

TEACHERS' PERCEPTIONS ABOUT THE USE OF LEARNING MANAGEMENT SYSTEMS DURING THE COVID-19 PANDEMIC CONSIDERING DATA SCIENCE

Dr. Ricardo-Adan SALAS-RUEDA

ORCID: 0000-0002-4188-4610

Instituto de Ciencias Aplicadas y Tecnologia
Universidad Nacional Autonoma de Mexico
Mexico City, MEXICO

Dr. Clara ALVARADO-ZAMORANO

ORCID: 0000-0001-9122-7590

Instituto de Ciencias Aplicadas y Tecnologia
Universidad Nacional Autonoma de Mexico
Mexico City, MEXICO

Received: 19/03/2022 **Accepted:** 15/02/2023

ABSTRACT

Technological advances such as Learning Management System (LMS) are changing the teaching-learning conditions, organization of school activities and functions of educators. In particular, the use of LMS in the educational field is necessary due to the appearance of the SARS-CoV-2 virus. This quantitative research analyzes the teachers' perception about the use of LMS during the COVID-19 pandemic considering data science. The sample is 115 teachers from the National Autonomous University of Mexico. These teachers took the "Classroom of the Future 2020" Diploma in order to create new educational spaces. The results of the machine learning technique indicate that the performance of the school activities in LMS positively influences the learning process, motivation and participation of the students during the COVID-19 pandemic. Also, the decision tree technique identifies three predictive models about the use of this technological tool in the educational field considering the academic level and sex of the teachers. In conclusion, educators can improve the learning conditions, organize creative activities inside and outside the classroom, achieve the innovation in the educational context and build virtual spaces through LMS.

Keywords: Learning Management System, teaching, learning, data science, COVID-19.

INTRODUCTION

Technological tools and Internet are revolutionizing the planning and organization of the school activities (Castillo-Cuesta et al., 2022; Rashid, Guo, & Babenko, 2020; Sezer & Yilmaz, 2019). In fact, the emergence of LMS is causing a substantial transformation in the roles of educators and students during the teaching-learning process (Alserhan & Yahaya, 2021; Hanafi et al., 2020; Ueda et al., 2018). LMS allows the delivery, dissemination and administration of e-learning courses (Alhosban & Ismaile, 2018; Koh & Kan, 2020; Sabirova et al., 2019). For example, Moodle facilitates the realization of the student-centered activities from anywhere (Muñoz et al., 2017; Ueda et al., 2018). Also, the use of this technological tool facilitates the construction of new educational virtual spaces and increases the motivation of the students (Aldiab et al., 2019; Koh & Kan, 2020; Moonsamy & Govender, 2018).

According to Zanjani et al. (2017), LMS promotes the active role, collaboration, critical thinking and construction of knowledge. In fact, Blackboard allows that teachers organize creative activities where students participate before, during and after the face-to-face sessions (Gibeault, 2018; Zanjani et al., 2017). Teachers use LMS to plan and carry out the activities inside and outside the classroom (Alserhan & Yahaya, 2021; Fathema & Akanda, 2020; Ohliati & Abbas, 2019). In particular, Blackboard and Blended Learning

(BL) allow the interaction and communication between the participants of the educational process at any time (Liu, 2016). Also, LMS has a fundamental role to update the school activities in the distance modality (Beyatli, Altinay, & Altinay, 2018; Fathema & Akanda, 2020). For example, the use of Moodle (Sabirova et al., 2019), Blackboard (Liu, 2016), Edmodo (Wahyuni et al., 2020) and Canvas (Fathema & Akanda, 2020) in educational institutions improve the teaching-learning conditions during the 21st century.

Various authors (e.g., Fathema & Akanda, 2020; Wahyuni et al., 2020) mention that the incorporation of technology in the educational field increases the academic performance, satisfaction and motivation of the students. In fact, teachers use Information and Communication Technologies (ICTs) to build new spaces where students have the main role during the educational process (Sabirova et al., 2019; Sanchez-Gonzalez & Castro-Higueras, 2022; Wang, 2022; Xue, 2022). In particular, the use of LMS in the educational field is necessary due to the conditions caused by the SARS-CoV-2 virus. Therefore, this quantitative research analyzes the teachers' perception about the use of LMS considering data science. The research questions are:

- What is the teachers' perception about the use of LMS for the performance of the school activities?
- How the performance of the school activities in LMS influences the learning process, motivation and participation of the students during the COVID-19 pandemic considering the linear regression technique?
- What are the predictive models about the use of LMS in the educational field considering the decision tree technique?

LITERATURE REVIEW

Due to the appearance of the SARS-CoV-2 virus, educators incorporated LMS to facilitate the learning from anywhere, delivery of the activities, realization of the discussion forums, communication and consultation of the school resources at any time. In particular, this quantitative research analyzes the teachers' perception about the use of LMS during the COVID-19 pandemic considering data science in order to discover new information about this technological tool.

Today, Moodle, Blackboard and Canvas allow the creation of new school activities that favor the assimilation of knowledge and development of skills (Beyatli, Altinay, & Altinay, 2018; Fathema & Akanda, 2020; Hanafi et al., 2020; Wahyuni et al., 2020). For example, LMS have improved the teaching-learning conditions in the courses of Recruitment and employment management (Liu, 2016), Medicine (Alhosban & Ismaile, 2018), Sciences (Wahyuni et al., 2020), Health (Zain, Fadil, & Hadi, 2018), English language (Beyatli, Altinay, & Altinay, 2018) and Islamic Education (Hanafi et al., 2020).

Teachers use LMS as a support tool during the performance of the school activities (Fathema & Akanda, 2020; Hanafi et al., 2020; Wahyuni et al., 2020). For example, Canvas facilitated the assimilation of knowledge, development of competencies and communication at the higher educational level (Fathema & Akanda, 2020). In the field of Sciences, the students consulted the audiovisual contents and didactic resources in Edmodo to assimilate the knowledge and develop their skills at any time (Wahyuni et al., 2020).

Educational institutions use LMS to transmit the materials of the courses, submit the online announcements, receive the assignments, disseminate the grades and communicate with the students (Alserhan & Yahaya, 2021; Zain, Fadil, & Hadi, 2018; Wahyuni et al., 2020). In the Faculty of Health, the use of Moodle facilitated the realization of the online exams and organization of the student-centered activities (Zain, Fadil, & Hadi, 2018). On the other hand, Hanafi et al. (2020) propose the use of the LMS called e-BBQ together with the ADDIE pedagogical model to transform the Islamic Education course. Likewise, Edmodo transformed the roles of teachers and students in the secondary schools (Beyatli, Altinay, & Altinay, 2018). In the English Language course, this LMS increased the motivation of the students, developed the oral skills and facilitated the feedback of the school activities (Beyatli, Altinay, & Altinay, 2018).

According to Moonsamy and Govender (2018), the advantages about the use of Blackboard in the educational field are the ease of use and availability of information at any time and place. In the Recruitment and Employment Management course, the teacher used Blackboard and BL to organize creative school activities such as the discussion forums, consultation of the multimedia resources and realization of the online exams (Liu, 2016). Also, the consultation of materials such as digital presentations and multimedia resources in

Blackboard improved the academic performance of the students and facilitated the dissemination of the grades, delivery of the school activities and sending of the messages during the Medicine course (Alhosban & Ismaile, 2018). In addition, the students of the Physics course actively participated inside and outside the classroom through Moodle (Sabirova et al., 2019). Finally, technological advances such as LMS allow the updating of courses, construction of new educational spaces and organization of creative school activities (Aldiab et al., 2019; Juhanak, Zounek, & Rohlikova, 2019).

METHOD

Data science and Machine Learning algorithms allow the identification of new information about the incorporation of technological tools in the educational field to make the decisions (Immekus et al., 2022; Yagci, 2022). The linear regression technique allows evaluating the research hypotheses (Lincke et al., 2021; Salas-Rueda et al., 2023). On the other hand, the decision tree technique facilitates the construction of models to discover valuable information (Nti et al., 2022; Salas-Rueda, 2022).

This work used the Machine Learning algorithms on linear regression and decision tree to analyze the use of LMS during the COVID-19 pandemic. The particular aims of this quantitative research are (1) analyze the teachers' perception about the use of LMS for the performance of the school activities (2) analyze how the performance of the school activities in LMS influences the learning process, motivation and participation of the students during the COVID-19 pandemic considering the linear regression technique and (3) identify the predictive models about the use of LMS in the educational field considering the decision tree technique.

Participants

The sample is composed of 115 teachers (53 men and 62 women) from the National Autonomous University of Mexico who have the Bachelor (n = 32, 27.83%), Specialty (n = 4, 3.48%), Master (n = 55, 47.83%) and Doctorate (n = 24, 20.87%). These teachers come from the Institute of Geophysics, National Preparatory School no. 7, Faculty of Philosophy and Letters, Faculty of Psychology, Institute of Geology and CCH Vallejo.

Procedure

The teachers of the National Autonomous University of Mexico took the "Classroom of the Future 2020" Diploma in order to create new educational spaces through the incorporation of pedagogy and technological tools in the school activities (See Figure 1). For example, educators can organize the discussion forums, share the multimedia resources of the courses, receive the assignments from anywhere and promote the active role of the students through LMS.

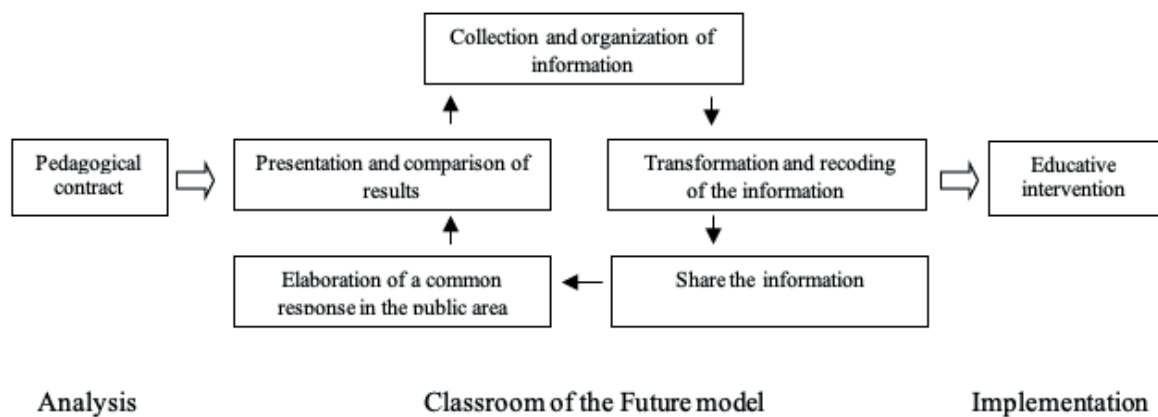


Figure 1. "Innovation in University Teaching 2020" Diploma

This research proposes the following model to analyze the use of this technological tool in the educational field (See Figure 2).

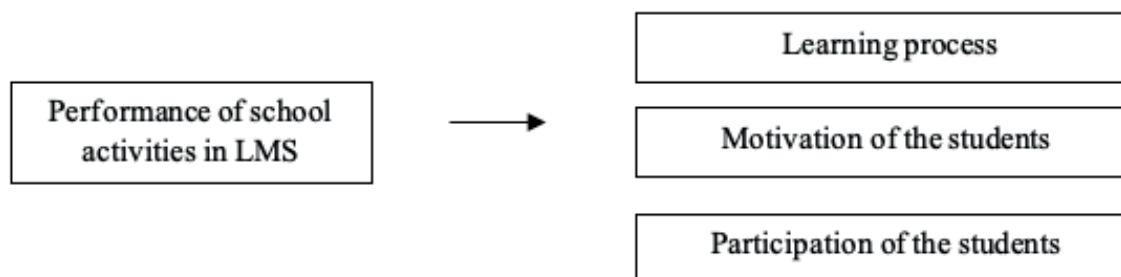


Figure 2. Model about the impact of LMS

Various authors (e.g., Muñoz-Arteaga et al., 2022; Sanchez-Gonzalez & Castro-Higueras, 2022) mention that technological advances such as LMS allow the realization of the school activities in the distance modality and cover the educational needs caused by the SARS-CoV-2 virus. Therefore, the research hypotheses about the use of LMS in the educational field are:

- Hypothesis 1 (H1): The performance of the school activities in LMS positively influences the learning process during the COVID-19 pandemic
- Hypothesis 2 (H2): The performance of the school activities in LMS positively influences the motivation of the students during the COVID-19 pandemic
- Hypothesis 3 (H3): The performance of the school activities in LMS positively influences the participation of the students during the COVID-19 pandemic

The decision tree technique allows identifying the following predictive models about the use of LMS in the educational field:

- Predictive Model 1 (PM1) about the performance of the school activities in LMS and learning process during the COVID-19 pandemic
- Predictive Model 2 (PM2) about the performance of the school activities in LMS and motivation of the students during the COVID-19 pandemic
- Predictive Model 3 (PM3) about the performance of the school activities in LMS and participation of the students during the COVID-19 pandemic

Data Collection

Data collection was carried out through a questionnaire during the “Classroom of the Future 2020” Diploma at the National Autonomous University of Mexico (See Table 1).

Table 1. Questionnaire about LMS

No.	Variable	Dimension	Question	Answer	n	%
1	Profile of teacher	Sex	1. Indicate your sex	Man	53	46.09%
				Woman	62	53.91%
	Academic level	2. Indicate your academic level	Bachelor	32	27.83%	
			Specialty	4	3.48%	
Master			55	47.83%		
			Doctorate	24	20.87%	

2	Technology in the educational field	LMS	3. LMS facilitate the performance of the school activities	Very much (1)	56	48.70%
				Much (2)	39	33.91%
				Little (3)	19	16.52%
				Very little (4)	1	0.87%
		Learning process	4. ICTs improve the learning process during the COVID-19 pandemic	Very much (1)	53	46.09%
				Much (2)	42	36.52%
		Little (3)	20	17.39%		
		Very little (4)	0	0.00%		
	Motivation of the students	5. ICTs improve the motivation of the students during the COVID-19 pandemic	Very much (1)	53	46.09%	
			Much (2)	48	41.74%	
			Little (3)	14	12.17%	
			Very little (4)	0	0.00%	
	Participation of the students	6. ICTs improve the participation of the students during the COVID-19 pandemic	Very much (1)	56	48.70%	
			Much (2)	43	37.39%	
			Little (3)	15	13.04%	
			Very little (4)	1	0.87%	

Table 2 shows the validation for the questionnaire about the use of LMS in the educational field.

Table 2. Validation of the questionnaire

Variable	Dimension	Load factor	Cronbach's Alpha	Average Variance Extracted	Composite Reliability
Technology in the educational field	LMS	0.711	0.850	0.696	0.901
	Learning process	0.901			
	Motivation of the students	0.835			
	Participation of the students	0.878			

Data Analysis

The Rapidminer tool allows calculating the linear regressions to analyze the teachers' perception on the use of LMS during the COVID-19 pandemic and building the predictive models about this technological tool (See Figure 3).

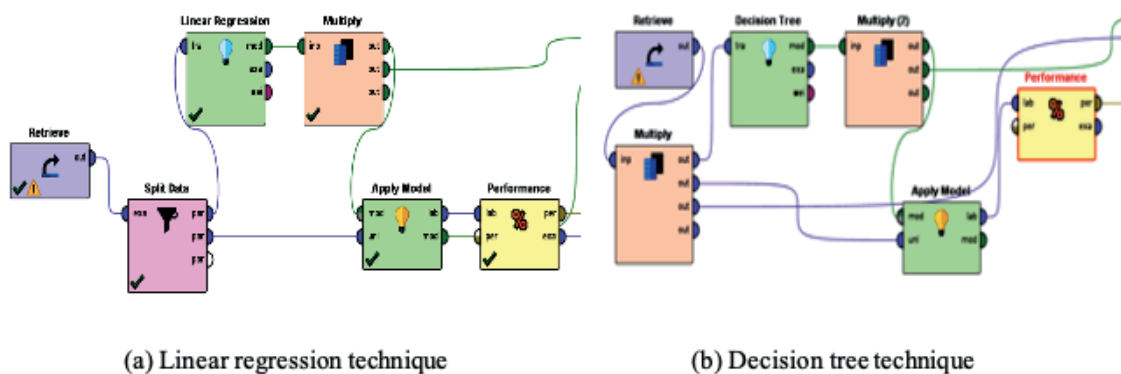


Figure 3. RapidMiner tool

In the machine learning technique, the training section is composed of 50% (n = 58), 60% (n = 69) and 70% (n = 81) of the sample and allows calculating the linear regressions to evaluate the research hypotheses. The independent variable is the performance of the school activities in LMS and the dependent variables are the learning process, motivation and participation of the students during the COVID-19 pandemic. Also, the evaluation section is composed of 50% (n = 57), 40% (n = 46) and 30% (n = 34) of the sample and allows identifying the accuracy of these linear regressions by means of the squared error.

Likewise, data science allows identifying 3 predictive models about the use of LMS and profile of the teachers (sex and academic level) through the decision tree technique. In this Machine Learning technique, the objective variables are the learning process, motivation and participation of the students during the COVID-19 pandemic.

FINDINGS

LMS facilitate very much (n = 56, 48.70%), much (n = 39, 33.91%), little (n = 19, 16.52%) and very little (n = 1, 0.87%) the performance of school activities (See Table 1). The results of machine learning technique indicate that the performance of the school activities in LMS positively influences the learning process, motivation and participation of the students during the COVID-19 pandemic (See Table 3).

Table 3. Results of machine learning technique

Hypothesis	Training	Linear regression	Conclusion	Squared error
H1: Performance of the school activities in LMS → learning process	50%	$y = 0.654x + 0.640$	Accepted: 0.654	0.545
	60%	$y = 0.596x + 0.684$	Accepted: 0.596	0.562
	70%	$y = 0.529x + 0.776$	Accepted: 0.529	0.469
H2: Performance of the school activities in LMS → motivation of the students	50%	$y = 0.504x + 0.846$	Accepted: 0.504	0.474
	60%	$y = 0.412x + 0.938$	Accepted: 0.412	0.479
	70%	$y = 0.350x + 1.015$	Accepted: 0.350	0.467
H3: Performance of the school activities in LMS → participation of the students	50%	$y = 0.604x + 0.738$	Accepted: 0.604	0.398
	60%	$y = 0.616x + 0.692$	Accepted: 0.616	0.356
	70%	$y = 0.529x + 0.776$	Accepted: 0.529	0.223

Learning Process

ICTs improve very much (n = 53, 46.09%), much (n = 42, 36.52%) and little (n = 20, 17.39%) the learning process during the COVID-19 pandemic (See Table 1). The results of machine learning technique with 50% (0.654), 60% (0.596) and 70% (0.529) of training indicate that H1 is accepted (See Table 3). Therefore, the performance of the school activities in LMS positively influences the learning process during the COVID-19 pandemic.

Table 4 presents 12 conditions of the PM1 with an accuracy of 66.96%. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Doctorate then ICTs improve very much the learning process during the COVID-19 pandemic.

Table 4. Conditions of the PM1

No.	LMS → performance of the school activities	Sex	Academic level	ICTs → learning process
1	Very much	-	Bachelor	Very much
2	Very much	-	Specialty	Much
3	Very much	-	Master	Very much
4	Very much	-	Doctorate	Very much
5	Much	-	-	Much
6	Little	Man	Bachelor	Much
7	Little	Woman	Bachelor	Little
8	Little	Man	Master	Little
9	Little	Woman	Master	Very much
10	Little	Man	Doctorate	Much
11	Little	Woman	Doctorate	Very much
12	Very little	-	-	Little

The sex of the educators determines 6 conditions of the PM1. For example, if the teacher considers that LMS facilitate little the performance of the school activities, is a woman and has the academic level of Bachelor then ICTs improve little the learning process during the COVID-19 pandemic.

Also, the academic level of the educators determines 10 conditions of the PM1. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Master then ICTs improve very much the learning process during the COVID-19 pandemic.

Motivation of the Students

ICTs improve very much ($n = 53$, 46.09%), much ($n = 48$, 41.74%) and little ($n = 14$, 12.17%) the motivation of the students during the COVID-19 pandemic (See Table 1). The results of machine learning technique with 50% (0.504), 60% (0.412) and 70% (0.350) of training indicate that H2 is accepted (See Table 3). Therefore, the performance of the school activities in LMS positively influences the motivation of the students during the COVID-19 pandemic.

Table 5 presents 10 conditions of the PM2 with an accuracy of 68.70%. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Doctorate then ICTs improve very much the motivation of the students during the COVID-19 pandemic.

Table 5. Conditions of the PM2

No.	LMS → performance of the school activities	Sex	Academic level	ICTs → motivation of the students
1	Very much	-	Bachelor	Very much
2	Very much	-	Specialty	Much
3	Very much	-	Master	Very much
4	Very much	-	Doctorate	Very much
5	Much	-	-	Much
6	Little	-	Bachelor	Much
7	Little	-	Master	Much
8	Little	Man	Doctorate	Little
9	Little	Woman	Doctorate	Much
10	Very little	-	-	Much

The sex of the educators determines 2 conditions of the PM2. For example, if the teacher considers that LMS facilitate little the performance of the school activities, is a man and has the academic level of Doctorate then ICTs improve little the motivation of the students during the COVID-19 pandemic.

Also, the academic level of the educators determines 8 conditions of the PM2. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Bachelor then ICTs improve very much the motivation of the students during the COVID-19 pandemic.

Participation of the Students

ICTs improve very much (n = 56, 48.70%), much (n = 43, 37.39%), little (n = 15, 13.04%) and very little (n = 1, 0.87%) the participation of the students during the COVID-19 pandemic (See Table 1). The results of machine learning technique with 50% (0.604), 60% (0.616) and 70% (0.529) of training indicate that H3 is accepted (See Table 3). Therefore, the performance of the school activities in LMS positively influences the participation of the students during the COVID-19 pandemic.

Table 6 presents 11 conditions of PM3 with an accuracy of 73.04%. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Doctorate then ICTs improve very much the participation of the students during the COVID-19 pandemic.

Table 6. Conditions of the PM3

No.	LMS → performance of the school activities	Sex	Academic level	ICTs → participation of the students
1	Very much	-	Bachelor	Very much
2	Very much	-	Specialty	Much
3	Very much	-	Master	Very much
4	Very much	-	Doctorate	Very much
5	Much	-	-	Much
6	Little	Man	Bachelor	Much
7	Little	Woman	Bachelor	Little
8	Little	Man	Master	Little
9	Little	Woman	Master	Much
10	Little	-	Doctorate	Very much
11	Very little	-	-	Very little

The sex of the educators determines 4 conditions of the PM3. For example, if the teacher considers that LMS facilitate little the performance of the school activities, is a woman and has the academic level of Bachelor then ICTs improve little the participation of the students during the COVID-19 pandemic.

The academic level of the educators determines 4 conditions of the PM3. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Bachelor then ICTs improve very much the participation of the students during the COVID-19 pandemic. Finally, Table 7 shows the Pearson correlations about LMS, learning process, motivation and participation of the students.

Table 7. Pearson correlations

	LMS	Learning process	Motivation of the students	Participation of the students
LMS	1	-	-	-
Learning process	0.500	1	-	-
Motivation of the students	0.382	0.750	1	-
Participation of the students	0.571	0.715	0.621	1

DISCUSSION

During the 21st century, teachers use LMS to build new educational spaces (Bervell, Nyagorme, & Arkorful, 2020; Capacho, Jimeno, & Salazar, 2019; Sezer & Yilmaz, 2019). As mentioned by Fathema and Akanda (2020), the use of LMS in the educational field allows the assimilation of knowledge, development of competencies and

communication. In particular, 48.70% of educators consider that LMS facilitate very much the performance of school activities. In fact, teachers can organize the discussion forums and share the multimedia resources of the courses through this technological tool. Also, LMS facilitate much ($n = 39$, 33.91%) the performance of school activities. Therefore, most of the participants have a favorable opinion about this aspect.

Learning Process

The use of technology in the educational field allows improving the conditions for the learning process (Lakarnchua, Balme, & Matthews, 2020; Nieuwoudt, 2020; Wang, 2022). For example, LMS is an educational tool that encourages the active role at any time (Annamalai et al., 2021; Salas-Rueda et al., 2022; Wahyuni et al., 2020). In fact, 46.09% of the educators think that ICTs improve very much the learning process during the COVID-19 pandemic. Further, teachers use LMS to receive and grade the assignments from anywhere. Also, ICTs improve much ($n = 42$, 36.52%) the learning process during the COVID-19 pandemic. Therefore, most of the participants have a favorable opinion about this aspect.

As mentioned by Wahyuni et al. (2020), the incorporation of LMS in the educational field facilitates the assimilation of knowledge and development of skills. According to Lincke et al. (2021), Machine Learning algorithms allow evaluating the research hypotheses by means of the linear regression technique. The results of machine learning technique on H1 are greater than 0.520, therefore, the performance of the school activities in LMS positively influences the learning process during the COVID-19 pandemic. The function, $y = 0.529x + 0.776$, allows predicting this educational phenomenon with a squared error of 0.469.

Data science identifies 12 conditions of PM1 with an accuracy of 66.96%. In this predictive model, the sex and academic level of the educators determine the relationship between the use of LMS and ICTs for the learning process through the decision tree technique. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Doctorate then ICTs improve very much the learning process during the COVID-19 pandemic. Likewise, the correlation coefficient on LMS and learning process is higher than 0.490.

Motivation of the Students

LMS allow the creation of educational spaces that increase the motivation of students inside and outside the classroom (Bervell, Nyagorme, & Arkorful, 2020; Koh & Kan, 2020; Sezer & Yilmaz, 2019). In particular, 46.09% of the educators consider that ICTs improve very much the motivation of the students during the COVID-19 pandemic. Educational institutions organize creative school activities in the distance modality through LMS. Also, ICTs improve much ($n = 48$, 41.74%) the motivation of the students during the COVID-19 pandemic. Therefore, most of the participants have a favorable opinion about this aspect.

In addition, Sabirova et al. (2019) explain that the use of the LMS facilitates the construction of new spaces for learning and teaching in the distance modality. The results of machine learning on H2 are higher than 0.349, therefore, the performance of the school activities in LMS positively influences the motivation of the students during the COVID-19 pandemic. The function, $y = 0.350x + 1.015$, allows predicting this educational phenomenon with a squared error of 0.467.

According to Zain et al. (2018), the use of LMS allows the planning and carrying out of student-centered activities. Data science identifies 10 conditions of the PM2 with 68.70% accuracy. In this predictive model, the sex and academic level of the educators determine the relationship between the use of LMS and ICTs for the motivation of the students through the decision tree technique. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Bachelor then ICTs improve very much the motivation of the students during the COVID-19 pandemic. Likewise, the correlation coefficient on LMS and motivation is greater than 0.380.

Participation of the Students

Teachers organize and carry out creative activities to facilitate the participation of students before, during and after the class through the use of technological advances (Castillo-Cuesta et al., 2022; Cheah, 2020; Wang, 2022). As Alserhan and Yahaya (2021) point out, educators use LMS to submit the online announcements,

disseminate the grades, transmit the educational materials and communicate with the students. For example, 48.70% of the educators consider that ICTs improve very much the participation of the students during the COVID-19 pandemic. In fact, educational institutions use LMS to promote the active role of the participants. Also, ICTs improve much ($n = 43$, 37.39%) the participation of the students during the COVID-19 pandemic. Therefore, most of the participants have a favorable opinion about this aspect.

Various authors (e.g., Sabirova et al., 2019; Wahyuni et al., 2020) mention that the use of LMS facilitates the participation of the students. The results of machine learning on H3 are higher than 0.520, therefore, the performance of the school activities in LMS positively influences the participation of the students during the COVID-19 pandemic. The function, $y = 0.529x + 0.776$, allows predicting this educational phenomenon with a squared error of 0.223.

Data science identifies 11 conditions of PM3 with the accuracy of 73.04%. In this predictive model, the sex and academic level of the educators determine the relationship between the use of LMS and ICTs for the participation of the students through the decision tree technique. For example, if the teacher considers that LMS facilitate very much the performance of the school activities and has the academic level of Bachelor then ICTs improve very much the participation of the students during the COVID-19 pandemic. Likewise, the correlation coefficient on LMS and participation is greater than 0.570.

Finally, educational institutions together with teachers have the possibility of improving the learning process through technology (Castillo-Cuesta et al., 2022; Kadioglu, Tacgin, & Sahin, 2020; Oinas et al., 2020). In particular, LMS transforms the functions, behavior and roles of participants during the educational process (Capacho, Jimeno, & Salazar, 2019; Lakarnchua, Balme, & Matthews, 2020; Ozkan, Cigdem, & Erdogan, 2020).

CONCLUSION

Educators use technological advances to improve the teaching-learning conditions. In particular, LMS facilitate the organization of new educational spaces for the consultation and delivery of the school activities from anywhere. The results of the machine learning technique indicate that the performance of the school activities in LMS positively influences the learning process, motivation and participation of the students during the COVID-19 pandemic.

The implications of this research are the incorporation of LMS in educational institutions to facilitate the active role of the students, update the courses in the distance modality and create new school activities. In fact, the use of LMS in the educational field is necessary due to the conditions caused by the SARS-CoV-2 virus. For example, teachers can use the LMS to organize new school activities such as discussion forums, online exams and consultation of multimedia resources at any time.

The limitations of this study are the perception of the teachers and analysis about the use of LMS and ICTs for the learning process, motivation and participation. Therefore, future research can analyze the impact this technological tool for the communication and development of skills considering the opinion of students and educators.

This research recommends that educational institutions and educators use LMS to cover the educational needs under the distance modality. In conclusion, LMS represent a technological alternative to transform the teaching-learning conditions and update the school activities of the courses during the COVID-19 pandemic.

Authors' Note: This research product received the support of the following the PAPIIME projects: PE106420 (El Aula del Futuro del CCH Vallejo), PE102920 (El Aula del Futuro del Instituto de Geofísica), PE106419 (El Aula del Futuro: de la Escuela Nacional Preparatoria 7), PE314819 (SUAYED de la Facultad de Filosofía y Letras), PE306619 (El Aula del Futuro: SUA de la Facultad de Psicología) and PE104720 (El Aula del Futuro del Instituto de Geología).

BIODATA and CONTACT ADDRESSES of AUTHORS



Dr. Ricardo-Adan SALAS-RUEDA is a full-time researcher at the Instituto de Ciencias Aplicadas y Tecnologia, Universidad Nacional Autonoma de Mexico. Dr. Ricardo-Adan gained his Ph.D. in New Technologies Design at July, 2014. His academic interest areas are educative technology, web application design, data science, machine learning and neural networks. He has 42 journal articles published in international indexes, 10 international book chapters and 4 international books.

Ricardo-Adan SALAS-RUEDA

Instituto de Ciencias Aplicadas y Tecnologia, Universidad Nacional Autonoma de Mexico

Address: Circuito Exterior S/N, Ciudad Universitaria, 04510, Mexico City, Mexico.

Phone: +55 5622 8601

E-mail: ricardo.salas@icat.unam.mx



Dr. Clara ALVARADO-ZAMORANO is a Titular Academic Technician “C” at the Instituto de Ciencias Aplicadas y Tecnologia, Universidad Nacional Autonoma de Mexico. Dra. Clara gained her Ph.D. in Research in Teaching and Learning of Experimental, Social Sciences and Mathematics at July, 2012. Her academic interest areas are pedagogy and educative technology. She has 13 journal articles published in international indexes, 4 international book chapters and 6 international books.

Clara ALVARADO-ZAMORANO

Instituto de Ciencias Aplicadas y Tecnologia, Universidad Nacional Autonoma de Mexico

Address: Circuito Exterior S/N, Ciudad Universitaria, 04510, Mexico City, Mexico.

Phone: +55 5622 8601

E-mail: clara.alvarado@icat.unam.mx

REFERENCES

- Aldiab, A., Chowdhury, H., Kootsookos, A., Alam, f., & Allhibi, H. (2019). Utilization of Learning Management Systems (LMSs) in higher education system: A case review for Saudi Arabia. *Energy Procedia*, 160, 731-737.
- Alhosban, F. & Ismaile, S. (2018). Perceived Promoters of and Barriers to Use of a Learning Management System in an Undergraduate Nursing Program. *International Journal of Emerging Technologies in Learning*, 13(2), 226-233.
- Annamalai, N., Ramayah, T., Kumar, J. A., & Osman, S. (2021). Investigating the Use of Learning Management System (LMS) for Distance Education in Malaysia: A Mixed-Method Approach. *Contemporary Educational Technology*, 13(3), ep313.
- Alserhan, S., & Yahaya, N. (2021). Teachers' Perspective on Personal Learning Environments via Learning Management Systems Platform. *International Journal of Emerging Technologies in Learning*, 16(24), 57-73.
- Bervell, B., Nyagorme, P., & Arkorful, V. (2020). LMS-Enabled Blended Learning Use Intentions among Distance Education Tutors: Examining the Mediation Role of Attitude Based on Technology-Related Stimulus-Response Theoretical Framework. *Contemporary Educational Technology*, 12(2), ep273.

- Beyatli, O., Altinay, F., & Altinay, Z. (2018). Evaluation of the Users of Edmodo Content Management System in Secondary Education. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(7), 3191-3195.
- Capacho, J., Jimeno, M., & Salazar, A. (2019). Operational Indicators of the Learning Management System in Virtual Spaces Supported by ICT. *Turkish Online Journal of Distance Education*, 20(3), 103-118.
- Castillo-Cuesta, L., Ochoa-Cueva, C., & Cabrera-Solano, P. (2022). Virtual Workspaces for Enhancing Collaborative Work in EFL Learning: A Case Study in Higher Education. *International Journal of Emerging Technologies in Learning*, 17(2), 4-18.
- Cheah, C. S. (2020). Factors Contributing to the Difficulties in Teaching and Learning of Computer Programming: A Literature Review. *Contemporary Educational Technology*, 12(2), ep272.
- Fathema, N. & Akanda, M. H. (2020). Effects of instructors' academic disciplines and prior experience with learning management systems: A study about the use of Canvas. *Australasian Journal of Educational Technology*, 36(4), 113-125.
- Gibeault, M. J. (2018). Organization of Materials and Accessing the Library in Blackboard: A Learner-centered Usability Study. *The Journal of Academic Librarianship*, 44(2), 190-195.
- Hanafi, Y., Murtadho, N., Ikhsan, M. A., & Diyana, T. N. (2020). Reinforcing Public University Student's Worship Education by Developing and Implementing Mobile- Learning Management System in the ADDIE Instructional Design Model. *International Journal of Interactive Mobile Technologies*, 14(2), 215-240.
- Immekus, J. C., Jeong, T. & Yoo, J. E. (2022). Machine learning procedures for predictor variable selection for schoolwork-related anxiety: evidence from PISA 2015 mathematics, reading, and science assessments. *Large-scale Assessments in Education*, 10, 1-12.
- Juhanak, L., Zounek, J., & Rohlikova, L. (2019). Using process mining to analyze students' quiz-taking behavior patterns in a learning management system. *Computers in Human Behavior*, 92, 496-506.
- Kadioglu, M., Tacgin, Z., & Sahin, N. (2020). Instructional Design and Material Development Progress to eLearning Environments: A Sample of Obstetrical Nursing Education. *Contemporary Educational Technology*, 12(1), ep265.
- Koh, J. H. L. & Kan, R. Y. P. (2020). Perceptions of learning management system quality, satisfaction, and usage: Differences among students of the arts. *Australasian Journal of Educational Technology*, 36(3), 26-40.
- Lakarnchua, O., Balme, S., & Matthews, A. (2020). Insights from the implementation of a flipped classroom approach with the use of a commercial learning management system. *Turkish Online Journal of Distance Education*, 21(3), 63-76.
- Lincke, A., Jansen, M., Milrad, M., & Berge, E. (2021). The performance of some machine learning approaches and a rich context model in student answer prediction. *Research and Practice in Technology Enhanced Learning*, 16, 1-10.
- Liu, H. (2016). An Analysis on Blended Learning Pattern Based on Blackboard Network Platform. *International Journal of Emerging Technologies in Learning*, 11(9), 4-8.
- Muñoz-Arteaga, J., Muñoz-Zavala, A. E., & Cardona-Reyes, H. (2022). Challenges of inclusive teaching at elementary school level during COVID-19. *Campus Virtuales*, 11(1), 125-135.
- Nieuwoudt, J. E. (2020). Investigating synchronous and asynchronous class attendance as predictors of academic success in online education. *Australasian Journal of Educational Technology*, 36(3), 15-25.
- Nti, I. K., Akyeramfo-Sam, S., Bediako-Kyeremeh, B., & Agyemang, S. (2022). Prediction of social media effects on students' academic performance using Machine Learning Algorithms (MLAs). *Journal of Computers in Education*, 9, 195-223.
- Ohliati, J. & Abbas, B. S. (2019). Measuring Students Satisfaction in Using Learning Management System. *International Journal of Emerging Technologies in Learning*, 14(4), 180-189.

- Oinas, S. E., Thuneberg, H., Vainikainen, M. P., & Hotulainen, R. (2020). Technology-enhanced Feedback Profiles and their Associations with Learning and Academic Well-being Indicators in Basic Education. *Contemporary Educational Technology, 12*(2), ep271.
- Ozkan, U., Cigdem, H., & Erdogan, T. (2020). Artificial neural network approach to predict lms acceptance of vocational school students. *Turkish Online Journal of Distance Education, 21*(3), 156-169.
- Moonsamy, D. & Govender, I. (2018). Use of Blackboard Learning Management System: An Empirical Study of Staff Behavior at a South African University. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(7), 3069-3082.
- Muñoz, A., Delgado, R., Rubio, E., Grilo, C., & Basto-Fernandes, V. (2017). Forum participation plugin for Moodle: Development and Discussion. *Procedia Computer Science, 121*, 982-989.
- Rashid, M., Guo, Q., & Babenko, O. (2020). The Influence of Students' Perceptions of Learning Environment on Coping with Academic Challenges: A Structural Equation Modeling Study. *Teaching and Learning in Medicine, 32*(2), 204-217.
- Sabirova, F. M., Shurygin, V. Y., Deryagin, A. V., & Sahabiev, I. A. (2019). Historical and Biographical Approaches towards Teachers Training in Learning Physics Using Moodle LMS. *EURASIA Journal of Mathematics, Science and Technology Education, 15*(3), 1-8.
- Salas-Rueda, R. A. (2022). Use of flipped classroom in the teaching-learning process on descriptive statistics. *Turkish Online Journal of Distance Education, 23*(4), 53-64.
- Salas-Rueda, R.-A., Ramirez-Ortega, J., Alvarado-Zamorano, C., & Dominguez-Hernandez, A. (2022). Students' Perception About the Incorporation of Technological Tools in the Educational Field During the COVID-19 Pandemic. *Online Journal of Communication and Media Technologies, 12*(3), e202218.
- Salas-Rueda, R. A., Ramirez-Ortega, J., Martinez-Ramirez, S. M., & Alvarado-Zamorano, C. (2023). Use of Machine Learning algorithms to analyze Moodle and smartphones in the educational process of Physics. *Texto Livre, 16*, e41293.
- Sanchez-Gonzalez, M., & Castro-Higuera, A. (2022). Mentoring for university professors in the fase of the Covid-19: evaluation of a case. *Campus Virtuales, 11*(1), 181-200.
- Sezer, B. & Yilmaz, R. (2019). Learning management system acceptance scale (LMSAS): A validity and reliability study. *Australasian Journal of Educational Technology, 35*(3), 15-30.
- Ueda, H., Furukawa, M., Yamaji, k., & Nakamura, M. (2018). SCORMAdaptiveQuiz: Implementation of Adaptive e-Learning for Moodle. *Procedia Computer Science, 126*, 2261-2270.
- Wahyuni, S., Erman, E., Sudikan, S. Y., & Jatmiko, B. (2020). Edmodo-Based Interactive Teaching Materials as an Alternative Media for Science Learning to Improve Critical Thinking Skills of Junior High School Students. *International Journal of Interactive Mobile Technologies, 14*(9), 166-181.
- Wang, L. (2022). Influence of Teacher Behaviors on Student Activities in Information-Based Classroom Teaching. *International Journal of Emerging Technologies in Learning, 17*(2), 19-31.
- Xue, H. (2022). A New Integrated Teaching Mode for Labor Education Course Based on STEAM Education. *International Journal of Emerging Technologies in Learning, 17*(2), 128-142.
- Yagci, M. (2022). Educational data mining: prediction of students' academic performance using machine learning algorithms. *Smart Learning Environments, 9*, 1-11.
- Zain, N. M., Fadil, N. F., & Hadi, A. A. (2018). Learning Management System: An Experience and Perception Study from Medical Imaging Lecturers and Scholars in a Private University. *International Journal of Interactive Mobile Technologies, 9*, 174-180.
- Zanjani, N., Edwards, S. L., Nykvist, S. & Geva, S. (2017). The important elements of LMS design that affect user engagement with e-learning tools within LMSs in the higher education sector. *Australasian Journal of Educational Technology, 33*(1), 19-31.