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Analysis of Facebook in the Teaching-Learning Process about Mathematics Through Data Science

Analyse de Facebook dans le processus d'enseignement-apprentissage des mathématiques par la science des données

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Abstract

The aim of this quantitative research is to analyze the impact of Facebook in the teaching-learning process in financial mathematics education, using data science, machine learning, and neural networks. The sample is composed of 46 students from the Bachelor of Administration, Commerce and Marketing program at La Salle University. The results of machine learning (linear regression) indicate that sending messages, watching instructional videos, and publishing exercises on Facebook supports the teaching-learning process in financial mathematics. Likewise, data science identified six predictive models for the use of Facebook in the educational context by means of the decision tree technique. Analysis using neural networks identified the influence of sending messages, watching instructional videos, and publishing exercises on Facebook during the assimilation of knowledge and development of mathematical skills. Finally, Facebook is a technological and communication tool that transforms the organization of teaching and learning activities in financial mathematics education.

Keywords: Facebook; social network; learning; data science; neural networks

Résumé

L'objectif de cette recherche quantitative est d'analyser l'impact de Facebook dans le processus éducatif sur les mathématiques financières à travers la science des données, l'apprentissage automatique et les réseaux de neurones. L'échantillon est composé de 46 étudiants du baccalauréat en administration, commerce et marketing à l'Université La Salle. Les résultats de l'apprentissage automatique (régression linéaire) indiquent que l'envoi de messages, la consultation de vidéos et la publication d'exercices sur Facebook favorisent le processus d'enseignement-apprentissage en mathématiques financières. De même, la science des données a identifié six modèles prédictifs sur l'utilisation de Facebook dans le

contexte éducatif à l'aide de la technique de l'arbre de décision. Les réseaux de neurones ont identifié l'influence de l'envoi de messages, de la consultation de vidéos et de la publication d'exercices sur Facebook lors de l'assimilation des connaissances et du développement des compétences en mathématiques. Enfin, Facebook est un outil technologique et de communication qui transforme l'organisation des activités scolaires dans le domaine des mathématiques financières.

Mots-clés : Facebook ; réseau social ; apprentissage ; data science ; réseaux de neurones

Introduction

Information and communication technologies (ICTs) are causing radical changes in the planning and organization of the educational activities (Ben-Chayim & Offir, 2019; Hannigan & Gonzalez, 2019; Salas-Rueda, 2019). Therefore, teachers seek, select, and use technological applications to achieve the development of competences among their students (Alizadeh et al., 2019; Arteaga-Sánchez et al., 2014; Salas-Rueda et al., 2019).

Interactive web tools are modifying the behaviour and functions of students in educational contexts (Hershkovitz & Forkosh-Baruch, 2019; Llorens & Capdeferro, 2011; Reed, 2013). Social networks improve participation, communication, and interaction during the teaching-learning process (Maheshwari & Mukherjee, 2021; Stankov et al., 2012). Nowadays, teachers use social networking sites to build learning spaces on the Internet (Rambe, 2012; Teo et al., 2018; Vivakaran & Maraimalai, 2019). For example, Facebook facilitates interaction and communication among students during the educational process through discussion, analysis, and reflection (Akcaoglu & Lee, 2018; Mukhlif & Challob, 2021; Rambe & Ngambi, 2014). Within higher education the use of Facebook is growing because this social network improves communication among participants and facilitates the dissemination of learning content (Awidi et al., 2019; Maheshwari & Mukherjee, 2021; Souleles, 2012). For example, Salas-Rueda et al. (2018) used Facebook to facilitate the assimilation of knowledge about computational mathematics, increase motivation, and develop the technological skills of the students.

Escobar-Rodriguez et al. (2014) explain that the incorporation of the social networks in education allows the creation of fun, useful, and entertaining spaces for learning. The use of Facebook has been shown to improve the teaching-learning conditions through the dissemination of digital resources, sending of comments, transmission of information, and fostering of communication among participants within the educational process (Mukhlif & Challob, 2021; Rambe, 2012).

Thai et al. (2019) point out that the use of Facebook in the teaching-learning process improves the academic performance of students and relationships among participants. This social network has been shown to increase the satisfaction of the students during educational activities (Akcaoglu & Lee, 2018; Akhmadieva et al., 2020; Sarapin & Morris, 2015). Therefore, this quantitative study aims to analyze the impact of Facebook in the teaching-learning process in financial mathematics education, using data science (decision tree technique), machine learning (linear regression), and neural networks. The research questions are:

- What is the impact of Facebook in the teaching-learning process in financial mathematics education when Facebook is used to send messages, watch instructional videos, and publish cation of exercises?
- What predictive models emerge from examining the use of Facebook in the teaching-learning process in financial mathematics education?
- What is the impact of sending messages, watching instructional videos, and publishing exercises through Facebook in the process of assimilating knowledge and developing mathematical skills?

Social Networks in Education

Social networks are acquiring a fundamental role during educational activities because these technological and communication tools facilitate the development of skills (Arteaga-Sánchez et al., 2014; Callaghan & Fribbance, 2016; Demiraslan-Cevik, et al., 2014). For example, Facebook allows the construction of educational spaces that facilitate communication and the dissemination of information (Demiraslan-Cevik et al., 2014; Maheshwari & Mukherjee, 2021; Teo et al., 2018). Interactive web tools are transforming communication during teaching and learning activities (Elverici, 2020; Hershkovitz & Forkosh-Baruch, 2019; Staines & Lauchs, 2013). Teachers use social networks to share learning content such as videos, images, readings, and presentations (Akhmadieva et al., 2020; Staines & Lauchs, 2013). Facebook is a support tool that allows collaboration among students and teachers (Awidi et al., 2019; Kent, 2016; Toker & Baturay, 2019).

The advantages of using Facebook in educational contexts include fostering communication among participants, extending the teaching-learning process outside the classroom, and enhancing participation of the students (Awidi et al., 2019; Llorens & Capdeferro, 2011; Mukhlif & Challob, 2021; Ngussa et al., 2020; Souleles, 2012). For example, students use Facebook's chat feature to communicate with their teachers and peers (Escobar-Rodriguez et al., 2014). Social networks facilitate interaction, foster collaborative work, and encourage active roles for the students (Mukhlif & Challob, 2021; Toker & Baturay, 2019).

Several authors (e.g., Ngussa et al., 2020; Souleles, 2012; Staines & Lauchs, 2013) have used Facebook during the teaching-learning process. Souleles (2012) used Facebook as a support tool in Graphic Design education, with the purpose of facilitating the assimilation of knowledge and improving communication among students. In the same way, Vivian et al. (2014) used this social network at the higher education level to promote the discussion of the topics, facilitate the sending of tasks, and consult on the learning content. Salmon et al. (2015) observed improvements in the academic performance of students through learning activities using Facebook and the use of a massive open online course (MOOC). Finally, Staines and Lauchs (2013) facilitated the assimilation of knowledge and the development of skills through the dissemination of learning materials via Facebook.

Social networks improve teaching-learning conditions through fostering interaction among students and teachers on the Internet, allowing communication from anywhere, and facilitating

consultation regarding learning content at any time (Elverici, 2020; Escobar-Rodriguez et al., 2014; Ramadan, 2017).

Method

The aim of this quantitative research is to analyze the impact of Facebook in the teaching-learning process in financial mathematics education, using data science, machine learning, and neural networks.

Participants

Study participants consisted of 46 students – 20 men (43.48%) and 26 women (56.52%) – enrolled in a single financial mathematics course at one Mexican university during the 2017 school year. Participants were pursuing a Bachelor's degree in administration (n = 20, 43.48%), commerce (n = 16, 34.78%), or marketing (n = 10, 21.74%). This third semester course belongs to the common core of the Faculty of Business at La Salle University.

Procedure

For six weeks, the students used Facebook in the process of learning about the topics of simple and compound interest. The students of administration, commerce, and marketing used this social network to send messages, watch instructional videos, and publish exercises on Facebook.

The research hypotheses on the use of Facebook in the educational process and assimilation of knowledge are:

- Hypothesis 1 (H1): The assimilation of knowledge through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education.
- Hypothesis 2 (H2): The assimilation of knowledge through the watching of instructional videos on Facebook positively influences the teaching-learning process in financial mathematics education.
- Hypothesis 3 (H3): The assimilation of knowledge through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education.

The research hypotheses about the use of Facebook in the educational process and development of mathematical skills are:

- Hypothesis 4 (H4): The development of mathematical skills through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education.
- Hypothesis 5 (H5): The development of mathematical skills through the watching of instructional videos on Facebook positively influences the teaching-learning process in financial mathematics education.

- Hypothesis 6 (H6): The development of mathematical skills through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education.

The predictive models on the use of Facebook in the educational process and assimilation of knowledge were trained on the following:

- Predictive Model 1: The sending of messages through Facebook, assimilating knowledge, and teaching-learning process in financial mathematics education.
- Predictive Model 2: The watching of instructional videos on Facebook, assimilation of knowledge, and teaching-learning process in financial mathematics education.
- Predictive Model 3: The publication of exercises on Facebook, assimilation of knowledge, and teaching-learning process in financial mathematics education.

On the other hand, the predictive models about the use of Facebook in the educational process and development of mathematical skills were trained on the following:

- Predictive Model 4: The sending of messages on Facebook, development of mathematical skills, and teaching-learning process in financial mathematics education.
- Predictive Model 5: The watching of instructional videos on Facebook, development of mathematical skills, and teaching-learning process in financial mathematics education.
- Predictive Model 6: The publication of exercises on Facebook, development of mathematical skills, and teaching-learning process in financial mathematics education.

Data Analysis

The RapidMiner tool allows for linear regression (machine learning technique) with 60% (n = 28 students), 70% (n = 32 students), and 80% (n = 37 students) of training to evaluate the use of Facebook in the teaching-learning process in financial mathematics education. Also, this software allows the construction of the predictive models through the decision tree technique (Salas-Rueda, 2021; Salas-Rueda et al., 2021).

Finally, the RapidMiner tool allows for identifying which aspects of Facebook (sending of messages, watching of instructional videos, and publication of exercises) influence the teaching-learning process in financial mathematics education through the neural network technique.

Data Collection

Table 1 shows the measurement instrument (questionnaire) used to collect the data during the 2017 school year. The response scale used in the questionnaire includes the categories of too much (1), much (2), little (3), and very little (4) to apply data science techniques (machine learning, decision tree and neural network).

Results

The independent variables are assimilation of knowledge and development of mathematical skills and the dependent variable is teaching-learning process. The Student Profile variable is used to create the predictive models through the decision tree technique.

Table 1

Questionnaire

Variable	Dimension	Question	Answer	n	%
Student profile	Sex	1. Indicate your sex	Man	20	43.48%
			Woman	26	56.52%
	Bachelor's degree	2. Indicate your Bachelor's degree type	Administration	20	43.48%
			Commerce	16	34.78%
			Marketing	10	21.74%
	Age	3. Indicate your age	18 years old	4	8.70%
			19 years old	18	39.13%
			20 years old	14	30.43%
			21 years old	4	8.70%
			22 years old	6	13.04%
			23 years old	0	0.00%
			24 years old	0	0.00%
Assimilation of knowledge	Sending of messages	4. The sending of messages on Facebook facilitates the assimilation of knowledge	Too much	30	65.22%
			Much	13	28.26%
			Little	3	6.52%
			Very little	0	0.00%
	Watching of instructional videos	5. The watching of instructional videos on Facebook facilitates the assimilation of knowledge	Too much	31	67.39%
			Much	13	28.26%
			Little	2	4.35%
			Very little	0	0.00%
	Publication of exercises	6. The publication of exercises on Facebook facilitates the assimilation of knowledge	Too much	34	73.91%
			Much	10	21.74%
			Little	2	4.35%
			Very little	0	0.00%
Development of mathematical skills	Sending of messages	7. The sending of messages on Facebook facilitates the development of mathematical skills	Too much	27	58.70%
			Much	15	32.61%
			Little	4	8.70%
			Very little	0	0.00%
	Watching of instructional videos	8. The watching of instructional videos on Facebook facilitates the development of mathematical skills	Too much	33	71.74%
			Much	9	19.57%
			Little	4	8.70%
			Very little	0	0.00%
	Publication of exercises		Too much	27	58.70%
			Much	17	36.96%

Variable	Dimension	Question	Answer	n	%
		9. The publication of exercises on Facebook facilitates the development of mathematical skills	Little	2	4.35%
			Very little	0	0.00%
Teaching-learning process	Use of Facebook	10. The use of Facebook facilitates the teaching-learning process in financial mathematics education	Too much	21	45.65%
			Much	21	45.65%
			Little	4	8.70%
			Very little	0	0.00%

The assimilation of knowledge and development of mathematical skills through the sending of messages, watching of instructional videos, and publication of exercises on Facebook positively influence the teaching-learning process in financial mathematics education (Table 2).

Table 2

Results of Machine Learning (Linear Regression)

Hypothesis		Training	Linear regression	Conclusion
H1:	Assimilation of knowledge through the sending of messages on Facebook → teaching-learning process	60%	y = 0.316x + 1.137	Accepted: 0.316
		70%	y = 0.213x + 1.200	Accepted: 0.213
		80%	y = 0.142x + 1.317	Accepted: 0.142
H2:	Assimilation of knowledge through the watching of instructional videos on Facebook → teaching-learning process	60%	y = 0.191x + 1.319	Accepted: 0.191
		70%	y = 0.213x + 1.200	Accepted: 0.213
		80%	y = 0.221x + 1.208	Accepted: 0.221
H3:	Assimilation of knowledge through the publication of exercises on Facebook → teaching-learning process	60%	y = 0.136x + 1.402	Accepted: 0.136
		70%	y = 0.260x + 1.141	Accepted: 0.260
		80%	y = 0.220x + 1.212	Accepted: 0.220
H4:	Development of mathematical skills through the sending of messages on Facebook → teaching-learning process	60%	y = 0.180x + 1.316	Accepted: 0.180
		70%	y = 0.035x + 1.447	Accepted: 0.035
		80%	y = 0.051x + 1.439	Accepted: 0.051
H5:	Development of mathematical skills through the watching of instructional videos on Facebook → teaching-learning process	60%	y = 0.486x + 0.909	Accepted: 0.486
		70%	y = 0.367x + 1.017	Accepted: 0.367
		80%	y = 0.370x + 1.032	Accepted: 0.370
H6:	Development of mathematical skills through the publication of exercises on Facebook → teaching-learning process	60%	y = 0.301x + 1.136	Accepted: 0.301
		70%	y = 0.208x + 1.193	Accepted: 0.208
		80%	y = 0.212x + 1.208	Accepted: 0.212

Assimilation of Knowledge

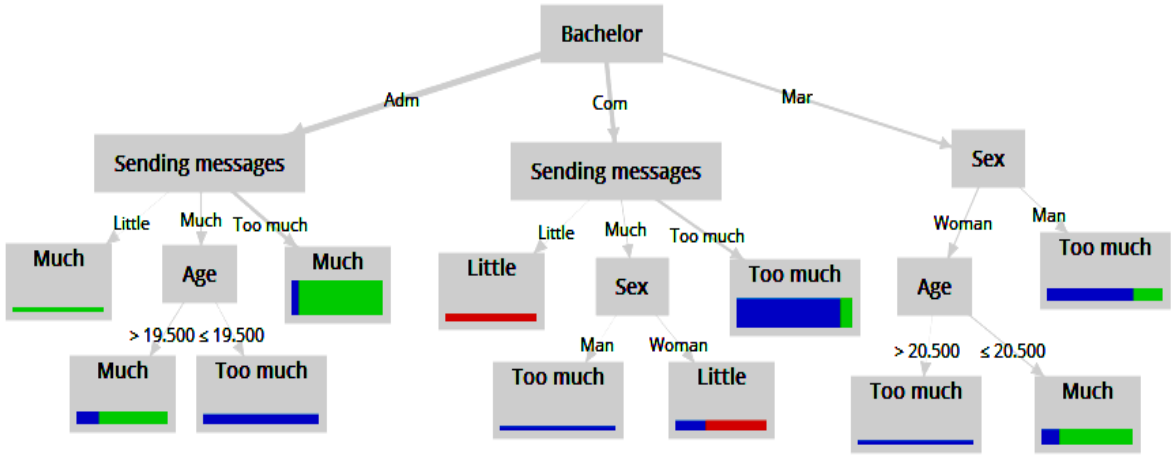
Sending of Messages on Facebook

Table 1 shows that almost two-thirds of participants felt that the sending of messages on Facebook facilitates *too much* the assimilation of knowledge. Also, the results of machine learning indicate that Hypothesis 1 is accepted (Table 2), and therefore, the assimilation of knowledge through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education.

Figure 1 shows the Predictive Model 1 on the use of Facebook in the educational process (accuracy of 86.96%). For example, if the person studies in the Bachelor of Administration and believes that the sending of messages on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *much* the teaching-learning process in financial mathematics education. The decision tree technique identified 11 conditions in the Predictive Model 1 (Figure 1). For example, if the person studies in the Bachelor of Commerce, believes that the sending of messages on Facebook facilitates *much* the assimilation of knowledge and is a man, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

Figure 1

Predictive Model 1 on the Use of Facebook in the Educational Process



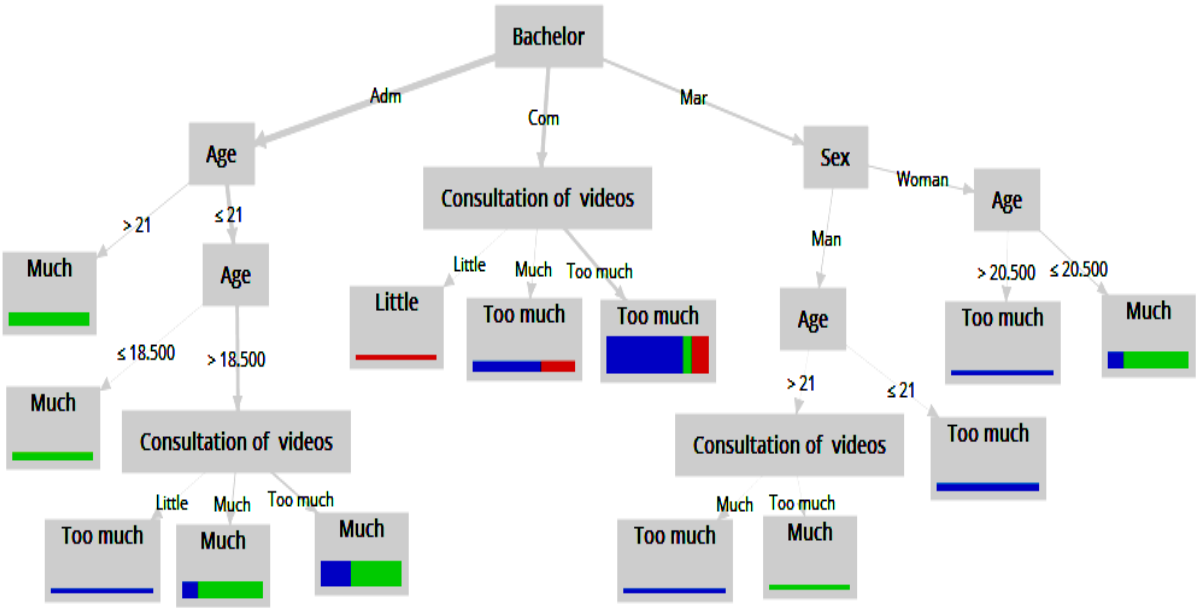
Instructional Videos

Table 1 shows that more than two-thirds of participants felt that the watching of instructional videos on Facebook facilitates *too much* the assimilation of knowledge. Also, the results of machine learning indicate that Hypothesis 2 is accepted (Table 2). Therefore, the assimilation of knowledge through the watching of instructional videos on Facebook positively influences the teaching-learning process in financial mathematics education.

Figure 2 shows the Predictive Model 2 on the use of Facebook in the educational process (accuracy of 80.43%). For example, if the person studies in the Bachelor of Marketing, is a man, is older than 21 years, and believes that the watching of instructional videos on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *much* the teaching-learning process in financial mathematics education. The decision tree technique identified 13 conditions in the Predictive Model 2 (Figure 2). For example, if the person studies in the Bachelor of Commerce and believes that the watching of instructional videos on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

Figure 2

Predictive Model 2 on the Use of Facebook in the Educational Process



Publication of Exercises

Table 1 shows that almost three-quarters of participants felt that the publication of exercises on Facebook facilitates *too much* the assimilation of knowledge. Also, the results of machine learning indicate that Hypothesis 3 is accepted (Table 2). Therefore, the assimilation of knowledge through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education.

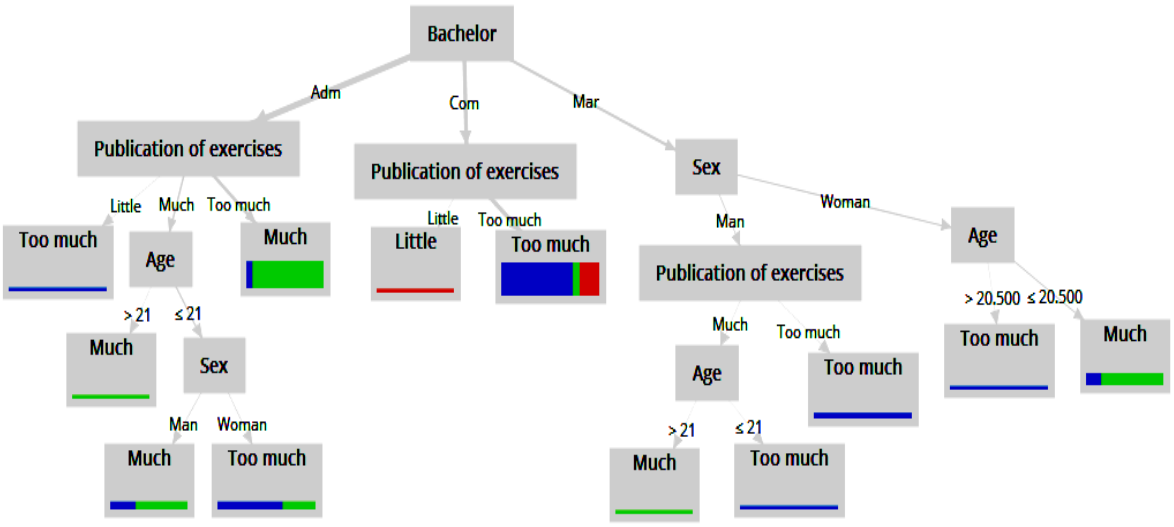
Figure 3 shows the Predictive Model 3 on the use of Facebook in the educational process (accuracy of 82.61%). For example, if the person studies in the Bachelor of Commerce and believes that the publication of exercises on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The decision tree technique identified 12 conditions in the Predictive Model 3 (Figure 3). For example, if the person studies in the Bachelor of Marketing, is a man, and believes that the publication of exercises on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

Finally, the neural network indicates that the sending of messages (0.068), watching of instructional videos (0.220), and publication of exercises (0.484) on Facebook positively influence the assimilation of knowledge in financial mathematics education. In fact, the most significant factor is the publication of exercises on Facebook.

Figure 3

Predictive Model 3 on the Use of Facebook in the Educational Process



Development of Mathematical Skills

Sending of Messages on Facebook

Table 1 shows that more than half of participants felt that the sending of messages on Facebook facilitates *too much* the development of mathematical skills. Also, the results of machine learning indicate that Hypothesis 4 is accepted (Table 2). Therefore, the development of mathematical skills through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education.

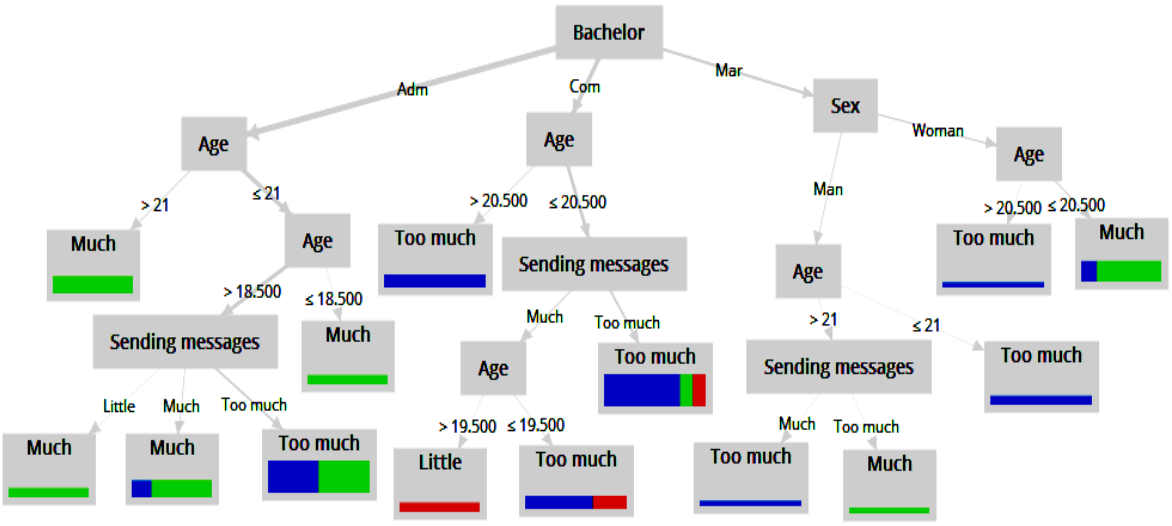
Figure 4 shows the Predictive Model 4 on the use of Facebook in the educational process (accuracy of 80.43%). For example, if the person studies in the Bachelor of Commerce, has an age ≤ 19.5 years, and believes that the sending of messages on Facebook facilitates *much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The decision tree technique identified 14 conditions in the Predictive Model 4 (Figure 4). For example, if the person studies in the Bachelor of Marketing, is a man, is older than 21 years, and believes that the sending of messages on Facebook facilitates *much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The decision tree technique identified 14 conditions in the Predictive Model 4 (Figure 4). For example, if the person studies in the Bachelor of Marketing, is a man, is older than 21 years, and believes that the sending of messages on Facebook facilitates *much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

Figure 4

Predictive Model 4 on the Use of Facebook



Watching of Instructional Videos

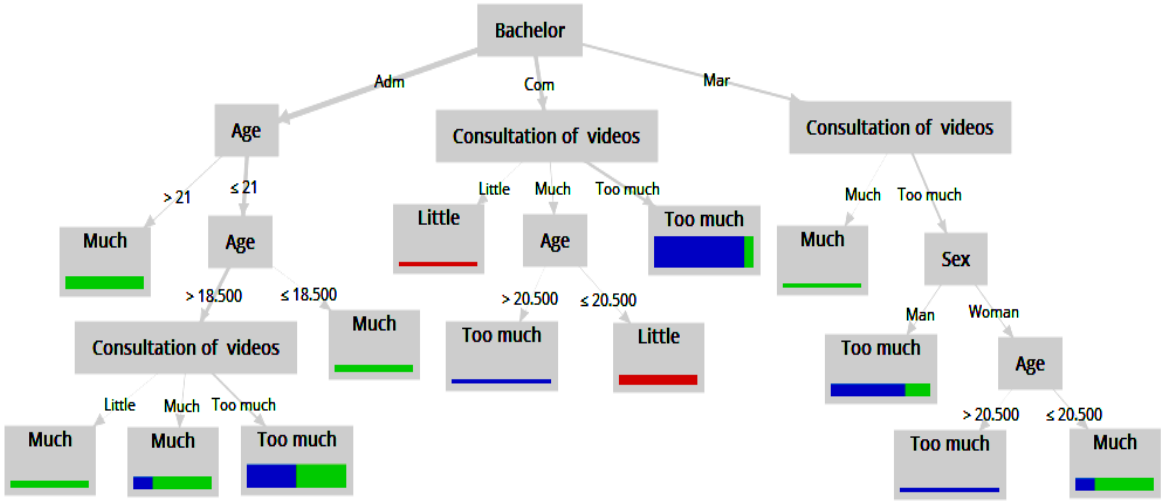
Table 1 shows that almost three-quarters of participants felt that the watching of instructional videos on Facebook facilitates *too much* the development of mathematical skills. Also, the results of machine learning indicate that Hypothesis 5 is accepted (Table 2). Therefore, the development of mathematical skills through the watching of instructional videos on Facebook positively influences the teaching-learning process in financial mathematics education.

Figure 5 shows the Predictive Model 5 on the use of Facebook in the educational process (accuracy of 82.61%). For example, if the person studies in the Bachelor of Commerce and believes that the watching of instructional videos on Facebook facilitates *too much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The decision tree technique identified 13 conditions in the Predictive Model 5 (Figure 5). For example, if the person studies in the Bachelor of Marketing, believes that the watching of instructional videos on Facebook facilitates *too much* the development of mathematical skills and is man, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

Figure 5

Predictive Model 5 on the Use of Facebook



Publication of Exercises

Table 1 shows that more than half of participants felt that the publication of exercises on Facebook facilitates *too much* the development of mathematical skills. Also, the results of machine learning indicate that Hypothesis 6 is accepted (Table 2). Therefore, the development of mathematical skills through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education.

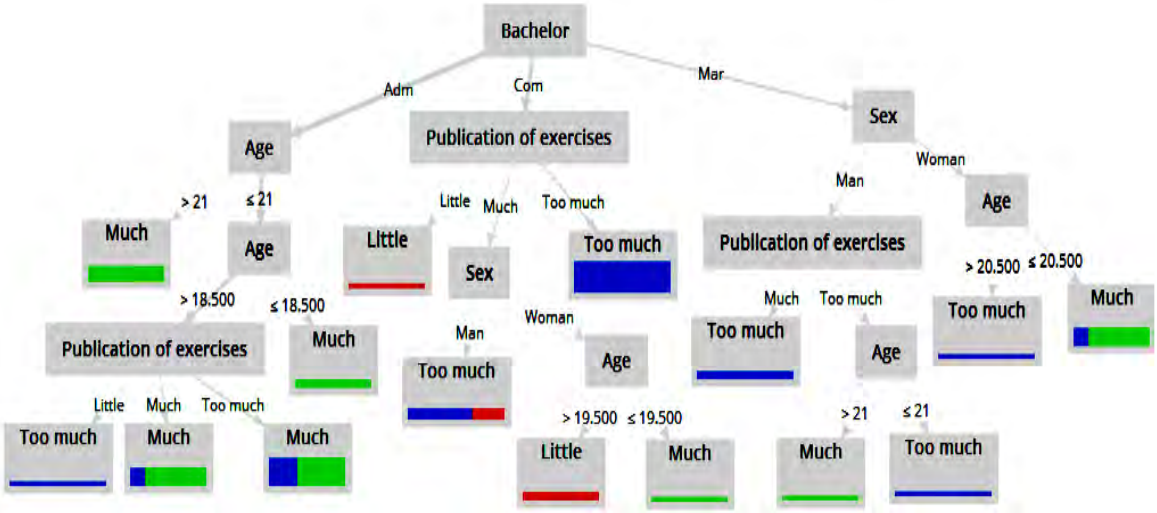
Figure 6 shows the Predictive Model 6 on the use of Facebook in the educational process (accuracy of 86.96%). For example, if the person studies in the Bachelor of Commerce and believes that the publication of exercises on Facebook facilitates *too much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The decision tree technique identified 15 conditions in the Predictive Model 6 (Figure 6). For example, if the person studies in the Bachelor of Marketing, is a man, believes that the publication of exercises on Facebook facilitates *too much* the development of mathematical skills, and is older than 21 years, then the use of Facebook facilitates *much* the teaching-learning process in financial mathematics education.

Finally, the neural network indicates that the sending of messages (0.379), watching of instructional videos (1.000), and publication of exercises (1.000) on Facebook have a positive influence on the development of mathematical skills. In fact, the most significant factors are the watching of instructional videos and the publication of exercises on Facebook.

Figure 6

Predictive Model 6 on the Use of Facebook



Discussion

Social networks are transforming educational activities and practices in the 21st century (Callaghan & Fribbance, 2016; Thai et al., 2019; Vivakaran & Maraimalai, 2019). This quantitative research proposes the sending of messages, watching of instructional videos, and publication of exercises on Facebook to improve the teaching-learning process in financial mathematics education. Facebook is a social network that allows building virtual spaces for teaching and learning (Awidi et al., 2019; Sarapin & Morris, 2015; Teo et al., 2018).

Assimilation of Knowledge

The sending of messages, watching of instructional videos, and publication of exercises on Facebook was observed to facilitate *too much* the assimilation of knowledge. The results shown through machine learning demonstrate that the assimilation of knowledge through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education. Data science identified 11 conditions in the Predictive Model 1 with the accuracy of 86.96%. For example, if the person studies in the Bachelor of Administration and believes that the sending of messages on Facebook facilitates too *much* the assimilation of knowledge, then the use of Facebook facilitates *much* the teaching-learning process in financial mathematics education.

Facebook allows improving the teaching-learning conditions through the watching of instructional videos (Ramadan, 2017; Toker & Baturay, 2019). The results shown through machine learning demonstrate that the assimilation of knowledge through the watching of instructional videos on Facebook positively influences the teaching-learning process on financial mathematics. The decision tree technique identified 13 conditions in the Predictive Model 2 with the accuracy of 80.43%. For example, if the person studies in the Bachelor of Marketing, is a man, is older than 21 years, and

believes that the watching of instructional videos on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *much* the teaching-learning process in financial mathematics education.

Likewise, social networks facilitate the implementation of the educational activities through the publication of various digital resources (Awidi et al., 2019; Kent, 2016; Toker & Baturay, 2019). The results shown through machine learning demonstrate that the assimilation of knowledge through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education. Data science identified 12 conditions in the Predictive Model 3 with the accuracy of 82.61%. For example, if the person studies in the Bachelor of Commerce and believes that the publication of exercises on Facebook facilitates *too much* the assimilation of knowledge, then the use of Facebook facilitates *too much* the teaching-learning process on financial mathematics.

The above observations are supported by the neural network results, which indicate that the sending of messages, watching of instructional videos, and publication of exercises on Facebook positively influence the assimilation of knowledge about financial mathematics. The most significant factor observed is the publication of exercises on Facebook.

Development of Mathematical Skills

Several authors (e.g., Barden, 2014; Chou et al., 2019; Thai et al., 2019) mention that social networks foster the development of skills. In this study, the sending of messages, watching of instructional videos, and publication of exercises on Facebook were observed to facilitate *too much* the development of mathematical skills. The results shown through machine learning demonstrates that the development of mathematical skills through the sending of messages on Facebook positively influences the teaching-learning process in financial mathematics education. Data science identified 14 conditions in the Predictive Model 4 with the accuracy of 80.43%. For example, if the person studies in the Bachelor of Commerce, has an age $\leq$ 19.5 years, and believes that the sending of messages on Facebook facilitates *much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The results shown through machine learning demonstrate that the development of mathematical skills through the watching of instructional videos on Facebook positively influences the teaching-learning process in financial mathematics education. The decision tree technique identified 13 conditions in the Predictive Model 5 with the accuracy of 82.61%. For example, if the person studies in the Bachelor of Commerce and believes that the watching of videos on Facebook facilitates *too much* the development of mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

The results shown through machine learning demonstrate that the development of mathematical skills through the publication of exercises on Facebook positively influences the teaching-learning process in financial mathematics education. Data science identified 15 conditions in the Predictive Model 6 with the accuracy of 86.96%. For example, if the person studies in the Bachelor of Commerce and believes that the publication of exercises on Facebook facilitates *too much* the development of

mathematical skills, then the use of Facebook facilitates *too much* the teaching-learning process in financial mathematics education.

These observations relating to development of mathematical skills are supported by neural network results that indicate the sending of messages, watching of instructional videos, and publication of exercises on Facebook have a positive influence on the development of mathematical skills. The most significant factors observed are the watching of instructional videos and publication of exercises on Facebook.

Social networks facilitate educational activities that improve conditions for 21st Century teaching and learning (Akcaoglu & Lee, 2018). Facebook, for example, is an ideal tool for the education because this social network allows communication among the participants during the teaching-learning process at any time and place (Kent, 2016).

Conclusion

Social networks facilitate creative educational activities. Sending messages, watching instructional videos, and publishing exercises on Facebook foster the assimilation of knowledge and development of mathematical skills. Results observed through machine learning indicate that Facebook support the teaching-learning process in financial mathematics education. Likewise, analyses using neural networks identified that the publication of exercises on Facebook significantly influence the assimilation of knowledge and development of mathematical skills. This research supports the incorporation of social networks in educational activities.

The limitations of this quantitative study are related to the use of Facebook and analysis of the students' perceptions about the impact of this social network in their financial mathematics course within a higher education context. Therefore, future research may analyze the effect of other social networks, such as Twitter, in the middle schools, high schools, and universities. Likewise, researchers may analyze the incorporation of Facebook in courses in other disciplines, such as business, engineering, medicine, and chemistry, considering the motivation and satisfaction of the students observed in this study.

The implications of this study encourage the use of technological and communication tools such as social networks during the teaching-learning process to facilitate the assimilation of knowledge and development of mathematical skills. Finally, Facebook allows for innovative educational activities through the sending of messages, watching of instructional videos, and publication of exercises.

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