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ANÁLISE DO AGENTE CONVERSACIONAL EM MATEMÁTICA POR MEIO DA CIÊNCIA DE DADOS
ANALYSIS OF THE CONVERSATIONAL AGENT ON MATHEMATICS THROUGH DATA SCIENCE
ANÁLISIS DEL AGENTE CONVERSACIONAL SOBRE LAS MATEMÁTICAS POR MEDIO DE LA CIENCIA DE DATOS

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RESUMO

Introdução: O agente conversacional para matemática é uma ferramenta tecnológica que atualiza as práticas educacionais porque os usuários podem obter informações visualmente e textualmente.

Objetivo: O objetivo geral desta pesquisa mista é analisar o agente conversacional em matemática por meio da Ciência de Dados.

Métodos: Esta aplicação web apresenta conteúdo sobre noções básicas de matemática financeira, respondendo a perguntas dos usuários em formato de voz e texto. Participam 19 professores que concluíram o Mestrado em Docência para o Ensino Médio na Universidade Nacional Autônoma do México durante o ano letivo de 2024.

Resultados: Os resultados da regressão linear, um algoritmo de aprendizado de máquina, indicam que o uso do agente conversacional influencia positivamente a motivação e o papel ativo. Além disso, o algoritmo de árvore de decisão estabeleceu dois modelos para prever a motivação e o papel ativo com base no uso deste aplicativo, levando em consideração as características do usuário. Os benefícios do agente conversacional para a matemática incluem interação por voz e texto, resolução imediata de dúvidas, aprendizagem personalizada e facilidade de uso.

Conclusão: Concluindo, os professores podem incorporar o agente conversacional nas atividades escolares porque essa ferramenta oferece flexibilidade de tempo e espaço, estimula a autonomia e facilita a aprendizagem.

Palavras-chave: TIC; ensino; agente conversacional; matemática

ABSTRACT

Introduction: The conversational agent on mathematics is a technological tool that updates the educational practices because users can obtain the information visually and textually.

Objective: The general aim of this mixed research is to analyze the conversational agent on mathematics through Data Science.

Methods: This web application presents the basic concepts of financial mathematics, considering the user's questions in voice and text form. The participants are 19 educators who completed the master's degree in teaching for Higher Education at the National Autonomous University of Mexico during the 2024 school year.

Results: The results of the linear regression, a machine learning algorithm, indicate that the use of the conversational agent positively influences motivation and active role. Likewise, the decision tree algorithm established two models to predict the motivation and active role, considering the use of this application and user characteristics. The benefits of the conversational agent on mathematics are the interaction through voice and text, the resolution of doubts, personalized learning, and ease of use.

Conclusion: In conclusion, teachers can incorporate the conversational agent into school activities because this tool offers the flexibility of time and space, encourages autonomy, and facilitates learning.

Keywords: ICT; teaching; conversational agent; mathematics

RESUMEN

Introducción: El agente conversacional sobre las matemáticas es una herramienta tecnológica que actualiza las prácticas educativas debido a que los usuarios pueden obtener la información de forma visual y textual.

Objetivo: El objetivo general de esta investigación mixta es analizar el agente conversacional sobre las matemáticas por medio de la ciencia de datos.

Métodos: Esta aplicación web presenta los contenidos sobre los conceptos básicos de las matemáticas financieras considerando las preguntas de los usuarios en forma de voz y texto. Los participantes son 19 profesores que cursaron la Maestría en Docencia para la Educación Media Superior en la Universidad Nacional Autónoma de México durante el ciclo escolar 2024.

Resultados: Los resultados de la regresión lineal, algoritmo de machine learning, indican que el uso del agente conversacional influye positivamente en la motivación y el rol activo. Asimismo, el algoritmo de árbol de decisión estableció dos modelos para pronosticar la motivación y el rol activo a partir del uso de esta aplicación considerando las características del usuario. Los beneficios del agente conversacional sobre las matemáticas son la interacción por medio de la voz y el texto, la resolución de dudas en forma inmediata, el aprendizaje personalizado y la facilidad de uso.

Conclusión: En conclusión, los profesores pueden incorporar el agente conversacional en las actividades escolares debido a que esta herramienta ofrece flexibilidad de tiempo y espacio, fomenta la autonomía y facilita el aprendizaje.

Palabras clave: TIC; enseñanza; agente conversacional; matemáticas

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INTRODUCTION

Technological advances are opening new opportunities to facilitate learning and encourage communication between participants in the educational process (Rodríguez-Florida et al., 2024). In this century, the Internet makes the course activities more dynamic and entertaining (Nugraha et al., 2024). With the support of digital tools, the students of Mathematics can analyze, express, and evaluate the exercises to achieve critical thinking (Biton & Segel, 2024).

Educational strategies such as the flipped classroom and blended learning allow students to actively participate from home and in the classroom through technological tools (Hernández-Sellés et al., 2024). Virtual environments are causing teachers to organize new educational interventions before, during, and after the classes (Marange & Tatira, 2023; Martínez-De-Miguel-López et al., 2024; Yáñez-Pérez et al., 2024). For example, GeoGebra, a free web application, is used in the mathematics courses to check the results of the exercises (Marange & Tatira, 2023). With this application, the students can graph the functions to find the maximum and minimum (De-Carvalho et al., 2024; Marange & Tatira, 2023).

The COVID-19 pandemic changed the way of thinking, acting, and organizing school activities in educational institutions because Information and Communication Technology (ICT) became a fundamental axis during the realization of the teaching-learning process (Masalimova et al., 2024). In fact, artificial intelligence is modifying the planning of the activities and realization of the educational experiences (Romero-Rodríguez et al., 2023; Schmidl et al., 2024). In particular, universities are integrating artificial intelligence tools such as conversational agents to improve the educational quality (Fuertes-Alpiste, 2024; Gurl et al., 2024; Romero-Rodríguez et al., 2023).

According to Opesemowo and Adewuyi (2024), artificial intelligence is revolutionizing how students learn and interact with the content of the courses. In fact, these tools favor the personalization of learning in the area of mathematics (He, 2024; Opesemowo & Adewuyi, 2024). In particular, the conversational agent called ChatGPT improved the mathematical abilities and increased the enthusiasm during the learning process on geometry (Wardat et al., 2023). Likewise, this application showed the resolution of mathematical problems (Wardat et al., 2023).

The accelerated growth of new technologies is causing teachers to search, select, build, and use digital tools to promote learning regardless of time and space (Salas-Rueda et al., 2025; Salas-Rueda, 2024). In this investigation, a prototype of the conversational agent on mathematics was built using the PHP programming language. The general aim of this mixed research is to analyze the conversational agent on mathematics through Data Science. This web application presents the basic concepts of financial mathematics, considering the user's questions in voice and text form. The research questions are:

- How does the use of the conversational agent influence the motivation and active role of the students who took the master's degree in Teaching for Higher Education, considering the linear regression algorithm?
- What are the models on the use of this technological tool and the user profile to forecast the motivation and active role, considering the decision tree algorithm?
- What is the users' perception about the benefits of the conversational agent on mathematics?

1. LITERATURE REVIEW

Technology advances such as mobile applications (Biton & Segel, 2024), web tools (De-Carvalho et al., 2024; Marange & Tatira, 2023; Weingarden et al., 2024), augmented reality (Bertrand et al., 2024), and software related to artificial intelligence (Gurl et al., 2024; Opesemowo & Adewuyi, 2024; Wardat et al., 2023) are positively influencing the teaching-learning process in mathematics.

Biton and Segel (2024) improved the teaching-learning conditions of mathematics through WhatsApp. In particular, this mobile application was used in the blended learning modality with the purpose of sharing various school activities, discussing the topics, and reflecting on the solutions of the mathematical exercises (Biton & Segel, 2024).

In the educational context of mathematics, Opesemowo and Adewuyi (2024) explain that tools based on artificial intelligence allow the resolution of doubts and offer help to students during the teaching-learning process. These applications even allow users to learn the school topics at their own pace (Opesemowo & Adewuyi, 2024).

Gurl et al. (2024) explain that artificial intelligence tools are used in the educational field of mathematics to organize the units and determine the aspects of the evaluation in the courses. For example, ChatGPT is a support tool for the educators of mathematics courses because it efficiently organizes the school content and activities (Gurl et al., 2024).

Marange and Tatira (2023) explain that the incorporation of GeoGebra in the Geometry courses has caused an increase in the academic performance and motivation of the students. In fact, this web tool facilitated the development of mathematical skills (Marange & Tatira, 2023).

Similarly, Weingarden et al. (2024) explain that web applications promote learning about systems of equations, reflection of the ideas, and development of mathematical skills in the virtual and in-person modalities. Even Bertrand et al. (2024) propose the use of software called Cospaces to facilitate the assimilation of knowledge about mathematics through the use of augmented reality. In the Geometry course, the incorporation of ChatGPT created new spaces for the interaction and communication between the participants of the educational process with the purpose of developing their mathematical skills (Wardat et al., 2023). According to Wardat et al. (2023), artificial intelligence tools are used by teachers as support resources to facilitate learning at any time.

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With the support of the flipped classroom, the students of the mathematics course learned the topics about fractions, geometric shapes, and polynomials by consulting the multimedia resources from home (Palau & Fornons, 2022). In fact, these participants reviewed the information on the Moodle platform to solve the Edpuzzle application exercises outside the classroom (Palau & Fornons, 2022). During face-to-face classes, the students worked collaboratively, resolved their doubts, analyzed the answers to the exercises, and debated the solutions to problems related to the field of mathematics (Palau & Fornons, 2022).

Suparman et al. (2024) mention that GeoGebra is an ideal educational tool for geometry courses because students learn the topics through spatial visualization. In fact, this web application allows the creation and analysis of third-dimensional objects such as cones, pyramids, prisms, and cylinders (Suparman et al., 2024).

De-Carvalho et al. (2024) used GeoGebra in the Calculus course in order to facilitate the learning about Riemann sums through the construction of a three-dimensional graph. The incorporation of this web tool caused students to understand the calculus topics in a fun way through a graphical environment (De-Carvalho et al., 2024).

Wahba et al. (2024) highlight the relevance of the use of artificial intelligence tools in the teaching-learning process of mathematics. For example, ChatGPT changed the role of the teacher and students during the understanding of statistics topics (Wahba et al., 2024). This intelligent application even caused an increase in enthusiasm and motivation (Wahba et al., 2024).

Finally, educational strategies together with digital tools create virtual environments where the students learn at their own pace and develop their mathematical skills at any time (Gurl et al., 2024; Palau & Fornons, 2022; Wardat et al., 2023).

2. METHODS

In this mixed study, the particular aims are (1) to analyze the use of the conversational agent for the motivation and active role of the students who took the master's degree in Teaching for Higher Education, considering the linear regression algorithm, and (2) to build predictive models on this technological tool and user profile, considering the algorithm. decision tree, and (3) analyze the users' perception about the benefits of the conversational agent.

2.1 Participants

The participants are 19 educators who completed the master's degree in Teaching for Higher Education at the National Autonomous University of Mexico during the 2024 school year. This sample is non-probabilistic, and the approaches used are descriptive and causal.

2.2 Procedure

First, the conversational agent on mathematics was built through the PHP programming language (See Figure 1). This prototype presents the basic concepts related to Financial Mathematics. For example, if the user asks textually or verbally, "What is the simple amount formula?" then the conversational agent shows the requested formula and answers, "The formula for the simple amount is shown below".



Figure 1 - Conversational agent on mathematics

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The conversational agent uses a Deep learning algorithm function to adapt the contents, which was obtained through the RapidMiner tool. Another example of the use of the conversational agent is where the user asks: “What is the amount?” Subsequently, this application answers verbally and textually, “Amount is the value of money in the future”.

The research hypotheses are:

- Hypothesis 1: The use of the conversational agent positively influences the motivation
- Hypothesis 2: The use of the conversational agent positively influences the active role

The predictive models on the use of the conversational agent are:

- Model 1 on the use of the conversational agent, user characteristics, and motivation
- Model 2 on the use of the conversational agent, user characteristics, and active role

2.3 Data collection

During the month of October 2024, data collection was carried out at the National Autonomous University of Mexico (See Table 1).

Table 1 - Questionnaire

No.	Variable	Dimension	Question	Answer	n	%		
1	User characteristics	Sex	1. Indicate your sex	Man	9	47.37		
				Woman	10	52.63		
		Learning style	2. Indicate your learning style	Kinesthetic	8	42.11		
				Visual	10	52.63		
		Auditory	1	5.26				
2	Conversational agent	Personalized learning	3. The use of the conversational agent facilitates personalized learning	Very much (1)	4	21.05		
				Much (2)	14	73.68		
				Little (3)	1	5.26		
				Very little (4)	0	0.00		
		Motivation	4. The conversational agent increases the motivation	Very much (1)	5	26.32		
				Much (2)	10	52.63		
				Little (3)	4	21.05		
				Very little (4)	0	0.00		
				Active role	5. The conversational agent increases the active role	Very much (1)	6	31.58
						Much (2)	12	63.16
Little (3)	1	5.26						
		Very little (4)	0	0.00				
3	Perception	Benefits	6. What are the benefits of the conversational agent for the educational field?	Open	-	-		
		Personalized learning	7. Does the conversational agent facilitate personalized learning at any time?	Open	-	-		

2.4 Data analysis

The calculation of the machine learning algorithms on linear regression and decision trees was carried out in the RapidMiner tool. The linear regression algorithm allowed evaluating the hypotheses and identifying the most efficient forecast function. Likewise, the decision tree algorithm allowed the construction of the predictive models considering the conversational agent and user characteristics. The target variables are the motivation and active role.

3. RESULTS

The use of the conversational agent facilitates personalized learning very much (n = 4, 21.05%), much (n = 14, 73.68%), and little (n = 1, 5.26%). For example, if the user asks: “What is Capital?” then the conversational agent responds textually and verbally: “Capital is an amount of money located on a start date in a financial operation” (See Figure 2).

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Figure 2 - Concept of Capital in the conversational agent

Table 2 shows the results of the linear regression and machine learning algorithm on the use of the conversational agent.

Table 2 - Results of the machine learning algorithm on linear regression

Hypothesis	Training	Evaluation	Model	Statistical t	Value of p	Squared error	Conclusion
H1	70%	30%	$y = 0.5416x + 1.0000$	1.3125	$p < 0.050$	0.2352	Accepted
	80%	20%	$y = 0.4999x + 1.0000$	1.2315	$p < 0.050$	0.0625	Accepted
	90%	10%	$y = 0.4078x + 1.1973$	1.1666	$p < 0.050$	0.0001	Accepted
H2	70%	30%	$y = 0.4166x + 1.0000$	1.3867	$p < 0.050$	0.1632	Accepted
	80%	20%	$y = 0.4285x + 1.0000$	1.5491	$p < 0.050$	0.2401	Accepted
	90%	10%	$y = 0.4736x + 0.8421$	1.8232	$p < 0.050$	0.0445	Accepted

The function $y = 0.1060x_1 + 0.6161x_2 + 0.6818$ allows predicting the motivation, where x_1 is the use of the conversational agent, and x_2 is the active role of the students who took the master's degree in Teaching for Higher Education. Likewise, the function $y = 0.3475x_1 + 0.3460x_2 + 0.4226$ allows predicting the active role, where x_1 is the use of the conversational agent, and x_2 is the motivation.

3.1 Motivation

The conversational agent increases very much ($n = 5$, 26.32%), much ($n = 10$, 52.63%), and little ($n = 4$, 21.05%) the motivation. In the machine learning algorithm, the results of the linear regression 70% (0.5416), 80% (0.4999), and 90% (0.4078) indicate that hypothesis 1 is accepted. Therefore, the use of the conversational agent positively influences motivation.

Figure 3 shows the decision tree obtained for the model 1, which consists of 5 predictive conditions. For example, if the user considers that the use of the conversational agent facilitates personalized learning very much and the learning style is auditory, then this technological tool increases motivation very much.

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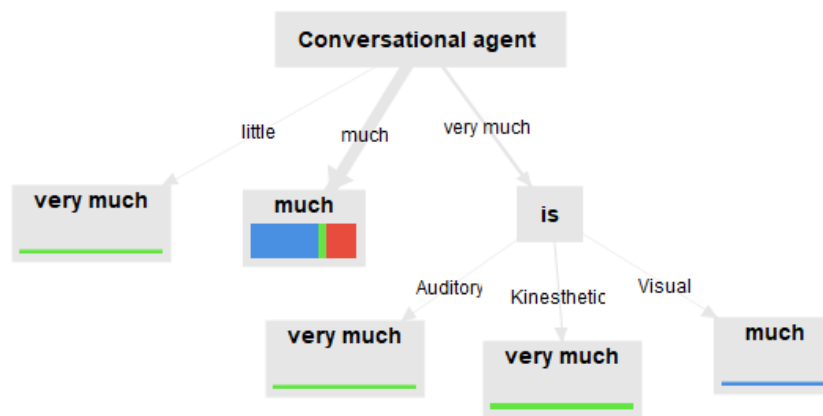


Figure 3 - Predictive model of the conversational agent and motivation

Learning style determines 3 conditions in this model. For example, if the user considers that the use of the conversational agent facilitates personalized learning very much and the learning style is visual, then this technological tool greatly increases much the motivation. Also, if the user considers that the use of the conversational agent facilitates personalized learning very much and the learning style is kinesthetic, then this technological tool increases motivation very much.

3.2 Active role

The conversational agent increases very much ($n = 6, 31.58\%$), much ($n = 12, 63.16\%$), and little ($n = 1, 5.26\%$) the active role. In the machine learning algorithm, the results of the linear regression 70% (0.4166), 80% (0.4285), and 90% (0.4736) indicate that hypothesis 2 is accepted. Therefore, the use of the conversational agent positively influences the active role.

Figure 4 shows the decision tree obtained for model 2, which consists of 5 predictive conditions. For example, if the user considers that the use of the conversational agent facilitates personalized learning and the learning style is visual, then this technological tool greatly increases much the active role.

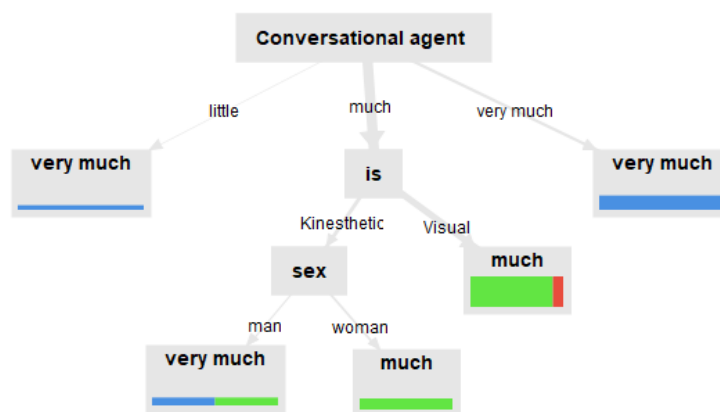


Figure 4 - Predictive model on the conversational agent and active role

Learning style determines 3 conditions in this model. For example, if the user considers that the use of the conversational agent facilitates personalized learning much more, is a man, and the learning style is kinesthetic, then this technological tool increases the active role very much.

In addition, sex determines 2 conditions in this model. For example, if the user considers that the use of the conversational agent facilitates personalized learning, is a woman, and the learning style is kinesthetic, then this technological tool greatly increases much the active role.

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3.3 Benefits

The conversational agent allowed the student to control the teaching-learning process through voice and text.

“It allows the self-regulated learning”.

“It has a positive impact on learning, since it accompanies and helps in the educational process through AI”.

According to the students of the master’s degree in teaching for Higher Education, the conversational agent facilitated the resolution of the doubts.

“Encourage the participation and resolution of the doubts”.

“It allows students to be more autonomous during the learning process and adapt it to their needs, according to their doubts”.

The conversational agent created virtual spaces where the student was motivated to learn the school topics. Likewise, this tool encouraged curiosity.

“This technology facilitates and motivates the learning”.

“It’s fun to ask the AI, I think it arouses curiosity”.

The benefits of the conversational agent on mathematics are associated with the flexibility of time and space.

“It is an interactive material that is available at all times and accessible from everywhere”.

“It allows distance learning and provides guidance on topics”.

The most frequent words are learning (n = 6), students (n = 5), doubts (n = 3), help (n = 2), concepts (n = 2), and distance (n = 2) for the next question: “What are the benefits of the conversational agent for the educational field?”

3.4 Personalized learning

The conversational agent on mathematics facilitated personalized learning because the students could access it from mobile devices.

“Yes, because it is possible to use it from anywhere through mobile devices”.

“Yes, because students can consult it from their personal computers”.

According to the participants, the conversational agent answered the questions considering their needs.

“Yes, because I consult it according to my needs”.

“Yes. The access is easy, and the information is reliable”.

At the National Autonomous University of Mexico, the respondents mentioned that the conversational agent on mathematics facilitated personalized learning.

“Yes, each person can occupy it at their own pace”.

“It allows a more personalized interaction according to the needs of the student”.

Likewise, the students of the master’s degree in teaching for Higher Education mentioned that this technological tool is easy to use during the teaching-learning process in mathematics.

“Yes, due to accessibility and ease of use”.

“Yes. Each person will obtain the information according to the questions”.

The most frequent words are Internet (n = 5), access (n = 2), agreement (n = 2), support (n = 2), connection (n = 2), and available (n = 2) for the next question: “Does the conversational agent facilitate personalized learning at any time?”

4. DISCUSSION

As mentioned by Biton and Segel (2024), the incorporation of technology in the field of mathematics favors the acquisition of knowledge and communication from anywhere. According to the respondents, one of the benefits related to the use of the conversational agent in mathematics was the interaction through voice and text during the teaching-learning process.

Gurl et al. (2024) explain that artificial intelligence tools support educators and students during the organization and preparation of content for the courses. In this study, 94.74% of the participants mention that the use of the conversational agent facilitated very much and much the personalized learning. Therefore, the majority have a favorable opinion on this aspect.

4.1 Motivation

Marange and Tatira (2023) highlight the importance of web applications in the educational field of mathematics to create virtual teaching-learning spaces where the student is motivated. In this research, 78.95% of the participants mentioned that the conversational agent increased their motivation.

Various authors (e.g., Rodriguez-Florido et al., 2024) highlight that the incorporation of technology into schools causes a new educational experience where the student cooperates and actively participates. In this study, the participants mentioned that the conversational agent favored the resolution of doubts and created virtual spaces where students were motivated during the teaching-learning process.

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Gurl et al. (2024) and Romero-Rodríguez et al. (2023) establish that artificial intelligence is a means to improve the quality in the educational field. For hypothesis 1, the results indicate that the use of the conversational agent positively influenced the motivation. On the other hand, the best function with the smallest squared error to predict the motivation is $y = 0.4078x + 1.1973$. As pointed out by Wahba et al. (2024), artificial intelligence is a technological vehicle that promotes the enthusiasm and motivation of students during the teaching-learning process. Regarding the decision tree algorithm, model 1 has 5 predictive conditions where the learning style influences the forecast of the motivation. For example, if the user considers that the use of the conversational agent facilitates personalized learning very much and the learning style is auditory, then this technological tool increases motivation very much.

4.2 Active role

Opesemowo and Adewuyi (2024) explain that artificial intelligence tools are used in the educational field of mathematics because students have control of the learning process. In this research, the respondents considered that the conversational agent allowed the personalization of the learning because these users can access the content on mathematics from computers and mobile devices.

Artificial intelligence tools promote that students interact more frequently in the educational process and develop their mathematical skills (Bhullar et al., 2024; Naamati-Schneider & Alt, 2024; Wardat et al., 2023; Zhou & Kim, 2024). In this study, 94.74% of the participants mentioned that the conversational agent increased their active role very much. Therefore, the majority have a favorable opinion on this aspect.

Weingarden et al. (2024) point out that the use of applications in mathematics courses favors the reflection of the ideas, debate, development of skills, and learning at any time. For hypothesis 2, the results indicate that the use of the conversational agent positively influenced the active role. On the other hand, the best function with the smallest squared error to predict the active role is $y = 0.4736x + 0.8421$.

Wahba et al. (2024) highlight that the use of artificial intelligence in the educational context changes the way students learn in mathematics courses because students have control and understand the topics at their own pace. Regarding the decision tree algorithm, model 2 has 5 predictive conditions where the learning style and sex influence the prediction of the active role. For example, if the user considers that the use of the conversational agent facilitates personalized learning much more, is a man, and the learning style is kinesthetic, then this technological tool increases the active role very much.

Technology opens new opportunities to improve the organization and implementation of practices and activities in the courses; therefore, teachers must search and select the most appropriate tools to meet the needs of the students (Biton & Segel, 2024; Gurl et al., 2024; Wahba et al., 2024). Finally, the students of the master's degree in teaching for Higher Education consider that the conversational agent has a simple interface that is easy to use from anywhere.

CONCLUSION

The conversational agent on mathematics is a technological tool that updates the educational practices because users can obtain the information visually and textually. In this study, the results of the linear regression indicate that the use of the conversational agent positively influenced motivation and active role. Likewise, the decision tree algorithm established two models to predict the motivation and active role, considering the use of this application and user characteristics.

The limitations of this research are the sample size and the dependent variables. Future work can analyze the use of the conversational agent for the development of mathematical skills in high schools and universities to increase the number of participants.

On the other hand, the benefits of the conversational agent on mathematics are the interaction through voice and text, resolution of doubts, personalized learning, and ease of use. In conclusion, teachers can incorporate the conversational agent into school activities because this tool offers the flexibility of time and space, encourages autonomy, and facilitates learning.

AUTHORS' CONTRIBUTION

Conceptualization, R.A.S.R., E.P.S.R. and R.D.S.R.; data curation, R.A.S.R., E.P.S.R. and R.D.S.R.; formal analysis, R.A.S.R., E.P.S.R. and R.D.S.R.; funding acquisition, R.A.S.R.; investigation, R.A.S.R., E.P.S.R. and R.D.S.R.; methodology, R.A.S.R., E.P.S.R. and R.D.S.R.; project administration, R.A.S.R.; resources, R.A.S.R.; software, R.A.S.R., E.P.S.R. and R.D.S.R.; supervision, R.A.S.R., E.P.S.R. and R.D.S.R.; validation, R.A.S.R.; visualization, R.A.S.R.; writing – original draft, R.A.S.R., E.P.S.R. and R.D.S.R.; writing – review & editing, R.A.S.R., E.P.S.R. and R.D.S.R.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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