

Evaluation of Artificial Intelligence as a Source of Motivation in the Teaching of Chemistry: A Study with Tenth Grade Students at the Adventist School of Ibagué

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Abstract

The objective of this research has been to evaluate the effect of the integration of Artificial Intelligence on the motivation of students, in the area of Chemistry of tenth grade of the Adventist School of Ibagué. To this end, a methodology with a qualitative approach and a Participatory Action Research design with four phases were used: planning, action, observation and reflection. The information was collected through observation and interview techniques for which field diaries and structured script were used as research instruments. This information was analyzed with the Atlas.ti 23 software, the resulting codes allowed the definition of the categories: experience in the use of artificial intelligence, motivation and commitment, meaningful learning and perceptions about teaching and learning. The results obtained reflect an increase in student motivation and engagement, as well as a favorable impact on meaningful learning. They highlight the pedagogical potential of this resource, to diversify and enrich didactics in the teaching of chemistry. A positive perception by students towards the implementation of AI in the classroom was identified. It is concluded that the use of AI mediated with the design of pedagogical strategies to create learning environments and situations can improve the motivation of students, generating a space for knowledge and meaningful learning. However, challenges were also identified, such as the need for teacher and student training in the management and proper use of technological resources. In addition, the importance of not considering artificial intelligence as a total replacement for the role of the teacher, but as a complementary tool that requires an adequate pedagogical approach, is highlighted.

Keywords: AI, motivation, teaching and learning, pedagogical strategy, secondary education.

1. Introduction

Currently, Artificial Intelligence (AI) has generated a profound impact on various fields of society. Among the range of technologies considered as AI are software and hardware capable of perceiving the environment and making it safer, systems that produce text or images as well as systems that compose musical pieces or make translations into different languages; in devices ranging from a mobile phone, through personal assistants, robots to supercomputers (Casali, 2007; Valverde, 2019; Majid & Lakshmi, 2022), this incursion of AI into society is generating an algorithmic society (Sanabria-Navarro et al., 2023), benefiting fields such as medicine, business, communication, and even education.

The implementation of Artificial Intelligence in Education that seeks to enhance teaching and learning processes is known as AIED (Artificial Intelligence in Education). The contribution of AIED ranges from the automation of teaching administrative work and the optimization of time that can be used in other activities, to the improvement of teaching strategies that are based on the interests and characteristics of students, for whom AI additionally offers permanent accompaniment (Majid & Lakshmi, 2022). This, in turn, provides more efficient processes in the approach to the contents and the acquisition of the competencies required for the level of education. Therefore, the AIED is considered a strategic ally for educational reforms that tend to innovation and respond to the needs of twenty-first-century students (UNESCO, 2020; UNESCO, 2019).

Various international organizations have recently highlighted the importance of promoting artificial intelligence for the progress of Latin American countries. To do this, it is necessary to know the experience of the use of artificial intelligence in classrooms and how the learning process can be impacted by its arrival in different school environments (Rivas et al. (2023).

Recent research on the application of AI in educational contexts has shown the promotion of new pedagogical strategies (Mejías et al., 2022), however, conceptual or reflective studies on the challenges and opportunities of AI for educational processes are more abundant, studies on significant ethical and deontological aspects associated with the implementation of artificial intelligence in the educational field are also highlighted. (Flores-Vivar & García-Peñalvo, 2023). In contrast, those studies that emerge from the real application of this technology in the classroom are scarce (de la Ossa et al., 2024).

The relationship between AI and education is manifested in three main dimensions: first, learning using AI, i.e. making use of AI-based tools; second, learning about AI, understanding its technologies and techniques; and third, AI readiness, which involves understanding all of its implications and potential applications. In this dynamic and promising context, the need arises to explore and understand the scope and implications of AI. With this research, it was sought to evaluate whether the introduction of AI, as an educational tool in the area of chemistry, increases the motivation of students, to achieve meaningful learning, in such a way that it strengthens the essential competencies for the academic level and enriches the teaching and learning process.

Taking into account that school motivation is the engine of progress in learning and is an essential and indispensable element that must be present in classrooms. As teachers, this must be made a

constant tool in the pedagogical work. Motivation can originate from different sources and is classified into intrinsic and extrinsic motivation. Intrinsic motivation arises from internal factors such as self-determination, curiosity, challenge, and effort. On the other hand, extrinsic motivation comes from external factors and varies according to the level of autonomy of the individual. This indicates that a person is extrinsically motivated towards an activity when they perceive the possibility of obtaining some external benefit from it (Domínguez & Pino-Juste, 2016).

However, since adolescents in the twenty-first century, belonging to the Centennial generation, can more easily achieve meaningful learning, with the accompaniment of digital tools, such as those offered by the Centennial Generation to facilitate the formation of soft skills, including student motivation (González-Zamar et al., 2020); it was necessary to design a didactic sequence that included active methodologies, accompanied by the use of artificial intelligence resources with a collaborative learning approach. These pedagogical strategies were implemented in the Chemistry classes of the Adventist School of Ibagué, Colombia and allowed to determine that the implementation of AI in the classroom favors the motivation and meaningful learning of students.

2. Methodology

This research was carried out with a qualitative approach and a Participatory Action Research (PAR) design. Being of a participatory type, this design seeks the contribution of the actors involved and seeks to transcend the intervention in order to promote a change in the mediated situations (Sagastizabal & Perlo, 2002). The PAR model proposed by Kemmis et al., (2014) was used, who propose a process carried out in four phases: planning, action or change, observation and reflection.

The initial population is 24 students from the Adventist School of Ibagué enrolled in grade 10[°]B. Of which 11 are female and 13 are male. The students are between 14 and 18 years old, come from different educational institutions and socioeconomic strata. Students who regularly attended the sessions developed for research purposes were included.

An inductive method was used to collect the information. Understanding that action research is based on particular facts of subjects who live in a society with specific problems and it is from there that it is a matter of seeking solutions to these situations, as Rojas (2008) refers to.

In this research, the categories that were defined as problematic were: experience in the use of artificial intelligence, motivation and commitment, meaningful learning and perceptions about teaching and learning. Subcategories were proposed to provide clarity on the initial categories. The subcategories were intervened using two collection techniques: observation and interview, for which field diaries and structured script were used as research instruments. Table 1 presents the categorization of the information in detail.

Table 1 Categorization of information

Analysis category	Subcategories	Technique	Instrument
Experience of using Artificial Intelligence	Students' perceptions of how they feel about using technology in their chemistry classes.	Observation	Field diaries
	Opinions on the novelty and usefulness of Artificial Intelligence in the learning process.	Interview	Structured scripts
Motivation and commitment	Observation of changes in students' intrinsic and extrinsic motivation due to the implementation of Artificial Intelligence.	Observation	Field diaries
	Self-determination in the levels of interest and enthusiasm for the subject of the chemistry subject.	Interview	Structured scripts
Meaningful Learning	Identification of learning moments or activities that students consider most significant with the use of Artificial Intelligence.	Observation	Field diaries
	Comparison of understanding and retention of concepts before and after implementation.	Interview	Structured scripts
Perceptions about teaching and learning.	Students' opinions on how Artificial Intelligence changes the dynamics of classes and the relationship with teachers.	Interviews	Structured scripts

Methodological source

The interviews were transcribed verbatim, and both these and the field diaries went through a coding process using the Atlas.ti software 23. The resulting codes were triangulated between both instruments and with the defined categories. For triangulation, abstract, word frequency and new coding were used. The final codes were regrouped into the initial categories.

Ethical considerations

This research project complies with the ethical principles established by the Adventist University Corporation (CEIUNAC, n.d.). The present study was conducted with the highest level of ethical integrity, ensuring respect for the dignity, privacy, and rights of all participants involved. Who approved their participation through informed consents.

3. Results

The analysis of the field diaries and interviews conducted in the Atlas.ti software allowed the identification of impressions of students and teachers, from which four categories were consolidated. With this information, it was determined that the implementation of AI as an educational resource in the teaching of chemistry, in the competencies: Understanding the behavior of an ideal gas and its variables (temperature, pressure and volume) and explanation of everyday events based on mathematical relationships between its variables, in the 10°B grade of the CADI, it managed to motivate students in significant learning processes. Below are the findings for each category investigated.

Experience of using artificial intelligence.

The introduction of AI in the classroom was considered positive and enriching by the students. Since it managed to capture their attention, increase their participation in class by being an innovative and exciting educational tool in their learning process. Students described the experience with AI as rewarding and meaningful. This finding highlights the pedagogical potential of AI to diversify and enrich didactics in the teaching of chemistry. However, its use requires additional time, teacher training, equipment and technological resources, and the certainty that it does not replace the role of the teacher in the educational field. Additionally, it was found that interaction with technology can become a distracting factor in the classroom.

Motivation and commitment.

The implementation of AI in the learning process generated a positive impact among students, who demonstrated a high level of motivation and commitment. The use of various resources and platforms in the study of gas laws significantly facilitated their understanding. Although some students did not meet their student commitments within the established deadline, the general perception is that a pleasant and friendly classroom environment was created, favoring an environment conducive to learning.

On the other hand, the students' experience with AI reveals a duality: a level of motivation and commitment was evidenced when using this technology in various ways during classes. However, as mentioned above, students recognize the need to avoid external distractions since the possibility of browsing other pages could affect their concentration. In addition, it is highlighted that, despite general motivation, the presence of personal problems can act as a factor that interrupts students' motivation.

Meaningful Learning

The students valued the implementation of AI as beneficial, since it not only responds to queries, but also explains the process, which made it easier to understand. It was also found that the use of interactive activities with AI made learning fun and memorable. The students mentioned that you can learn better through this technology and wish it was applied in other classes. It was evident that by working in a group and being guided by the AI in the process, distractions are avoided (by their own thoughts or being distracted by colleagues who go off topic). In addition, it was identified that the student's attitude and the teacher's methodology are important to achieve lasting learning. Finally, the use of AI in the classroom contributed to improving the academic performance of students in the previously mentioned competencies, this was evidenced in the results obtained in the internal tests.

Perceptions of teaching and learning

Both students and teachers mentioned that the teaching and learning processes were successful, since the classroom climate was pleasant and dynamic. The objectives were met while feelings of satisfaction were generated by the positive attitudes of the participants in the process. The students considered that the use of AI in education is beneficial, as it increased their attention, interest, participation, teamwork, improved their concentration, favored the development of

critical skills and motivation for the class, and also facilitated the understanding of the topics. In short, it maximized opportunities for meaningful learning to take place. On the other hand, some students expressed better understanding when the teacher explained to them, highlighting the importance of interaction with teachers and traditional learning. In addition, they highlighted the need to use AI appropriately and combine it with other teaching strategies.

4. Discussion

Experience of using artificial intelligence

By implementing artificial intelligence in the classroom together with other traditional pedagogical strategies, students' attention is significantly engaged. The combination of activities contributes to a quality educational experience. In addition, AI increases their participation, creates a more pleasant and motivating classroom environment (UNESCO, 2018; Jara & Ochoa, 2020). Mangera et al., (2023) report that students felt very enthusiastic about using AI and also that it helped them feel more comfortable and effective, events that were also evident when conducting this research.

Although ICTs are useful in the teaching and learning processes of Chemistry (Barraqué et al., 2021; Martínez-Argüello et al., 2018; Suárez et al., 2021) likewise, AI proves to be an innovative tool to enhance didactics in teaching and learning in this area of knowledge. However, it should be noted that the use of AI in the classroom, as well as access to the internet or technological tools in general, although it diversifies and enriches classes, also represents a distracting factor for students, who sometimes stopped doing the requested work to inquire into their own interests. A similar situation was found by Santoveña-Casal & Bernal-Bravo (2019) who, by implementing social networks for classroom work, identified ample possibilities for communication and social contact, just as they became a source of distraction that affected the low academic performance of students. Therefore, responsibility and self-control of students are required, as well as guidance and accompaniment by teachers so that this type of technological tools are an ally of academic training and not a rival to it.

When implementing the IEDE, it is crucial to consider several additional aspects. More time needs to be spent instructing students on how to use the various resources, as well as encouraging reflection on their application and the material generated from them. In addition, the equipment necessary for the integration of AI into the educational process must be properly managed and its availability within the institution must be guaranteed. These findings are similar to those found by other researchers who report that the use of AI entails challenges that educational establishments must face, such as the lack of resources that could hinder the implementation of AI, the lack of time and training of teachers, which would imply negative consequences in the incorporation of AI and in the design of current digital resources (Ayuso & Gutiérrez, 2022; García-Peñalvo et al., 2024).

Finally, it should be considered that in view of the widespread fear on the part of teachers of being replaced by AI (Sumakul et al., 2022), it must be considered that AI cannot replace the

fundamental role of the teacher in the educational process. While AI can be a useful tool for improving teaching and learning, it lacks the empathy, experience, and human judgment that an educator brings to the classroom. The teacher not only transmits knowledge, but also guides, motivates and understands the individual needs of the students. Their presence and guidance are irreplaceable to foster the integral development of students and promote an enriching learning environment.

Motivation and commitment.

In this category, the research allowed us to know that the introduction of artificial intelligence in the classroom has generated a positive and significant impact on the motivation and commitment of tenth grade students of the Adventist School of Ibagué. The wide range of resources and platforms available has contributed to creating a pleasant environment, in which students have been stimulated in the learning process. This result allows us to validate what Ledesma and Cobos (2023) mention, who argue that motivational elements contribute to the student being able to overcome their limitations, enhancing their abilities, and at the same time, encouraging positive behavior in them.

This research showed that technology makes it possible to create interactive environments in classrooms (Moreno-Acosta & Zabala-Vargas, 2022; Maguiño et al., 2020; Bustos & Coll, 2010). Students' reactions to the incorporation of AI in classes indicate a desire to learn how to use it correctly, as well as an interest in teachers developing creative and innovative activities to maintain their attention, this aspect coincides with what Padilla (2019) mentioned. There is no doubt that teaching methods, ways of learning, access to knowledge and teacher training are in the process of a significant revolution.

In addition, when implementing AI in the teaching-learning processes of Chemistry, it was identified that commitment played a crucial role, since it revealed the relationship between motivation and commitment. When a student is motivated, he or she feels an obligation to fulfill the agreed commitments since motivational factors affect the student's cognitive commitment and, therefore, his or her academic performance (Lara et al., 2021; Tomás et al., 2016). Not to mention that some of the students delivered their commitments some time after the established date.

However, it is worth mentioning that there is a direct relationship between commitment, motivation and academic success or failure, in the words of Mirete et al., (2015) "lack of motivation and inadequate study strategies are foresight of future school failures" (p. 195), therefore, it is necessary to promote extrinsic motivation and student interest in order to counteract school failure. To this end, the methodology of work in the classroom can be modified, including active and technological strategies that diversify classes, make thematic content more understandable, the proposed competencies more achievable and, consequently, reduce school failure (Padilla, 2022).

Along the same lines, it is essential to recognize that intrinsic motivation, that which arises from within the individual rather than being driven by external factors, plays a crucial role in academic performance (Padilla, 2022; Mirete et al., 2015). When students find meaning and relevance in

what they are learning, they are more inclined to engage with the educational process and pursue academic goals with determination. However, the challenge lies in cultivating and nurturing this intrinsic motivation, especially in an environment where distractions and external demands can divert your attention and energy. Therefore, in addition to adapting teaching strategies, it is essential to foster an environment of emotional support and recognition, where students feel valued and empowered to reach their full potential. In this way, a solid foundation can be built to counter school failure and foster a path to academic and personal success.

Finally, when implementing AI with students in the tenth grade of CADI, it was found that the presence of personal problems can act as a factor that interrupts motivation. Ledesma and Cobos (2023) express it well, who, when considering motivational factors, highlight that the aspects that affect the progress of students include academic, emotional, and social elements. However, recognizing the influence of the emotional area on student performance, it is essential that educators address the emotional well-being of students, as this enhances their abilities to face academic challenges and solve problems more efficiently, thus strengthening the learning process and promoting integral development.

Meaningful Learning

Our research showed that by implementing teamwork and AI as learning material, positive attitudes or predispositions are promoted; thus promoting meaningful learning in accordance with the characteristics and elements presented by González-Zamar et al., (2020) and by Souza (2021). To reaffirm this, it is worth mentioning that by using AI as well as collaborative work in the classroom, the student is given prominence and the teacher becomes a collaborator or guide of the process, an issue that Barraqué et al., (2020) consider essential to achieve meaningful learning.

If we take into account that learning is significant when it is built from previous knowledge and that the teacher plays an important role since he or she must know what students know so that they can build learning with new information from there (González-Zamar et al., 2020; Castellanos & Yaya, 2013; Souza, 2021), the implementation of AI together with other pedagogical and didactic resources provide valuable inputs for the construction of knowledge in pedagogical models that consider prior knowledge as part of the process.

However, when reviewing the characteristics of AI and selecting the resources to be used for classroom work in the CADI, it was found that it not only provides answers but also has the ability to present processes in a detailed way, contextualized topics and even, through the diversity of resources, different learning styles can be addressed. This is essential for educational processes since it allows for personalized and adaptive teaching, facilitates the understanding of concepts, contributes to connecting learning with real life and, according to González and Silveira (2022), can favor analysis, the production of scientific discourse, and the "expansion of educational platforms" (p. 73).

The results of this research showed, as did other studies, that AI classes are more attractive to students (Ocaña-Fernández et al., 2019; Carbonell-García, 2023). By using different striking resources, students mention that they generate various emotions, turning learning into

memorable memories. According to Marcos-Merino et al., (2022) these types of positive and stimulating emotions are opposed to negative depressant emotions (except nervousness) and therefore favor learning. The author also points out that positive anticipatory emotions provide a better classroom climate. This was evident in the classroom work of our research, since the students expressed expectations and a positive predisposition towards the activities to be carried out. And consequently, the development of the classes was facilitated as well as the performance of the students.

With the implementation of AI, students improved their understanding of the thematic contents, this can provide a starting point for teachers in the area of natural sciences or more specifically in the subject of chemistry since students achieved the competencies proposed for this research: understanding the behavior of an ideal gas and its variables (temperature, pressure, pressure, pressure, pressure and volume) and explanation of everyday events based on mathematical relationships between their variables. In addition, the students expressed greater pleasure in the activities to be carried out, felt the desire to go further or explore more deeply the orientations given and obtained better grades. These results are in line with those presented by Ayuso and Gutiérrez (2022), who found that when implementing AI, schoolchildren express enjoyment of the project development process, demonstrated satisfaction and achievement at the end of the task, expressed that they would like to learn more about the subject, and considered that they learn faster and meaningful learning is encouraged.

In addition, flexibility is a feature of AI, which contributes to meeting the needs of students, allowing the personalization of learning and leading to the creation of inclusive educational resources. When students are presented with the possibility of using modern technologies in collaboration to create new products or ideas, a space is provided for the efficient development of the academic competencies proposed and creativity is stimulated. This highlights the importance of evolving from passive teaching strategies to a meaningful approach to AI-assisted learning, in which students can participate more actively in the learning process (Zhou, 2022; Padilla, 2019).

However, the role of the teacher as a mediator of knowledge resignifies the use of AI. This is evident since at the beginning of the research the students mentioned using some AI resources only to copy, transcribe and deliver their assignments. After the verbal and written direction in the learning guides, from us as teacher-researchers, the students carried out reflective processes: they read, analyzed texts, tables, images, found errors that the AI showed and corrected them, all these practices contributed to the students making better use of AI and taking advantage of it for classroom work, as well as outside of it. This leads us to think that teacher guidance for the use of AI contributes to developing autonomy in students (Barraqué et al., 2020), facilitates the understanding of concepts and therefore also contributes to the improvement of academic performance (Ayuso & Gutiérrez, 2022).

When reviewing the use of AI by students as well as teachers, the ethical implications of the implementation of artificial intelligence in education must be considered. Unlike other fields where important case studies have been conducted, in the field of education there is a notable paucity of research. This is concerning since the literature has reported serious cases of violation

or transformation of moral axioms or human rights due to AI, and pedagogy seems to maintain a silence on the subject, possibly due to bewilderment or ignorance (De la Ossa et al., 2023).

Although working with AI in class yielded the benefits described above, it should also be mentioned that it represents some challenges. Among these are the scarcity of devices, the loading speed of applications, the management of new applications and the challenges of collaborative work; such as differences of opinion or the correct interpretation/appropriation of content. These well-directed situations foster an academic, technological, and social learning environment in which students develop creativity as well as soft skills, specifically for conflict management and resolution. Factors that would also contribute to the achievement of significant and enriching learning (Ayuso & Gutiérrez, 2022).

Another challenge that arose and that we consider affects the achievement of significant learning and academic performance is emotional stability, in this case of students. Who manifested in the interviews and was also observed through the field diaries; they did not feel motivated even if AI was used when they had personal problems, had not slept well or felt affected by situations outside the class. This type of circumstance reflects that there is a close relationship between emotional intelligence and academic performance (Flores et al., 2023). It is therefore important for the teacher to have the ability to identify, recognize the behaviors and needs of their students and look for AI or other resources or strategies "that allow motivating or reconnecting the student with the knowledge of the course" (Sumakul et al., 2022).

Finally, we allude to a challenge that we as teachers-researchers see and that is the need for training in the technological area. To make AI an effective resource in the scope of meaningful learning, it is necessary to be at the forefront of technological knowledge as well as other fundamental areas for the development of this work. Particularly with the novelty of AIED, it is necessary for teachers to research and learn about AI technologies and learn how to manage them for classroom work (Getchell, 2022; Viñals & Cuenca, 2016) as well as for administrative work; taking advantage of the benefits of this and preparing children and young people for their development in today's society.

Perceptions about teaching and learning

The results obtained in this research showed how the implementation of AI in the school context requires a process of adaptation and training of the teacher in the use of AI tools and also an investment of additional time for the design of learning environments. for the selection of appropriate pedagogical strategies and the design of didactic sequences integrated with the use of AI, which would allow the development of critical thinking and not only the transcription of information.

This initial phase was an extra burden for the educators, as the project was carried out in the course of the school year and required them to meet their usual pedagogical commitments. However, it is important to recognize that the investment of time and effort in this initial stage generated long-term benefits since the students achieved the learning objectives and the teachers felt satisfied to observe how their students enjoyed the process itself. It can be said that AI has the potential to optimize and enrich the teaching-learning process, offering new tools and

resources to engage students more effectively and achieve more meaningful and satisfying learning (UNESCO, 2020; UNESCO, 2019).

A similar study, but with the use of AI/chat-GPT with university professors, showed how artificial intelligence can represent a valuable resource in the teaching process. However, its use implies that teachers must create educational approaches that encourage the development of critical thinking in students, instead of simply transmitting information passively. This requires careful integration with active pedagogical and didactic strategies, where the emphasis is on the active participation of students and the generation of knowledge through analysis and reflection (Ojeda et al., 2023). Another research entitled Project-based learning supported by a techno-pedagogical design for the teaching of descriptive statistics also showed that the techno-pedagogical design must be adapted to the particularities and specific demands of the educational environment and the classroom in question. This will ensure a successful selection of the pedagogical strategy, such as the problem-based approach (PBL), as well as the appropriate information and communication technologies (ICTs) to facilitate and improve the teaching process (Vargas et al., 2021).

On the other hand, in the study carried out by Ayuso and Gutiérrez, (2022) and including the present one, it is inferred that the implementation of AI reduces the dependence of the teacher on the student for the solution of doubts, in the resolution of problems. Thus freeing the teacher from the repetition of tasks of low cognitive level. This would be another long-term compensation for the teacher for the time invested in training and design of pedagogical strategies for the appropriate implementation of AI, time that could be reinvested in the same process, thus reducing the gap between the accelerated development of AI and the preparation of schools to address it.

In addition, CADI students showed interest in the knowledge of the tools offered by AI, since it made it easier for them to make academic commitments, that is, it allowed them to make summaries, schemes, presentations, avatars for their presentations, accompaniment in the answers to reflective questions, problem solving, optimized the management of information and the time invested in the realization of their assignments oriented with pedagogical sequences designed to avoid only copying information. This coincides with the findings of (Tuomi, 2018), which states that students are interested in knowing and learning more about AI as a tool that allows them to acquire new knowledge in a more practical and faster way. Another study that confirms the increase in students' interest in the use of AI is that of Ayuso and Gutiérrez (2022), who showed that AI makes teaching and learning processes more fun and interesting, likewise the students of Ayuso and Gutiérrez's (2022) research expressed that they would like to use AI as a tool for study. They also added that they would like their professors to use it, which coincides with what was expressed by the CADI students, however, some of them also said that along with the support of the AI, they required the teacher's explanation. From the above, it can be seen that there is a technological gap between the accelerated advance of AI and the slow pace of the integration of this tool into school classrooms, although it is true that traditional processes have their benefits in the pedagogical field, the need to enhance them with active methodologies and

pedagogical strategies to implement AI and make learning a process is also real in which learning in an innovative and creative way also translates into fun.

On the other hand, the use of AI allowed most CADI students to develop competencies linked to problem solving in chemistry, competencies that require skills in mathematical operations; this was also evidenced by the research of Castro et al., (2011), in which the use of AI was possible to increase academic performance in the problem-solving competency. in the area of mathematics. Ayuso and Gutiérrez (2022) also report that using AI in the classroom stimulates the development of problem-solving skills. However, in the CADI study it did not apply to all students, since, as said in previous sections, there remains the challenge of reaching with diverse pedagogical strategies those students who did not show autonomy, nor motivation for the integration of AI in their learning process, but that technology led them to be distracted by it in non-academic activities. and also to reach those others who require direct accompaniment from teachers for the development of their critical thinking, perhaps because they presumably have disabilities or learning disorders, for which the school situations created by the didactic sequences were not inclusive of their learning rhythms and diversity. In the research of Castro et al., (2011) students mention that learning is easier for them using AI than in the traditional way, also Tapalova and Zhiyenbayeva (2022) conclude in their study that the use of AI in education empowers students, facilitating personalized learning in which the student is the center. These findings contrast with what was expressed by the CADI students, who consider that although it is true that AI facilitated their understanding of problem solving, they do not rule out the traditional methodology in terms of the teacher's explanation for their learning, it is likely, as mentioned above, that for some students of the present research due to their particular learning conditions they require personalized pedagogical interventions by the teacher.

Educational experience has shown that not all groups of students are similar, even if they are in the same grade and in equal age ranges, some groups do not respond in the same way as the majority, hence the need for the teacher to provide personalized support to those students who require it, either at a cognitive level or as described by Ojeda et al., (2023) in their study on AI integration, the role of the teacher is currently focused on the development and strengthening of students' social, emotional, and critical skills.

5. Conclusions

After carrying out this research, it was evident that the implementation of Artificial Intelligence as a teaching-learning resource in the area of Chemistry favors student motivation. The AIED provides more efficient processes in the approach to the contents and the acquisition of the competencies required for the school level of the academic average. Therefore, AIED is considered a strategic ally for educational reforms that tend towards innovation and respond to the needs of twenty-first-century students (Lede & Varela, 2022; Majid & Lakshmi, 2022)

On the other hand, the integration of AI proved to be an essential tool to boost students' intrinsic motivation and improve their academic performance, which has resulted in a notable increase in their willingness to learn. As Bolaño-García and Duarte-Acosta (2023) confirm, artificial

intelligence offers specific feedback to address strengths and weaknesses, which not only improves the understanding of thematic content, but also maintains and stimulates motivation to learn. Therefore, artificial intelligence promotes and facilitates a stimulating and welcoming learning environment.

The implementation of AI in the classroom, together with the design of pedagogical strategies and a collaborative learning approach, as carried out in this research, became a powerful tool to promote meaningful learning, as Ayuso and Gutiérrez (2022) also point out. However, the inherent risks to students must be taken into account, in order to avoid the inappropriate use of AI (Delgado et al., 2024). It is therefore necessary to develop logical and analytical thinking skills, as well as competencies in effective communication and conflict management, as pointed out by Jara and Ochoa (2020). The challenges and limitations that the implementation of AI implies in schools in terms of the effective use of AI-based educational applications, which require access to devices and a high-speed internet connection, must also be foreseen (Jara & Ochoa, 2020; Trejo et al., 2014).

AI proved to be a valuable resource in teaching, to facilitate the learning of students' competencies and optimize the teacher's time, but its use requires teachers to design pedagogical, didactic, and active strategies that promote students' critical thinking rather than simply passively imparting knowledge (Peña et al., 2020). The study conducted by Delgado et al., (2024) revealed that educators have limited knowledge about the applications of the IEA and some reservations regarding its use, despite recognizing its potential. This implies a gradual training of teachers to improve their educational practice.

Three questions emerge from the results of this research: will the AIDE replace traditional pedagogical strategies?, b) Are developing countries prepared for this transition? and c) how to maximize the benefits of IPA for teaching and learning processes? To answer these, some lines of research are suggested: the impact of AI on the development of cognitive, socio-emotional and digital skills of students could be explored, comparing it with the skills developed through traditional pedagogical methods in the contexts of developed and developing countries. Another area of research could examine the design of educational environments that integrate AIED effectively to address the individual needs of all students. These lines of research can provide valuable information to optimize the use of AIDE and maximize its benefits for all those involved in the educational process.

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