Research in Learning Technology
Vol. 27, 2019

ASSOCIATION FOR LEARNING TECHNOLOGY ALT

ORIGINAL RESEARCH ARTICLE

Construction and evaluation of a web application for the educational process on Normal Distribution considering the science of data and machine learning

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(Received 17 May 2018; final version received 8 March 2019; Published: 29 March 2019)

This mixed research aims at the planning, construction and implementation of a web application to facilitate the educational process on the Normal Distribution through the technological, pedagogical and content knowledge of the Technological Pedagogical Content Knowledge (TPACK) model. This study proposes the use of the PHP programming language (technological knowledge), the topics of Normal Distribution (content knowledge) and computer simulation (pedagogical knowledge) to create the Web Application on the Educational Process of Statistics (WAEPS). The sample consists of 61 students who took the subject Statistical Instrumentation for Business during the 2018 school year. The results of the linear regression (machine learning with 50% and 70% of training) indicate that the WAEPS facilitates the educational process on statistics. In fact, the WAEPS promotes the active role in the student, develops mathematical skills and facilitates the assimilation of knowledge about the calculation of upper and lower limits in the Normal Distribution by means of data simulation, interactivity and navigation. Even students consider that this web application is innovative and useful for the educational field. In addition, data science (decision tree technique) identifies various predictive models on the impact of the WAEPS in the educational process. Finally, the TPACK model is an ideal frame of reference to innovate the teaching–learning process through technological, pedagogical and content knowledge.

Keywords: ICT; TPACK model; technology; data science; machine learning.

Introduction

The new information and communication technologies are transforming the functions, roles, strategies and activities of teachers in the educational process (Ay, Karadag, and Acat 2015; Paiva, Ferreira, and Frade 2017; Wu 2016). In particular, universities are increasing the use of web applications and platforms with the purpose of creating innovative educational virtual spaces (Deschaine and Whale 2017; Kryukov and Gorin 2017; Lee 2017; Salas Rueda and Salas Silis 2018).

In fact, educational institutions are identifying and selecting new teaching–learning models to achieve the efficient incorporation of technological tools in school activities

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Citation: Research in Learning Technology 2019, **27**: 2085 - http://dx.doi.org/10.25304/rlt.v27.2085
(page number not for citation purpose)

(Broadbent 2017; Jang and Tsai 2012; Murphy and Stewart 2017). According to Ay, Karadag, and Acat (2015), there are different models to achieve the successful integration of technological tools in the classroom, such as Technology Integration Planning Model, Systematic ICT Integration Model and Technological Pedagogical Content Knowledge (TPACK) Model.

Teachers use the knowledge of the TPACK model to identify ideal digital tools for the educational field (Mouza *et al.* 2014). Several authors (e.g. Archambault and Barnett 2010; López, Duarte, and Ibáñez 2017; Phillips 2017) point out that the TPACK model aims to improve the teaching–learning process through content knowledge (topics of the subject), technological knowledge (information and communication tools) and pedagogical knowledge (practices, procedures and educational strategies).

The TPACK model also allows teachers to improve educational practices in the 21st century (Archambault and Barnett 2010; Khine, Ali, and Afari 2017). Therefore, this mixed research proposes to innovate the teaching–learning process on statistics through the planning, organisation and construction of the Web Application on the Educational Process of Statistics (WAEPS) considering the use of PHP programming language (technological knowledge), computer simulation (pedagogical knowledge) and the topics on the upper and lower limits in the Normal Distribution (content knowledge).

The research questions are the following:

- What is the impact of the WAEPS on the educational process on Normal Distribution (machine learning with 50% and 70% of training)?
- How does the TPACK model influence the planning, organisation and creation of the WAEPS?
- What are the perceptions of students about the incorporation of the WAEPS in the subject Statistical Instrumentation for Business?
- What are the predictive models about the use of WAEPS in the educational process (decision tree technique)?

TPACK model

Technological advances and students' digital skills are causing teachers to identify, select and use new information and communication tools in the educational process (Karno 2018; Naraian and Surabian 2014; Salas Rueda 2018). The TPACK model is a reference framework that analyses teachers' competencies in order to achieve a successful incorporation of the technology in the classroom (Brinkley-Etzkorn 2018; Yurdakul *et al.* 2012).

In fact, teachers use the content, technological and pedagogical knowledge of the TPACK model to achieve efficient planning and organisation of the school activities (Archambault and Barnett 2010; Mecoli 2017). Even this model allows to identify the degree of success on the integration of new digital tools in the educational context (Graham 2011; Liu, Zhang, and Wang 2015).

The origin of the TPACK model came from the ideas proposed by Shulman in 1986 on the relationship between content and pedagogical knowledge (Jang and Tsai 2012). Subsequently, Mishra and Koehler (2006) established the TPACK reference framework considering this knowledge and the use of digital tools.

The technological knowledge of the TPACK model refers to the knowledge necessary to use computers and programs (Chai *et al.* 2011; López, Duarte, and Ibáñez 2017). The pedagogical knowledge is the knowledge to plan the instruction and realisation of the lessons (Ay, Karadag, and Acat 2015; Chai *et al.* 2011; Khine, Ali, and Afari 2017). The content knowledge is the knowledge about the topics of the subjects (Chai *et al.* 2011; Phillips 2017).

The TPACK model is a reference framework on technological, pedagogical and content knowledge to improve the instructional design, planning of educational practices and preparation of digital materials (Mouza *et al.* 2014).

According to various authors (e.g., Jang and Tsai 2012; Khine, Ali, and Afari 2017), the interaction between content, pedagogical and technological knowledge in the TPACK model fosters the emergence of pedagogical content knowledge, technological content knowledge and technological pedagogical knowledge.

The pedagogical content knowledge refers to the selection of teaching–learning approaches, methods and techniques (Ay, Karadag, and Acat 2015; Phillips 2017; Tomte *et al.* 2015). The technological content knowledge is the use of digital tools to transmit the contents of the subjects (Ay, Karadag, and Acat 2015; López, Duarte, and Ibáñez 2017). The technological pedagogical knowledge is the effect of technological applications in the teaching–learning process (Ay, Karadag, and Acat 2015; Koh and Divaharan 2011).

Teachers have used the content, technological and pedagogical knowledge of the TPACK model at various educational levels, such as primary (Chai *et al.* 2011), secondary (Jang 2010) and university (Kushner and Ward 2013; Tomte *et al.* 2015) levels, in order to improve teaching and learning.

The TPACK model facilitates the incorporation of digital tools in the classroom. For example, interactive whiteboards, pedagogical knowledge and content knowledge improve academic performance and increase student motivation at the secondary level (Jang 2010; Jang and Tsai 2012). Finally, the demands and needs of students in the 21st century encourage educational institutions to make changes in the contents of the courses considering the use of information and communication technologies (Kushner and Ward 2013; Mouza *et al.* 2014).

Method

The objective of this mixed research was to analyse the impact of WAEPS in the educational process on Normal Distribution by means of linear regression (machine learning) and data science (decision tree technique).

The participants comprised 61 students from the following disciplines: Bachelor of Administration (n = 9, 18.66 years old), Commerce (n = 19, 18.78 years old), Accounting (n = 15, 18.86 years old), Information Technology (n = 2, 19 years old) and Marketing (n = 16, 18.93 years old). These students also completed Statistical Instrumentation for Business during the 2018 school year.

Procedure

The procedure of this study began with the use of the TPACK model to plan and construct the WAEPS (see Table 1).

Table 1. Use of the TPACK model.

TPACK model	Teacher's knowledge	Description
Technological knowledge	PHP programming language	The PHP programming language allows the construction of dynamic websites to retrieve, send and display information on the Internet.
Pedagogical knowledge	Simulation by the computer	Computer simulation allows the student to take an active role in learning by interacting with technological applications.
Content knowledge	Limits in the Normal Distribution	To perform the calculation of the upper and lower limits in the Normal Distribution, statistical data about the population standard deviation, sample size, population mean and level of significance are necessary.
Technological pedagogical knowledge	Use of the PHP programming language in computer simulation	Through the web forms, the PHP programming language retrieves the information provided by the student to start the simulation.
Technological content knowledge	Use of the PHP programming language in the topics of the Normal Distribution	The PHP programming language allows the creation of pleasant, fast, efficient and useful sites for the presentation of topics on the Normal Distribution.
Pedagogical content knowledge	Use of computer simulation to show topics about Normal Distribution	The computer simulation allows showing the detailed procedure to calculate the upper and lower limits in the Normal Distribution

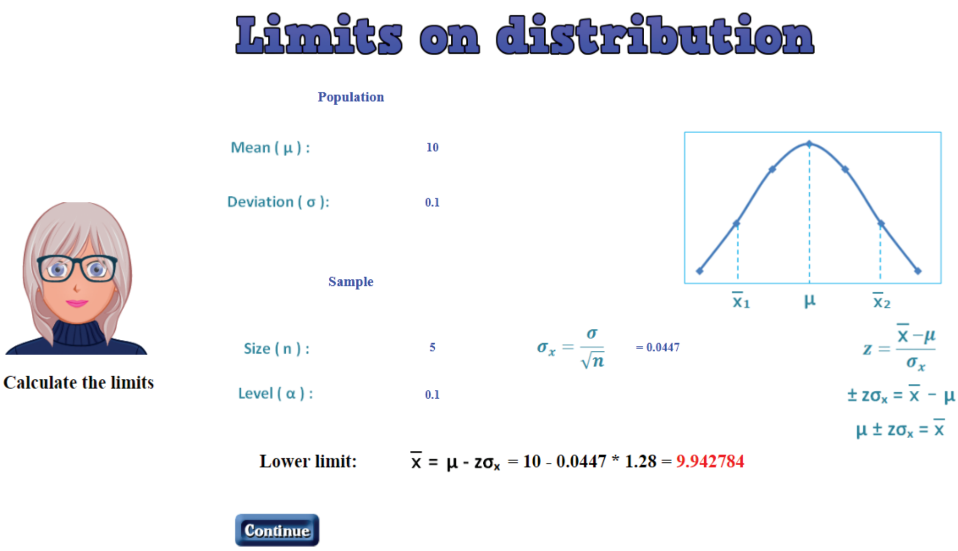

Figure 1. Use of the TPACK model for the construction of the WAEPS.

Figure 1 shows the use of technological, pedagogical and content knowledge for the construction of the WAEPS.

This mixed research analyses the impact of the WAEPS (simulation of data, interactivity and navigation) in the teaching–learning process on Normal Distribution (assimilation of knowledge, development of mathematical skills and active role).

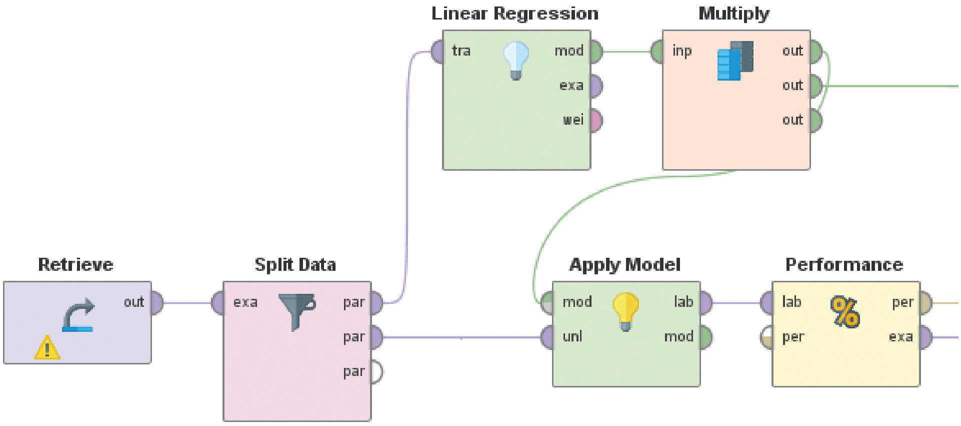

Figure 2. Machine learning in the Rapidminer tool.

The simulation of data refers to the presentation of the calculations and procedures on the normal distribution in the WAEPS. Interactivity refers to the interaction and communication between the user and WAEPS. Navigation refers to the ease of using the WAEPS interface.

The Rapidminer tool is used to calculate the linear regression (machine learning with 50% and 70% of training) and build predicted models regarding the use of the WAEPS in the educational process.

Figure 2 shows the use of the Rapidminer tool for the calculation of linear regression. The Split Data Component allows to set the training and evaluation values in the machine learning.

Therefore, the hypotheses about the use of the WAEPS in the educational process on the Normal Distribution are the following:

- H1: The simulation of data in the WAEPS positively influences the assimilation of knowledge about the Normal Distribution
- H2: The interactivity in the WAEPS positively influences the assimilation of knowledge about the Normal Distribution
- H3: The navigation in the WAEPS positively influences the assimilation of knowledge about the Normal Distribution

The hypotheses about the development of mathematical skills through the use of the WAEPS are the following:

- H4: The simulation of data in the WAEPS positively influences the development of mathematical skills
- H5: The interactivity in the WAEPS positively influences the development of mathematical skills
- H6: The navigation in the WAEPS positively influences the development of mathematical skills

Likewise, the hypotheses about WAEPS and the student's active role in learning are the following:

- H7: The simulation of data in the WAEPS positively influences the active role of the student during the learning process

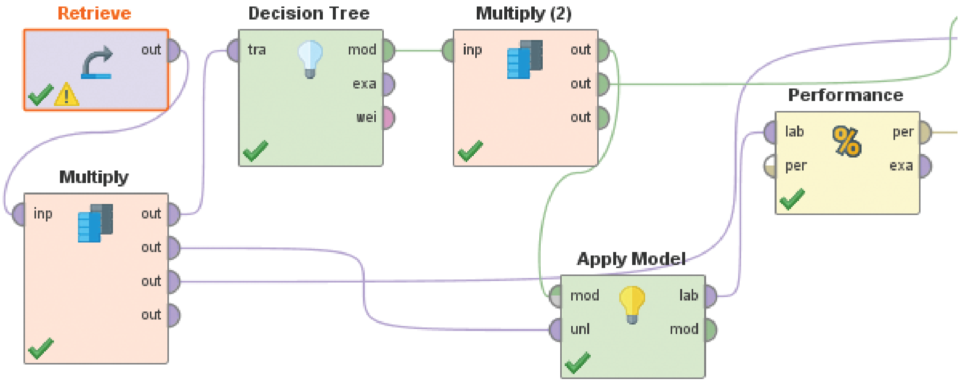

Figure 3. Predictive models in the Rapidminer tool.

- H8: The interactivity in the WAEPS positively influences the active role of the student during the learning process
- H9: The navigation in the WAEPS positively influences the active role of the student during the learning process

Figure 3 shows the use of the Rapidminer tool for the creation of predictive models on the WAEPS in the educational process.

Using the decision tree technique, this research constructed the following predictive models regarding the impact of WAEPS on the assimilation of knowledge about the Normal Distribution:

- Predictive Model 1: Use of the WAEPS (simulation) for the assimilation of knowledge about the Normal Distribution
- Predictive Model 2: Use of the WAEPS (interactivity) for the assimilation of knowledge about the Normal Distribution
- Predictive Model 3: Use of the WAEPS (navigation) for the assimilation of knowledge about the Normal Distribution

The decision tree technique uses information about the student profile, WAEPS and teaching–learning process about the normal distribution. For example, Figure 4 shows the information used for the construction of Predictive Model 3.

In addition, the predictive models regarding the impact of the WAEPS on the development of mathematical skills are the following:

- Predictive Model 4: Use of the WAEPS (simulation) for the development of mathematical skills
- Predictive Model 5: Use of the WAEPS (interactivity) for the development of mathematical skills
- Predictive Model 6: Use of the WAEPS (navigation) for the development of mathematical skills

Finally, predictive models regarding the impact of WAEPS to facilitate the active role of the student during the learning process are the following:

- Predictive Model 7: Use of the WAEPS (simulation) to facilitate the active role of the student during the learning process

Citation: Research in Learning Technology 2019, **27**: 2085 - http://dx.doi.org/10.25304/rlt.v27.2085

Row No.	Assimilation...	Sex	Age	Career	Navigation
1	Too much	Woman	19	Acc	Too much
2	Much	Woman	19	Com	Much
3	Much	Man	19	Com	Much
4	Too much	Woman	18	Acc	Too much

Figure 4. Information for Predictive Model 3.

Table 2. Quantitative variables of this study.

Variable	Dimension	Load factor	Cronbach's alpha	Average variance extracted
Web interface of the WAEPS	Data simulation	0.790	0.770	0.598354
	Interactivity	0.781		
	Navigation	0.749		
Teaching–learning process	Assimilation of knowledge	0.820	0.843	0.685134
	Mathematical skills	0.881		
	Active role of the student	0.779		

- Predictive Model 8: Use of the WAEPS (interactivity) to facilitate the active role of the student during the learning process
- Predictive Model 9: Use of the WAEPS (navigation) to facilitate the active role of the student during the learning process

Data collection

Table 2 shows the measurement instrument related to the quantitative variables.

According to Celina and Campo (2005), Cronbach's alpha must be greater than 0.7 to ensure reliability. To guarantee validity, the average variance extracted must exceed 0.5 (Fornell and Lacker 1981). From Table 2 it is evident that the variables on the WAEPS and the teaching–learning process meet these criteria.

Also, qualitative variables include the educational process on statistics, motivation, knowledge assimilation, skills development, innovative tool, web interface design, simulation, benefits, satisfaction and utility.

Analysis of data

At the end of the Normal Distribution unit, the measuring instrument is applied to the students of Bachelor of Administration, Commerce, Accounting, Information Technology and Marketing. Subsequently, the SPSS software is used to calculate the load factor, Cronbach's alpha and average variance extracted. In addition, the Rapidminer tool is used to calculate the linear regression (machine learning with 50% and 70% of training) and build predictive models on the use of the WAEPS in the educational process.

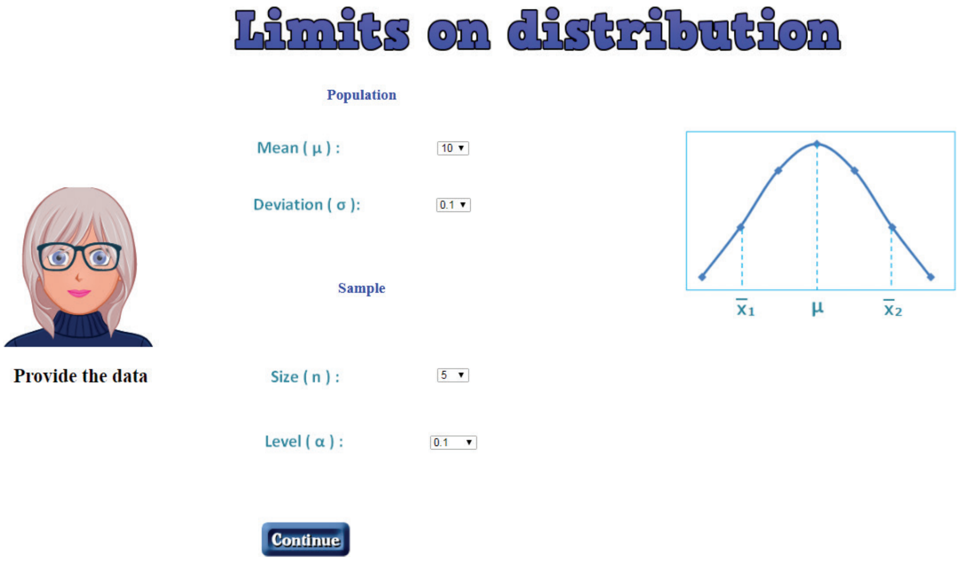

Figure 5. WAEPS interface.

Results

The results of this research include the design of the WAEPS, assimilation of knowledge about the Normal Distribution, development of mathematical skills, active role and perceptions of students.

Design of the WAEPS

Figure 5 shows that the web interface of the WAEPS requests data on the population mean, population standard deviation, sample size and level of significance.

The WAEPS shows the formula and calculation of the statistical error considering the values of the population standard deviation and size of the sample (see Figure 6).

Figure 7 shows the formula for calculating the upper and lower limits in the Normal Distribution.

The WAEPS presents the calculation of the lower limit in the Normal Distribution (see Figure 8).

Figure 9 shows the calculation of the upper limit in the Normal Distribution.

Assimilation of knowledge about the Normal Distribution

Figure 10 shows Predictive Model 1. For example, if the student considers that the simulation of data in the WAEPS facilitates much the educational process, is man, is older than 18.5 years and studies Administration (Adm), then this web application facilitates too much the assimilation of knowledge about the Normal Distribution.

The accuracy of Predictive Model 1 is 85.25% (see Figure 11).

Figure 12 shows Predictive Model 2. For example, if the student considers that the interactivity in the WAEPS facilitates much the educational process and is less than or

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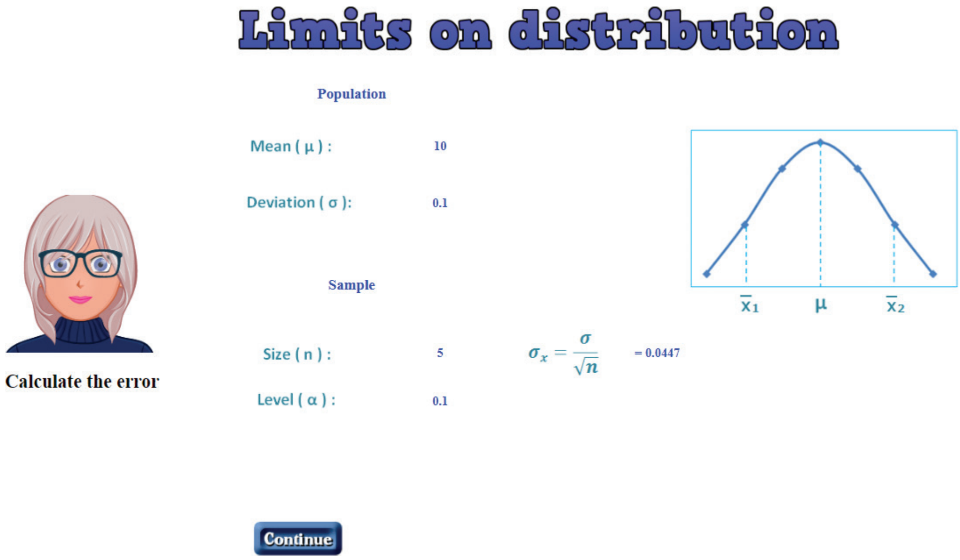

Figure 6. Calculation of the statistical error in the WAEPS.

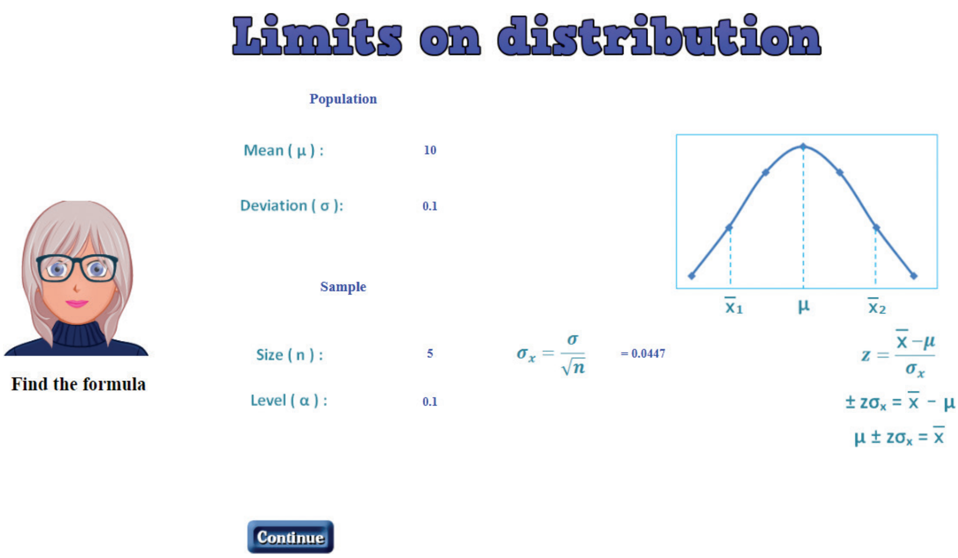

Figure 7. Formula of the upper and lower limits in the Normal Distribution.

equal to 17.5 years old, then this web application facilitates too much the assimilation of knowledge about the Normal Distribution.

The accuracy of Predictive Model 2 is 78.69% (see Figure 13).

Figure 14 shows Predictive Model 3. For example, if the student considers that the navigation in the WAEPS facilitates too much the educational process and is less than

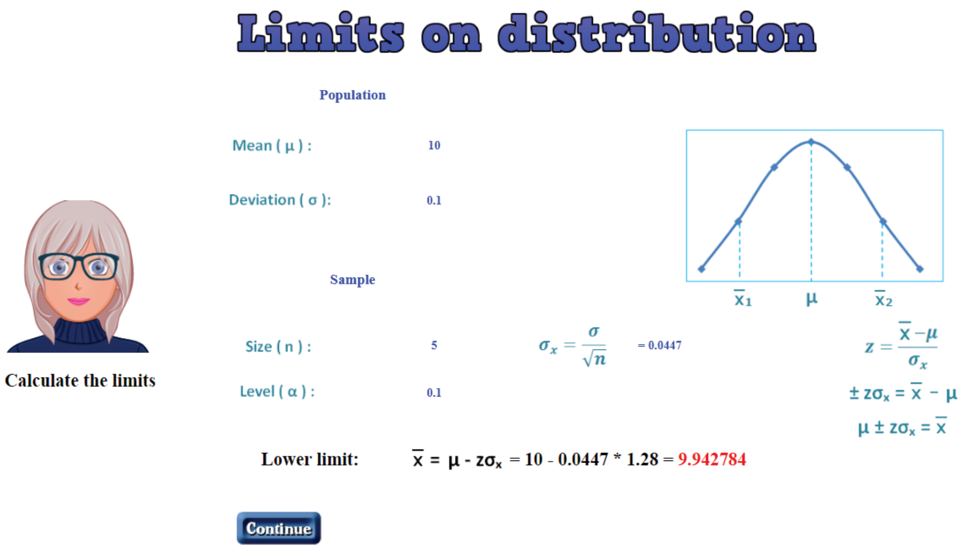

Figure 8. Calculation of the lower limit in the WAEPS.

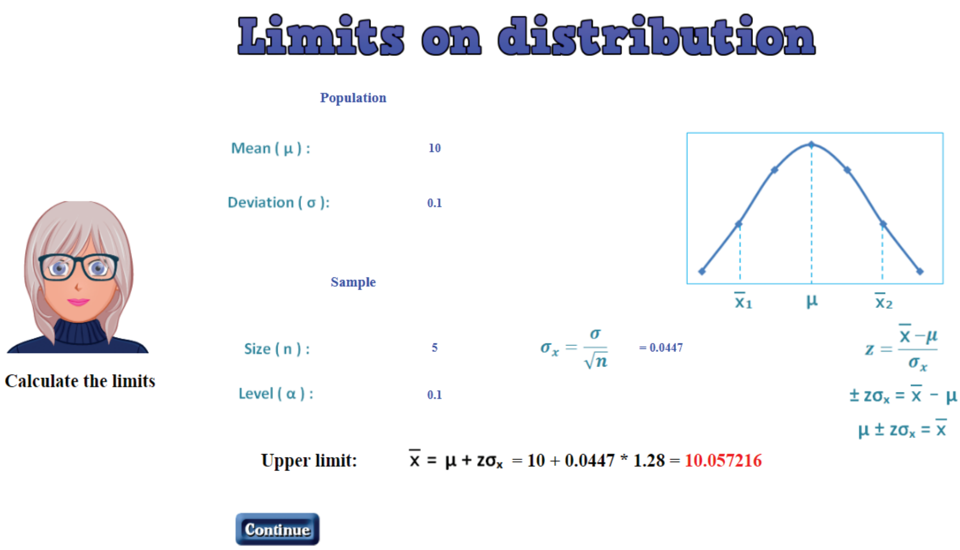

Figure 9. Calculation of the upper limit in the WAEPS.

or equal to 21.5 years old, then this web application facilitates too much the assimilation of knowledge about the Normal Distribution.

The accuracy of Predictive Model 3 is 90.16% (see Figure 15).

The results of the machine learning with 50% of training and 50% of evaluation (linear regression) indicate that hypothesis 1 (0.757), hypothesis 2 (0.743) and hypothesis 3 (0.741) are accepted (see Table 3).

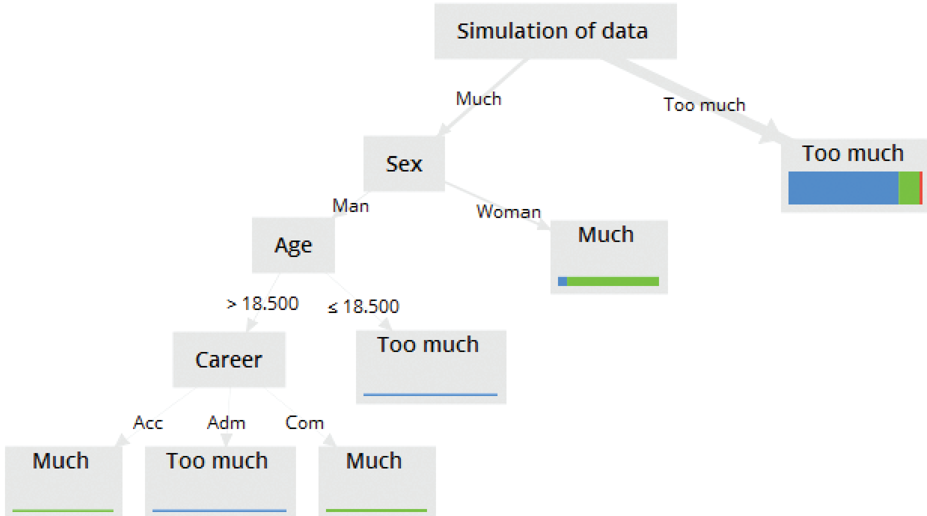

Figure 10. Predictive Model 1.

accuracy: 85.25%

	true Too much	true Much	true Moderately	class precision
pred. Too much	39	7	1	82.98%
pred. Much	1	13	0	92.86%
pred. Moderately	0	0	0	0.00%
class recall	97.50%	65.00%	0.00%	

Figure 11. Accuracy of Predictive Model 1.

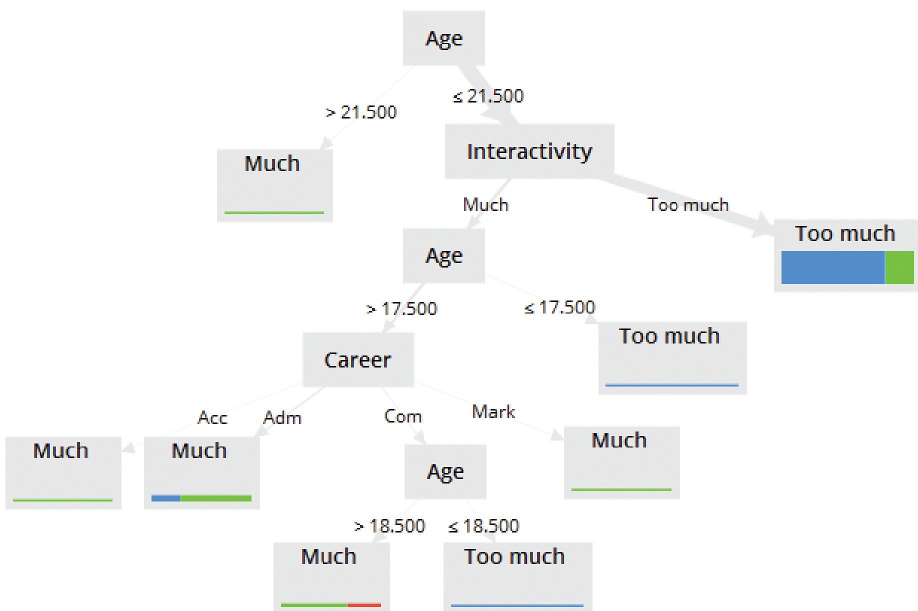

Figure 12. Predictive Model 2.

accuracy: 78.69%

	true Too much	true Much	true Moderately	class precision
pred. Too much	38	10	0	79.17%
pred. Much	2	10	1	76.92%
pred. Moderately	0	0	0	0.00%
class recall	95.00%	50.00%	0.00%	

Figure 13. Accuracy of Predictive Model 2.

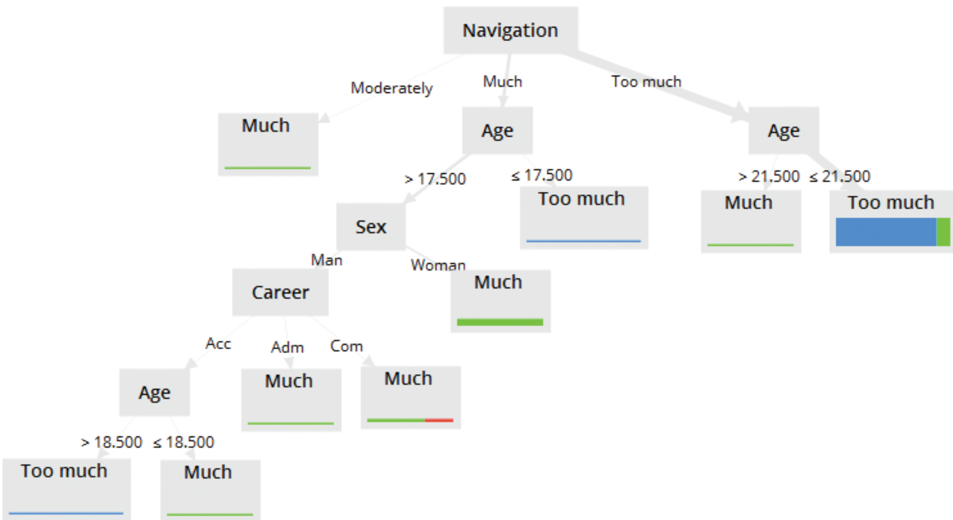

Figure 14. Predictive Model 3.

accuracy: 90.16%

	true Too much	true Much	true Moderately	class precision
pred. Too much	40	5	0	88.89%
pred. Much	0	15	1	93.75%
pred. Moderately	0	0	0	0.00%
class recall	100.00%	75.00%	0.00%	

Figure 15. Accuracy of Predictive Model 3.

Table 3. Machine learning with 50% of training.

Hypothesis	Linear regression	Conclusion	Squared_ error
H1: Simulation → assimilation of knowledge	$y = 0.757x + 0.385$	Accepted: 0.757	0.215
H2: Interactivity → assimilation of knowledge	$y = 0.743x + 0.184$	Accepted: 0.743	0.239
H3: Navigation → assimilation of knowledge	$y = 0.741x + 0.741$	Accepted: 0.741	0.141

Similarly, hypothesis 1 (0.689), hypothesis 2 (0.612) and hypothesis 3 (0.575) are accepted by the machine learning with 70% training and 30% evaluation (see Table 4).

Development of mathematical skills

Figure 16 shows Predictive Model 4. For example, if the student considers that the simulation in the WAEPS facilitates too much the educational process and studies Marketing (Mark), then this web facilitates too much the development of mathematical skills about the Normal Distribution.
The accuracy of Predictive Model 4 is 85.25% (see Figure 17).

Figure 18 shows Predictive Model 5. For example, if the student considers that the interactivity in the WAEPS facilitates too much the educational process, then this web facilitates too much the development of mathematical skills about the Normal Distribution.

The accuracy of Predictive Model 5 is 81.97% (see Figure 19).

Figure 20 shows Predictive Model 6. For example, if the student considers that the navigation in the WAEPS facilitates too much the educational process and is less

Table 4. Machine learning with 70% training.

Hypothesis	Linear regression	Conclusion	Squared_ error
H1: Simulation → assimilation of knowledge	y = 0.689x + 0.472	Accepted: 0.689	0.101
H2: Interactivity → assimilation of knowledge	y = 0.612x + 0.620	Accepted: 0.612	0.147
H3: Navigation → assimilation of knowledge	y = 0.575x + 0.682	Accepted: 0.575	0.151

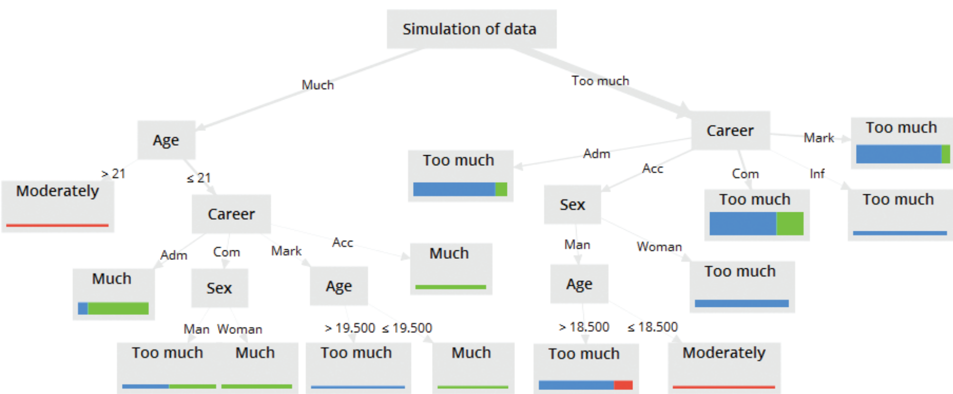

Figure 16. Predictive Model 4.

accuracy: 85.25%

	true Too much	true Much	true Moderately	class precision
pred. Too much	39	7	1	82.98%
pred. Much	1	11	0	91.67%
pred. Moderately	0	0	2	100.00%
class recall	97.50%	61.11%	66.67%	

Figure 17. Accuracy of Predictive Model 4.

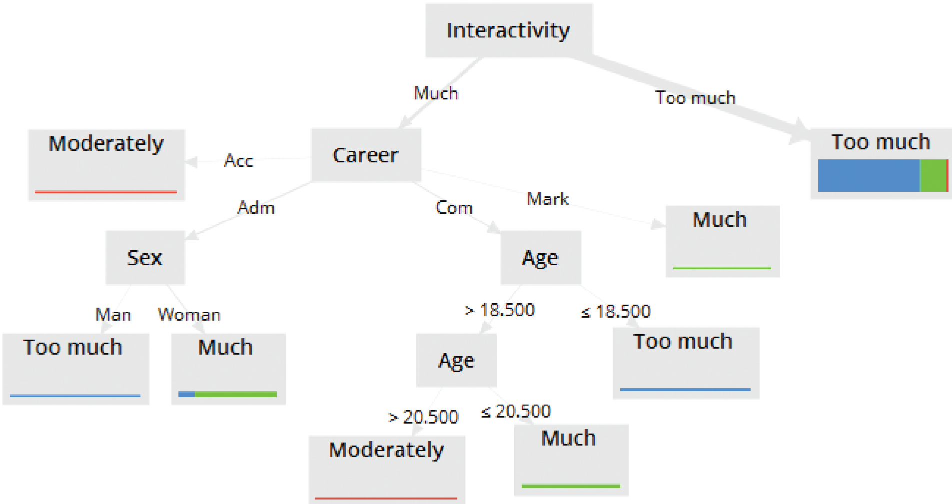

Figure 18. Predictive Model 5.

accuracy: 81.97%

	true Too much	true Much	true Moderately	class precision
pred. Too much	39	9	1	79.59%
pred. Much	1	9	0	90.00%
pred. Moderately	0	0	2	100.00%
class recall	97.50%	50.00%	66.67%	

Figure 19. Accuracy of Predictive Model 5.

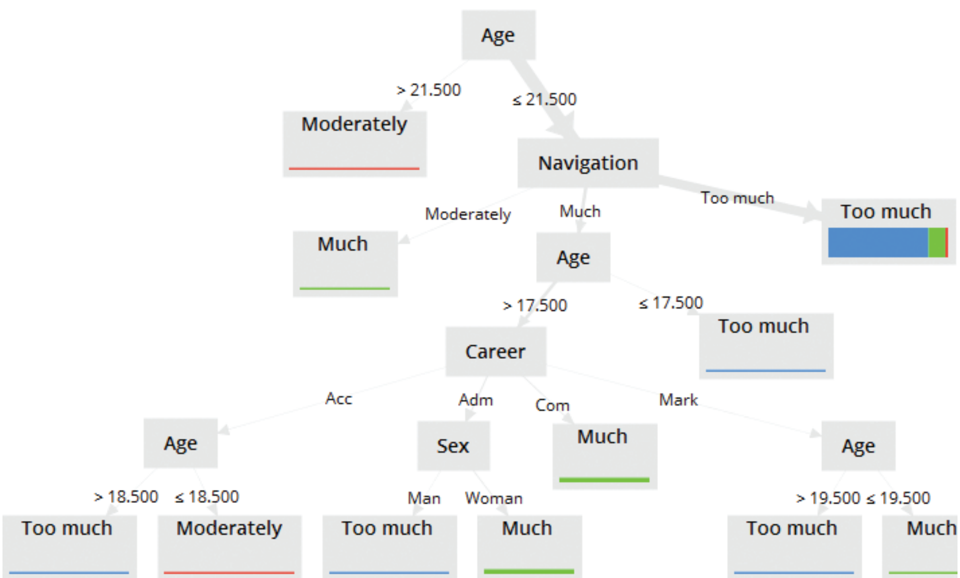

Figure 20. Predictive Model 6.

than or equal to 21.5 years old, then this web facilitates too much the development of mathematical skills about the Normal Distribution.

The accuracy of Predictive Model 6 is 88.52% (see Figure 21).

The results of the machine learning with 50% of training and 50% of evaluation (linear regression) indicate that hypothesis 4 (0.857), hypothesis 5 (0.709) and hypothesis 6 (0.592) are accepted (see Table 5).

Similarly, hypothesis 4 (0.579), hypothesis 5 (0.658) and hypothesis 6 (0.575) are accepted by the machine learning with 70% training and 30% evaluation (see Table 6).

Active role

Figure 22 shows Predictive Model 7. For example, if the student considers that the simulation of data in the WAEPS facilitates too much the educational process, then this web facilitates too much the active role of the student during the learning process about the Normal Distribution.

The accuracy of Predictive Model 7 is 91.80% (see Figure 23).

Figure 24 shows Predictive Model 8. For example, if the student considers that interactivity in the WAEPS facilitates much the educational process, is less than or equal to 18.5 years old and is man, then this web facilitates too much the active role of the student during the learning process about the Normal Distribution.

accuracy: 88.52%

	true Too much	true Much	true Moderately	class precision
pred. Too much	40	6	1	85.11%
pred. Much	0	12	0	100.00%
pred. Moderately	0	0	2	100.00%
class recall	100.00%	66.67%	66.67%	

Figure 21. Accuracy of Predictive Model 6.

Table 5. Machine learning with 50% training.

Hypothesis	Linear regression	Conclusion	Squared_error
H4: Simulation → development of mathematical skills	y = 0.857x + 0.285	Accepted: 0.857	0.316
H5: Interactivity → development of mathematical skills	y = 0.709x + 0.480	Accepted: 0.709	0.270
H6: Navigation → development of mathematical skills	y = 0.592x + 0.617	Accepted: 0.592	0.266

Table 6. Machine learning with 70% training.

Hypothesis	Linear regression	Conclusion	Squared_error
H4: Simulation → assimilation of knowledge	y = 0.579x + 0.687	Accepted: 0.579	0.115
H5: Interactivity → assimilation of knowledge	y = 0.658x + 0.599	Accepted: 0.658	0.184
H6: Navigation → assimilation of knowledge	y = 0.575x + 0.652	Accepted: 0.575	0.205

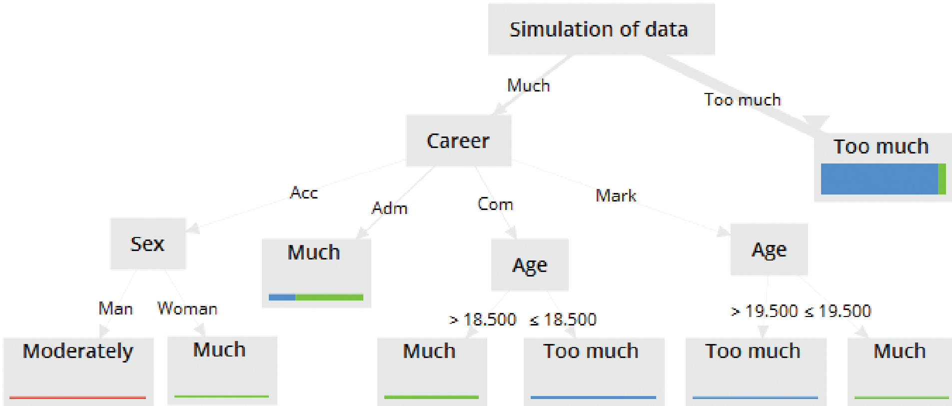

Figure 22. Predictive Model 7.

accuracy: 91.80%

	true Too much	true Much	true Moderately	class precision
pred. Too much	45	3	0	93.75%
pred. Much	2	10	0	83.33%
pred. Moderately	0	0	1	100.00%
class recall	95.74%	76.92%	100.00%	

Figure 23. Accuracy of Predictive Model 7.

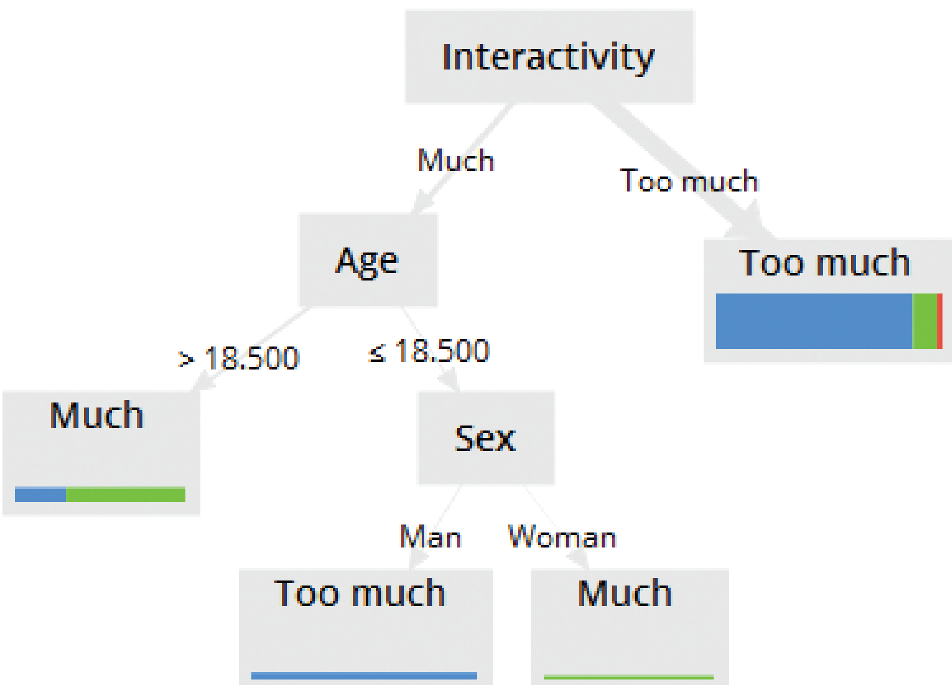

Figure 24. Predictive Model 8.

The accuracy of Predictive Model 8 is 85.25% (see Figure 25).

Figure 26 shows Predictive Model 9. For example, if the student considers that the navigation in the WAEPS facilitates too much the educational process and is less than or equal to 21.5 years old, then this web facilitates too much the active role of the student during the learning process about the Normal Distribution.

The accuracy of Predictive Model 9 is 86.89% (see Figure 27).

The results of the machine learning with 50% of training and 50% of evaluation (linear regression) indicates that hypothesis 7 (0.804), hypothesis 8 (0.509) and hypothesis 9 (0.670) are accepted (see Table 7).

accuracy: 85.25%

	true Too much	true Much	true Moderately	class precision
pred. Too much	44	5	1	88.00%
pred. Much	3	8	0	72.73%
pred. Moderately	0	0	0	0.00%
class recall	93.62%	61.54%	0.00%	

Figure 25. Accuracy of Predictive Model 8.

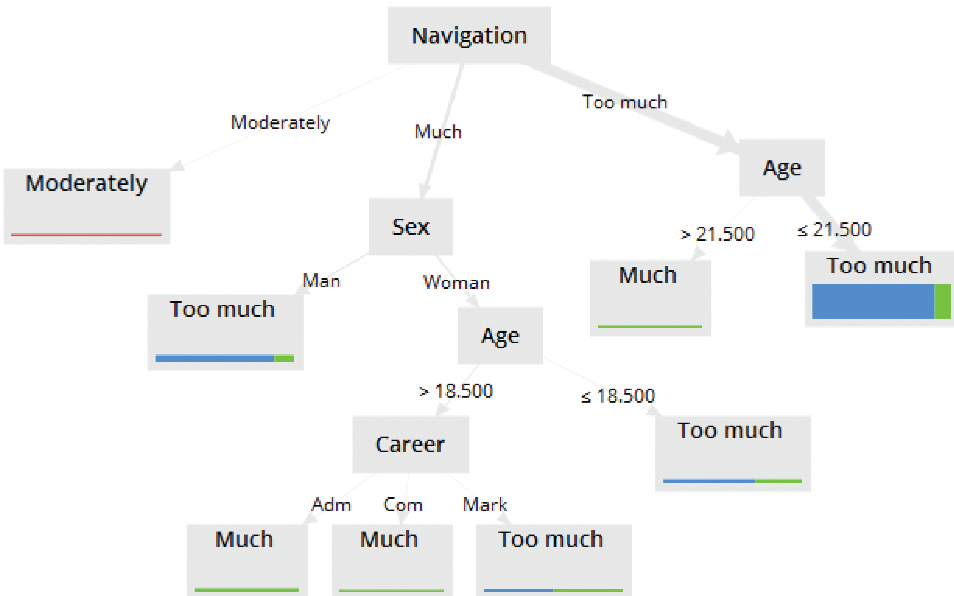

Figure 26. Predictive Model 9.

accuracy: 86.89%

	true Too much	true Much	true Moderately	class precision
pred. Too much	47	8	0	85.45%
pred. Much	0	5	0	100.00%
pred. Moderately	0	0	1	100.00%
class recall	100.00%	38.46%	100.00%	

Figure 27. Accuracy of Predictive Model 9.

Table 7. Machine learning with 50% training.

Hypothesis	Linear regression	Conclusion	Squared_error
H7: Simulation → active role	y = 0.804x + 0.290	Accepted: 0.804	0.116
H8: Interactivity → active role	y = 0.509x + 0.680	Accepted: 0.509	0.160
H9: Navigation → active role	y = 0.670x + 0.446	Accepted: 0.670	0.213

Table 8. Machine learning with 70% training.

Hypothesis	Linear regression	Conclusion	Squared_error
H7: Simulation → active role	y = 0.592x + 0.507	Accepted: 0.592	0.024
H8: Interactivity → active role	y = 0.422x + 0.739	Accepted: 0.422	0.144
H9: Navigation → active role	y = 0.459x + 0.648	Accepted: 0.459	0.126

Similarly, hypothesis 7 (0.592), hypothesis 8 (0.422) and hypothesis 9 (0.459) are accepted through the machine learning with 70% training and 30% evaluation (see Table 8).

Perceptions of students

According to the students of the Business School, the WAEPS facilitates the teaching–learning process on the upper and lower limits in the Normal Distribution:

> Yes, it is a good learning method. (Student 1, female, 19 years old, Accounting)
> Yes, it is a more dynamic way of understanding the topics. (Student 37, female, 18 years old, Commerce)

Even the students consider that the WAEPS allows the creation of a virtual space for learning:

> Yes, because it facilitates the process. (Student 24, male, 18 years old, Administration)
> Yes, it is easier to understand. (Student 28, male, 19 years old, Administration)

In addition, this web application allows practising and reviewing the topics on the calculation of the upper and lower limits in the Normal Distribution:

> Yes, it allows us to practice the exercises. (Student 2, female, 19 years old, Commerce)
> Yes, it helps to practice class topics. (Student 52, female, 20 years old, Administration)

The students of Bachelor of Administration, Commerce, Accounting, Information Technology and Marketing are motivated to use the WAEPS during the educational process on statistics:

> Yes, it is less tedious. (Student 5, female, 18 years old, Accounting)
> Yes, it is an innovative application and helps students to be motivated. (Student 40, female, 19 years old, Accounting)

Also, the participants are motivated because the use of technology propitiates an active and dynamic role during the learning process:

> Yes, since it keeps us active. (Student 30, male, 19 years old, Accounting)
> Yes, because it is more dynamic. (Student 35, female, 19 years old, Marketing)

Likewise, the respondents are motivated to use the WAEPS because this technological tool is easy to use:

> Yes, it is easy to use. (Student 38, female, 18 years old, Commerce)
> Yes, it is easy to use and gives quick results. (Student 52, female, 20 years old, Administration)

The students of Statistical Instrumentation for Business indicate that the WAEPS facilitates the assimilation of knowledge about Normal Distribution:

> Yes, it shows us the exercises more easily. (Student 2, female, 19 years old, Commerce)
> Yes, because it helps to solve doubts. (Student 5, female, 18 years old, Accounting)

Also, this web application allows the development of mathematical and technological skills:

> Yes, not only mathematical skills but also computer skills. (Student 14, female, 18 years old, Marketing)
> Yes, because we can practice and study with the application. (Student 46, female, 19 years old, Marketing)

The students of the Business School consider that the WAEPS is an innovative tool in the educational field:

> Yes, because it is new and dynamic. (Student 30, male, 19 years old, Accounting)
> Yes, because few teachers are supported by an effective application to teach. (Student 46, female, 19 years old, Marketing)

Even the students point out that the teaching–learning process based on technology is very different from traditional methods:

> Yes, it is very different from traditional classes. (Student 37, female, 18 years old, Commerce)
> Yes, it is not like the traditional methods. (Student 58, female, 19 years old, Accounting)

Furthermore, the participants highlight the availability of this web application on the Internet:

> Yes, because it is on the web. (Student 28, male, 19 years old, Administration)
> Yes, it is practical and we can use it anywhere. (Student 52, female, 20 years old, Administration)

With respect to the design of the web interface, the students mention that the WAEPS is user-friendly:

> Yes, it looks very friendly and motivates. (Student 37, female, 18 years old, Commerce)
> Yes, it is a friendly and dynamic application. (Student 40, female, 19 years old, Accounting)

In the same way, the aesthetics of the WAEPS (use of colour, images and distribution of objects) creates a striking, attractive and pleasant virtual environment for the learning process:

> Yes, it is very striking and colorful. (Student 14, female, 18 years old, Marketing)
> Yes, the design and colors are very good. (Student 41, female, 19 years old, Marketing)

The simulation of data in the WAEPS facilitates the teaching–learning process on Normal Distribution:

> Yes, it helps learning. (Student 12, female, 20 years old, Administration)
> Yes, it facilitates learning. (Student 13, female, 19 years old, Marketing)

Even the students of Bachelor of Administration, Commerce, Accounting, Information Technology and Marketing can provide various statistical data (population standard deviation, sample size, population mean and level of significance) during the simulation:

> Yes, we can explore different data to understand. (Student 37, female, 18 years old, Commerce)
> Yes, we can make several examples. (Student 55, male, 19 years old, Accounting)

One of the benefits of the WAEPS is related to learning about Normal Distribution:

> Effective learning. (Student 1, female, 19 years old, Accounting)
> Facilitates the assimilation of knowledge. (Student 41, female, 19 years old, Marketing).

Furthermore, the students of the Business School indicate that this web application is fast and efficient:

> Fast and efficient (Student 10, male, 19 years old, Accounting)
> Fast, efficient and easy to use. (Student 18, female, 20 years old, Administration)

Another benefit linked to this web application is the ease of use:

> Friendly and easy to use. (Student 37, female, 18 years old, Commerce)
> Innovative, simple and easy (Student 60, male, 19 years old, Commerce)

The students of Statistical Instrumentation for Business are satisfied to use the WAEPS during the teaching–learning process on the Normal Distribution:

Yes, it helped solve my doubts. (Student 5, female, 18 years old, Accounting)
Yes, I like this method of teaching. (Student 36, male, 18 years old, Administration)

Finally, the WAEPS is a useful tool for the educational process on statistics:

Yes, we learn and study in a didactic way. (Student 46, female, 19 years old, Marketing)
Yes, since it complements the class themes. (Student 61, female, 19 years old, Commerce).

Discussion

New developments and technological inventions are modifying the behaviour and functions of teachers and students in the educational process (Magen and Steinberger 2017; Santoso *et al.* 2018; Witte, Haelermans, and Rogge 2015). In fact, the tools of information and communication are transforming the planning of school activities inside and outside the classroom (Bhaumik 2013; Dudaite and Prakapas 2017; Manwaring *et al.* 2017). For example, the WAEPS allows students to interact with the technology by simulating the calculation of the upper and lower limits in the Normal Distribution.

This research shares the ideas of various authors (e.g. Brinkley-Etzkorn 2018; Chai *et al.* 2011; Phillips 2017) on the importance of the TPACK model to design and organise new teaching–learning activities through the use of digital tools. In particular, the students of the Business School consider that the WAEPS is an innovative web application for the field of statistics. Even the aesthetics of this technological tool (educational agent, colors and organisation of objects) increases the motivation of the students.

The TPACK model facilitates the teaching–learning process through technological, content and pedagogical knowledge (Jang and Tsai 2012). In this mixed research, the technological knowledge (PHP programming language) plays a fundamental role in the construction of the WAEPS by allowing the management, recovery and presentation of information on the Normal Distribution. Likewise, pedagogical knowledge (computer simulation) and content knowledge (topics on Normal Distribution) allow the construction of ideal virtual spaces for the teaching–learning process on statistics.

The simulation, interactivity and navigation of the WAEPS positively influence the assimilation of knowledge and the development of mathematical skills on the calculation of the upper and lower limits in the Normal Distribution. Likewise, the students of Bachelor of Administration, Commerce, Accounting, Information Technology and Marketing acquire an active and dynamic role in learning, that is, the students initiate the simulation on the calculation of the Normal Distribution through the selection of population standard deviation, size of the sample, population mean and level of significance.

The benefits of the WAEPS are related to the improvement of the learning process through a friendly, pleasant, simple, fast and easy-to-use web interface. Also, the students of Statistical Instrumentation for Business are satisfied to use the WAEPS because this web application allows practising the topics, checking the results and solving the doubts. Even students mention that this technological tool is useful for the educational context.

The results of the machine learning with 50% and 70% of training indicate that the WAEPS facilitates the assimilation of knowledge about the Normal Distribution, development of mathematical skills and active role of the student during the learning process. Likewise, data science identified several predictive models about the use of WAEPS in the educational process through the decision tree technique.

Finally, the TPACK model facilitates the planning, organisation and construction of virtual educational spaces through the use of technological, pedagogical and content knowledge (Brinkley-Etzkorn 2018; Liu, Zhang, and Wang 2015; Mecoli 2017).

Conclusions

Teachers must modify the educational conditions through technological, pedagogical and content knowledge in order to meet the needs of the society. In particular, the TPACK model is a reference framework that allows to improve the teaching–learning process through the incorporation of digital tools in school activities.

The technological (PHP programming language), pedagogical (computer simulation) and content (topics on Normal Distribution) knowledge of the TPACK model allowed the planning and construction of the WAEPS. This web application presents the simulation on the calculation of the upper and lower limits in the Normal Distribution by means of the selection of various statistical data, such as the population standard deviation, sample size, population mean and level of significance.

The simulation, interactivity and navigation of the WAEPS facilitate the assimilation of knowledge, develop mathematical skills and promote the active role of students in the learning process. The limitations of this study are related to the calculation of the limits in the Normal Distribution for the test of two-tailed hypothesis. Also, the significance levels used in the simulation are 0.1, 0.05 and 0.025.

Therefore, it is recommended to develop web applications that show the limits for other hypothesis tests, such as one tail. Likewise, future research can create simulations considering different languages for offering a personalised learning process. Finally, educational institutions have the possibility to innovate the teaching–learning process through the technological, pedagogical and content knowledge of the TPACK model.

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