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Perception about and Effect of Adaptive Educational Application on Electronics Topics on Students' Virtual Spaces, Motivation, Satisfaction and Active Role

Ricardo-Adán Salas-Rueda

National School of Earth Sciences, National Autonomous University of Mexico, Mexico

Keywords

ICT, higher education, adaptive application, electronics, data science

Abstract

Currently, educators seek to offer personalised contents to facilitate autonomy during the educational process. The aim of this mixed study (quantitative and qualitative approach) was to build and analyse the effectiveness of the Adaptive Educational application on electronics topics (AEET) considering Data Science (machine learning algorithm on linear regression). In particular, AEET presents the content about logic gates, considering student learning style, through a web simulator, digital files, and YouTube videos. The participants were 41 students from the National School of Earth Sciences, National Autonomous University of Mexico. The results of the machine learning algorithm on linear regression indicated that the content of AEET positively affected the creation of virtual educational environments, motivation, satisfaction, and active role. At the National School of Earth Sciences, the use of AEET facilitated personalised learning at any time, autonomy, and flexibility of space during the educational process. In conclusion, it was found that AEET is a technological development that improved learning about logic gates through a web simulator, digital files, and YouTube videos.

Introduction

Nowadays, technological applications adapt the content and multimedia resources of courses to student learning style. Consequently, students acquire knowledge considering their own characteristics and needs. Researchers, teachers, and universities seek to transform the learning environment for the virtual, face-to-face, and mixed modalities through the incorporation of technological tools in the learning activities (Afify et al., 2023; Chikileva et al., 2023; Dias-Trindade et al., 2023; Karan-Aynagoz & Unal, 2024). In particular, the planning, construction and implementation of adaptive educational applications offers a new context where students learn school topics autonomously because the design of the content considers the user profile (Hwang et al., 2020; Raj & Renumol, 2022; Ristic et al., 2023).

Adaptive educational applications can use learning styles to select and present the information of courses (Katsaris & Vidakis, 2021; Kolekar et al., 2019; Oussous et al., 2023). For example, Ristic et al. (2023) built an adaptive educational system and used the learning style questionnaire called VAK (Visual-Auditory-Kinaesthetic) to personalise the contents on Moodle. Various authors (e.g., Katsaris & Vidakis, 2021; Kolekar et al., 2019; Oussous et al., 2023)

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mention that these technological tools organise and implement new teaching-learning spaces through the User Model, Domain Model, and Adaptation Model.

The User Model is composed of the preferences, learning style, knowledge, or behaviour of the students in the system (Katsaris & Vidakis, 2021; Kolekar et al., 2019; Oussous et al., 2023). The Domain Model exhibits content structure and conceptual relationships (Katsaris & Vidakis, 2021; Kolekar et al., 2019; Oussous et al., 2023). Finally, the Adaptation or Teaching Model refers to the adaptation strategies such as Based on Rules, Decision Tree, K-means, Deep Learning or Bayesian Networks (Katsaris & Vidakis, 2021; Kolekar et al., 2019; Oussous et al., 2023).

Katsaris and Vidakis (2021) explain that adaptive applications for the teaching-learning process are classified as: (1) Adaptive Hypermedia, where hypertext and hypermedia personalise the learning, (2) Adaptive Educational Hypermedia, which presents school materials considering the level of knowledge and learning objectives, (3) Adaptive Educational Hypermedia, where the learning style and needs of the students adapt to the school content, and (4) Intelligent Tutor, where the behaviour of the students in the application determines the information.

According to Oussous et al. (2023), adaptive applications in the educational field manage the school content and teaching resources considering the characteristics of the participants, that is, the preferences, learning style, knowledge, interests, and experiences of the students determine the information.

Teachers in the field of electronics seek to improve the educational conditions with the support of technology because students demand new strategies to understand the content and learn the school topics autonomously from anywhere. AEET presents the content about logic gates, considering the learning style through a web simulator, digital files, and YouTube videos.

This mixed research (quantitative and qualitative approaches) proposes to innovate the educational field of electronics through the construction and use of an adaptive educational application called AEET. The architecture of this technological tool was composed of the User Model (learning style), Domain Model (web simulator, digital files, and YouTube videos about logic gates) and Adaptation Model (rule-based technique).

Research Questions

The aim of this study was to build and analyse the effectiveness of AEET considering Data Science. The research questions were:

- What is the perception of the students about the use of AEET in the educational field?
- How does the use of AEET affect the creation of virtual educational spaces, motivation, satisfaction, and active role considering the linear regression algorithm?

Hypotheses

The following research hypotheses on the use of AEET were formulated:

- Hypothesis 1: The content of AEET positively affects the creation of virtual educational environments.
- Hypothesis 2: The content of AEET positively affects motivation.
- Hypothesis 3: The content of AEET positively affects satisfaction.
- Hypothesis 4: The content of AEET positively affects the active role.

Review of Research

Perception of Adaptive Applications for the Educational Field

Information and Communication Technology (ICT) plays a fundamental role in achieving innovation in the educational field and updating courses (Farsawang & Songkram, 2023; Patiño et al., 2023; Ucar & Ugurhan, 2023). In fact, technological advances allow selecting digital resources and information, considering the characteristics of the students, to facilitate their understanding of the topics (Karaferye, 2024; Ristic et al., 2023). Currently, adaptive applications represent an alternative to improve the teaching-learning conditions because students learn in diverse ways (Lim et al., 2023; Oussous et al., 2023; Ristic et al., 2023).

During the construction of adaptive applications, the characteristics of the students, such as learning style, level of knowledge or preferences, determine the school content and multimedia resources (Katsaris & Vidakis, 2021; Kolekar et al., 2019; Lim et al., 2023; Oussous et al., 2023). For example, Lim et al. (2023) created an adaptive application considering the Rule-Based technique to guide the students during the preparation of an essay. According to Lim et al. (2023), the Rule-Based technique uses the experience of educators to generate the adaptation conditions.

According to Raj and Renumol (2022), adaptive systems are built considering the following techniques: (1) Rule-Based, (2) Machine Learning Algorithms such as Decision Tree, K-means, Deep Learning or Bayesian Networks, (3) Software Agents, and (4) Genetic Algorithms.

In the area of engineering, Kolekar et al. (2019) built an adaptive educational application where the learning style determined the educational resources and information. This technological tool was based on the Felder and Silverman model of identifying learning style, that is, the contents are adapted considering the classifications of Visual/Verbal, Inductive/Deductive, Sequential/Global, Active/Reflective and Sensitive /Intuitive (Kolekar et al., 2019).

In the educational field of computer science, Aeiad and Meziane (2019) designed an adaptive application, with the support of the Rule-Based technique, to facilitate the understanding of programming topics considering the learning style and level of knowledge. Finally, Oussous et al. (2023) propose the construction of adaptive applications, with the support of the Rule-Based technique, to manage the content on LMS platforms such as Moodle and Blackboard.

Effectiveness of Adaptive Applications for the Educational Field

Adaptive applications are designed to create virtual environments where the student becomes the axis of the teaching-learning process (Lim et al., 2023; Oussous et al., 2023). In fact, these technological tools increase the motivation of students because the content is personalised according to their own characteristics (Oussous et al., 2023).

In addition, adaptive applications rely on learning styles with the aim of improving the user experience and increasing their satisfaction during the teaching-learning process (Aeiad & Meziane, 2019; Kolekar et al., 2019; Oussous et al., 2023). For example, Aeiad and Meziane (2019) built an adaptive application to transform the role of the students in a Computer Science course through personalised learning.

The adaptive applications in the schools benefit the active role of the students, flexibility of time and space, and increase academic performance and autonomy (Lim et al., 2023). Even

Kolekar et al. (2019) highlighted that this technological tool improved the educational conditions because the materials were adapted considering student learning style.

Data Science uses machine learning algorithms to analyse the incorporation of technological advances such as Adaptive applications in the teaching-learning process (Lincke et al., 2021; Salas-Rueda & Alvarado-Zamorano, 2024; Zheng & Na, 2021).

In the educational field, Data Science is used to evaluate, classify, and predict the technological and educational phenomena (Lincke et al., 2021; Salas-Rueda & Alvarado-Zamorano, 2024; Zheng & Na, 2021). In fact, Data Science relies on machine learning algorithms such as linear regression, decision tree and deep learning to discover the information about the use of technological tools in the educational institutions (Lincke et al., 2021; Salas-Rueda & Alvarado-Zamorano, 2024; Zheng & Na, 2021).

For example, Lincke et al. (2021) used the linear regression algorithm to evaluate the incorporation of virtual platforms such as Moodle during the teaching-learning process. In addition, this machine learning algorithm predicted the students' academic performance regarding the online exams (Lincke et al., 2021).

Salas-Rueda and Alvarado-Zamorano (2024) mention that machine learning algorithms allow analysing the perceptions of students and educators about the use of technological tools in the teaching-learning process. Through the linear regression algorithm, it was demonstrated that the performance of the school activities on the LMS positively influenced the learning process, motivation, and participation of the students during the Covid-19 pandemic (Salas-Rueda & Alvarado-Zamorano, 2024).

Even Zheng and Na (2021) highlighed that the linear regression algorithm allows identification of the predictive models related to the technology and teaching-learning process. Finally, Data Science and machine learning algorithms allow analysing the incorporation of digital tools in the educational field (Lincke et al., 2021; Salas-Rueda & Alvarado-Zamorano, 2024; Zheng & Na, 2021).

Methods

Research Methodology

This study deployed qualitative and quantitative (mixed) research to address the following two questions: (1) What is the perception of the students about the use of AEET in the educational field, and (2) How does the use of AEET for the creation of virtual educational spaces affect motivation, satisfaction, and active role through the linear regression algorithm. This study was based within causal, descriptive, and correlational research.

Sample

The participants were 41 students (16 men and 25 women) from the National School of Earth Sciences, National Autonomous University of Mexico, who had completed the Bachelor's Degree in Applied Geography and the Bachelor's Degree in Earth Sciences during the 2023 school year. Also, this sample was non-probabilistic.

Procedure

The PHP programming language was used to create AEET. The architecture of this tool includes the User Model (learning style), Domain Model (web simulator, digital files, and YouTube videos about logic gates) and Adaptation Model (Rule-Based technique). In addition, AEET is available at the Electrónica website (http://sistemasusables.com/2023COA/c2/menu.html).

First, AEET requests the realisation of the questionnaire on learning style to adapt the content. This web tool presents the electronics topics considering the following options: profile of Kinesthetic includes a web simulator about logic gates, profile of Kinesthetic-Visual includes web simulator and digital files about logic gates, and profile of Kinesthetic-Auditory includes web simulator and YouTube videos about logic gates.

Figure 1 shows the independent and dependent variables used in the study.

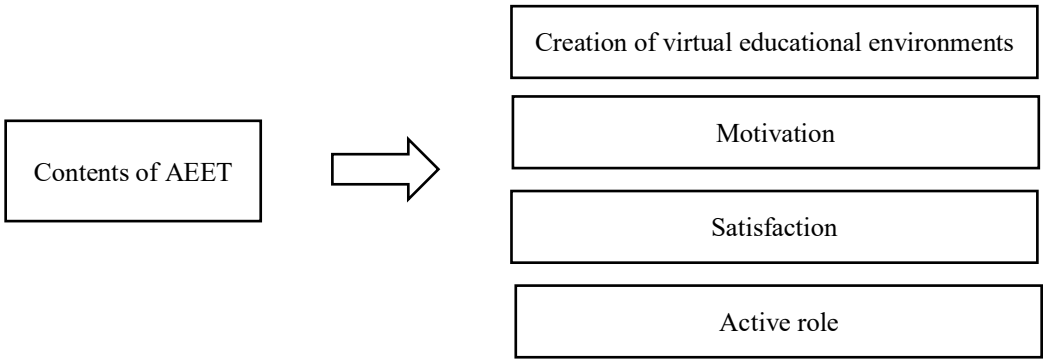

Figure 1: Variables of this study

Instruments

In October 2023 data collection was carried out at the National School of Earth Sciences, National Autonomous University of Mexico (See Table 1). This questionnaire consisted of three open-ended questions and five closed questions about the use of AEET.

Table 1: Questionnaire about AEET

No.	Variables	Dimension	Question	Answer	n	%
1	Perception of the students	Benefits	1. What are the benefits about the use of AEET?	Open	-	-
		Personalisation of learning	2. Does the use of AEET allow the personalisation of learning?	Open	-	-
		Distance education	3. Does the use of AEET facilitate the distance education?	Open	-	-

No.	Variables	Dimension	Question	Answer	n	%
2	Effectiveness of AETT	Learning through the contents	4. AEET facilitates the learning through the contents			
				Very much (1)	18	43.90%
				Much (2)	19	46.34%
				Little (3)	4	9.76%
				Very little (4)	0	0.00%
		Creation of virtual educational environments	5. AEET facilitates the creation of virtual educational environments			
				Very much (1)	18	43.90%
				Much (2)	18	43.90%
				Little (3)	5	12.20%
				Very little (4)	0	0.00%
		Motivation	6. AEET increases the motivation			
				Very much (1)	15	36.59%
				Much (2)	21	51.22%
				Little (3)	5	12.20%
				Very little (4)	0	0.00%
		Satisfaction	7. AEET increases the satisfaction			
				Very much (1)	10	24.39%
				Much (2)	26	63.41%
				Little (3)	5	12.20%
				Very little (4)	0	0.00%
		Active role	8. AEET increases the active role			
				Very much (1)	16	39.02%
				Much (2)	21	51.22%
				Little (3)	4	9.76%
				Very little (4)	0	0.00%

Table 2 shows the validation of the questionnaire. To validate this measuring instrument the value of the Load factor must be > 0.500, the value of the Average Variance Extracted must be > 0.600, and the value of the Composite Reliability must be > 0.700. In this mixed study, the value of the Load factor was > 0.810, the value of the Average Variance Extracted was > 0.780, and the value of the Composite Reliability was > 0.940. Therefore, this questionnaire on the use of AEET met the validation criteria.

Table 2: Validation of the Measuring Instrument

Variable	Dimension	Load Factor	Average Variance Extracted	Composite Reliability
Use of AEET in the educational field	Learning through the contents	0.819	0.789	0.949
	Creation of virtual educational environments	0.945		
	Motivation	0.928		
	Satisfaction	0.877		
	Active role	0.867		

Data Analysis

To calculate the linear regression algorithm, this study used the RapidMiner tool. This algorithm divided the sample into two sections: a training section to identify the linear functions (regression) and an evaluation section to determine the accuracy of these functions. This research used 50%, 60% and 70% of the sample for the training section, and 50%, 40% and 30% of the sample for the evaluation section. Also, the squared error (e^2) allowed determination of the linear function that best predicted the technological-educational phenomena.

Likewise, this study used the Word-Cloud application to analyse the open-ended questions about the use of AEET (benefits, personalisation of learning and distance education) by identifying the frequency of the words.

Results

Perception of the Students

Research Objective 1 was to analyse the students' perception about the use of AEET in the educational field. In this section, the Word-Cloud application was used to identify the most significant words related to the following open-ended questions: (1) What are the benefits of the use of AEET? (2) Does the use of AEET allow the personalisation of learning? and (3) Does the use of AEET facilitate distance education?

i) Below are the results of the question, “What are the benefits about the use of AEET?”

At the National School of Earth Sciences, the students mentioned that the interface of AEET was pleasant and useful:

- “It has a nice interface and is easy to consult”.
- “I learn in a more personal and effective way”.

The presentation of the contents in AEET allowed the learning because this tool adapted the information considering the learning style:

- “It focuses on your own learning. It makes more individual and specific. Also, it facilitates the learning”.
- “It allows that students learn through their learning style. It facilitates the assimilation of the contents”.

Another benefit about the use of AEET in the educational field was the creation of virtual spaces that promoted learning about electronics:

- "Being an innovative application, it promotes the interest in the students".
- "For the visual learners, this application helps us a lot".

The students at the National Autonomous University of Mexico highlighted that the design of AEET included the learning styles Kinesthetic, Visual and Auditory:

- "It is an application that helps reinforce the knowledge through the use of other senses such as sight and hearing".

Finally, the use of AEET allowed the personalisation of the learning about logic gates:

- "This tool personalises the contents through the learning channels".
- "It is innovative because it considers the learning styles of the students".

Figure 2 shows that the words most frequently related to the question "What are the benefits about the use of AEET?" were: learning (n = 15), students (n = 8), helps (n = 5), application (n = 4), know (n = 4), learn (n = 4) and use (n = 4).

Figure 2: Benefits of AEET in the educational context

ii) Below are the results of the question, "Does the use of AEET allow the personalisation of learning?"

According to the respondents, AEET facilitated the understanding of electronics through the presentation of various educational contents such as a web simulator, digital files, and YouTube videos:

- "Yes, because it offers particular support depending on our learning style".
- "Yes, because the application gives activities to each student depending on their learning style".

AEET personalised the learning because this tool allowed the assimilation of knowledge about electronics from anywhere:

- "Yes, because it also works as an online tool".

- "Yes, it is another new way to learn from anywhere".

Likewise, AEET personalised the learning on electronics through the web simulator, digital files, and YouTube videos:

- "Yes, it identifies the best learning channel; the material that is shared is more specific".
- "Yes, each person advances and learns according to their type of learning and uses tools according to their study method".

Finally, the students at the National Autonomous University of Mexico learned at their own pace through AEET:

- "Yes, because I learn in my own way and pace".
- "Yes, I can repeat the exercises if I can't understand".

Figure 3 shows that the words most frequently related to the question, "Does the use of AEET allow the personalisation of learning?" were: learning (n = 17), understand (n = 9), way (n = 9), student (n = 6), topic (n = 6), options (n = 5), pace (n = 5) and style (n = 5).

Figure 3: Personalisation of learning through AEET

iii) Below are the results of the question, "Does the use of AEET facilitate the distance education?"

AEET offered flexibility during the educational process because this tool could be used from anywhere:

- "Yes, I can learn from anywhere".
- "Yes, since I can study from anywhere and at any time".

AEET allowed distance education because the students accessed this technological tool through their mobile devices:

- "For the ease of accessing to the knowledge remotely and at any time from our mobile devices".
- "Yes, everything can be done from any mobile device".

The web simulator, digital files, and YouTube videos of AEET allowed students to learn the electronics topics:

- "It is useful for someone who is just beginning to study these topics".
- "Yes, because it is a different tool where we can interact didactically to learn the topic on electronic".

In addition, the respondents expressed that AEET was an interactive tool that facilitated the review of electronics topics:

- "Yes, because it allows creating a space to review and I can also experiment".
- "Yes, because it is interactive and innovative".

Figure 4 shows that the words most frequently related to the question, "Does the use of AEET facilitate the distance education?" were: understand (n = 12), path (n = 10), learning (n = 9), topic (n = 7), use (n = 6), anywhere (n = 5), help (n = 5), and learn (n = 5).

Figure 4: AEET for distance education

Effectiveness of AETT

Research Objective 2 was to analyse the use of AEET for the creation of virtual educational spaces, motivation, satisfaction, and active role through the linear regression algorithm. The RapidMiner tool used 50%, 60% and 70% of the sample (training section) to build the predictive models and evaluate the hypothesis. On the other hand, the evaluation section with 50%, 40% and 30% of the sample allowed the calculation of the squared error.

AEET facilitated learning through the content very much (n = 18, 43.90%), much (n = 19, 46.34%) and little (n = 4, 9.76%). The results of the Machine Learning algorithm indicate that the content of AEET positively affected the creation of virtual educational environments, motivation, satisfaction, and active role (see Table 3).

Table 3: Linear Regression Algorithm

Hypothesis	Sample	Function	p-value	Conclusion	Squared Error
H1	50%	y = 0.6538x + 0.5769	0.001	Accepted, p < 0.05	0.1780
	60%	y = 0.6999x + 0.4800	< 0.000	Accepted, p < 0.05	0.2061
	70%	y = 0.7579x + 0.4267	< 0.000	Accepted, p < 0.05	0.1568
H2	50%	y = 0.5769x + 0.8956	0.006	Accepted, p < 0.05	0.2313
	60%	y = 0.6599x + 0.7040	0.001	Accepted, p < 0.05	0.2275
	70%	y = 0.7133x + 0.6369	< 0.000	Accepted, p < 0.05	0.2265
H3	50%	y = 0.4999x + 1.0714	0.003	Accepted, p < 0.05	0.2391
	60%	y = 0.5399x + 0.9760	0.001	Accepted, p < 0.05	0.2410
	70%	y = 0.5987x + 0.8917	< 0.000	Accepted, p < 0.05	0.2227
H4	50%	y = 0.6153x + 0.7362	0.006	Accepted, p < 0.05	0.2199
	60%	y = 0.6199x + 0.7280	0.002	Accepted, p < 0.05	0.2332
	70%	y = 0.6082x + 0.7038	0.001	Accepted, p < 0.05	0.2180

Table 4 shows the Pearson correlations related to the contents of AEET, creation of virtual educational environments, motivation, satisfaction, and active role. The most significant correlation on Content of AEET was located in Virtual educational environments.

Table 4: Pearson Correlations about the use of AEET

	Content of AEET	Virtual Educational Environments	Motivation	Satisfaction	Active Role
Contents of AEET	1	-	-	-	-
Virtual educational environments	0.752	1	-	-	-
Motivation	0.666	0.869	1	-	-
Satisfaction	0.654	0.814	0.741	1	-
Active role	0.588	0.748	0.827	0.684	1

AEET facilitated the creation of virtual educational environments very much (n = 18, 43.90%), much (n = 18, 43.90%) and little (n = 5, 12.20%). The results of Hypothesis 1 with 50% (0.6538, $e^2 = 0.1780$), 60% (0.6999, $e^2 = 0.2061$) and 70% (0.7579, $e^2 = 0.1568$) of the sample established that the content of AEET positively affected the creation of virtual educational environments. The smallest squared error was 0.1568, therefore, the function y =

0.7579x + 0.4267 represents the best option to predict the creation of educational virtual environments through this technological tool. Also, the value of the Pearson correlation between the Content of AEET and Virtual educational environments was 0.752, therefore, these variables are related.

AEET increased motivation very much (n = 15, 36.59%), much (n = 21, 51.22%) and little (n = 5, 12.20%). The results of Hypothesis 2 with 50% (0.5769, $e^2 = 0.2313$), 60% (0.6599, $e^2 = 0.2275$) and 70% (0.7133, $e^2 = 0.2265$) of the sample established that the contents of AEET positively affected motivation. The smallest squared error was 0.2265, therefore, the function y = 0.7133x + 0.6369 represents the best option to predict motivation through this technological tool. Also, the value of the Pearson correlation between the Content of AEET and Motivation was 0.666, therefore, these variables are related.

AEET increased satisfaction very much (n = 10, 24.39%), much (n = 26, 63.41%) and little (n = 5, 12.20%). The results of Hypothesis 3 with 50% (0.4999, $e^2 = 0.2391$), 60% (0.5399, $e^2 = 0.2410$) and 70% (0.5987, $e^2 = 0.2227$) of the sample established that the contents of AEET positively affected satisfaction. The smallest squared error was 0.2227, therefore, the function y = 0.5987x + 0.8917 represents the best option to predict satisfaction through this technological tool. Also, the value of the Pearson correlation between the Content of AEET and Satisfaction was 0.654, therefore, these variables are related.

AEET increased the active role very much (n = 16, 39.02%), much (n = 21, 51.22%) and little (n = 4, 9.76%). The results of Hypothesis 4 with 50% (0.6153, $e^2 = 0.2199$), 60% (0.6199, $e^2 = 0.2199$) and 70% (0.6082, $e^2 = 0.2180$) of the sample established that the Content of AEET positively affected the Active Role. The smallest squared error was 0.2180, therefore, the function y = 0.6082x + 0.7038 represents the best option to predict the active role through this technological tool. Also, the value of the Pearson correlation between Contents of AEET and Active role was 0.588, therefore, these variables are related.

Discussion

Technology is causing educators to organise new activities that promote autonomy and personalised learning (Beege & Schneider, 2023; Karrenbauer et al., 2023; Li et al., 2023). This study built AEET to present content about logic gates considering the learning style of students. According to the students at the National School of Earth Sciences, the interface of this tool was pleasant and useful to use.

Lim et al. (2023) explain that adaptive applications are tools that facilitate the understanding of school topics because the selection of the content considers the characteristics of the students. In this mixed research, AEET facilitated the understanding of electronics through the presentation of various resources such as a web simulator, digital files, and YouTube videos. In this study, 90.24% of the respondents believed that AEET facilitated learning through the content very much and much.

As mentioned by Kolekar et al. (2019), adaptive applications use learning style to create personalised teaching-learning spaces. At the National Autonomous University of Mexico, 87.80% of the students considered that AEET facilitated the creation of virtual educational environments very much and much

The participants of this study highlighted the flexibility of time and space, that is, the contents of AEET were available at any time. The results of Hypothesis 1 were higher than 0.6530, therefore, the content of AEET positively affected the creation of virtual educational environments. Likewise, the function y = 0.7579x + 0.4267 allows predicting this phenomenon

with a squared error of 0.1568. The value of the Pearson correlation between the Content of AEET and Virtual educational environments was 0.752.

Various authors (e.g., Aeiad & Meziane, 2019; Li et al., 2023; Oussous et al., 2023) have explained that adaptive applications improve the educational scenario because students receive digital resources according to their needs. In this study, 87.81% of the participants mentioned that AEET increased their motivation very much and much.

Also, the respondents pointed out that the Content of AEET improved their learning in the field of electronics because this tool presented information considering the profiles of Kinesthetic, Kinesthetic-Visual and Kinesthetic-Visual. The results of Hypothesis 2 were higher than 0.5760, therefore, the Content of AEET positively affected the motivation. Likewise, the function $y = 0.7133x + 0.6369$ allows predicting this phenomenon with a squared error of 0.2265. The value of the Pearson correlation between the Content of AEET and Motivation was 0.666.

Similar to Aeiad and Meziane (2019), the design of adaptive application uses the Rule-Based technique and learning style to facilitate the understanding of school topics. In this research, 87.80% of the participants commented that AEET increased their satisfaction very much and much.

Likewise, the students at the National Autonomous University of Mexico learned at their own pace through AEET. The results of Hypothesis 3 were higher than 0.4990, therefore, the Content of AEET positively affected satisfaction. Likewise, the function $y = 0.5987x + 0.8917$ allows predicting this phenomenon with a squared error of 0.2227. The value of the Pearson correlation between the Content of AEET and Satisfaction was 0.654.

As mentioned by Oussous et al. (2023), adaptive applications are ideal tools to manage educational resources. In this study, 90.24% of the respondents thought that AEET increased the active role very much and much.

In this study, a web simulator, digital files, and YouTube videos of AEET allowed students to learn the electronics topics. The results of Hypothesis 4 were higher than 0.6080, therefore, the Content of AEET positively affected the active role. Likewise, the function $y = 0.6082x + 0.7038$ allows predicting this phenomenon with a squared error of 0.2180. The value of the Pearson correlation between the Content of AEET and Active role was 0.588.

At the National School of Earth Sciences, AEET improved distance education because mobile devices facilitated access to this web application. Finally, AEET is an interactive tool that allowed the review of the electronics topics.

Conclusion

In this study, AEET transformed the educational process about electronics because this tool adapted the content considering the learning styles of the students. The architecture of AEET includes the User Model (learning style), Domain Model (web simulator, digital files, and YouTube videos about logic gates) and Adaptation Model (rule-based technique).

At the National Autonomous University of Mexico, the students expressed that AEET is an interactive tool that facilitated the review of electronics topics. The results of the Machine Learning algorithm indicated that the Content of AEET positively affected the creation of virtual educational environments, motivation, satisfaction, and active role.

AEET allowed distance education because the students of Applied Geography and Earth Sciences accessed this technological tool through their mobile devices. Also, these participants mentioned that the web interface was pleasant and useful to use.

This research recommends the construction of adaptive applications because the student received the information considering their characteristics. For example, AEET adapted the Content related to the web simulator, digital files, and YouTube videos to meet the needs of the Kinesthetic, Kinesthetic-Visual and Kinesthetic-Visual.

At the National School of Earth Sciences, the use of AEET facilitated personalised learning at any time, autonomy, and flexibility of space during the educational process. In fact, this web tool allowed students to learn at their own pace.

The limitations of this study are the adaptation through the learning style and Rule-Based technique. Therefore, researchers can use the learning style along with students' preferences and knowledge level to personalise the information about electronics. Even the adaptation of the resources can be carried out through the Rule-Based technique and Deep Learning technique. Likewise, AEET can be implemented at various educational levels in Mexico City.

In conclusion, AEET is a technological development that improves learning about logic gates through a web simulator, digital files, and YouTube videos. In fact, this tool improves the educational process about electronics because the teaching resources consider student learning style.

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Author Notes

Dr. Ricardo-Adán Salas-Rueda is a Doctor in Design of New Technologies and a full-time academic at the National School of Earth Sciences, National Autonomous University of Mexico. His publications are related to research in the use of data science in the educational field, and development of intelligent applications for the teaching-learning process. Email: ricardo.salas@encit.unam.mx (http://orcid.org/0000-0002-4188-4610)

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