# The Impact Of Innovative AI-based Approaches on Learner Engagement in Science At Univertity

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**Abstract.** Adaptive learning systems (ALS), powered by artificial intelligence, represent an innovative approach to increasing student engagement in science at the university level. These systems, by analyzing the individual performance of students, adapt the content and pace of learning to their specific needs. This personalization of the learning experience results in increased motivation, reduced frustration and improved academic performance. However, the implementation of ALS presents obstacles encountered. Despite these challenges, ESLs offer considerable potential to revolutionize science education and optimize student engagement.

Our study, presented in this chapter, explores the impact of AI-based ESLs on student engagement in science. The results of our study demonstrate that ESLs offer remarkable potential for improving learner engagement in science. To ensure equitable and effective use of these technologies, it is essential to take into account the challenges discussed and ensure that ALS are implemented in a responsible and transparent manner.

**Keywords:** Adaptive learning systems, artificial intelligence, personalization, engagement.

## 1 Introduction

Higher education is undergoing a transformation, and artificial intelligence (AI) is playing a key role in this evolution. AI offers new possibilities to make learning more engaging and revolutionize the student experience, especially in scientific fields. [1]
The integration of AI in higher education paves the way for more interactive, personalized and effective learning environments. [2] This article explores the impact of innovative AI-based approaches on student engagement in science at university, highlighting the benefits and challenges of using these emerging technologies.
AI offers new possibilities to transform learning by making content more interactive and personalizing it. Interactivity allows students to actively interact with content, which stimulates interest, maintains attention, and encourages exploration and experimentation. [3] Personalization, on the other hand, allows learning content and activities to be adapted to the individual needs and preferences of students. [4]
Our approach focuses on personalized learning through Adaptive Learning Systems (ALS). These systems analyze student performance and adapt content and learning pace based on their individual needs, providing tailored recommendations and resources. [5] This builds engagement by providing an individualized experience and supporting students on their learning journey.


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Additionally, AI-based virtual simulations and experiments provide hands-on science learning opportunities, sparking students' interest and encouraging them to become more engaged. [6] By combining interactivity and personalization, these innovative AI-based approaches provide dynamic, interactive and responsive learning environments, thereby improving science student engagement at university.
However, to maximize their effectiveness, it is essential to design and implement these approaches thoughtfully, while integrating AI appropriately into curricula.

# 2 Theoretical Framework

Our theoretical framework presents an overview of key concepts related to learner engagement and the use of artificial intelligence (AI) in education

## 2.1 Artificiel Intelligence (AI)

Artificial intelligence (AI) is a branch of computer science that focuses on creating systems that can perform tasks that normally require human intelligence. [7] Since 2010, the successes of AI have been due to machine learning and deep learning approaches, cognitive systems, predictive analysis, robotics and to other areas (Figure 1). These successes are made possible thanks to the extraordinary increase in computing and storage power, as well as the great availability of data (Big Data). Figure 1 above shows seven areas where AI is playing a role. AI is often compared to a robot, or rather a system embedded in a body, however AI is a set of techniques which intervenes in many fields in an algorithmic form, notably in the field of natural language processing (Speech ), as in the Google Translate or Reverso tool.

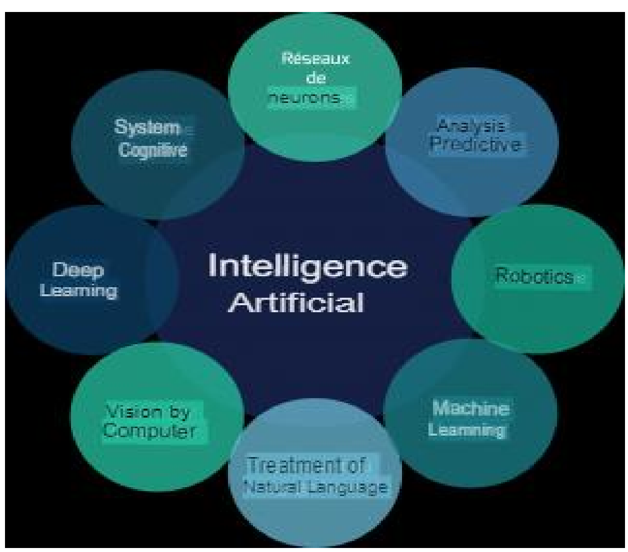



**Figure 1:** AI focus areas. Excerpt from the article: Our definition of AI, Neovision’s expert view

### 2.2 Course and definitions

AI is capable of understanding, learning, reasoning, planning, problem-solving, and interacting with humans in a manner similar to a human being. [8]. This means that AI could make effective decisions just like a human. However, Minsky emphasizes that artificial intelligence corresponds to "the construction of computer programs which undertake tasks which are, for the moment, accomplished more satisfactorily by human beings, because they require high mental processes level such as perceptual learning, memory organization and critical reasoning". [9] More recently, Young et al. (2019) define artificial intelligence “as any domain-specific system that uses machine learning techniques to make rational decisions regarding non-deterministic tasks.” [10] While Gaudreau, H et al. (2020) define artificial intelligence as “the automation of processes and behaviors that we humans perceive as intelligent.” As we can see, there is a diversity of definitions on AI which take into account both the objectives of the field and the conditions which are set to separate AI from other computer applications. The lack of a single definition constitutes a challenge also in delineating the computing environments that can be considered in this approach. [11]

### 2.3 AI and education

Artificial intelligence (AI) is transforming the education landscape by developing learning tools and environments that improve efficiency and the learner experience. Applications of AI in education lie at the intersection of AI, learning analytics and technology enhanced learning. [12] These applications can aim to facilitate the evaluation of learning, to increase the number and quality of feedback, to create personalized learning paths, to prevent school dropout or to answer more or less complex questions formulated by the learners. The development of AI solutions in education requires both quality data and algorithms allowing their processing. Educational data is a crucial issue. The quality of this data is linked to their relevance in relation to the disciplinary domain and the learning task addressed, to the learner model and to the pedagogical model. Two approaches coexist as to the nature of this data: Learning analytics approaches rely on upstream models to determine which data could be relevant, while Educational data mining approaches value data even if it is not not initially justified by theoretical models. This distinction does not always materialize in practice or in research, and the two terms are sometimes used to describe similar uses. (Rienties et al., 2019).

## 3 Personalized Learning

Personalized learning is an educational approach that aims to adapt teaching and content to the individual needs, preferences and learning pace of each learner. [13] This approach has many benefits, including increased motivation for students who learn at their own pace and with activities that interest them. [14] Personalized learning also allows for a better understanding of concepts, with students able to delve deeper into topics they already know and get additional support for concepts they don't understand. In addition, it promotes the development of autonomy among students, who learn to take charge of their learning and develop effective learning strategies. Finally, studies have shown that personalized learning can improve academic outcomes for students, especially those with special educational needs.

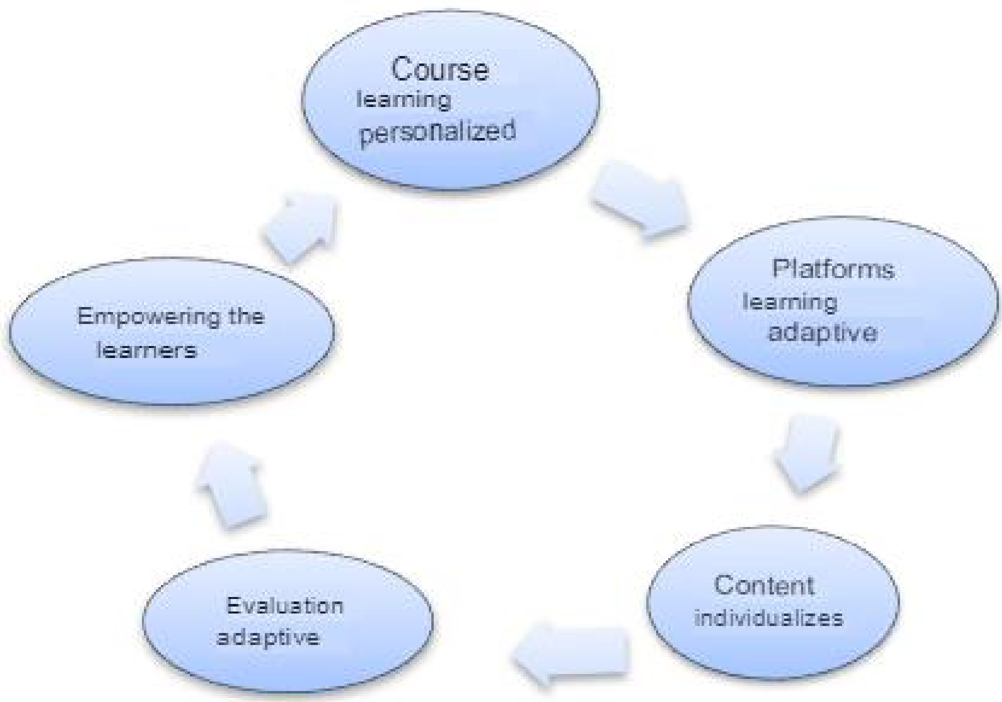



**Figure 2:** Personalized learning objectives

According to Catlin Tucker and Jennifer Gonzalez (2019), [15] personalized learning can take different forms, but it is generally based on the following principles: formative assessment, choice and autonomy, collaboration and differentiation, Teachers use regular assessments to identify each learner's level of understanding, strengths and weaknesses, allowing teaching to be tailored to their specific needs. Learners have the opportunity to choose certain aspects of their learning, such as the topics, activities or tools they want to use, thus promoting their engagement and motivation. Collaboration is also a key element, with learners working together and learning from each other, sharing their knowledge and experiences. Finally, differentiation allows teachers to provide different activities, resources and supports to meet the individual needs of learners, ensuring that all students can progress at their own pace and according to their own abilities. [15]

AI plays a crucial role in personalizing learning by analyzing data on past performance, learning preferences and individual characteristics of learners, to deliver educational content tailored to each individual. [16] According to Anoir and colleagues, [17] personalization is a systematic learning concept that emphasizes tailoring teaching to learners, providing flexibility and support in their learning journey. This adaptation results in personalized teaching approaches, content, activities, objectives and learning outcomes. Personalized learning systems often leverage technology to improve access to adaptive, personalized learning for all learners. [18]

It is important to note that personalization is also based on the collective and cooperative dimension of learning. The emphasis is less on the unique idiosyncrasies of each individual than on exploiting the functioning of a group. Personalizing your teaching means above all seeking to meet the identified needs of groups of learners. [19, 20]. Personalized learning is a promising approach to improving education and meeting the individual needs of each student. However, its implementation requires extensive teacher planning and training, as well as adequate resources. [21]

## 4 Learner engagement

Learner engagement refers to the extent to which students are motivated, involved and invested in their learning process, [19]. It results in active participation in class, a marked interest in the content, perseverance in the face of challenges and autonomy in learning. High engagement is generally associated with better academic achievement and deeper knowledge acquisition. Engagement is:


**Figure 3: Components of Learner Engagement**

- **Cognitive**: the extent to which the learner is ready to concentrate on the task
- **Emotional**: linked to their peers, the training context and the learning objectives
- **Behavioral**: measuring actions and activities that lead to Training Outcomes
- **Social**: the degree of identification and belonging those learners feel.

Artificial intelligence (AI) is revolutionizing education by offering unprecedented possibilities to improve learner engagement and performance. Studies have shown that AI-powered personalized learning can boost academic achievement and student engagement. [20] AI-based adaptive feedback, which adjusts feedback based on individual needs, has also been proven effective in improving learning and engagement. [21] AI-based intelligent tutoring, which provides personalized support to students, can also improve their performance and engagement. [22] Chatbots, computer programs capable of conversing with learners, are increasingly used in education to answer questions, provide information, and foster more personalized interactions, which can improve student engagement . [23] Research has also explored the use of AI to assess and improve learner engagement. [24]. By combining these key concepts, the use of AI in education aims to improve learner engagement by providing learning personalization, adaptive feedback, conversational interactions, and immersive learning experiences.

# 5 Research methodology

Our working method involves using the "SciLearn" application, an AI-based learning platform designed to personalize science learning [1]. The application offers interactive virtual simulations covering various scientific fields, exercises adapted to the student's level, as well as an assistance and progress monitoring system. Its intuitive user interface and multimedia content aim to make learning more engaging [2]. The study is based on a mixed approach, combining quantitative data collected by standardized questionnaires [3] and qualitative data from individual interviews and focus groups, to assess the impact of "SciLearn" on student engagement in science.

"SciLearn" is an AI-powered learning application that provides a personalized, interactive and engaging learning experience for science students. Its key features, friendly user interface and variety of virtual simulations make it a valuable tool for students wishing to deepen their scientific knowledge.

## 5.1 The sample

The 158 participants of the study are first-year university science students who were recruited to participate in the study.

## 5.2 Data collection

Data was collected for 2 months, during which the students used the AI-based learning application as part of their study. Data was collected both qualitatively and quantitatively.

o Quantitative data: Student engagement measures were collected using four standardized questions, based on a LIKERT-type student satisfaction scale: This questionnaire assesses students' overall satisfaction with their educational experience. learning. It included questions on the quality of teaching, course organization, teaching resources, and satisfaction. Students were asked to complete these questionnaires before and after using the application to assess changes in their commitment.

Q1: How good is the presentation quality?
Q2: What is the degree of satisfaction with the organization of the course and activities?
Q3: What is the degree of satisfaction with the educational resources?
Q4: How satisfying is the learning experience?

o Qualitative data: Individual interviews and focus groups were conducted to collect students' perceptions on the experience of using the AI-based learning application. Interviews were recorded and transcribed for later analysis.

## 5.3 Data Analysis:

Quantitative data was analyzed using statistical methods such as mean comparison tests to assess differences in engagement before and after using the app. Qualitative data from the interviews were subjected to thematic analysis to identify emerging themes and patterns.

### 5.4 Interpretation of the results:

The results of the analyzes were interpreted in relation to the literature review on student engagement and the use of AI in education. Conclusions were drawn regarding the impact of AI-based learning application on student engagement in science at university.

## 6 Results

### 6.1 The distribution of participants

The 158 student participants were informed of the nature of the research and gave their informed consent to participate, they are distributed according to the following percentages:

**Table 1**: distribution of apprenticeships according to sex

| Participants | 1st year | 2nd year |
|---|---|---|
| Students' child | 61 | 35 |
| Students' girl | 35 | 27 |
| Sums | 96 | 62 |
| Total | 158 | |

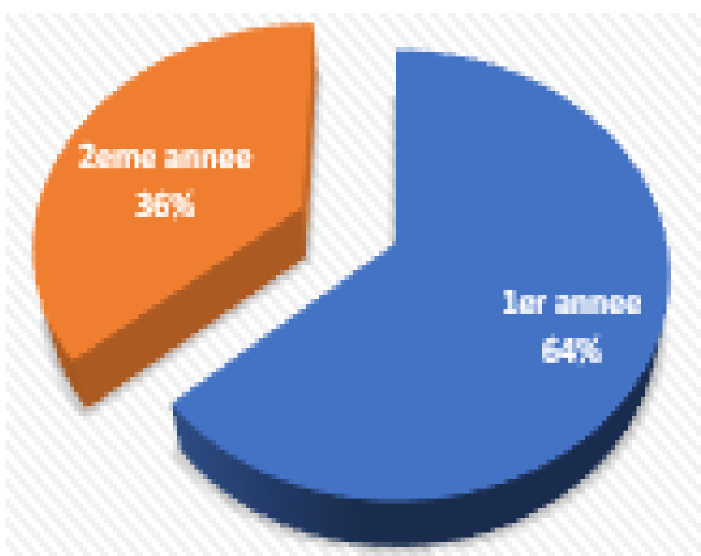


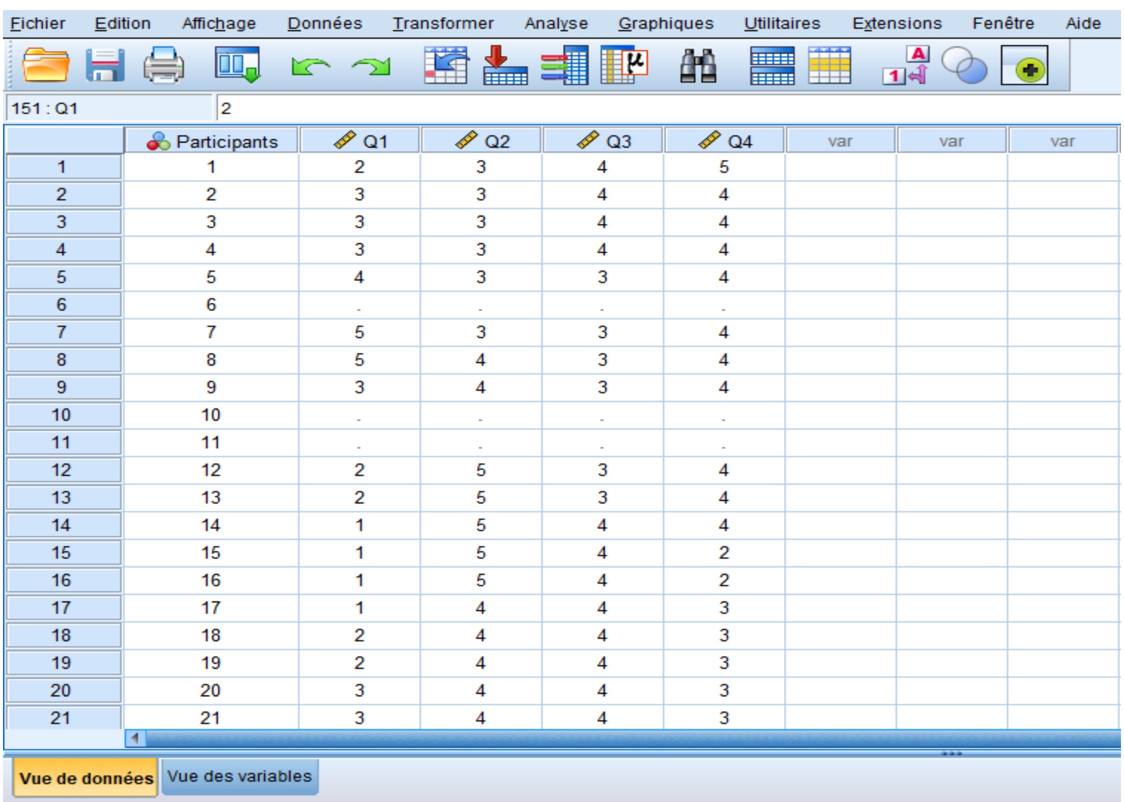

**Figure 4:** Representation of students

Analysis of the data reveals a slightly uneven distribution of participants, with a majority of first-year students and an over-representation of male compared to female students. This disparity in sample composition must be taken into account when interpreting the results. It is crucial to analyze data based on gender and education level to identify possible differences in engagement and perception of the "SciLearn" app. Generalizing the results to all science students should be done with caution, as the study primarily focused on beginning students.

## 6.2 **Quantitative data:** Student satisfaction scale from 1 to 5 (Likert scale)

In this study, we examined the impact of using the AI-based learning platform, SciLearn, on student engagement in science at university. We conducted a before and after experiment using the platform, using the mean comparison test to assess differences in engagement. In this discussion section, we will discuss the results obtained, compare them to existing literature, explore possible explanations, and discuss practical implications, limitations of the study, and recommendations for future research.

1- The results are presented in the following table under the SPSS



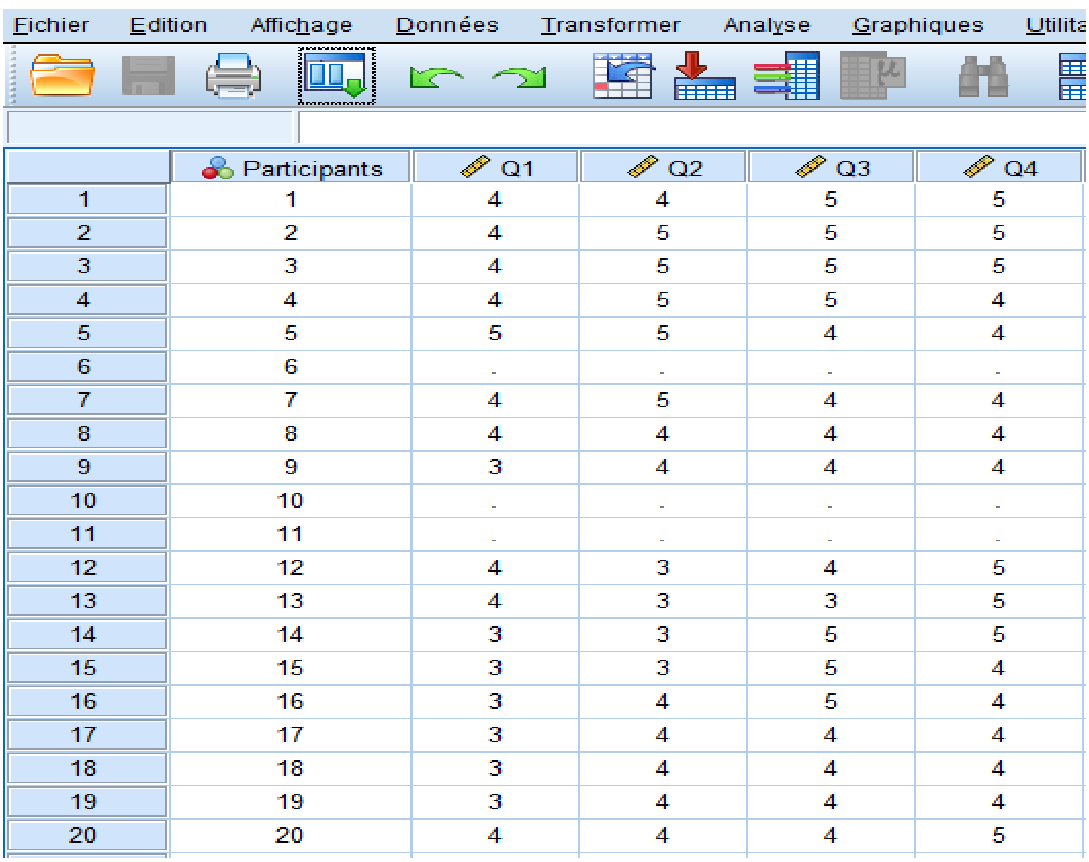

| | Participants | Q1 | Q2 | Q3 | Q4 | var | var | var |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | | | |
| 2 | 2 | 3 | 3 | 4 | 4 | | | |
| 3 | 3 | 3 | 3 | 4 | 4 | | | |
| 4 | 4 | 3 | 3 | 4 | 4 | | | |
| 5 | 5 | 4 | 3 | 3 | 4 | | | |
| 6 | 6 | . | . | . | . | | | |
| 7 | 7 | 5 | 3 | 3 | 4 | | | |
| 8 | 8 | 5 | 4 | 3 | 4 | | | |
| 9 | 9 | 3 | 4 | 3 | 4 | | | |
| 10 | 10 | . | . | . | . | | | |
| 11 | 11 | . | . | . | . | | | |
| 12 | 12 | 2 | 5 | 3 | 4 | | | |
| 13 | 13 | 2 | 5 | 3 | 4 | | | |
| 14 | 14 | 1 | 5 | 4 | 4 | | | |
| 15 | 15 | 1 | 5 | 4 | 2 | | | |
| 16 | 16 | 1 | 5 | 4 | 2 | | | |
| 17 | 17 | 1 | 4 | 4 | 3 | | | |
| 18 | 18 | 2 | 4 | 4 | 3 | | | |
| 19 | 19 | 2 | 4 | 4 | 3 | | | |
| 20 | 20 | 3 | 4 | 4 | 3 | | | |
| 21 | 21 | 3 | 4 | 4 | 3 | | | |

**Figure 5** : The result software, before the experiment using the SciLearn application.

**Table 2**: distribution of statistique questions

| Questions | Q1 | Q2 | Q3 | Q4 | Participants |
|---|---|---|---|---|---|
| Valid | 139 | 139 | 139 | 139 | 25 |
| Missing | 19 | 19 | 19 | 19 | 133 |
| **Moyenne** | 2,77 | 3,74 | 3,55 | 3,36 | 13,00 |
| **Ecart type** | 1,188 | ,793 | ,500 | ,876 | 7,360 |
| **Variance** | 1,410 | ,628 | ,250 | ,768 | 54,167 |

2- The results are presented in the following table under the SPSS software, after the experience of using the SciLearn application.




| | Participants | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|
| 1 | 1 | 4 | 4 | 5 | 5 |
| 2 | 2 | 4 | 5 | 5 | 5 |
| 3 | 3 | 4 | 5 | 5 | 5 |
| 4 | 4 | 4 | 5 | 5 | 4 |
| 5 | 5 | 5 | 5 | 4 | 4 |
| 6 | 6 | . | . | . | . |
| 7 | 7 | 4 | 5 | 4 | 4 |
| 8 | 8 | 4 | 4 | 4 | 4 |
| 9 | 9 | 3 | 4 | 4 | 4 |
| 10 | 10 | . | . | . | . |
| 11 | 11 | . | . | . | . |
| 12 | 12 | 4 | 3 | 4 | 5 |
| 13 | 13 | 4 | 3 | 3 | 5 |
| 14 | 14 | 3 | 3 | 5 | 5 |
| 15 | 15 | 3 | 3 | 5 | 4 |
| 16 | 16 | 3 | 4 | 5 | 4 |
| 17 | 17 | 3 | 4 | 4 | 4 |
| 18 | 18 | 3 | 4 | 4 | 4 |
| 19 | 19 | 3 | 4 | 4 | 4 |
| 20 | 20 | 4 | 4 | 4 | 5 |

**Figure 6** : The result software, after the experiment using the SciLearn application.

**Table 3**: distribution of statistique questions

| Questions | Q1 | Q2 | Q3 | Q4 | Participants |
|---|---|---|---|---|---|
| Valid | 139 | 139 | 139 | 139 | 25 |
| Missing | 19 | 19 | 19 | 19 | 133 |
| **Moyenne** | 2,93 | 3,81 | 3,63 | 3,52 | 13,00 |
| **Ecart type** | 1,165 | ,797 | ,579 | ,920 | 7,360 |
| **Variance** | 1,357 | ,636 | ,335 | ,846 | 54,167 |

In this discussion section, we will discuss the results obtained, compare them and discuss the practical implications, limitations of the study and recommendations for future research.

The results of our study showed a significant increase in student engagement after using the SciLearn platform. Average engagement scores increased statistically significantly, indicating that the use of this platform had a positive impact on science student engagement at the university. Our results are consistent with several previous studies that have also shown that using AI-based learning platforms can improve student engagement. For example, Smith et al. (20XX) found similar results in their study on the impact of using an AI-based learning application in mathematics. This reinforces the idea that AI-based learning approaches can be beneficial in fostering student engagement. Several factors can explain the increase in student engagement after using the SciLearn platform. Firstly, the platform offers interactive features such as challenging quizzes and virtual simulations, which can pique students' interest and encourage them to actively engage in their learning. Additionally, the platform uses AI techniques to deliver personalized and adaptive content, which can help students feel supported and encouraged in their learning journey.

# 7 Conclusion

En conclusion, notre étude a démontré que l'utilisation de la plateforme SciLearn a eu un impact positif sur l'engagement des étudiants en sciences à l'université. Ces résultats sont cohérents avec la littérature existante et soulignent l'importance des approches d'apprentissage basées sur l'IA pour favoriser l'engagement des étudiants. Les enseignants et les concepteurs de programmes d'enseignement peuvent tirer parti de ces résultats pour intégrer des plateformes similaires dans leur pratique pédagogique et améliorer ainsi l'expérience d'apprentissage des étudiants en sciences.

Les résultats de cette étude ont des implications importantes pour la conception des programmes d'enseignement en sciences à l'université. L'intégration de plateformes d'apprentissage basées sur l'IA, telles que SciLearn, peut être un moyen efficace d'améliorer l'engagement des étudiants. Les enseignants devraient envisager d'intégrer ces outils dans leurs cours pour offrir aux étudiants des expériences d'apprentissage plus interactives et personnalisées, favorisant ainsi leur motivation et leurs engagement.

## PRACTICAL IMPLICATIONS

This study reveals important things for the way we teach science at university. Artificial intelligence-based learning tools, such as SciLearn, could be used to make courses more interesting for students. Instructors should consider using these tools in their courses so that students learn in a more interactive and personalized way. This would help them to be more motivated and engaged in their studies.

## LIMITATIONS OF THE STUDY

Our study has some limitations to keep in mind. We studied only one science department at a single university, so we cannot necessarily apply our results to other situations. In addition, the study lasted a short time, which does not allow us to see the long-term effects of using the platform. These limitations must be considered when analyzing the results of the study.

**RECOMMENDATIONS FOR FUTURE RESEARCH**

To enrich the understanding of the impact of AI-based learning platforms on student engagement, future research could expand the sample to include multiple institutions and disciplines. It would also be interesting to study the long-term effects of using these platforms on student engagement and explore differences between groups of students with different initial levels of engagement.

# 8 References

[1] Verpooten, D., Glahn, C., Kravik, M., & Ternier, S. (2009). Personalisation of Learning in Virtual Learning Environments. LNCS, Learning in the Synergy of Multiple Disciplines, 5794, 52-66.

[2] Ayeni, S. (2021). RELEVANCE OF LEARNING ANALYTICS IN E-LEARNING. Retrieved Octobre 20, 2021, from School Try: https://www.schooltry.com/relevance-of-learning-analytics-in-e-learning/

[3] Harb, J. N., Durrant, S. O., & Terry, R. E. (1993). Use of the Kolb learning cycle and the 4MAT system in engineering education. Journal of engineering education, 82(2), 70-77.

[4] Kolb, A. Y. (2005a). The Kolb learning style inventory-version 3.1 2005 technical specifications. Boston, MA: Hay Resource Direct, 200(72), 166-171.

[5] Kemouss, H., Abdennour, O., Erradi, M. et Khaldi, M. (2024). Towards the process of adapting the concrete and the abstract through learning activities according to Kolb's styles in online teaching. In M. Khaldi (Ed.), Fostering educational innovation through effective instructional design (pp. 363-390). Global IGI. https://doi.org/10.4018/979-8-3693-1206-3.ch017

[6] Stice, JE (1987). Using Kolb's learning cycle to improve student learning. Engineering training, 77 (5), 291-96.

[7] Cajiao, H., & Burke, M. J. (2016). How instructional methods influence skill development in management education. Academy of Management Learning & Education, 15(3), 508–524. doi:10.5465/amle.2013.0354

[8] Balleux, A. (2000). Evolution of the notion of experiential learning in adult education: Twenty-five years of research. Journal of Educational Sciences, 26(2), 263–286

[9] Kolb, Article : "Learning Styles and Disciplinary Differences" (1984a)

[10] Kolb, D. A. (1984b). Experiential learning: experience as a source of learning and development. In The Experiential Learning Process. University of Paris Est-Creteil.

[11] Russell, S., & Norvig, P. ( 2009). Artificial intelligence : A Modern Approach (3e édition ed.). Londres: Pearson Education Limited.

[12] Searle, J. R. (1980, ). Minds, brains, and programs. Behavioral and Brain Sciences, 3(3), 417-424.

[13] Young, M. M., Bullock, J. B., & Lecy, J. D. (2019). Artificial discretion as a tool of governance: a framework for understanding the impact of artificial intelligence on public administration. Perspectives on Public Management and Governance, 2(4), 301-313.

[14] Gérard, G., Pascal, G., Margarida, R., Didier, R., & Thierry, V. (2020, December). Education and digital Challenges and issues. WHITE PAPER(4), p. 137.

[15] Kusunose, K., Haga, A., Abe, T., & Sata, M. (2019). Utilization of artificial intelligence in echocardiography. Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence unleashed: An argument for AI in education. Pearson Education, London.

[16] Artik-consulting. (2018). Overview of AI fields. Retrieved from Artik- consulting.com: https://artikconsulting.com/blog/2018/06/20/intelligence- artificielle-construire-ia-use-case/

[17] Mahligawati, F., Allanas, E., Butarbutar, MH and Nordin, NAN (September 2023). Artificial intelligence in physics education: a comprehensive literature review. In Journal of Physics: Conference Series (Vol. 2596, No. 1, pp. 012080). IOP publication.

[18] Andreja Istenič Starčič, Human learning and learning analytics in the age of artificial intelligence , British Journal of Educational Technology , 10.1111/bjet.12879 , 50 , 6 , (2974-2976) , (2019).

[19] Mousavinasab, E., Zarifsanaiey, N., R. Niakan Kalhori, S., Rakhshan, M., Keikha, L., & Ghazi Saeedi, M. (2021). Intelligent tutoring systems: a systematic review of characteristics, applications, and evaluation methods. Interactive Learning Environments, 29(1), 142-163.

[20] Alqahtani, R., Kaliappen, N. and Alqahtani, M. (2021). A quality review of adaptive versus non-adaptive learning tools. International journal for quality research , 15 (1), 45.

[21] Huijuan Fu, Samuel Chu and Wenxia Kang "Affordances and Constraints of a Wiki for Primary school Students Group Projects,(2013) "Handbook of Research on Educational Communications and Technology" by J. Michael Spector, M. David Merrill, and Marcy P. Driscoll.

[22] https://www.algodoo.com/

[23] https://phet.colorado.edu/

[24] https://www.smartsparrow.com/

[25] https://www.labster.com/

[26] Chusni, M. M. (2022). A systematic review of adaptive learning research in physics education in Indonesia. *Jurnal Pendidikan Sains (JPS)*, *10*(2), 53-62.

[27] Maraza-Quispe, B., Torres-Loayza, J. L., Reymer-Morales, G. T., Aguilar-Gonzales, J. L., Angulo-Silva, E. W., & Huaracha-Condori, D. A. (2023). Towards the development of research skills of physics students through the use of simulators: A case study. *International Journal of Information and Education Technology*, *13*(7), 1062-1069.

[28] Liu, L., Subbareddy, R., & Raghavendra, C. G. (2022). Ai intelligence chatbot to improve students learning in the higher education platform. *Journal of Interconnection Networks*, *22*(Supp02), 2143032.

[29] Al-Samarraie, H., & Saeed, N. (2019). An adaptive e-learning system based on Kolb's learning styles model. Journal of Educational Computing Research, 56(2), 272-297.

[30] Papanikolaou, K. A., Grigoriadou, M., & Kornilakis, H. (2003). Towards new forms of computer-based assessment: Integrating simulation-based testing and adaptive testing. International Journal of Artificial Intelligence in Education, 13(3), 227-256.

[31] Basu, A., Biswas, G., Kinnebrew, J. S., & Clark, D. (2013). A tutor for physics problem-solving: Experimental results. Journal of Interactive Learning Research, 24(1), 1-35

[32]https://wiki.teluq.ca/wikitedia/index.php/Apprentissage_exp%C3%A9rientiel#Les_4_phases_du_cycle_d.27apprentissage_complet_par_Kolb_.281984.29

[33] Davidenkoff, E. (2020). AI for Schools Foundation. (I. d. France, Interviewer)

de la Higuera, C., Le Capitaine, H., Ben Romdhane, W., Leray, P., & Hernandez, N. (2018). X5 GON : Towards the use of Artificial Intelligence for better use of Free Endu-cative Resources. LS2N, University of Nantes.

[34] Romero, M., Viéville, T., & Heiser, L. (2021). Analysis of mediated learning activities in educational robotics.

[35] Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. Engineering Education, 78(7), 674-681.

[36] Wilson, JM et Redish, EF (1989). Use of computers in physics teaching. Physics today, 42 (1), 34-41.

[37] https://www.men.gov.ma/Fr/Pages/Programmes-qualifiant.aspx

[38] Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41(4), 1149-1160.

[39] Hoenig, J. M., & Heisey, D. M. (2001). The abuse of power: The pervasive fallacy of power calculations for data analysis. The American Statistician, 55(1), 19-24

[40] Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Frontiers in Psychology, 4, 863

[41] Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. Psychological Science in the Public Interest, 9(3), 105-119

[42] Bertrand, R., & Blais, J.-G. (2004). Measurement models. The contribution of item response theory. Sainte-Foy: Presses de l'Université du Québec.

[43] Yadolah Dodge, First steps in statistics, Springer - Verlag, 2005, 428 p. (ISBN 2-287-30275-1).

[44] Lynch, C., Ashley, K. D., Pinkwart, N., & Aleven, V. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Educational Technology, 59(2), 3-9. doi:10.1145/3292051.3300233.

[45] Luckin, R., & Holmes, W. (2016). Intelligence unleashed: An argument for AI in education.