Ed Process Int J | www.edupij.com
ISSN 2147-0901 | e-ISSN 2564-8020

EDUCATIONAL PROCESS
INTERNATIONAL JOURNAL

ARTICLE HISTORY
Received *January 08, 2022*
Accepted *May 14, 2022*
Published Online *June 28, 2022*

CORRESPONDENCE
Ricardo-Adán Salas-Rueda
ricardo.salas@icat.unam.mx
Universidad Nacional Autónoma de México.

AUTHORS DETAILS
Additional information about the authors is available at the end of the article.

How to cite: *Salas-Rueda, R.A., Alvarado-Zamorano, C., & Ramírez-Ortega, J. (2022). Construction of a Web Game for the Teaching-Learning Process of Electronics during the COVID-19 pandemic. Educational Process: International Journal, 11(2): 130-146.*

RESEARCH ARTICLE

Construction of a Web Game for the Teaching-Learning Process of Electronics during the COVID-19 Pandemic

Ricardo-Adán Salas-Rueda · Clara Alvarado-Zamorano · Jesús Ramírez-Ortega

ABSTRACT

Background/purpose – During the COVID-19 pandemic, teachers were required to update school activities using various technological tools. The aim of this mixed research was the construction and usage analysis of the Digital Game for the teaching-learning process on Electronics (DGE) version 3.0 in the Combinational Circuits unit through data science.

Materials/methods – DGE version 3.0 facilitates the construction of new educational spaces in the distance modality. This web game consists of a simulator that presents the contents of the output function for two variables and their representation through logic gates. The participants of the study were 15 electronic and electrical engineering students who took a digital design course at the National Autonomous University of Mexico during the 2021 academic year.

Results – The machine learning (linear regression) results indicate that the interface, design, and color of the DGE version 3.0 web game positively influenced the students' assimilation of knowledge and skills development in the field of electronics. On the other hand, the decision tree technique identified six predictive models with regards to the use of the DGE version 3.0.

Conclusion – Technological advances such as web gaming can facilitate the teaching-learning process from virtually any location.

Keywords – web game, higher education, data science, engineering, learning, ICT

To link to this article–https://dx.doi.org/10.22521/edupij.2022.112.7

1. INTRODUCTION

Due to the COVID-19 pandemic, educational institutions worldwide were forced to transform their activities away from the face-to-face modality (Cabero-Almenara & Llorente-Cejudo, 2020; Demuyakor, 2020). Teachers employed information and communication technologies (ICTs) to establish new virtual spaces that facilitated the teaching-learning process according to the distance modality (Belonovskaya et al., 2020; García-Ruiz & Pérez-Escoda, 2021; Schwarzenberg et al., 2020).

Technological tools enable students to acquire the requisite knowledge from the courses they attend, irrespective of their location (Aeberhard et al., 2019; Demir, 2020; Hawamdeh & Soykan, 2021; Hebert et al., 2021). The incorporation of web applications within the educational field favors the active role of students both inside and outside of the classroom (Burnett et al., 2020; Lim & Newby, 2020; Marchetti, 2021).

In particular, the use of web games in the educational field increases students' motivation and academic performance (Aeberhard et al., 2019; Hannig et al., 2012; Salas-Rueda et al., 2020). In an Introduction to Statistics course, the WGODS game helped to improve the assimilation and development of students' mathematical skills (Salas-Rueda et al., 2020). At the RWTH Aachen University Medical School, students used a web game called eMedOffice in order to facilitate their learning process, and reportedly developed skills on the use of medical components (Hannig et al., 2012). Similarly, the COSMOS game helped to facilitate the skills development of learners in the field of psychology (Aeberhard et al., 2019).

During the COVID-19 pandemic, the teacher of a Digital Design course helped to improve the learning conditions by incorporating technology within the school activities. As such, the aim of this mixed research study was the construction and usage analysis of the Digital Game for the teaching-learning process on Electronics (DGE) version 3.0 in the Combinational Circuits Unit through data science. This web game consists of a simulator that presents the contents of the output function for two variables and their representation through logic gates. Therefore, the research questions of the study are:

- What is the impact of DGE version 3.0 on the Digital Design course?
- How do the interface, design, and color of the DGE version 3.0 influence the assimilation of knowledge and development of skills for the field of electronics?
- What are the predictive models for the use of the DGE version 3.0 in the educational field?
- What are the students' perceptions about the use of the DGE version 3.0 in the Digital Design course?

2. LITERATURE REVIEW

Today, the design, construction, and implementation of technological applications has enabled the improvement and updating of the teaching-learning process for software engineering (Sasmito et al., 2021), computer science (Salas-Rueda & Salas-Silis, 2018), language learning (Suryanto et al., 2020; Watomakin et al., 2020), and financial mathematics (Salas-Rueda, 2020).

In a software engineering course, Sasmito et al. (2021) developed a mobile application in order to increase the academic performance and motivation of the students through the use of audiovisual content, tutorials, and online questionnaires. The developed technological

tool helped to facilitate the assimilation of the students' knowledge about the lifecycle and requirements of software development (Sasmito et al., 2021).

The design, construction, and implementation of web games in the educational field improved the teaching-learning conditions inside and outside the classroom (Salas-Rueda & Salas-Silis, 2018; Watomakin et al., 2020). For example, computer science students increased their academic performance and developed their PHP language programming skills through the use of the JPEP game in a study by Salas-Rueda and Salas-Silis (2018).

Watomakin et al. (2020) developed the Lamaholot game to facilitate English language learning and to develop the students' grammatical skills. Also, this game helped to improve the assimilation of knowledge of the English language in terms of the use of verbs, the identification of parts of the human body, and the naming of animal species (Watomakin et al., 2020).

Similarly, Suryanto et al. (2020) developed an application called Enggang Kanayatn Quiz (EKQ) to facilitate the educational process in learning the Dayak Kanayatn language through the use of gamification. In particular, this technological tool helped to improve the teaching and learning conditions through the use of videos and question-answer games (Suryanto et al., 2020).

In a financial mathematics course, incorporation of the WATLSD application in the school activities helped to improve the assimilation of knowledge about simple interest, and helped to develop the mathematical skills of the students (Salas-Rueda, 2020). In actuality, this technological tool helped to improve the learning process about simple discount through the use of a web simulator (Salas-Rueda, 2020).

Finally, the development and usage of technological applications within school activities allow the construction of new educational virtual spaces that favor the development of skills and promote the active role of the students prior to, during, and following face-to-face teaching sessions (Suryanto et al., 2020; Watomakin et al., 2020).

3. METHODOLOGY

The particular aims of this mixed research were; (1) to build the DGE version 3.0, (2) to analyze usage of the DGE version 3.0 in the Combinational Circuits unit, (3) to analyze the impact of the interface, design, and color of the DGE version 3.0 in the assimilation of knowledge and development of skills for the field of electronics through the machine learning technique, (4) to identify predictive models for the use of DGE version 3.0 through the decision tree technique, and (5) to analyze students' perceptions regarding the use of DGE version 3.0 in the Digital Design course during the 2021 academic year.

3.1 Participants

The study's participants were 15 electronic and electrical engineering students undertaking a digital design course at the National Autonomous University of Mexico during the 2021 academic year.

3.2 Procedure

The procedure began with the organization and construction of the DGE version 3.0 considering the ADDIE pedagogical model (see Table 1).

Table 1. Use of the ADDIE model

No.	Stage	Item	Description
1	Analysis	Problem	Due to the COVID-19 pandemic, the teacher of the Digital Design course improved the teaching-learning conditions through the incorporation of technology in the Combinational Circuits unit.
		Students' characteristics	15 electronic and electrical engineering students
		Course	Digital Design
		Educational institution	National Autonomous University of Mexico
2	Design	Learning objective	Understand the procedure to obtain the output function. Understand the relationship between the output function and logic gates. Understand the use of the output function for the electronic field.
		Incorporation of technology	Design and construct the DGE version 3.0 web game using PHP programming language.
3	Development	Before class	Students used the DGE version 3.0 at home.
		After class	Students used the DGE version 3.0 after the class.
4	Implementation	Unit	Combinational Circuits
		Academic year	2021

Figure 1 shows the DGE version 3.0, which is available at the following web address: http://sistemasusables.com/2021version2/inicio1.html

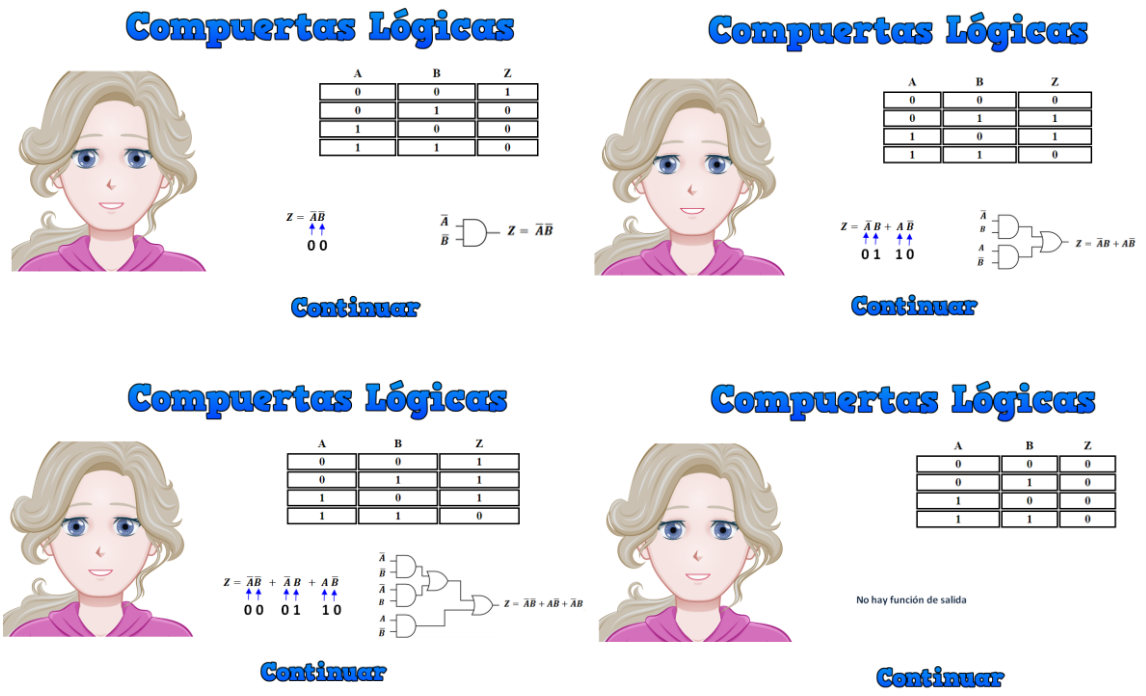

Figure 1. DGE version 3.0

Figure 2 shows the model used to analyze the impact of using DGE version 3.0.

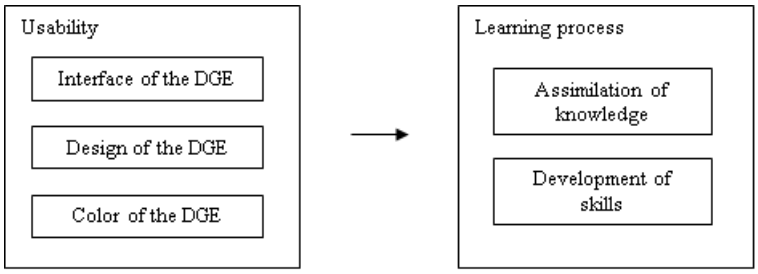

Figure 2. Model on usage of DGE version 3.0

Various authors (e.g., Sasmito et al., 2021; Watomakin et al., 2020) mentioned that the design and construction of web applications can facilitate the assimilation of knowledge both inside and outside of the classroom environment. Therefore, the hypotheses established with regards to the use of DGE version 3.0 and the assimilation of knowledge are as follows:

- Hypothesis 1 (H1): The interface of the web game positively influences the assimilation of knowledge in the field of electronics.
- Hypothesis 2 (H2): The design of the web game positively influences the assimilation of knowledge in the field of electronics.
- Hypothesis 3 (H3): The color of the web game positively influences the assimilation of knowledge in the field of electronics.

The design and construction of technological applications can help facilitate the creation of new educational spaces where students develop their skills and increase their motivation (Sasmito et al., 2021; Watomakin et al., 2020). Therefore, the hypotheses on the use of DGE version 3.0 and the development of skills are as follows:

- Hypothesis 4 (H4): The interface of the web game positively influences the development of skills for the field of electronics.

- Hypothesis 5 (H5): The design of the web game positively influences the development of skills for the field of electronics.
- Hypothesis 6 (H6): The color of the web game positively influences the development of skills for the field of electronics.

The decision tree technique allowed for the construction of six predictive models about the impact of using DGE version 3.0 within the educational field. As such, the predictive models about this web game and the assimilation of knowledge are as follows:

- Predictive Model 1 (PM1): Interface of the web game and assimilation of knowledge in the field of electronics.
- Predictive Model 2 (PM2): Design of the web game and assimilation of knowledge in the field of electronics.
- Predictive Model 3 (PM3): Color of the web game and assimilation of knowledge in the field of electronics.

On the other hand, the predictive models about the usage of DGE version 3.0 and the development of skills are as follows:

- Predictive Model 4 (PM4): Interface of the web game and development of skills for the field of electronics.
- Predictive Model 5 (PM5): Design of the web game and development of skills for the field of electronics.
- Predictive Model 6 (PM6): Color of the web game and development of skills for the field of electronics.

3.3 Data collection

Table 2 shows the questionnaire used to collect the data on the usage of DGE version 3.0 by students during the 2021 academic year.

Table 2. Questionnaire on usage of DGE version 3.0

No.	Variable	Dimension	Question	Response	*n*	%
1	Student profile	Gender	1. Indicate your gender	Male	12	80.00
				Female	3	20.00
		Age	2. Indicate your age	20 years	1	6.67
				21 years	5	33.33
				22 years	2	13.33
				23 years	4	26.67
				24 years	3	20.00
2	DGE	Game interface	3. Game interface facilitates creation of a pleasant educational environment	Very much (1)	5	33.33
				Much (2)	5	33.33
				Little (3)	4	26.67
				Very little (4)	1	6.67
		Game design	4. Game design facilitates	Very much (1)	5	33.33

No.	Variable	Dimension	Question	Response	*n*	%
			navigation during learning process	Much (2)	7	46.67
				Little (3)	3	20.00
				Very little (4)	0	0.00
		Game color	5. Game color facilitates learning	Very much (1)	2	13.33
				Much (2)	11	73.33
				Little (3)	2	13.33
				Very little (4)	0	0.00
		Knowledge assimilation	6. Game facilitates assimilation of knowledge in the field of electronics	Very much (1)	7	46.67
				Much (2)	6	40.00
				Little (3)	2	13.33
				Very little (4)	0	0.00
		Skills development	7. Game facilitates development of skills for the field of electronics	Very much (1)	5	33.33
				Much (2)	8	53.33
				Little (3)	2	13.33
				Very little (4)	0	0.00
3	Students' perception	Game use	8. Does the web game allow the personalization of the learning process through the simulator?	Open question	-	-

Table 3 shows the validation of the questionnaire on the use of DGE version 3.0 in the Digital Design course during the 2021 academic year.

Table 3. Validation of the questionnaire

Variable	Dimension	Load factor	Cronbach's alpha	Average variance extracted	Composite reliability
DGE	Web game interface	0.923	.827	0.604	0.881
	Web game design	0.579			
	Web game color	0.671			
	Knowledge assimilation	0.877			
	Skills development	0.784			

3.4 Data analysis

The RapidMiner tool facilitates machine learning (linear regression) and the building of predictive models. In the machine learning, training with 50%, 60%, and 70% of the sample allows the calculation of linear regressions on the use of the DGE version 3.0 web game, whilst evaluation with 50%, 40%, and 30% of the sample allows for accuracy assessments of these regressions by means of the squared error.

On the other hand, the decision tree technique allows for the construction of the predictive models regarding the interface, design, and color of DGE version 3.0 web game, the assimilation of knowledge, and the development of skills for the field of electronics based on the students' profile.

4. FINDINGS

According to the participant electronic and electrical engineering students, the interface of the DGE version 3.0 web game facilitates very much (*n* = 5, 33.33%), much (*n* = 5, 33.33%), little (*n* = 4, 26.67%), and very little (*n* = 1, 6.67%) in terms of creating a pleasant educational environment (see Table 2). Likewise, the design of DGE version 3.0 reportedly was found to facilitate very much (*n* = 5, 33.33%), much (*n* = 7, 46.67%), and little (*n* = 3, 20.00%) in terms of navigation during the learning process. Also, the color of the DGE version 3.0 web game facilitated very much (*n* = 2, 13.33%), much (*n* = 11, 73.33%), and little (*n* = 2, 13.33%) in terms of the students' learning.

The results of machine learning (linear regression) indicate that the interface, design, and color of the DGE version 3.0 web game positively influenced the assimilation of knowledge and development of skills for the field of electronics (see Table 4).

Table 4. Results of machine learning

Hypothesis	Training	Linear Regression	Result	*t*	*p*	Squared error
H1: Interface of the web game → assimilation of knowledge	50%	y = 0.490x + 0.454	Accepted: 0.490	2.116	0.078	0.231
	60%	y = 0.488x + 0.581	Accepted: 0.488	3.044	0.018	0.270
	70%	y = 0.491x + 0.608	Accepted: 0.491	3.526	0.006	0.342
H2: Design of the web game → assimilation of knowledge	50%	y = 0.826x + 0.173	Accepted: 0.826	2.480	0.047	0.933
	60%	y = 0.749x + 0.055	Accepted: 0.749	2.825	0.025	1.022
	70%	y = 0.518x + 0.555	Accepted: 0.518	1.867	0.094	0.714
H3: Color of the web game → assimilation of knowledge	50%	y = 0.478x + 0.476	Accepted: 0.478	1.107	0.310	0.561
	60%	y = 0.461x + 0.692	Accepted: 0.461	1.128	0.296	0.498
	70%	y = 0.468x + 0.656	Accepted: 0.468	1.213	0.255	0.627
H4: Interface of the web game → development of skills	50%	y = 0.490x + 0.454	Accepted: 0.490	6.749	0.001	0.693
	60%	y = 0.418x + 1.069	Accepted: 0.418	2.244	0.059	0.237
	70%	y = 0.466x + 0.933	Accepted: 0.466	2.905	0.017	0.260
H5: Design of the web game →	50%	y = 0.478x + 0.478	Accepted: 0.478	1.800	0.121	1.306

Hypothesis	Training	Linear Regression	Result	*t*	*p*	Squared error
development of skills	60%	y = 0.236x + 1.631	Accepted: 0.236	0.663	0.528	0.651
	70%	y = 0.117x + 1.705	Accepted: 0.117	0.399	0.698	0.444
H6: Color of the web game → development of skills	50%	y = 0.478x + 0.478	Accepted: 0.478	1.800	0.121	0.883
	60%	y = 0.346x + 1.269	Accepted: 0.346	0.814	0.442	0.372
	70%	y = 0.374x + 1.125	Accepted: 0.374	0.904	0.389	0.262

4.1 Assimilation of knowledge

The DGE version 3.0 web game reportedly facilitated very much (*n* = 7, 46.67%), much (*n* = 6, 40.00%), and little (*n* = 2, 13.33%) in terms of assimilation of knowledge in the field of electronics (see Table 2). The results of machine learning with 50% (0.490), 60% (0.488), and 70% (0.491) indicate that H1 is accepted (see Table 4). Therefore, the interface of the DGE version 3.0 web game may be said to positively influence the assimilation of knowledge in the field of electronics.

Figure 3 shows eight conditions of Predictive Model 1 (PM1) on the use of DGE version 3.0 with an accuracy of 93.33%. For example, if a student considers that the interface of the DGE version 3.0 facilitates much the creation of a pleasant educational environment and has an age ≤ 22 years, then this web game facilitates much the assimilation of knowledge in the field of electronics.

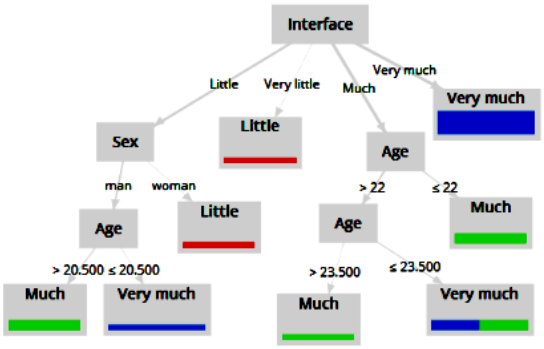

Figure 3. PM1 on usage of DGE version 3.0

The results of machine learning with 50% (0.826), 60% (0.749), and 70% (0.518) indicate that H2 is accepted (see Table 4). Therefore, the design of the DGE version 3.0 web game positively influences the assimilation of knowledge in the field of electronics.

Figure 4 shows seven conditions of Predictive Model 2 (PM2) on the use of DGE version 3.0 with an accuracy of 80.00%. For example, if a student considers that the design of the DGE version 3.0 facilitates very much the navigation during the learning process, has an age ≤ 22.5 years and is male, then the DGE version 3.0 web game facilitates very much the assimilation of knowledge in the field of electronics.

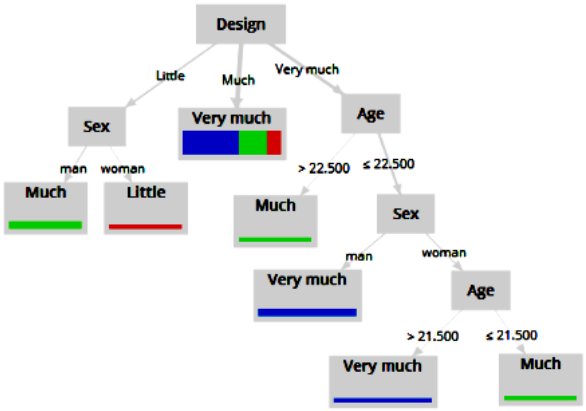

Figure 4. PM2 on usage of DGE version 3.0

The results of machine learning with 50% (0.478), 60% (0.461), and 70% (0.468) indicate that H3 is accepted (see Table 4). Therefore, the color of the DGE version 3.0 web game positively influences the assimilation of knowledge in the field of electronics.

Figure 5 shows seven conditions of Predictive Model 3 (PM3) on the use of DGE version 3.0 with an accuracy of 80.00%. For example, if a student considers that the color of the DGE version 3.0 facilitates much the learning, has an age ≤ 22.5 years and is female, then the DGE version 3.0 web game facilitates much the assimilation of knowledge in the field of electronics.

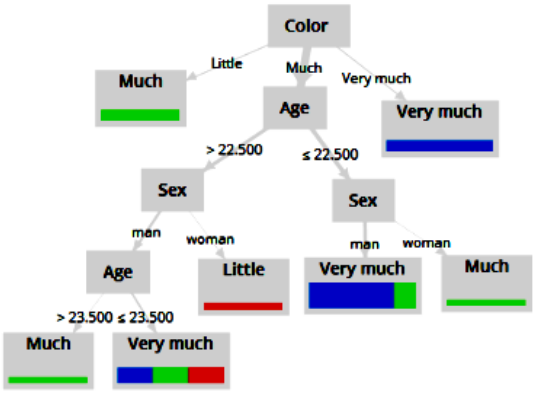

Figure 5. PM3 on usage of DGE version 3.0

4.2 Development of skills

The DGE version 3.0 facilitates very much (*n* = 5, 33.33%), much (*n* = 8, 53.33%), and little (*n* = 2, 13.33%) the development of skills for the field of electronics (see Table 2). The results of machine learning with 50% (0.490), 60% (0.418), and 70% (0.466) indicate that H4 is accepted (see Table 4). Therefore, the DGE version 3.0 web game interface positively influences the development of skills for the field of electronics.

Figure 6 shows six conditions of Predictive Model 4 (PM4) on the use of DGE version 3.0 with an accuracy of 86.67%. For example, if a student considers that the interface of the DGE version 3.0 facilitates much the creation of a pleasant educational environment and has an age ≤ 22 years, then this web game facilitates much the development of skills for the field of electronics.

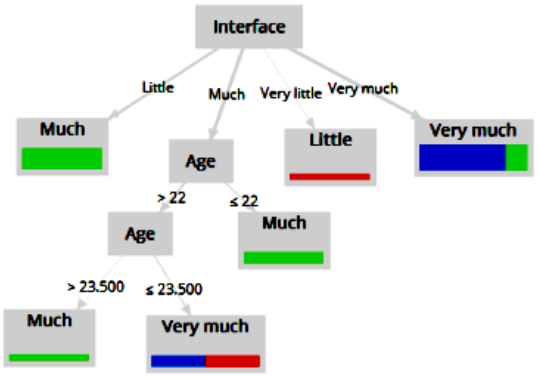

Figure 6. PM4 on usage of DGE version 3.0

The results of machine learning with 50% (0.478), 60% (0.236), and 70% (0.117) indicate that H5 is accepted (see Table 4). Therefore, the design of the DGE version 3.0 web game positively influences the development of skills for the field of electronics.

Figure 7 shows seven conditions of Predictive Model 5 (PM5) on the use of DGE version 3.0 with an accuracy of 80.00%. For example, if a student considers that the design of the DGE version 3.0 facilitates very much the navigation during the learning process and has an age ≤ 21.5 years, then the DGE version 3.0 web game facilitates much the development of skills for the field of electronics.

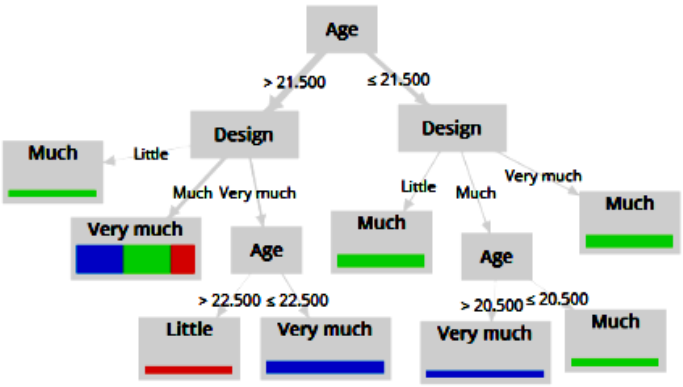

Figure 7. PM5 on usage of DGE version 3.0

The results of machine learning with 50% (0.478), 60% (0.346), and 70% (0.374) indicate that H6 is accepted (see Table 4). Therefore, the color of the DGE version 3.0 web game positively influences the development of skills for the field of electronics.

Figure 8 shows six conditions of Predictive Model 6 (PM6) on the use of DGE version 3.0 with an accuracy of 86.67%. For example, if a student considers that the color of DGE version 3.0 facilitates much the learning and has an age ≤ 21.5 years, then the DGE version 3.0 web game facilitates much the development of skills for the field of electronics.

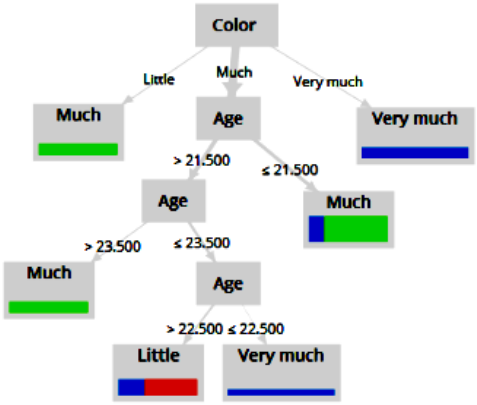

Figure 8. PM6 on usage of DGE version 3.0

4.3 Students' perception

According to the students of electronic and electrical engineering, the simulator of DGE version 3.0 facilitated the teaching-learning process in the Combinational Circuits Unit during the COVID-19 pandemic.

"I learned with examples because it is easy to configure." (Student 1, male, 22 years old)

"The simulator helps to reinforce what has been learned." (Student 3, female, 21 years old)

"The simulator helps to better understand the topic." (Student 6, female, 22 years old)

Likewise, the incorporation of the DGE version 3.0 web game in the Digital Design course facilitated the personalization of the learning process regarding the output function for two variables and their representation through the logic gates.

"Everyone experiments with the application differently." (Student 2, male, 21 years old)

"Students can review the topics at their own pace." (Student 15, male, 23 years old)

Finally, the use of DGE version 3.0 in the Combinational Circuits unit facilitated the construction of new educational spaces that were considered entertaining by the users during the teaching-learning process.

"It is a complementary tool that helps to reinforce the knowledge learned in a practical and entertaining way." (Student 12, male, 24 years old)

"It is fun to play and try the combinations." (Student 10, male, 21 years old)

5. DISCUSSION

Similar to Watomakin et al. (2020), the current study has shown that the incorporation of technological applications within the educational field can facilitate the organization and construction of new spaces for teaching and learning. In particular, 33.33% of the participant students ($n = 5$) considered that the DGE version 3.0 interface facilitates very much the creation of a pleasant educational environment. Also, the interface of this web game facilitates much ($n = 5$, 33.33%) the creation of a pleasant educational environment. Therefore, the majority of the students (66.66%) had a favorable opinion regarding this aspect of the web game.

As a result of the analysis performed, 46.67% of the participants students ($n = 7$) considered that the design of the DGE version 3.0 facilitates much the navigation during the learning process. Likewise, the design of this web game facilitates very much ($n = 5$, 33.33%)

the navigation during the learning process. Therefore, the majority of the participants (80.00%) had a favorable opinion about this aspect of the web game.

On the other hand, 73.33% of the students (*n* = 11) considered that the color of the DGE version 3.0 facilitates much the learning. Likewise, the color of this web game facilitates very much (*n* = 2, 13.33%) their learning. Therefore, the majority of the students (86.66%) had a favorable opinion about this aspect of the web game.

5.1 Assimilation of knowledge

As mentioned in the study by Suryanto et al. (2020), the design and construction of technological applications can facilitate the assimilation of knowledge both inside and outside of the classroom. As a result of the analysis performed in the current study, 46.67% of the students (*n* = 7) considered that the DGE version 3.0 facilitates very much the assimilation of knowledge in the field of electronics. Likewise, the web game reportedly facilitated much (*n* = 6, 40.00%) the assimilation of knowledge in the field of electronics. Therefore, the majority of the students (86.67%) had a favorable opinion about this aspect of the web game.

The results of machine learning with regards to H1 were shown to be higher than 0.480; therefore, the interface of the DGE version 3.0 can be said to positively influence the assimilation of knowledge in the field of electronics. On the other hand, the data science identified eight conditions of PM1 regarding the use of the web game. In this predictive model, the age of the participant students determines how the interface of the DGE version 3.0 influences their assimilation of knowledge in the field of electronics.

With respect to H2, the results of the machine learning were higher than 0.510; therefore, the design of the DGE version 3.0 can be said to positively influence the assimilation of knowledge in the field of electronics. On the other hand, the data science identified seven conditions of PM2 regarding usage of the web game. In this predictive model, the age and gender of the students determines how the design of the DGE version 3.0 influences the assimilation of knowledge in the field of electronics.

Finally, the results of machine learning about H3 were higher than 0.460; therefore, the color of the DGE version 3.0 can be said to positively influence the assimilation of knowledge in the field of electronics. On the other hand, the data science identified seven conditions of PM3 about the web game's usage. In this predictive model, the age and gender of the students determine how the color of the DGE version 3.0 influences the assimilation of knowledge in the field of electronics.

5.2 Development of skills

Various authors (e.g., Suryanto et al., 2020; Watomakin et al., 2020) in the literature have mentioned that the design, construction, and usage of technological applications can improve the teaching-learning conditions and facilitate the development of learners' skills. In particular, 53.33% of the students (*n* = 8) in the current study considered that the DGE version 3.0 facilitated much the development of skills for the field of electronics. Likewise, this web game facilitated very much (*n* = 5, 33.33%) the development of skills for the field of electronics. Therefore, the majority of the students (86.66%) can be said to have a favorable opinion about this aspect of the web game.

The results of the machine learning about H4 were higher than 0.410; therefore, the interface of the DGE version 3.0 can be said to positively influence the development of skills for the field of electronics. On the other hand, the data science identified six conditions of

PM4 regarding the web game's usage. In this predictive model, the age of the students determines how the interface of the DGE version 3.0 influences the development of skills for the field of electronics.

With respect to H5, the results of the machine learning were higher than 0.110; therefore, the design of the DGE version 3.0 can be said to positively influence the development of skills for the field of electronics. On the other hand, the data science identified seven conditions of PM5 regarding the use of the web game. In this predictive model, the age of the students determines how the design of the DGE version 3.0 influences the development of skills for the field of electronics.

Finally, the results of machine learning about H6 were higher than 0.340; therefore, the color of the DGE version 3.0 can be said to positively influence the development of skills for the field of electronics. On the other hand, the data science identified six conditions of PM6 about the web game's usage. In this predictive model, the age of the students determines how the color of the DGE version 3.0 influences the development of skills for the field of electronics.

6. CONCLUSION

During the COVID-19 pandemic, teachers were required to transform their teaching activities with the support of technological tools. For example, the DGE version 3.0 is a web game developed as a simulator that presents the contents of the output function for two variables and their representation through logic gates. In the study, machine learning (linear regression) indicated that the interface, design, and color of this web game positively influenced the assimilation of knowledge and development of skills for the field of electronics.

According to the participant electronic and electrical engineering students, the simulator of the DGE version 3.0 facilitated the teaching-learning process in the Combinational Circuits unit during the COVID-19 pandemic. Likewise, the incorporation of this web game in the educational field facilitated the personalization of the learning process about the output function for two variables and their representation through logic gates.

In conclusion, universities and other education institutions utilized technology to deliver education during the COVID-19 pandemic. For example, the DGE version 3.0 web game was developed to transform the school activities of a digital design course and to promote the active role of student learners in the distance modality.

7. SUGGESTIONS

The limitations of the current research concern the size of the sample used in the study and the content of the DGE version 3.0 web game. Therefore, future research could develop technological applications that consider the topics about Karnaugh maps and evaluate their impact in both high schools and universities. Likewise, the current study recommends the design and construction of new educational spaces in order to facilitate the teaching-learning process before, during, and following classroom teaching.

DECLARATIONS

Author Contributions. The authors contributed equally to the current research with both data collection and data analysis. All authors have read and approved the published final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

Funding. This work was supported by UNAM-DGAPA-PAPIME (PE400421): "Diseño y construcción del Juego Digital para el proceso de enseñanza-aprendizaje sobre la Electrónica (JDE)."

Ethical Approval. Ethical approval was received, and all procedures performed with human subjects were in accordance of the IRB (International Review Board) guidelines.

Data Availability Statement. To review the data from this study, contact the corresponding author. However, it should be noted that the study's data is not publicly available due to ethical guidelines.

Acknowledgments. None.

REFERENCES

Aeberhard, A., Gschwind, L., Kossowsky, J., Luksys, G., & Papassotiropoulos, A. (2019). Introducing COSMOS: a Web Platform for Multimodal Game-Based Psychological Assessment Geared Towards Open Science Practice. *Journal of Technology in Behavioral Science*, *4*, 234-244. https://doi.org/10.1007/s41347-018-0071-5

Belonovskaya, I. D., Matvievskaya, E. G., Saitbaeva, E. R., Ksenofontova, A. N., Usmanov, S. M., Zatsepina, M. B., & Bakshaeva, E. V. (2020). Digital Communication in Educational Process: Development Trends and New Opportunities. *Online Journal of Communication and Media Technologies*, *10*(2), e202008. https://doi.org/10.29333/ojcmt/7928

Burnett, C., Parry, B., Merchant, G., & Storey, V. (2020). Treading softly in the enchanted forest: exploring the integration of iPads in a participatory theatre education programme. *Pedagogies: An International Journal*, *15*(3), 203-220. https://doi.org/10.1080/1554480X.2019.1696199

Cabero-Almenara, J., & Llorente-Cejudo, C. (2020). Covid-19: radical transformation of digitization in university institutions. *Campus Virtuales*, *9*(2), 25-34. https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-972916

Demir, U. (2020). The effect of using negative knowledge based intelligent tutoring system evaluator software to the academic success in English language education. *Pedagogies: An International Journal*, *15*(4), 245-261. https://doi.org/10.1080/1554480X.2019.1706522

Demuyakor, J. (2020). Coronavirus (COVID-19) and Online Learning in Higher Institutions of Education: A Survey of the Perceptions of Ghanaian International Students in China. *Online Journal of Communication and Media Technologies*, *10*(3), e202018. https://doi.org/10.29333/ojcmt/8286

García-Ruiz, R., & Pérez-Escoda, A. (2021). Teacher's digital competence as key for strengthening a responsible use of the Internet. *Campus Virtuales*, *10*(1), 59-71. http://www.uajournals.com/campusvirtuales/en/journal/backissues.html?id=276

Hannig, A., Kuth, N., Ozman, M., Jonas, S., & Spreckelsen, C. (2012). eMedOffice: A web-based collaborative serious game for teaching optimal design of a medical practice. *BMC Medical Education*, *12*, Article 104. https://doi.org/10.1186/1472-6920-12-104

Hawamdeh, M., & Soykan, E. (2021). Systematic Analysis of Effectiveness of Using Mobile Technologies (MT) in Teaching and Learning Foreign Language. *Online Journal of Communication and Media Technologies*, *11*(4), e202124. https://doi.org/10.30935/ojcmt/11256

Hebert, C., Jenson, J., & Terzopoulos, T. (2021). "Access to technology is the major challenge": Teacher perspectives on barriers to DGBL in K-12 classrooms. *E-Learning and Digital Media*, *18*(3), 307-324. https://doi.org/10.1177/2042753021995315

Lim, J., & Newby, T. J. (2020). Preservice teachers' Web 2.0 experiences and perceptions on Web 2.0 as a personal learning environment. *Journal of Computing in Higher Education*, *32*, 234-260. https://doi.org/10.1007/s12528-019-09227-w

Marchetti, E. (2021). Are they playing? Analysing "play" in playful learning in occupational therapy education. *E-Learning and Digital Media*, *18*(3), 290-306. https://doi.org/10.1177/2042753020980114

Salas-Rueda, R. A. (2020). Design, Construction and Evaluation of a Web Application for the Teaching-Learning Process on Financial Mathematics. *International Journal of Emerging Technologies in Learning*, *15*(8), 100-115. https://doi.org/10.3991/ijet.v15i08.12275

Salas-Rueda, R. A., Salas-Rueda, E. P., & Salas-Rueda, R. D. (2020). Analysis and design of the web game on descriptive statistics through the ADDIE model, data science and machine learning. *International Journal of Education in Mathematics, Science and Technology*, *8*(3), 245-260. https://doi.org/10.46328/ijemst.v8i3.759

Salas-Rueda, R. A., & Salas-Silis, J. A. (2018). *Uso del modelo ADDIE durante la construcción del juego para el proceso educativo sobre PHP (JPEP)*. 3Ciencias.

Sasmito, A. P., Kustono, D., Purnomo, P., Elmunsyah, H., Nurhadi, D., & Sekarsari, P. (2021). Development of Android-Based Teaching Material in Software Engineering Subjects for Informatics Engineering Students. *International Journal of Engineering Pedagogy*, *11*(2), 25-40. https://doi.org/10.3991/ijep.v11i2.16299

Schwarzenberg, P., Navon, J., & Pérez-Sanagustín, M. (2020). Models to provide guidance in flipped classes using online activity. *Journal of Computing in Higher Education, 32*, 282-306. https://doi.org/10.1007/s12528-019-09233-y

Suryanto, P., Rahardjo, A. W., & Pranowo, E. (2020). Design of Dayak Kanayatn Language Learning Mobile Applications Using Gamification. *International Journal of Engineering Pedagogy*, *10*(4), 54-68. https://doi.org/10.3991/ijep.v10i4.12899

Watomakin, D. B., Santoso, A. J., & Suyoto, S. (2020). Mobile Application Design of Learning Word in Lamaholot Language for Children Using User-Centered Design. *International Journal of Engineering Pedagogy*, *10*(5), 103-115. https://doi.org/10.3991/ijep.v10i5.13411

ABOUT THE CONTRIBUTORS

Ricardo-Adán Salas-Rueda, PhD, is a full time researcher in the Instituto de Ciencias Aplicadas y Tecnología, Universidad Nacional Autónoma de México. Doctor in Design of New Technologies.
Email: ricardo.salas@icat.unam.mx
ORCID ID: http://orcid.org/0000-0002-4188-4610

Clara Alvarado-Zamorano, PhD, is an academic technician in the Instituto de Ciencias Aplicadas y Tecnología, Universidad Nacional Autónoma de México.
Email: clara.alvarado@icat.unam.mx
ORCID ID: http://orcid.org/0000-0001-9122-7590

Jesús Ramírez-Ortega, Master, is an academic technician in the Instituto de Ciencias Aplicadas y Tecnología, Universidad Nacional Autónoma de México.
Email: jesus.ramirez@icat.unam.mx
ORCID ID: https://orcid.org/0000-0002-4538-9203