IMPACT OF THE WEB APPLICATION FOR THE EDUCATIONAL PROCESS ON THE COMPOUND INTEREST CONSIDERING DATA SCIENCE

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ABSTRACT

This quantitative research analyzes the impact of the Web Application for the Educational Process on Compound Interest (WAEPCI) considering the machine learning and data science. The sample is composed of 46 students who studied the Financial Mathematics course in a Mexican university during the 2017 school year. WAEPCI presents the calculation of the Compound Interest and Compound Amount over a period of four years through the data simulation. The results of the machine learning (linear regression) indicate that WAEPCI positively influences the assimilation of knowledge and development of mathematical skills on the Compound Interest and Compound Amount. Data science establishes 4 predictive models on the use of WAEPCI in the educational process by means of the decision tree technique. The construction of web applications facilitates the active role of students, improves the assimilation of knowledge and allows the development of skills. Finally, WAEPCI improves the teaching-learning conditions on Financial Mathematics through the data simulation.

Keywords: Technology, higher education, web application, machine learning, data science.

INTRODUCTION

Technology is transforming the planning and organization of school activities through the construction and use of virtual spaces for learning and teaching (Gezgin, 2019; Mishra & Iyer, 2015; Yeoman & Ashmore, 2018). In particular, Information and Communication Technologies (ICT) are modifying the behavior of teachers and students during the educational process (Blaine, 2019; Lee, Yeung & Cheung, 2019; Mei & May, 2018).

Educational institutions must update pedagogical strategies through digital tools in order to meet the needs and demands of students (Carvalho & Yeoman, 2018; Rooney & Nystrom, 2018; Zeivots & Schuck, 2018). The use of technology such as videos, audiovisual contents and digital tools allows achieving the active role of students during the learning process (Le & Pinkwart, 2015).

Young teachers are more frequently using technological tools in the educational process because these individuals have developed digital skills (Ayale-Perez & Joo-Nagata, 2019). For example, Facebook improved communication and participation among students through the dissemination of school activities (Salas-Rueda & Salas-Rueda, 2019).

In fact, the incorporation of web applications in the classroom positively influences the teaching-learning process (Jack & Higgins, 2019; Scardamalia & Bereiter, 2014). Due to technological advances, teachers have the possibility to use a wide variety of educational applications on the Internet (Hughes & Dobbins, 2015; Marcel, 2019; Spector, 2014). For example, interactive multimedia systems and mobile applications favor the active role of students during the learning process (Bdiwi, Runz, Faiz, & Cherif, 2019).

One of the educational challenges in the 21st century is the creation of virtual spaces to improve teaching-learning conditions (Bidarra & Rusman, 2017; Doney, 2019). Therefore, this quantitative research proposes the construction of WAEPCI to improve teaching-learning conditions on financial mathematics.

The research questions are:

- What is the impact of WAEPCI on the assimilation of knowledge and development of mathematical skills on Compound Interest and Compound Amount?
- What are the predictive models on the use of WAEPCI in the teaching-learning process?

WEB APPLICATIONS IN THE EDUCATIONAL FIELD

The educational institutions are modifying the curricula in order to develop the competences of students through the technological tools (Herodotou, Heiser, & Rienties, 2017; Marshalsey & Sclater, 2018). In particular, universities face the challenge of improving the teaching-learning conditions through the construction of new virtual spaces (Marcel, 2019; Wang & Wang, 2017).

Web applications positively influence the participation of students during the educational process and encourage new ways to achieve the learning (Blaine, 2019; Zeivots & Schuck, 2018). In particular, Bdiwi, Runz, Faiz and Cherif (2019) propose to improve the educational process through the use of sensors, smart devices, web applications and Internet services.

The digital tools facilitate the planning and realization of educational activities centered on students (Mei & May, 2018). In fact, Internet is changing the functions and roles of teachers through the sending and receiving of information on the network (Ramadan, 2016).

Use and Construction of Web Applications

The design and construction of web applications is changing the way of carrying out the school activities (Mei & May, 2018). In particular, Salas-Rueda, Salas-Rueda, Salas-Rueda and Vargas-Perez (2019) designed a web application to facilitate the assimilation of knowledge during the educational process of statistics. Likewise, Noguchi, Kogure, Konishi and Itoh (2015) built an intelligent tutoring system called Intelligent Practice Supporting System (IPSS) with the purpose of improving the teaching-learning conditions in chemistry courses through the personalization of the contents.

The use of web applications in the educational field increases the motivation of students during the performance of the school activities (Zeivots & Schuck, 2018). For example, Salas-Rueda and Salas-Silis (2018) used the Logic.ly simulator in the classroom in order to facilitate the educational process on mathematics and increase motivation of the students.

Several authors (e.g., Gauthier & Jenkinson, 2018; Ke, 2014; Yeh, Chang & Chen, 2019) have built web applications to facilitate the teaching-learning process. Yeh, Chang and Chen (2019) built a digital game to improve educational conditions through interaction, rewards and feedbacks. In the field of biology, Gauthier and Jenkinson (2018) designed and implemented a web application to improve the assimilation of knowledge and development of skills about molecular environments.

Daradoumis, Marques-Puig, Arguedas and Calvet-Liñan (2019) designed a web tool to improve the performance of students in the field of information technology through the personalization of content. Also, Ke (2014) built an application to facilitate the teaching-learning process about mathematics at the basic educational level.

Finally, technology is modifying the activities carried out in formal and informal education contexts (Chorana, Lakhdari, Cherroun, & Oulad-Naoui, 2015). For example, the creation of web applications facilitates the assimilation of knowledge, allows the development of skills and increases the motivation of students during the learning process (Gauthier & Jenkinson, 2018; Yeh, Chang, & Chen, 2019).

METHOD

This quantitative research aims to analyze the impact of WAEPCI in the teaching-learning process about Financial Mathematics through the machine learning and data science. WAEPCI presents the calculation of the Compound Interest and Compound Amount over a period of four years by means of the data simulation.

Participants

The sample consists of 46 students who studied the Financial Mathematics course in a Mexican university during the 2017 school year. The participants, 26 women and 20 men, attended the careers of Administration (n=20, 43.48%), Marketing (n= 10, 21.74%) and Commerce (n=16, 34.78%).

Procedure

The procedure began with the design and construction of WAEPCI through the PHP programming language. Figure 1 shows the data requested by WAEPCI (Capital and Interest rate).

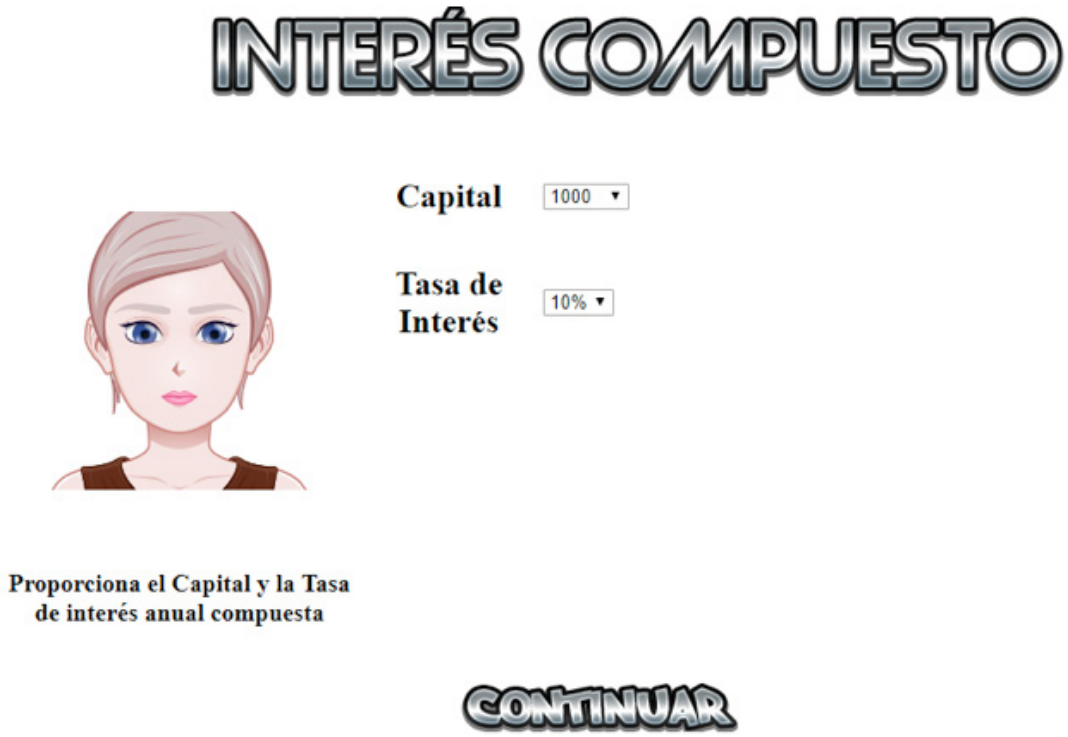

Figure 1. Homepage of WAEPCI

WAEPCI is available at the following web address: http://sistemasusables.com/matfin/sistema1/inicio.html

Figure 2 shows the data simulation of the Compound Interest and Compound Amount in WAEPCI for the year 1.

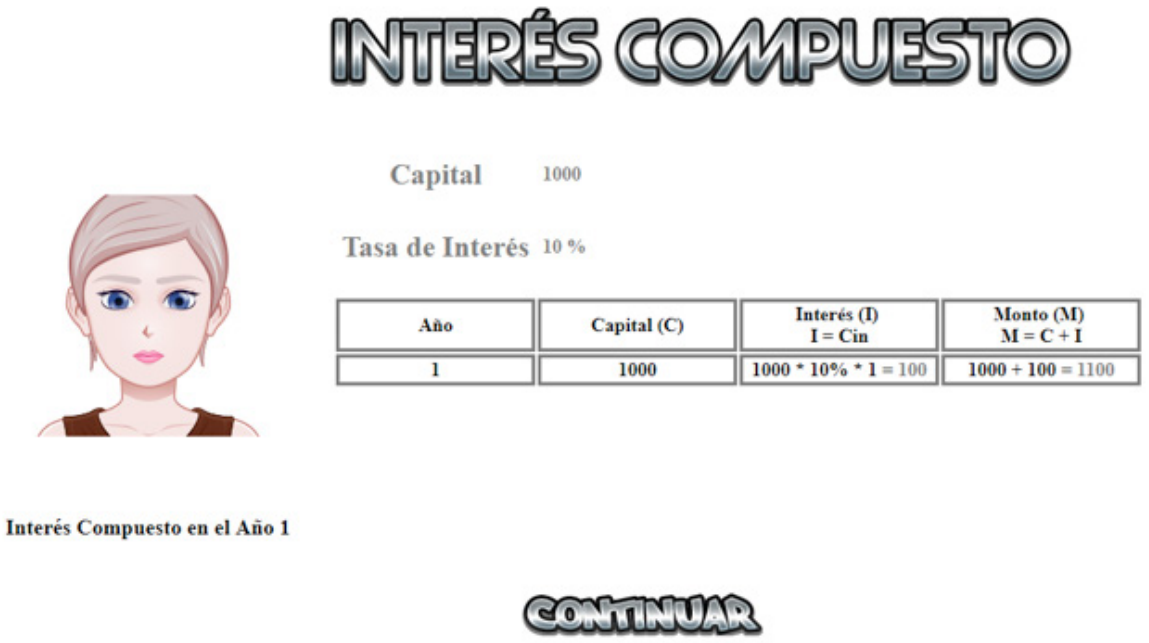

Figure 2. Compound Interest and Compound Amount in WAEPCI for the year 1

WAEPCI presents the calculation of the Compound Interest and Compound Amount for the year 2.

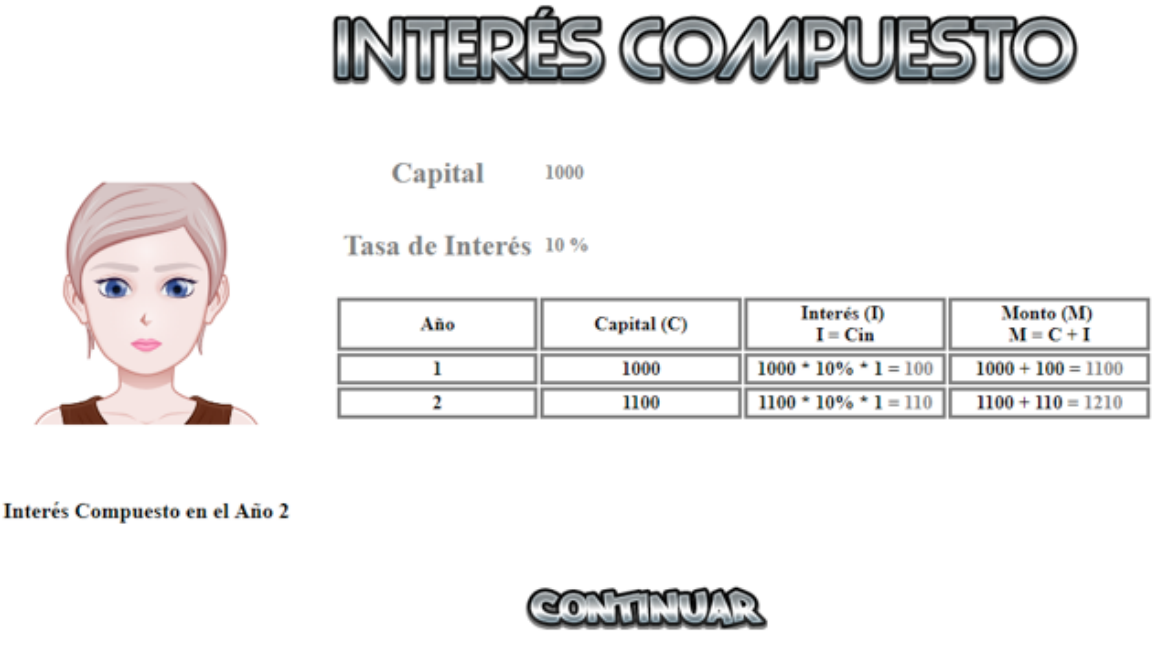

Figure 3. Compound Interest and Compound Amount in WAEPCI for the year 2

WAEPCI presents the data simulation on the Compound Interest and Compound Amount for the year 3 (See Figure 4).

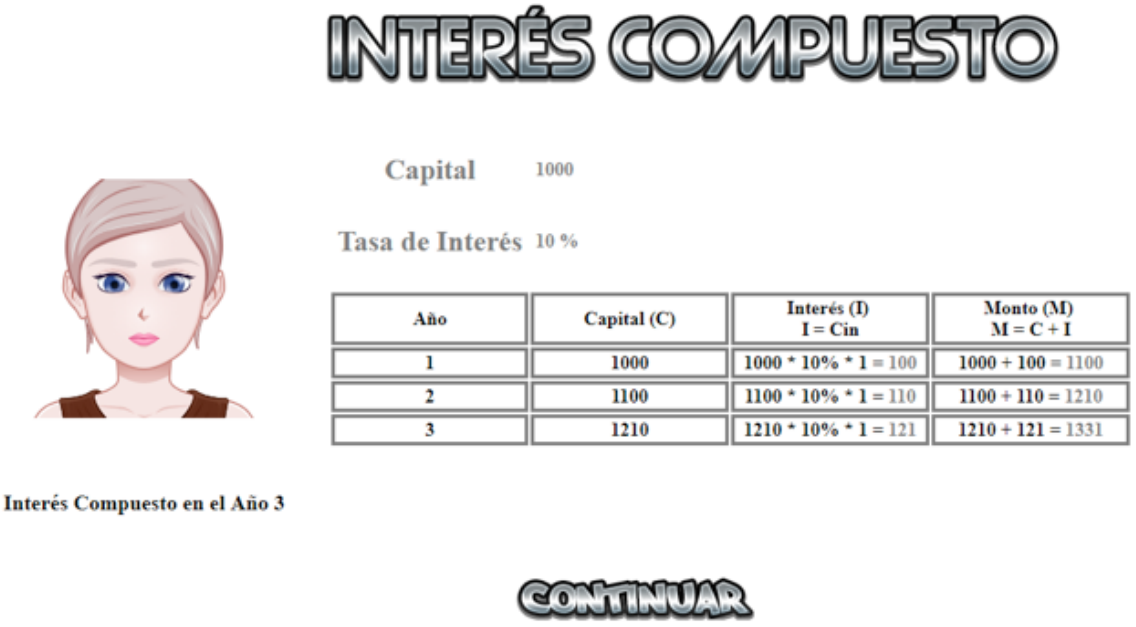

Figure 4. Compound Interest and Compound Amount in WAEPCI for the year 3

Finally, Figure 5 shows the calculation of the Compound Interest and Compound Amount in WAEPCI for the year 4.

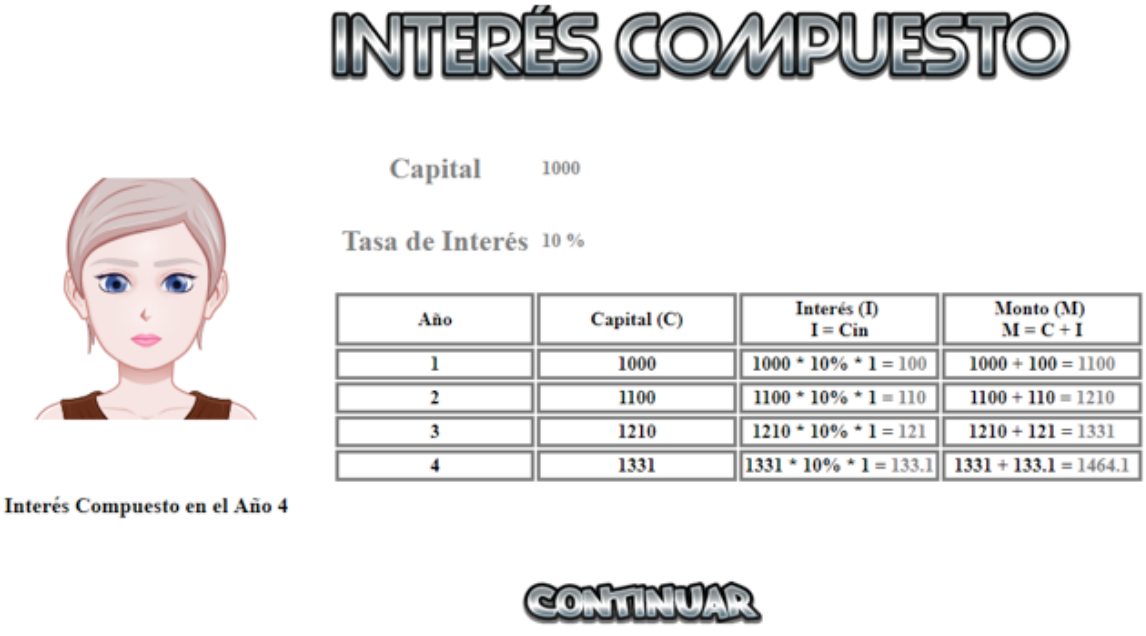

Figure 5. Compound Interest and Compound Amount in WAEPCI for the year 4

Figure 6 shows the technological acceptance model used in this quantitative research.

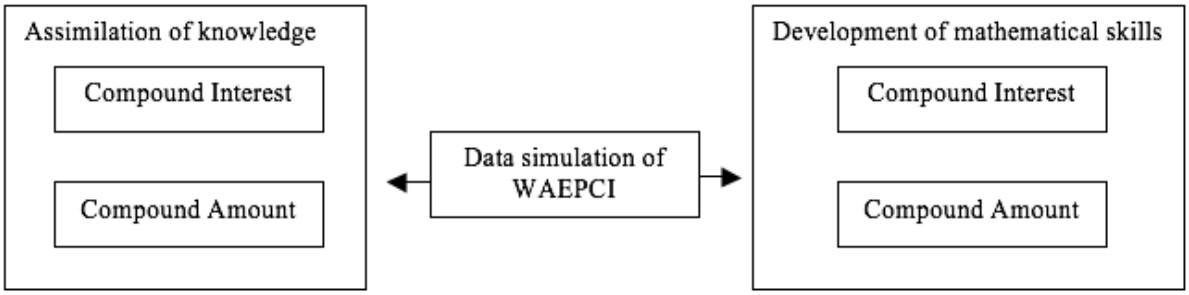

Figure 6. Technological acceptance model of WAEPCI

The research hypotheses about the impact of WAEPCI in the teaching-learning process are:

- Hypothesis 1 (H1): Data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Interest
- Hypothesis 2 (H2): Data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Amount
- Hypothesis 3 (H3): Data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Interest
- Hypothesis 4 (H4): Data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Amount

Information about the career, age, sex of the students, data simulation of WAEPCI and the teaching-learning process is used during the construction of the predictive models (decision tree technique).

The predictive models on the use of WAEPCI in the teaching-learning process are:

- Predictive model 1 on WAEPCI and assimilation of knowledge (Compound Interest)
- Predictive model 2 on WAEPCI and assimilation of knowledge (Compound Amount)
- Predictive model 3 on WAEPCI and development of mathematical skills (Compound Interest)
- Predictive model 4 on WAEPCI and development of mathematical skills (Compound Amount)

Data Analysis

The Rapidminer tool allows the calculation of the machine learning (linear regression) and construction of the predictive models by means of the decision tree technique (data science). Machine learning uses the training section to calculate the linear regressions and evaluate the hypotheses of this research, that is, 50% (n = 23 students), 60% (n = 27 students) and 70% (n = 32 students) of the sample allow knowing the impact of WAEPCI in the teaching-learning process. On the other hand, the evaluation section with 50% (n = 23 students), 40% (n = 19 students) and 30% (n = 14 students) of the sample allows identifying the accuracy of these linear regressions by means of the calculation on the squared error. (See Figure 7).

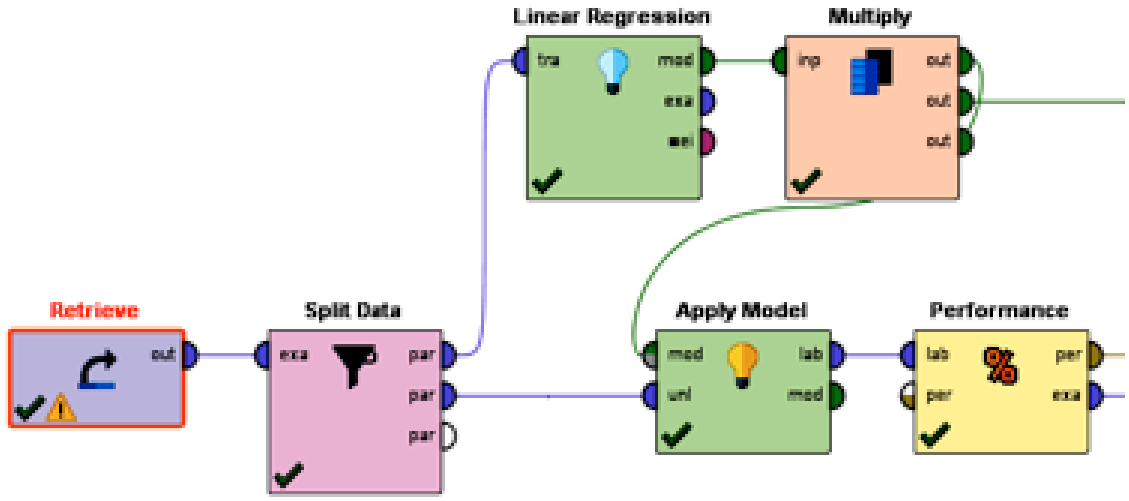

Figure 7. Machine learning in the Rapidminer tool

Figure 8 shows the use of the Rapidminer tool for the construction of predictive models by means of the decision tree technique.

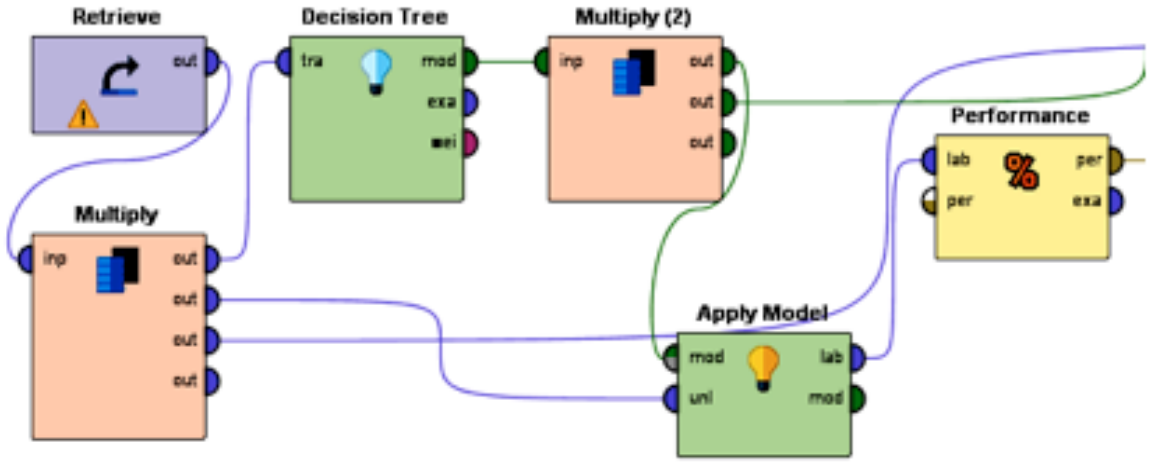

Figure 8. Predictive models in the Rapidminer tool

Data Collection

Table 1 shows the measurement instrument used for the collection of data about the use of WAEPCI in the teaching-learning process.

Table 1. Questionnaire

Variable	Dimension	Question	Answer	n	%
Profile of student	Career	1. Indicate your career			
			Administration	20	43.48%
			Commerce	16	34.78%
			Marketing	10	21.74%
	Sex	2. Indicate your sex			
			Man	20	43.48%
			Woman	26	56.52%
	Age	3. Indicate your age			
			18 years	4	8.70%
			19 years	20	43.48%
			20 years	14	30.43%
			21 years	4	8.70%
			22 years	4	8.70%
			23 years	0	0.00%
			24 years	0	0.00%
WAEPCI	Data simulation	4. Data simulation of WAEPCI is			
			Excellent (1)	30	65.22%
			Good (2)	14	30.43%
			Bad (3)	2	4.35%
Assimilation of knowledge	Compound Interest	5. The use of WAEPCI influences the assimilation of knowledge about the Compound Interest	Too much (1)	29	63.04%
			Much (2)	13	28.26%
			Little (3)	4	8.70%
	Compound Amount	6. The use of WAEPCI influences the assimilation of knowledge about the Compound Amount.	Too much (1)	30	65.22%
			Much (2)	12	26.09%
			Little (3)	4	8.70%
Development of mathematical skills	Compound Interest	7. The use of the WAEPCI influences the development of mathematical skills about the Compound Interest	Too much (1)	38	82.61%
			Much (2)	6	13.04%
			Little (3)	2	4.35%
	Compound Amount	8. The use of WAEPCI influences the development of mathematical skills about the Compound Amount	Too much (1)	31	67.39%
			Much (2)	13	28.26%
			Little (3)	2	4.35%

The data collection was done at the end of the Compound interest unit in the 2017 school year. Also, Cronbach's alpha for the Assimilation of knowledge (0.628) and Development of mathematical skills (0.824) are greater than the value of 0.620.

RESULTS

Data simulation of WAEPCI positively influences the assimilation of knowledge and development of mathematical skills about the Compound Interest and Compound Amount (See Table 2).

Table 2. Results of the machine learning (linear regression)

Hypothesis	Training	Linear regression	Conclusion	Squared error
H1: WAEPCI → Assimilation of knowledge about the Compound Interest	50%	y = 0.886x + 0.250	Accepted: 0.886	0.132
	60%	y = 0.909x + 0.197	Accepted: 0.909	0.163
	70%	y = 0.930x + 0.160	Accepted: 0.930	0.207
H2: WAEPCI → Assimilation of knowledge about the Compound Amount	50%	y = 0.721x + 0.312	Accepted: 0.721	0.215
	60%	y = 0.744x + 0.283	Accepted: 0.744	0.265
	70%	y = 0.743x + 0.360	Accepted: 0.743	0.165
H3: WAEPCI → Development of mathematical skills about the Compound Interest	50%	y = 0.647x + 0.375	Accepted: 0.647	0.179
	60%	y = 0.559x + 0.506	Accepted: 0.559	0.148
	70%	y = 0.677x + 0.360	Accepted: 0.677	0.183
H4: WAEPCI → Development of mathematical skills about the Compound Amount	50%	y = 0.664x + 0.437	Accepted: 0.664	0.209
	60%	y = 0.629x + 0.444	Accepted: 0.629	0.240
	70%	y = 0.693x + 0.400	Accepted: 0.693	0.220

Assimilation of Knowledge

The use of WAEPCI influences too much (n=29, 63.04%), much (n=13, 28.26%) and little (n=4, 8.70%) the assimilation of knowledge about the Compound Interest (See Table 1). Also, the results of machine learning (linear regression) with 50% (0.886), 60% (0.909) and 70% (0.930) of training indicate that hypothesis 1 is accepted (See Table 2). Therefore, data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Interest.

Figure 9 shows the predictive model 1 on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a man and has an age > 19.5 years then the use of WAEPCI influences much the assimilation of knowledge about the Compound Interest.

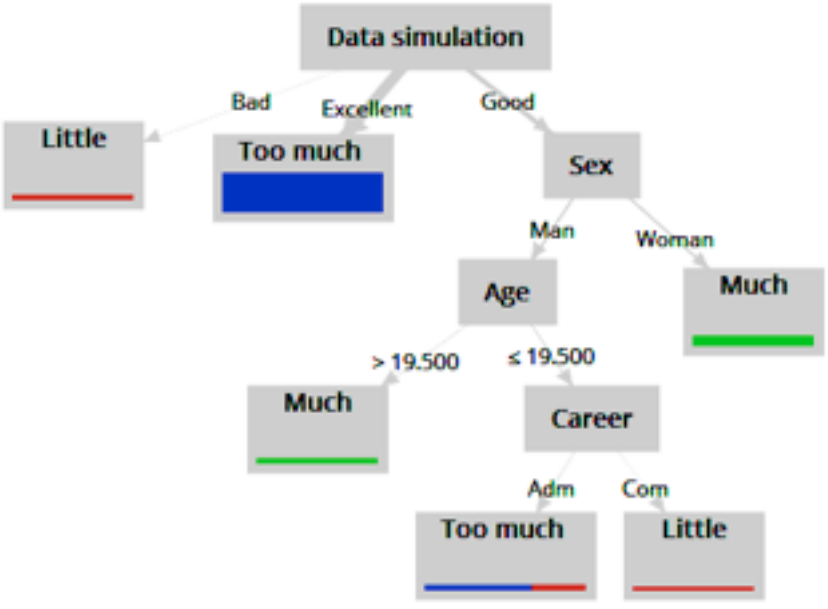

Figure 9. Predictive model 1 on the use of WAEPCI

The predictive model 1 has the accuracy of 97.83% and presents 6 conditions on the use of WAEPCI (See Table 3). For example, if the student considers that data simulation of WAEPCI is good and is a woman then the use of WAEPCI influences much the assimilation of knowledge about the Compound Interest.

Table 3. Conditions of the predictive model 1

No.	Data simulation of WAEPCI	Career	Sex	Age	Assimilation of knowledge (Compound interest)
1	Good	-	Man	> 19.5 years	Much
2	Good	Administration	Man	≤ 19.5 years	Too much
3	Good	Commerce	Man	≤ 19.5 years	Little
4	Good	-	Woman	-	Much
5	Excellent	-	-	-	Too much
6	Bad	-	-	-	Little

The use of WAEPCI influences too much (n=30, 65.22%), much (n=12, 26.09%) and little (n=4, 8.70%) the assimilation of knowledge about the Compound Amount (See Table 1). Also, the results of machine learning with 50% (0.721), 60% (0.744) and 70% (0.743) of training indicate that hypothesis 2 is accepted (See Table 2). Therefore, data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Amount. Figure 10 shows the predictive model 2 on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a woman and takes career of the Administration then the use of WAEPCI influences too much the assimilation of knowledge about the Compound Amount.

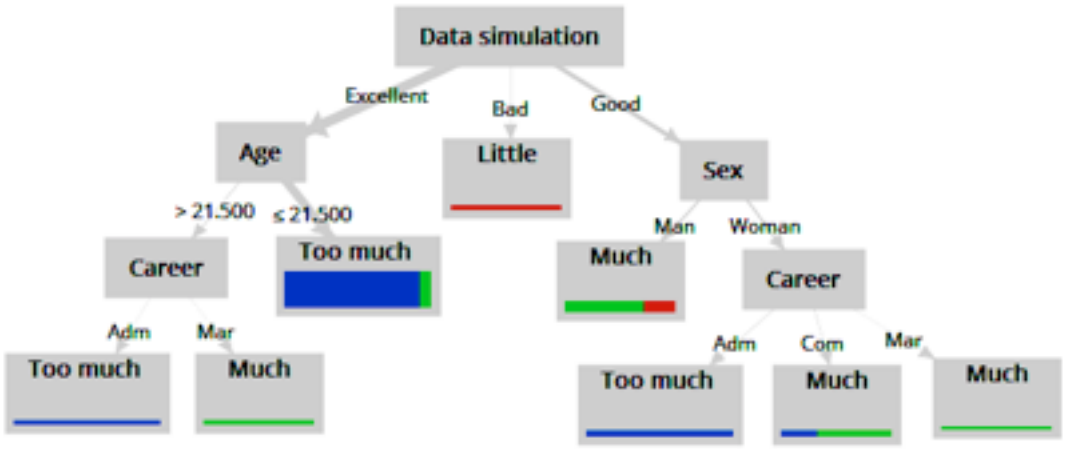

Figure 10. Predictive model 2 on the use of WAEPCI

The predictive model 2 has the accuracy of 89.13% and presents 8 conditions on the use of WAEPCI (See Table 4). For example, if the student considers that data simulation of WAEPCI is good and is a man then the use of WAEPCI influences much the assimilation of knowledge about the Compound Amount.

Table 4. Conditions of the predictive model 2

No.	Data simulation of WAEPCI	Career	Sex	Age	Assimilation of knowledge (Compound Amount)
1	Good	-	Man	-	Much
2	Good	Administration	Woman	-	Too much
3	Good	Commerce	Woman	-	Much
4	Good	Marketing	Woman	-	Much
5	Bad	-	-	-	Little
6	Excellent	Administration	-	> 21.5 years	Too much
7	Excellent	Marketing	-	> 21.5 years	Much
8	Excellent	-	-	≤ 21.5 years	Too much

Development of Mathematical Skills

The use of the WAEPCI influences too much (n=38, 82.61%), much (n=6, 13.04%) and little (n=2, 4.35%) the development of mathematical skills about the Compound Interest (See Table 1). Also, the results of machine learning with 50% (0.647), 60% (0.559) and 70% (0.677) of training indicate that hypothesis 3 is accepted (See Table 2). Therefore, data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Interest.

Figure 11 shows the predictive model 3 on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a woman and takes the career of Commerce then the use of the WAEPCI influences too much the development of mathematical skills about the Compound Interest.

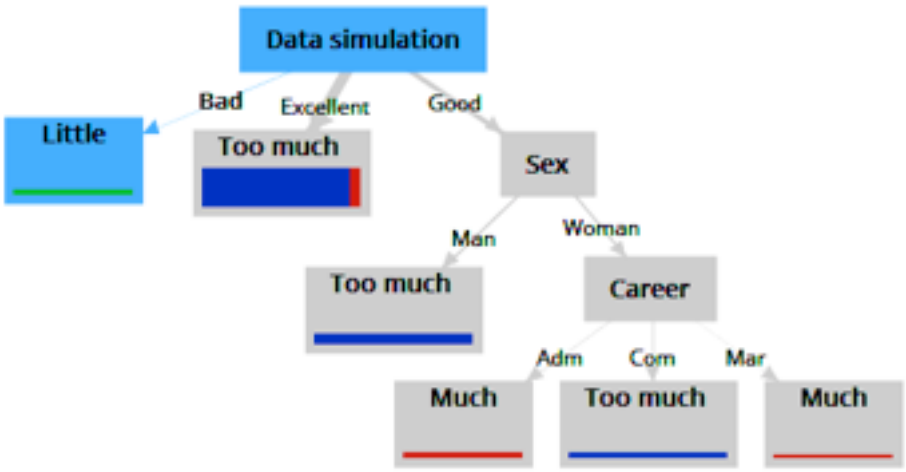

Figure 11. Predictive model 3 on the use of WAEPCI

The predictive model 3 has the accuracy of 95.65% and presents 6 conditions on the use of WAEPCI (See Table 5). For example, if the student considers that data simulation of WAEPCI is good and is man then the use of the WAEPCI influences too much the development of mathematical skills about the Compound Interest.

Table 5. Conditions of the predictive model 3

No.	Data simulation of WAEPCI	Career	Sex	Age	Development of mathematical skills about Compound Interest
1	Good	-	Man	-	Too much
2	Good	Administration	Woman	-	Much
3	Good	Commerce	Woman	-	Too much
4	Good	Marketing	Woman	-	Much
5	Excellent	-	-	-	Too much
6	Bad	-	-	-	Little

The use of WAEPCI influences too much (n=31, 67.39%), much (n=13, 28.26%) and little (n=2, 4.35%) the development of mathematical skills about the Compound Amount (See Table 1). Also, the results of machine learning with 50% (0.664), 60% (0.629) and 70% (0.693) of training indicate that hypothesis 4 is accepted (See Table 2). Therefore, data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Amount.

Figure 12 shows the predictive model 4 on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a man and takes the career of Commerce then the use of WAEPCI influences too much the development of mathematical skills about the Compound Amount.

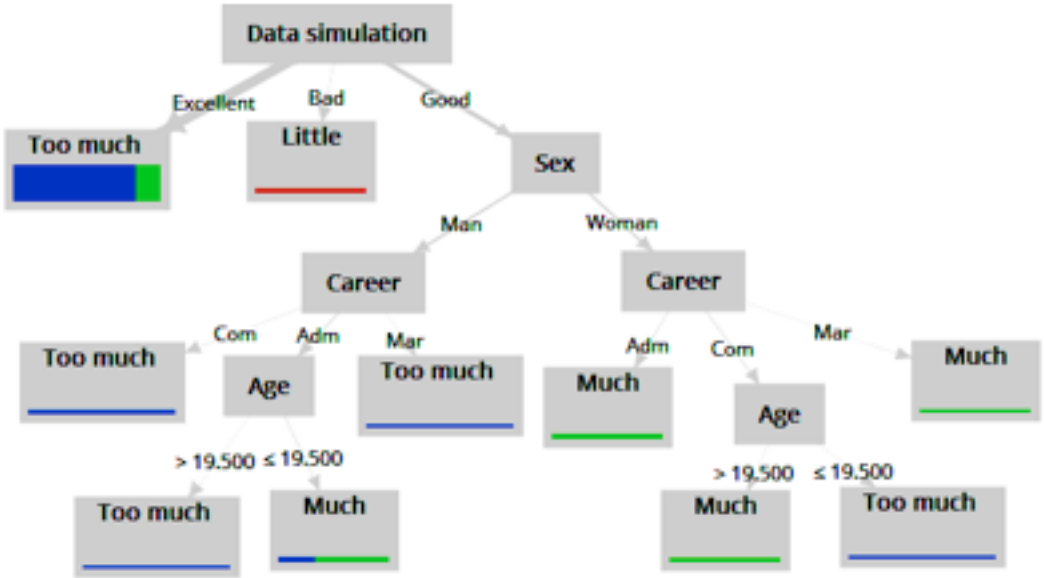

Figure 12. Predictive model 4 on the use of WAEPCI

The predictive model 4 has the accuracy of 86.96% and presents 10 conditions on the use of WAEPCI (See Table 6). For example, if the student considers that data simulation of WAEPCI is good, is a man and takes the career of Marketing then the use of WAEPCI influences too much the development of mathematical skills about the Compound Amount.

Table 6. Conditions of the predictive model 4

No.	Data simulation of WAEPCI	Career	Sex	Age	Development of mathematical skills about the Compound Amount
1	Good	Commerce	Man	-	Too much
2	Good	Administration	Man	> 19.5 years	Too much
3	Good	Administration	Man	≤ 19.5 years	Much
4	Good	Marketing	Man	-	Too much
5	Good	Administration	Woman	-	Much
6	Good	Commerce	Woman	> 19.5 years	Much
7	Good	Commerce	Woman	≤ 19.5 years	Too much
8	Good	Marketing	Woman	-	Much
9	Excellent	-	-	-	Too much
10	Bad	-	-	-	Little

DISCUSSION

The design, construction, use and implementation of web applications allow updating school activities inside and outside the classroom (Alderete, 2017; Barclay, Donalds, & Osei-Bryson, 2018; Jong, Sotiriou, & Gillet, 2014). For example, WAEPCI presents the calculation of the Compound Interest and Compound Amount over a period of four years by means of the data simulation.

Assimilation of Knowledge

The results of the machine learning for the Hypothesis 1 are greater than the value of 0.886. Therefore, data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Interest.

Also, the predictive model 1 presents 6 conditions on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a man and has an age > 19.5 years then the use of WAEPCI influences much the assimilation of knowledge about the Compound Interest.

On the other hand, the results of the machine learning for the Hypothesis 2 are greater than the value of 0.720. Therefore, data simulation of WAEPCI positively influences the assimilation of knowledge about the Compound Amount.

Also, the predictive model 2 presents 8 conditions on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a woman and takes career of the Administration then the use of WAEPCI influences too much the assimilation of knowledge about the Compound Amount. In fact, data simulation of WAEPCI has more influence on the assimilation of knowledge about the Compound Interest.

Development of Mathematical Skills

Several authors (e.g., Radovic, Maric, & Passey, 2019; Willis, Lynch, Fradale, & Yeigh, 2019) explain that technological tools facilitate the development of skills in the educational field. The results of the machine learning for the Hypothesis 3 are greater than the value of 0.558. Therefore, data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Interest.

Also, the predictive model 3 presents 6 conditions on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a woman and takes the career of Commerce then the use of the WAEPCI influences too much the development of mathematical skills about the Compound Interest.

On the other hand, the results of the machine learning for the Hypothesis 4 are greater than the value of 0.628. Therefore, data simulation of WAEPCI positively influences the development of mathematical skills about the Compound Amount.

Also, the predictive model 4 presents 10 conditions on the use of WAEPCI in the teaching-learning process. For example, if the student considers that data simulation of WAEPCI is good, is a man and takes the career of Commerce then the use of WAEPCI influences too much the development of mathematical skills about the Compound Amount. In fact, data simulation of WAEPCI has more influence on the development of mathematical skills about the Compound Amount.

Finally, technology is modifying the planning and organization of school activities in the 21st century (Kalolo, 2019; Mishra & Iyer, 2015; Terziyan, Golovianko, & Shevchenko, 2015). In particular, WAEPCI is a web application that facilitates the educational process on financial mathematics by means of the data simulation.

CONCLUSION

WAEPCI facilitates the assimilation of knowledge and development of mathematical skills on Compound Interest and Compound Amount. The results of machine learning with 50%, 60% and 70% of training indicate that WAEPCI positively influences the educational process on financial mathematics.

Data science identified 4 predictive models on the use of WAEPCI in the teaching-learning process through the decision tree technique. The accuracy of these predictive models presents an accuracy higher than 86.90%.

This research recommends the construction of web applications to achieve the active role of students through the data simulation. Also, teachers can incorporate technological tools in and out the classroom in order to develop the competencies of students.

The limitations of this research are the size of the sample and use of WAEPCI in the topics of Compound Interest and Compound Amount. Therefore, future research can build web applications that facilitate the educational process on annuities, amortizations and depreciation. Likewise, teachers can use digital games and web applications in the educational field with the purpose of creating new virtual spaces for learning.

The implications of this research are related to the use of technology in school activities to improve teaching-learning conditions. For example, WAEPCI is a web application that facilitates the assimilation of knowledge and allows the development of mathematical skills on financial mathematics.

Finally, educational institutions can modify the functions and activities of teachers and students through technological tools and media of communication. In particular, WAEPCI transforms the teaching-learning process on financial mathematics through the data simulation on the Compound Interest and Compound Amount.

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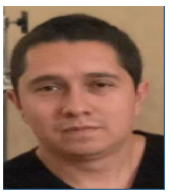

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