates the understanding of the topics and encourages the critical thinking during the learning process (Adam et al., 2017; Bonnes et al., 2017; Shaykina & Minin, 2018). In fact, this pedagogical model allows improving the educational quality through the incorporation of ICTs in the school activities (Liu, 2019; Lo & Hwang, 2018).

METHOD

The particular aims of this quantitative research are (1) analyze the impact of the YouTube videos before the class about descriptive statistics (2) analyze the impact of the Mathportal application during the class about descriptive statistics (3) analyze the impact of the Mathportal application after the class about descriptive statistics and (4) identify the predictive models about the use of flipped classroom through the decision tree technique.

The Mathportal application is a web tool that allows checking the results of the exercises on the mean, mode, median, range and quartiles at any time. This web application is free and available at: https://www.mathportal.org/calculators/statistics-calculator/descriptive-statistics-calculator.php

Participants

The participants are 49 students (27 men and 22 women) that took the Basic Statistics course during the 2017 school year. The average age of these participants is 20.12 years old. This study used a single group quasi-experiment to examine the research hypotheses about Flipped classroom.

Procedure

The procedure began with the analysis of the educational context (See Table 1). In the Basic Statistics course, the students have difficulties to assimilate the knowledge about mean, mode, median, range and quartiles. Therefore, this research proposes the consultation of YouTube videos before the class, use of the Mathportal application collaboratively during the class and use of the Mathportal application individually after the class.

Table 1. Educational context.

No.	Stage	Aspect	Description
1	Analysis	Problem	The students of the Basic Statistics course have difficulties to assimilate the knowledge, understand the topics, and develop their skills
		Characteristics of students	The participants studied the careers of Administration, Commerce and Marketing during the 2017 school year
		Course	Basic Statistics (second semester)
2	Design	Learning objectives	Remember, explain, understand and use of the mean
			Remember, explain, understand and use of the mode
			Remember, explain, understand and use of the median
			Remember, explain, understand and use of the range
			Remember, explain, understand and use of the quartiles
		Incorporation of technology	The YouTube videos about descriptive statistics and Mathportal application
3	Development	Flipped classroom	Before the class, the students consulted the YouTube videos about descriptive statistics
			During the class, the students used the Mathportal application collaboratively
			After the class, the students used the Mathportal application individually
4	Implementation	Unit	Descriptive Statistical (3 face-to-face sessions)
		Duration	Each face-to-face session lasted 90 minutes

The use of flipped classroom in the Basic Statistics course transformed the functions of the students before, during and after the face-to-face sessions (See Table 2).

Table 2. Activities of flipped classroom.

No.	Objective	Before the class	During the class	After the class
1	Remember, explain, understand and use the topics about the media and mode	Individually, the student consulted the videos about the media and mode	Collaboratively, the students solved the exercises about the mean and mode. Later, the students used the Mathportal application to check the results	Individually, the student solved the exercises about the mean and mode. Subsequently, the student used the Mathportal application to check the results
2	Remember, explain, understand and use the topics about the median and range	Individually, the student consulted the videos about the median and range	Collaboratively, the students solved the exercises about the median and range. Later, the students used the Mathportal application to check the results	Individually, the student solved the exercises about the median and range. Subsequently, the student used the Mathportal application to check the results
3	Remember, explain, understand and use the topics about the quartiles	Individually, the student consulted the videos about the quartiles	Collaboratively, the students solved the exercises about the quartiles. Later, the students used the Mathportal application to check the results	Individually, the student solved the exercises about the quartiles. Subsequently, the student used the Mathportal application to check the results

Flipped classroom proposes the use of technology at home in order to acquire the knowledge (Bonnes et al., 2017; Chokshi et al., 2017; Wittich et al., 2018). Therefore, the hypothesis about the use of flipped classroom before the face-to-face sessions is:

- Hypothesis 1 (H1): The consultation of the YouTube videos before the class positively influences the teaching-learning process on descriptive statistics

Teachers use flipped classroom in the classroom to build new learning spaces (Liu, 2019; Lockman, Haines, & McPherson, 2017; Santikarn & Wichadee, 2018). Therefore, the hypothesis about the use of flipped classroom during the face-to-face sessions is:

- Hypothesis 2 (H2): The use of the Mathportal application collaboratively during the class positively influences the teaching-learning process on descriptive statistics

Flipped classroom allows transforming the functions of students outside the classroom (Adam et al., 2017; Bonnes et al., 2017; Lockman, Haines, & McPherson, 2017). Therefore, the hypothesis about the use of flipped classroom after the face-to-face sessions is:

- Hypothesis 3 (H3): The use of the Mathportal application individually after the class positively influences the teaching-learning process on descriptive statistics

Likewise, the predictive models about the use of flipped classroom in the field of statistics are:

- Predictive Model 1 (PM1) about the consultation of the YouTube videos before the class and teaching-learning process on descriptive statistics
- Predictive Model 2 (PM2) about the use of the Mathportal application collaboratively during the class and teaching-learning process on descriptive statistics
- Predictive Model 3 (PM3) about the use of the Mathportal application individually after the class and teaching-learning process on descriptive statistics

Data Analysis

Various authors (e.g., Salas-Rueda, 2021; Salas-Rueda et al., 2022) have used data science to understand the use of technological tools in the educational field. For example, the RapidMiner tool allowed calculating the linear regressions (machine learning) to evaluate the research hypotheses through the training section (70%, 80% and 90% of the sample). The evaluation section (30%, 20% and 10% of the sample) allowed identifying the accuracy of these linear regressions through error squared. Likewise, this tool allowed the construction of predictive models about the use of flipped classroom in the teaching-learning process by means of the decision tree technique.

Data Collection

Table 3 shows the questionnaire used in a Mexican university for the data collection during the 2017 school year. The variables of this research instrument are Profile of the students (3 questions: Career, Sex and Age) and Flipped classroom (4 questions: Before the class, During the class, After the class and Teaching-learning process).

Table 3. Questionnaire about flipped classroom.

No.	Variable	Dimension	Question	Answer	n	%
1	Profile of the students	Career	1. Indicate your career	Administration	20	40.82%
				Commerce	19	38.78%
				Marketing	10	20.41%
		Sex	2. Indicate your sex	Man	27	55.10%
				Woman	22	44.90%
		Age	3. Indicate your age	18 years	0	0.00%
				19 years	15	30.61%
				20 years	23	46.94%
				21 years	5	10.20%
				> 21 years	6	12.24%
2	Flipped classroom	Before the class	4. The consultation of the YouTube videos facilitates the active role of the student	Very much (1)	27	55.10%
				Much (2)	20	40.82%
				Little (3)	2	4.08%
				Very little (4)	0	0.00%
		During the class	5. The use of the Mathportal application collaboratively facilitates the active role of the student	Very much (1)	25	51.02%
				Much (2)	22	44.90%
				Little (3)	1	2.04%
				Very little (4)	1	2.04%
		After the class	6. The use of the Mathportal application individually facilitates the active role of the student	Very much (1)	31	63.27%
				Much (2)	13	26.53%
				Little (3)	5	10.20%
				Very little (4)	0	0.00%
		Teaching-learning process	7. Flipped classroom (activities before, during and after the class) facilitates the teaching-learning process on statistics	Very much (1)	30	61.22%
				Much (2)	13	26.53%
				Little (3)	6	12.24%
				Very little (4)	0	0.00%

The values of Load Factor (> 0.680), Cronbach's Alpha (> 0.750) and Composite Reliability (> 0.840) allow validating the questionnaire about the use of flipped classroom (See Table 4).

Table 4. Validation of the questionnaire about the use of flipped classroom.

Variable	Dimension	Load Factor	Cronbach's Alpha	Average Variance Extracted	Composite Reliability
Flipped classroom	Before the class	0.781	0.755	0.582	0.847
	During the class	0.762			
	After the class	0.821			
	Teaching-learning process	0.682			

FINDINGS

Flipped classroom facilitates very much (n = 30, 61.22%), much (n = 13, 26.53%) and little (n = 6, 12.24%) the teaching-learning process on statistics (See Table 3). The results of machine learning indicate that the consultation of the YouTube videos before the class, use of the Mathportal application collaboratively during the class and use of the Mathportal application individually after the class positively influence the teaching-learning process on descriptive statistics (See Table 5).

Table 5. Results of machine learning.

Hypothesis	Training	Linear regression	Result	Value-t	Value-p	Error squared
H1: Consultation of the YouTube videos → teaching-learning process	70%	y = 0.282x + 1.059	Accepted: 0.282	1.428	0.162	0.184
	80%	y = 0.348x + 0.951	Accepted: 0.348	1.954	0.058	0.210
	90%	y = 0.333x + 0.954	Accepted: 0.333	2.014	0.050	0.192
H2: Use of the Mathportal application collaboratively → teaching-learning process	70%	y = 0.271x + 1.097	Accepted: 0.271	1.490	0.145	0.302
	80%	y = 0.298x + 1.038	Accepted: 0.298	1.777	0.083	0.354
	90%	y = 0.293x + 1.024	Accepted: 0.293	1.878	0.067	0.487
H3: Use of the Mathportal application individually → teaching-learning process	70%	y = 0.629x + 0.621	Accepted: 0.629	3.782	0.001	0.243
	80%	y = 0.570x + 0.664	Accepted: 0.570	4.221	0.000	0.301
	90%	y = 0.585x + 0.608	Accepted: 0.585	4.507	0.000	0.314

Table 6 shows the correlations about the use of flipped classroom in the teaching-learning process.

Table 6. Correlations about the use of flipped classroom.

	Before the class	During the class	After the class	Teaching-learning
Before the class	1	-	-	-
During the class	0.596	1	-	-
After the class	0.513	0.394	1	-
Teaching-learning	0.240	0.327	0.572	1

Before the Class

The consultation of the YouTube videos facilitates very much (n = 27, 55.10%), much (n = 20, 40.82%) and little (n = 2, 4.08%) the active role of the student (See Table 3). The results of machine learning (linear regression) with 70% (0.282, value-t = 1.428, value-p = 0.162), 80% (0.348, value-t = 1.954, value-p = 0.058) and 90% (0.333, value-t = 2.014, value-p = 0.050) of training indicate that H1 is accepted (See Table 5). Therefore, the consultation of the YouTube videos before the class positively influences the teaching-learning process on descriptive statistics.

Table 7 presents 16 predictive conditions of the PM1 about the use of flipped classroom with the accuracy of 83.67%. For example, if the student considers that the consultation of the YouTube videos facilitates very much the active role, takes the career of Commerce and is a man then Flipped classroom facilitates much the teaching-learning process on statistics.

Table 7. Conditions of the PM1.

No.	YouTube videos → active role	Career	Sex	Age	Flipped classroom → teaching-learning
1	Very much	Administration	-	-	Very much
2	Very much	Commerce	Man	-	Much
3	Very much	Commerce	Woman	> 20.5 years	Very much
4	Very much	Commerce	Woman	≤ 20.5 years	Little
5	Very much	Marketing	Man	-	Much
6	Very much	Marketing	Woman	-	Very much
7	Much	-	Man	> 19.5 years	Very much
8	Much	Administration	Woman	> 19.5 years	Very much
9	Much	Commerce	Woman	> 19.5 years	Little
10	Much	Marketing	Woman	> 19.5 years	Little
11	Much	Marketing	-	≤ 19.5 years	Much
12	Much	Administration	Man	≤ 19.5 years	Much
13	Much	Administration	Woman	≤ 19.5 years	Very much
14	Much	Commerce	-	≤ 19.5 years	Very much
15	Little	Commerce	-	-	Much
16	Little	Administration	-	-	Little

During the Class

The use of the Mathportal application collaboratively facilitates very much (n = 25, 51.02%), much (n = 22, 44.90%), little (n = 1, 2.04%) and very little (n = 1, 2.04%) the active role of the student (See Table 3). The results of machine learning with 70% (0.271, value-t = 1.490, value-p = 0.145), 80% (0.298, value-t = 1.777, value-p = 0.083) and 90% (0.293, value-t = 1.878, value-p = 0.067) indicate that H2 is accepted (See Table 5). Therefore, the use of the Mathportal application collaboratively during the class positively influences the teaching-learning process on descriptive statistics.

Table 8 shows 12 predictive conditions of the PM2 about the use of flipped classroom with the accuracy of 75.51%. For example, if the student thinks that the use of the Mathportal application collaboratively facilitates very much the active role of the student, takes the career of Commerce and has an age ≤ 19.5 years then flipped classroom facilitates very much the teaching-learning process on statistics.

Table 8. Conditions of the PM2.

No.	Mathportal application collaboratively → active role	Career	Sex	Age	Flipped classroom → teaching-learning
1	Very much	Administration	-	-	Very much
2	Very much	Commerce	-	> 20.5 years	Very much
3	Very much	Commerce	-	≤ 20.5 & > 19.5 years	Much
4	Very much	Commerce	-	≤ 19.5 years	Very much
5	Very much	Marketing	-	-	Very much
6	Much	-	-	> 22.5 years	Much
7	Much	-	-	≤ 22.5 & > 21.5 years	Very much
8	Much	Administration	-	≤ 21.5 years	Very much
9	Much	Commerce	-	≤ 21.5 years	Much
10	Much	Marketing	-	≤ 21.5 years	Much
11	Little	-	-	-	Much
12	Very little	-	-	-	Much

After the Class

The use of the Mathportal application individually facilitates very much (n = 31, 63.27%), much (n = 13, 26.53%) and little (n = 5, 10.20%) the active role of the student (See Table 3). The results of machine learning with 70% (0.629, value-t = 3.782, value-p = 0.001), 80% (0.570, value-t = 4.221, value-p = 0.000) and 90% (0.585, value-t = 4.507, value-p = 0.000) of training indicate that H3 is accepted (See Table 5). Therefore, the use of the Mathportal application individually after the class positively influences the teaching-learning process on descriptive statistics.

Table 9 shows 15 predictive conditions of the PM3 about the use of flipped classroom with the accuracy of 87.76%. For example, if the student considers that the use of the Mathportal application individually facilitates very much the active role of the student and takes the career of Administration then flipped classroom facilitates very much the teaching-learning process on statistics.

Table 9. Conditions of the PM3.

No.	Use of the Mathportal application individually → active role	Career	Sex	Age	Flipped classroom → teaching-learning
1	Very much	Administration	-	-	Very much
2	Very much	Commerce	Man	> 22.5 years	Much
3	Very much	Commerce	Man	≤ 22.5 years	Very much
4	Very much	Commerce	Woman	-	Very much
5	Very much	Marketing	-	-	Very much
6	Much	Commerce	Man	-	Much
7	Much	Commerce	Woman	-	Little
8	Much	Administration	-	-	Very much
9	Much	Marketing	Man	> 20.5 years	Much
10	Much	Marketing	Man	≤ 20.5 years	Very much
11	Much	Marketing	Woman	-	Much
12	Little	Commerce	-	-	Much
13	Little	Administration	-	> 19.5 years	Little
14	Little	Administration	-	≤ 19.5 years	Much
15	Little	Marketing	-	-	Little

DISCUSSIONS AND CONCLUSION

Flipped classroom is modifying the teaching-learning process through the use of tools, platforms and technological applications (Tiejun, 2017; Wenming & Erwen, 2018; Wittich et al., 2018). In particular, this research proposes the consultation of the YouTube videos before the class, use of the Mathportal application collaboratively during the class and use of the Mathportal application individually after the class. Analysis showed that flipped classroom facilitates very much (n = 30, 61.22%) the teaching-learning process on statistics. Also, flipped classroom facilitates much (n = 13, 26.53%) the teaching-learning process on statistics. Therefore, the majority of students (87.75%) have a favorable opinion about this pedagogical model.

Before the Class

Various authors (e.g., Bonnes et al., 2017; Chokshi et al., 2017; Wittich et al., 2018) mention that flipped classroom favors the active participation of students before the face-to-face sessions. In particular, 55.10% of the students (n = 27) thinks that the consultation of the YouTube videos facilitates very much the active role. Also, the consultation of the YouTube videos facilitates much (n = 20, 40.82%) the active role. Therefore, the majority of students (95.92%) have a favorable opinion about this aspect.

Similar to Wenming and Erwen (2018), the students reviewed the multimedia resources to acquire the knowledge at home. The results of machine learning about H1 are higher than 0.280, therefore, the consultation of the YouTube videos before the class positively influences the teaching-learning process on descriptive statistics.

Data science identifies 16 conditions of the PM1 with an accuracy greater than 83.60%. In this model, the age, career and sex of the student determine how the consultation of the YouTube videos influences the teaching-learning process on statistics. For example, the decision tree technique establishes 7 conditions where Flipped classroom facilitates very much the teaching-learning process on statistics.

During the Class

Various authors (e.g., Liu, 2019; Lockman, Haines, & McPherson, 2017; Santikarn & Wichadee, 2018) mention that flipped classroom is a pedagogical model that improves the teaching-learning conditions through technology. For example, the Mathportal application is a support tool that allows checking the results of the exercises about the mean, mode, median, range and quartiles at any time. In particular, 51.02% of the students (n = 25) thinks that the use of the Mathportal application collaboratively facilitates very much the active role. Also, the use of the Mathportal application collaboratively facilitates much (n = 22, 44.90%) the active role. Therefore, the majority of students (95.92%) have a favorable opinion about this aspect.

The incorporation of flipped classroom in the educational field favors the collaborative work during the face-to-face sessions (Cabero-Almenara et al., 2021; Tokmak, Yakin, & Dogusoy, 2019; Tiejun, 2017). The results of machine learning on H2 are higher than 0.270, therefore, the use of the Mathportal application collaboratively during the class positively influences the teaching-learning process on descriptive statistics.

Data science identifies 12 conditions of the PM2 with an accuracy greater than 75.50%. In this model, the age and career of the student determine how the use of the Mathportal application collaboratively influences the teaching-learning process on statistics. For example, the decision tree technique establishes 6 conditions where Flipped classroom facilitates very much the teaching-learning process on statistics.

After the Class

Flipped classroom allows the realization of creative activities outside the classroom (Adam et al., 2017; Bonnes et al., 2017; Lockman, Haines, & McPherson, 2017). In particular, 63.27% of the students (n = 31) thinks that the use of the Mathportal application individually facilitates very much the active role. Also, the use of the Mathportal application individually facilitates much (n = 13, 26.53%) the active role.

Flipped classroom allows that teachers organize and carry out creative activities outside the classroom where students have the main role during the learning process (Cabero-Almenara et al., 2021; Tokmak, Yakin, & Dogusoy, 2019; Tiejun, 2017). The results of machine learning about H3 are higher than 0.560, therefore, the use of the Mathportal application individually after the class positively influences the teaching-learning process on descriptive statistics.

Data science identifies 15 conditions of the PM3 with an accuracy greater than 87.70%. In this model, the age, sex and career of the student determine how the use of the Mathportal application individually influences the teaching-learning process on statistics. For example, the decision tree technique establishes 6 conditions where Flipped classroom facilitates very much the teaching-learning process on statistics.

Finally, flipped classroom is a pedagogical model that transforms the functions, roles and activities of teachers and students during the teaching-learning process (He, Holton, & Farkas, 2018; Villalba, Castilla, & Redondo, 2018; Yang, Sun, & Liu, 2017).

CONCLUSION

Universities together with teachers can improve the learning conditions through flipped classroom. In particular, the results of machine learning indicate that the activities of flipped classroom positively influence the educational process on descriptive statistics. On the other hand, data science allows the identification of 3 predictive models about the consultation of YouTube videos and use of the Mathportal application through the decision tree technique.

The limitations of this quantitative research are the sample size, consultation of the YouTube videos and use of the Mathportal application. Therefore, future research may analyze the impact of digital games, social media, technological tools, educational software, 3D applications and online questionnaires during the implementation of flipped classroom. In particular, educators can organize creative activities before the face-to-face sessions through readings, digital presentations and discussion on social media. During the classes, students can use mobile devices to access educational tools and consult the information on the Internet. Finally, teachers can plan, organize and conduct discussion forums on web platforms such as Moodle and Google Classroom.

This research recommends the use of the Mathportal application for the teaching-learning process on statistics. Even, this web application can be used in the courses of differential calculus, geometry, algebra and financial mathematics. The implications of this research are the transformation of the educational context through the use of flipped classroom and incorporation of technological tools inside and outside the classroom.

Finally, flipped classroom is a pedagogical model that allows the planning, organization and implementation of innovative and creative school activities before, during and after the face-to-face sessions through the use of ICTs such as the Mathportal application and YouTube videos.

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