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Optimizing Physics Teaching Through Artificial Intelligence: An Approach Adapted to Kolb's Divergent Learners

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Abstract: This article explores the integration of artificial intelligence (AI) in high school physics teaching, based on Kolb's learning model. The study aims to personalize learning according to students' individual preferences and learning styles, while improving educational effectiveness through the optimization of teaching methods and learning outcomes. In addition, it seeks to create immersive learning environments through technological tools that promote active, engaging, and interactive experimentation. To achieve these objectives, a literature review was conducted to establish a theoretical framework on AI in education and its application in science. This phase was followed by the development and implementation of AI tools in real classrooms, with a qualitative and quantitative evaluation of the results that show an increase in student motivation and engagement, an improvement in academic performance, as well as positive feedback from teachers, who noted a better management of the various levels of learning. Finally, the study highlights the transformative potential of AI in science education, particularly in physics, while emphasizing the importance of thoughtful implementation to maximize its benefits.

Keywords: Artificial intelligence (AI), Personalization, AI applications, High school physics, kolb styles.

I. Introduction

Teaching physics in secondary schools is crucial for understanding the fundamental principles of mechanics, electricity, optics, and nuclear energy [1]. However, traditional methods often rely on lectures, making students passive in their learning. In this context, improving students' ability to learn in a meaningful way is a major goal where learning physics becomes both interactive and personalized, offering students the opportunity to explore theoretical concepts at their own pace, thanks to artificial intelligence [2], developed an experiential learning model that identifies four learning styles: accommodative, assimilative, convergent, and divergent. The Kolb Learning Style Inventory (KLSI 4.0) helps learners understand how they learn from experience,[3]. Each style reflects individual preferences in terms of knowledge acquisition, raising the question: how can physics teaching be adapted to fully engage learners and offer them attractive experiences?

This article seeks to explore the use of artificial intelligence to create a physics learning environment that meets the specific needs of divergent learners, by integrating simulations, interactive virtual experiences and adaptive learning. Our experimental work was preceded by a survey of students in the physics and mathematics option, aimed at identifying the main difficulties encountered in learning physics, and then proposing a test in which our sample expressed their preferences for proposed AI-based activities on a LIKERT scale. The results obtained were very encouraging, highlighting the scientific interest of our research.

A. Research Problem

Students have difficulty understanding key physics concepts when teaching does not match their learning characteristics, styles, and preferences [4] . Furthermore, physics hands-on work plays a vital role in motivating students to learn and experimentalize concepts because it provides them with concrete, hands-on experience [5]. It is therefore important to explore how technological tools, such as artificial intelligence, can be integrated into physics teaching to better address the diversity of these students. The central question of this research is: how can artificial intelligence be used to create physics learning environments that foster engagement and success among

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learners with diverse backgrounds? This issue raises crucial issues regarding the pedagogical effectiveness and inclusiveness of science teaching methods [1].

B. Research Aim, Focus and Research Questions

The research focus of this study is on the integration of artificial intelligence (AI) in physics education, with a focus on students with divergent learning styles. The main objective is to explore how AI can create interactive and personalized learning environments, tailored to students' specific needs. This includes the personalization of learning paths using algorithms [6] . The use of AI tools to promote interactivity, as well as the implementation of continuous assessments to adjust teaching methods [7].

II. Theoretical Framework

Our theoretical framework consists of presenting a solid foundation for the practical part and proposes a description of the divergent style according to the KOLB learning model, its characteristics including the importance and adaptation of learning activities to promote student engagement, with two main parts: the first is a description of Kolb's experiential cycle and the styles that result from it with their characteristics. The second part deals with artificial intelligence (AI), its foundations and especially the use of AI in the context of physics.

A. Description and characteristics of Kolb's learning styles

Kolb's theory of experiential learning was still a topic of interest to many educational researchers [8]-[9]-[10]-[11].This theory remains relevant and continues to interest the field of education because of its potential to improve the effectiveness of teaching and learning, as well as to meet the individual needs of learners. Research has shown that learners learn in different ways and that each individual has their preferred learning style [12]. The application of learning styles theory is based on the work of Kolb, who identified a four-phase learning cycle in which each student has a particular learning style, and each style has a preference for a particular learning [13]. This article defines the specific characteristics of the divergent style. In addition, activities that can be used to achieve these goals are presented and discussed.[14]. Recent research has continued to explore and adapt this theory to various educational contexts, including: personalization of instruction, applications in online education, and improvement of teaching and learning [15]. Kolb argues that learning can only occur when the learner experiences the information he or she has acquired or discovered through experience. In other words, learning develops through action, in line with the concepts of experiential learning [16].According to his theory, learning is a process of adaptation of the individual to his environment, and Kolb believes that it is only complete when the four phases are experienced. Each learning style highlights specific preferences [17].Divergent learners have a strong inclination for learning through discovery, artistic activities and group discussions, as well as for exploring situations from different angles. They favor concrete experience and reflection, which allows them to adopt a creative and imaginative approach. Their ability to think holistically and generate new ideas is a major asset. In addition, they have a special ability to understand the emotions and motivations of others, thus enriching their interactions and collaborative learning [2]. According to [18].Divergent learners are inductive by nature and learn best through discovery, exploration, situations from different perspectives and by asking questions. The integration of artificial intelligence (AI) in physics learning for secondary students opens new perspectives, and offers them:

- More personalized learning experiences tailored to their individual needs, thanks to AI-based systems that analyze each student's performance and learning preferences.

- Targeted resources and activities to strengthen their understanding of physics concepts. This allows students to progress at their own pace and fill specific gaps.

B. Using AI to adapt physics learning resources and activities to divergent

According to [19]. AI attempts to program a machine to interpret language and abstract concepts in order to solve problems. Some approaches, called weak AI, aim for a formalization linked only to concrete problems, while others aim for a general modeling of human reasoning (strong AI) [20]. More recently. According to [21]. Young in 2019, define artificial intelligence "as any domain-specific system that uses machine learning techniques to make rational decisions on non-deterministic tasks"[22]. The aspect of AI in education is an interdisciplinary field, as Artik Consulting (2018) points out: from learning analytics to technology-enhanced learning, [23]. These uses may aim to facilitate the assessment of learning, increase the number and quality of feedback, create personalized learning paths, prevent school dropouts or even answer more or less complex questions asked by learners. For the development of AI solutions in education, it is necessary to have both quality educational data linked to their relevance to the disciplinary field and the learning task addressed, and algorithms allowing their processing. Two approaches coexist: learning analysis approaches tend to rely on models to determine the relevant data, and educational data mining approaches tend to value data [24]. AI uses information about learners' preferences, performance, and needs to provide resources that are tailored to learners in terms of format and learning style, promoting a personalized and effective physics learning experience [25]. These resources can provide detailed explanations, examples, and exercises to deepen the understanding of physics concepts, such as:

- Educational videos to explain physical concepts and phenomena in a visual and interactive way, [26]. These videos can include demonstrations, simulations, experiments, or theoretical explanations to help learners visualize and understand physics concepts in a concrete way.

- Interactive simulations allow learners to virtually experience physical phenomena, manipulate variables, observe results, and explore the consequences of different actions,[27].

- Educational apps and software: Mobile applications or online learning platforms specifically designed for learning physics. These tools may offer interactive lessons, hands-on exercises, quizzes, games, or other activities, [28].

- Virtual labs: Provide a realistic and safe experience to explore and observe physical phenomena, while allowing learners to collect data, analyze it, and draw conclusions,[29].

It should be noted that its resources may vary depending on the technical and available capabilities in the context of high school physics learning. AI is a valuable complement to provide interactive tools, personalized feedback, and opportunities for hands-on exploration, to develop a deeper understanding of physics concepts and strengthen their problem-solving abilities, [30].

In conclusion, integrating AI into high school physics learning offers multiple benefits. It allows for personalized learning, adaptive support, enriching hands-on experiences, and immediate feedback, thus helping to stimulate students' interest in physics and improve their academic performance.

III. Research Methodology

A. General Background

This section presents a general framework that guides the entire study, detailing the qualitative and quantitative approaches used to collect and analyze data. The research involves a combination of literature reviews, surveys, and classroom experiments to assess the impact of AI tools on student engagement and academic performance. By identifying best pedagogical practices and examining implications for science skills development. This methodology aims to provide insights relevant to educators and policy makers. This methodological framework thus establishes the necessary foundations for a thorough and rigorous study of the issues related to the use of AI in science education.

B. Sample / Participants / Group

The physics module of the baccalaureate in Mathematics A and B and Physical Sciences is organized around four fundamental parts: waves, nuclear transformations, electricity and mechanics, spread over two semesters with a mass of 118 hours, it allows the maintenance of fundamental notions and basic concepts. The chosen sample is 85 high school students in the baccalaureate gathered on the three scientific options mathematics, technology and physics (2SMA, 2SMB, 2SPhy).

C. Instrument and Procedures

After presenting the sample, our work is carried out through the following steps:

In the first part: A survey was carried out among the 85 high school students which consists of questioning and collecting information concerning the degree of dissatisfaction, the factors that present the most difficulties encountered in learning physics in collaboration with their teachers, namely:

- The language of instruction,

- Teacher-centered teaching,
- The overload of course content,
- The lack of deep understanding of abstract concepts of physics,
- The insufficiency of tutorials and practical work,
- The lack of prior knowledge or their forgetting.
- The inconsistencies between the mathematical tools learned in mathematics and used in physics.

In each question, the students responded according to their learning preferences and how they appreciate the way of acquiring and assimilating theoretical or practical knowledge according to a LIKERT scale.

In the second part: students were asked to answer online the ILS (Index of Learning Styles) test, a questionnaire that assesses individuals' learning preferences according to four dimensions: concrete experience, reflective observation, abstract conceptualization and active experimentation. Aiming to classify learners according to their dominant Kolb style.

In the last part: We propose an adaptive online questionnaire to collect information on the degree of preference of its students for the proposed learning activities that presents solutions based on applications of artificial intelligence, such as modeling and simulation, problem solving, experimentation support, adaptive learning, virtual laboratory simulation, etc., its activities were chosen according to precise criteria, and we also relied on a body of previous research, [31]-[32]-[33]-[34]-[35]. Assembled in Table 1, as follows :

Table 1: Questionnaire of learning activities proposed for each style of kolb based on IA

		Scale from 1 to 5				
Kolb Styles	**Proposed learning activities based on AI**	1	2	3	4	5
Q1 : Divergent	A1. Experimentation and exploration of situation problems B1. Interactive virtual experiences C1. Visualization and modeling D1. Collaboration and sharing E1. Learning Personalization					
Q2 : Assimilator	A2. Interactive presentations B2. Personalized online resources C2. Modeling activities D2. Guided Discussions E2. Case Resolution Issues					
Q3 : Convergent	A3. Interactive virtual laboratories B3. Interactive problem solving C3. AI-assisted engineering projects D3. AI-assisted hands-on experiments E3. Interactive educational games					
Q4 :Accommodator	A4. Hands-on experiments with detailed instructions B4. Technological applications of physics C4. Practical application projects D4. Case studies and real examples E4. Interactive experiential learning					

1:Very poor 2: poor 3:Average 4:Good 5: Very good

D. Data Analysis

The analysis will be carried out using the SPSS statistical software, on the four tables, of the four variables (Preferences to the divergent style, Preferences to the assimilative style, Preferences to the convergent style, Preferences to the accommodating style) measured by the 20 items which present activities designed by the AI, each variable groups together 5 items characterizing the style according to Kolb. We are interested in the study of the divergent style, the others of which will be treated in future work.

IV. Results

Presentation of the sample of high school students (2SMA, 2SMB, 2SPys), numbering N=85 distributed as follows:

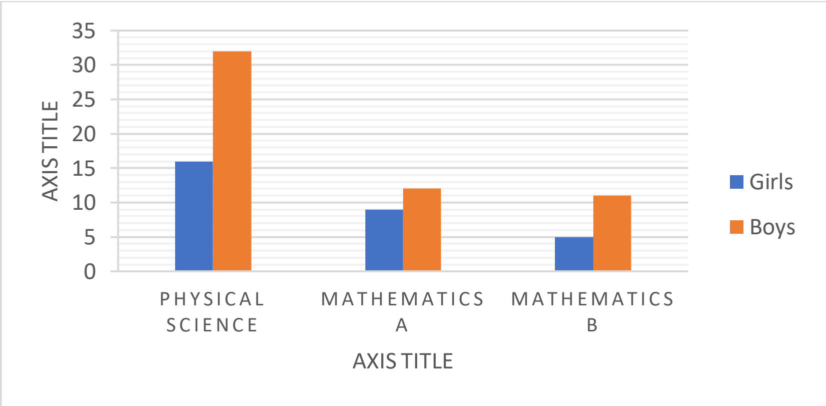


Fig 1: Graphical presentation of the distribution of students according to sex

In the study options presented, students in physical sciences show a strong male representation, with 66.67% boys compared to 33.33% girls. On the other hand, in mathematics A, girls represent 42.86%, while boys constitute 57.14%. For mathematics B, the male tendency is even more marked, with 31.25% girls compared to 68.75% boys. In total, 85 students chose these subjects, with a majority of boys in all options.

In the first part: The presentation of the difficulties encountered by high school students and their teachers in learning physics, detailed in the following table 3:

Table 2: The number of learners who responded to the proposals and their percentages

Prepositions	Number of learners who responded: yes out of 85 students	Percentage
Q1:The concepts of physics are abstract and is there a deep understanding?	68	74,12%
Q2: Is the language of instruction an obstacle?	78	91,76%
Q3: Is forgetting previous knowledge a factor in learning physics?	80	94,12%
Q4: Course content overload, presenting a problem?	83	97,65%
Q5: Is there a shortage of TDs?	75	88,24%
Q6: Is there a TP Insufficiency?	85	100,00%
Q7:Is teaching centered on the teacher and dominated by exposure?	72	84,71%
Q8:Are the mathematical tools used in physics difficult?	62	72,94%

The table 3, highlights the challenges faced by high school students and their teachers in learning physics. An overwhelming majority of students, 97.65%, highlight content overload as a major problem. In addition, 94.12% of students believe that forgetting prior knowledge hinders their learning, and 91.76% consider the language of instruction to be a barrier. The shortage of tutorials (TD) and practical work (TP) is also perceived as a significant problem, with 88.24% and 100% of students acknowledging this inadequacy, respectively. Finally, 84.71% of students indicate that teaching is too teacher-centered, which limits interaction. These results reveal critical areas for improvement to foster a better understanding of physics.

In the second part: The results of the questionnaire are grouped in the following Table 4:

Table 3: Learning styles according to sample options

Styles	Physical Science	Mathematics A	Mathematics B	The amount
Divergent	7	3	5	15
Assimilator	17	6	2	25
Convergent	15	7	4	26
Accommodator	9	5	5	19
The amount	48	21	16	85

Table 4 presents the students' learning styles according to the options chosen. In the sample, the convergent style is the most represented, with 26 students, followed by the assimilators, who represent 25 students. Divergent learners are fewer in number, totaling 15, while accommodators have 19 students. Regarding the subjects, physics attracts a significant number of convergent and assimilative learners, while mathematics A and B show a more varied distribution of styles. These results suggest that diversified teaching approaches may be necessary to better meet the needs of the different learning styles in each subject.

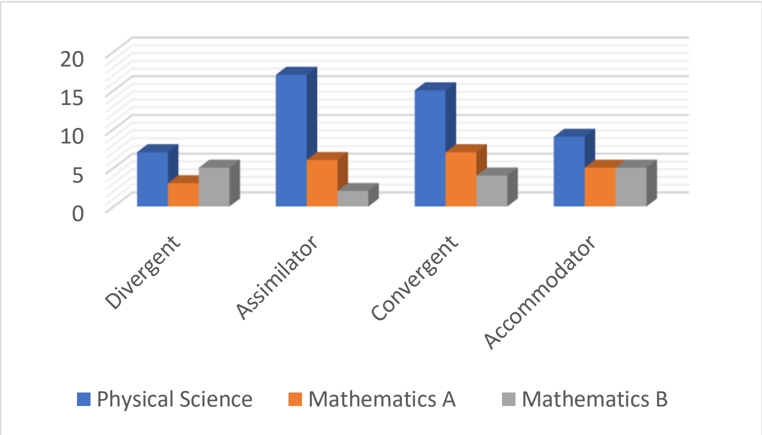
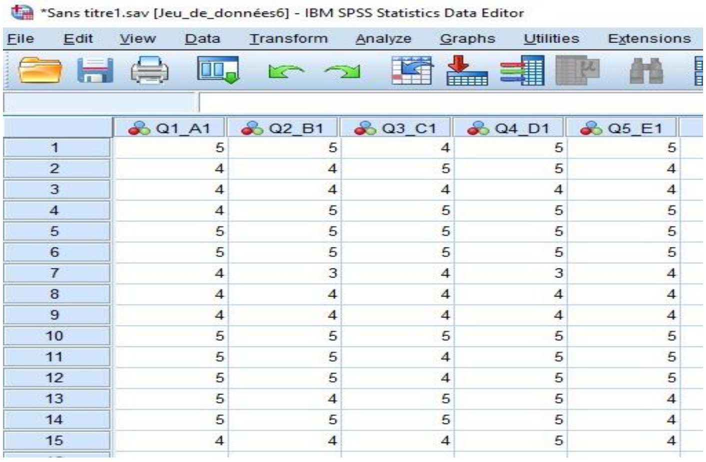


Figure 2: Representation and percentage of each style according to Kolb

In the last part: According to the proposed questionnaire, the cumulative results are presented in Figure 4, for the divergent style object of our study:



	Q1_A1	Q2_B1	Q3_C1	Q4_D1	Q5_E1
1	5	5	4	5	5
2	4	4	5	5	4
3	4	4	4	4	4
4	4	5	5	5	5
5	5	5	5	5	5
6	5	5	5	5	5
7	4	3	4	3	4
8	4	4	4	4	4
9	4	4	4	4	4
10	5	5	5	5	5
11	5	5	4	5	5
12	5	5	4	5	5
13	5	4	5	5	4
14	5	5	5	5	4
15	4	4	4	5	4

Figure 3: The preferences supported by divergent students for different activities based on AI

These results were processed by the SPSS statistical analysis software for its variables which are of ordinal qualitative type, the analysis was carried out on the numbers and cross tables of multiple responses, but before making a measurement of the reliability of the questionnaire it is necessary to measure the degree of consistency between the elements.

A. Measuring the reliability of preferences for activities according to divergent style

Statistical index varying between 0 and 1 which allows to evaluate the homogeneity (the coherence or the internal coherence) of the questionnaire composed of a set of items. In practice, we encounter the problem of the reliability of the measurements in a quiz or a test, among the existing methods, we have chosen the one based on the internal coherence called Cronbach's Alpha. [36]. It is generally considered that the homogeneity of the instrument is satisfactory when the value of the coefficient is at least equal to 0.70. [37].

Table 4: Case Processing Summary

		N	%
Cases	Valid	15	100,0
	Excluded[a]	0	,0
	Total	15	100,0

a. Listwise deletion based on all variables in the procedure.

Table 5: Reliability Statistics

Cronbach's Alpha	N of Items
,861	5

These results indicate that our items for the divergent are acceptable with a coefficient of 0.861.

Table 6: Presentation of the frequencies of the variables =Q1_A1, Q2_B1, Q3_C1, Q4_D1 et Q5_E1

		Experimentation and exploration of situation problems	Interactive virtual experiences	Visualization and modeling	Collaboration and sharing	Learning Personalization
N	Valid	15	15	15	15	15
	Missing	0	0	0	0	0
Median		5,00	5,00	4,00	5,00	4,00
Variance		,267	,410	,267	,381	,267

The median is used to give an indication of the central value and dispersion of the data, according to the results the median varies between 4 for questions Q3 and Q5 and 5 for the rest which indicates that the students' preference for these activities is excellent. for the variance which quantifies the dispersion of the data around the mean. According to the results, the variances are too low and represent a measure of dispersion of the data relatively low compared to the mean, this suggests that the observations tend to be grouped around the mean. This indicates that the data are relatively consistent and show little variation from one observation to another, as this indicates greater precision in the measurements made. This is detailed in the following tables:

Table 7: Experimentation and exploration of situation problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	7	46,7	46,7	46,7
	5	8	53,3	53,3	100,0
	Total	15	100,0	100,0	

Table 8: Interactive virtual experiences

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	6,7	6,7	6,7
	4	6	40,0	40,0	46,7
	5	8	53,3	53,3	100,0
	Total	15	100,0	100,0	

Table 9: Visualization and modeling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	8	53,3	53,3	53,3
	5	7	46,7	46,7	100,0
	Total	15	100,0	100,0	

Table 10: Collaboration and sharing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	6,7	6,7	6,7
	4	3	20,0	20,0	26,7
	5	11	73,3	73,3	100,0
	Total	15	100,0	100,0	

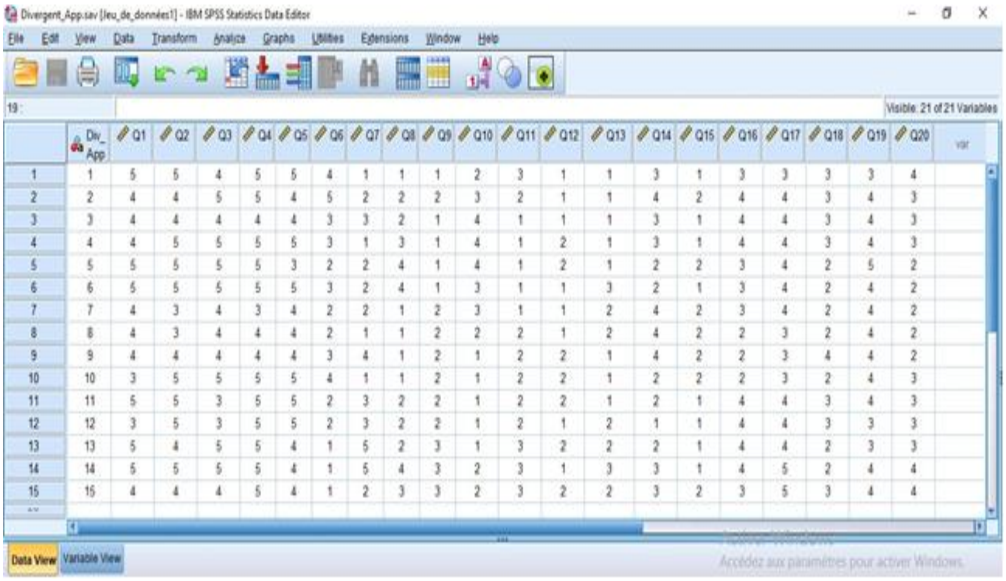
Table 11: Learning Personalization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	8	53,3	53,3	53,3
	5	7	46,7	46,7	100,0
	Total	15	100,0	100,0	

B. Analyse de fréquence selon les styles Kolb

Calculating a frequency allows for comparison of series of observations on populations that are unequally large. The expression in percentage, rounded to a precision that takes into account the size of the population, facilitates comparisons, [38].

Table 12 : Results of the questionnaire carried out by the divergent members of the sample.



Divergent_App.sav [Jeu_de_données1] - IBM SPSS Statistics Data Editor

	Div_App	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	var
1	1	5	5	4	5	5	4	1	1	1	2	3	1	1	3	1	3	3	3	3	4	
2	2	4	4	5	5	4	5	2	2	2	3	2	1	1	4	2	4	4	3	4	3	
3	3	4	4	4	4	4	3	3	2	1	4	1	1	1	3	1	4	4	3	4	3	
4	4	4	5	5	5	5	3	1	3	1	4	1	2	1	3	1	4	4	3	4	3	
5	5	5	5	5	5	3	2	2	4	1	4	1	2	1	2	2	3	4	2	5	2	
6	6	5	5	5	5	5	3	2	4	1	3	1	1	3	2	1	3	4	2	4	2	
7	7	4	3	4	3	4	2	2	1	2	3	1	1	2	4	2	3	4	2	4	2	
8	8	4	3	4	4	4	2	1	1	2	2	2	1	2	4	2	2	3	2	4	2	
9	9	4	4	4	4	4	3	4	1	2	1	2	2	1	4	2	2	3	4	4	2	
10	10	3	5	5	5	5	4	1	1	2	1	2	2	1	2	2	2	3	2	4	3	
11	11	5	5	3	5	5	2	3	2	2	1	2	2	1	2	1	4	4	3	4	3	
12	12	3	5	3	5	5	2	3	2	2	1	2	1	2	1	1	4	4	3	3	3	
13	13	5	4	5	5	4	1	5	2	3	1	3	2	2	2	1	4	4	2	3	3	
14	14	5	5	5	5	4	1	5	4	3	2	3	1	3	3	1	4	5	2	4	4	
15	15	4	4	4	5	4	1	2	3	3	2	3	2	2	3	2	3	5	3	4	4	

According to the SPSS analysis The output is such that: MULT RESPONSE GROUPS=

$Divergent Style (Q1 Q 2 Q 3 Q 4 Q 5)

$ Assimilator Style (Q 6 Q 7 Q 8 Q 9 Q 10)

$ Convergent Style (Q 11 Q 12 Q 13 Q 14 Q 15)

$Accommodator Style (Q 16 Q 17 Q 18 Q 19 Q 20)

/FREQUENCIES=$Divergent_Style $Assimilator_Style $Convergent_Style $Accommodator_Style.

Table 13: Multiple Response : Case Summary

	Valid		Cases Missing		Total	
	N	Percent	N	Percent	N	Percent
$Style_Divergent[a]	15	100,0%	0	0,0%	15	100,0%
$Style_Assimilator[a]	15	100,0%	0	0,0%	15	100,0%
$Style_Convergent[a]	15	100,0%	0	0,0%	15	100,0%
$Style_Accommodator[a]	15	100,0%	0	0,0%	15	100,0%

All styles (Divergent, Assimilator, Convergent, Accommodator) have a total of 15 valid cases, representing 100% of each category. No cases are missing, indicating perfect data completeness.

Table 14: Divergent Style Frequencies

$ Divergent Style_ Frequencies : Responses

		N	Percent	Percent of Cases
Style Divergent[a]	Average	8	10,7%	53,3%

	good	29	38,7%	193,3%
	Very good	38	50,7%	253,3%
Total		75	100,0%	500,0%

a. Group

The table represents the satisfaction rate with the divergent style, that 38 students expressed a satisfaction of very good, while 29 good and 8 average, while 67 were well satisfied with a percentage of 89.33%

Table 15: Assimilator Style Frequencies

$Assimilator Style Frequencies : Responses

		N	Percent	Percent of Cases
Style Assimilator[a]	Very poor	22	29,3%	146,7%
	poor	26	34,7%	173,3%
	Average	15	20,0%	100,0%
	Good	9	12,0%	60,0%
	Very Good	3	4,0%	20,0%
Total		75	100,0%	500,0%

a. Group

According to the results, the 15 differ from our sample: 64% weak and very weak, 20% average and 36% good and very good. This divergent group has a satisfaction rate for the assimilative style of 36%. This can judge that it does not have a perfect style but a spectrum where one is dominant.

Table 16 : Style Convergent Frequencies

$Convergent Style Frequencies : Responses

		N	Percent	Percent of Cases
Style Convergent[a]	tres faible	30	40,0%	200,0%
	faible	30	40,0%	200,0%
	moyen	11	14,7%	73,3%
	bien	4	5,3%	26,7%
Total		75	100,0%	500,0%

a. Group

According to the results of the 15 divergent from our sample: 80% weak and very weak, 14.6% average and 5.3% goodThis group of diverges has a satisfaction rate for the convergent style of 5.3%. This can justify, what must be strengthened the theoretical rating for the diverges.

Table 17 : Accommodator Style Frequencies

$Accommodator Style Frequencies : Responses

		N	Percent	Percent of Cases
Style Accommodator[a]	Poor	15	20,0%	100,0%
	Average	26	34,7%	173,3%
	Good	31	41,3%	206,7%
	Very Good	3	4,0%	20,0%
Total		75	100,0%	500,0%

a. Group

According to the results of the 15 divergent from our sample: 1.2% weak and very weak, 30.6% average and 57.3% good. This group of divergents has a satisfaction rate for the accommodating style of 57.3%. This can justify that the divergents are declined towards the accommodators than towards the assimilators, each time the strengthening of each style is necessary. The percentages of observations are greater than 100, this is normal since its questions are multiple choice and the number of responses is greater than the sample.

V. DISCUSSION

This work aims to exploit artificial intelligence applications to personalize physics learning according to the Kolb divergent learning style of our sample. In order to obtain more precise and representative results, we structured our work in three sections. The first concerns the distribution by gender and by options within a sample of 85 students. From the collected data, we carried out a statistical analysis using SPSS software, the results of which are presented in Figure 1. These statistics highlight the diversity of students in the scientific options, showing varied proportions of girls and boys in each option. We observe that the Mathematics Sciences A and B options are rarely chosen, while the Physical Sciences option is more popular. This observation will be explored in more detail in a future article. Then we conducted a survey among students to identify the difficulties encountered by them and their teachers in teaching and learning physics. The information collected indicates the number of students who reported factors of dissatisfaction and the main difficulties encountered in this area. The results, presented in Table 2, reveal, through a statistical analysis of the scores and percentages, a significant problem in the learning of physics in our sample. The proposals in the table reflect the concerns expressed by the 85 learners and their teachers, which encourages us to explore solutions, including those based on artificial intelligence, to address the issues raised during the survey.

To identify learning styles according to [39] we used the ILS tool (Kolb's Learning Styles), which consists of a questionnaire assessing individuals' learning preferences on four dimensions: concrete experience, reflective observation, abstract conceptualization, and active experimentation, according to [40]. This questionnaire presents a series of learning situations and asks learners to select the answers that best match their preferences in each case. The answers are then analyzed to determine the predominant learning style of each participant. The results, calculated to reflect the diversity of our sample, are grouped in Table 3, thus providing a significant overview of the homogeneity of the group. Finally, we conducted a test to measure the degree of preference of the proposed learning activities, using the Likert scale. These activities integrate solutions based on artificial intelligence applications to improve learning, engagement and understanding, specifically in the context of a high school physics course. Learners' responses indicate a strong propensity to appreciate the following activities:

Q1-A1,B1,C1,D1,E1: These activities explore various problem situations, ideas and perspectives, and encourage the search for alternatives in learning. They promote collaboration, sharing and discussion among peers, thus deepening the understanding of physical concepts through new questions and potential applications.

Q2-A2,B2,C2,D2,E2: These activities allow students to analyze and understand the theoretical principles of a new concept in physics. They encourage conceptual understanding and theoretical thinking by visually organizing ideas using diagrams, summaries, interactive presentations and guided discussions, establishing relationships between different aspects of the physical concept.

Q3-A3,B3,C3,D3,E3: These activities present standard methods for approaching new concepts in physics. The learner demonstrates the ability to apply physical principles, motivated by solving real-world problems and finding specific solutions using proven methods, rather than seeking alternatives.

Q4-A4,B4,C4,D4,E4: These hands-on experimentation and application of physics activities are designed to solve physical problems. Participation in independent research and exploration projects is a valuable learning experience, fostering the exploration of new ideas and concepts. The learner considers hands-on experimentation and solving real-world problems as essential means of assessing understanding.

In light of the results obtained, it is essential to interpret these data by comparing them with established theories on learning styles, particularly those of Kolb. Our observations indicate that the integration of artificial intelligence-based applications not only promoted a better understanding of physical concepts, but also led to increased student engagement. However, deviations from previously published results on the effectiveness of these methods could be due to contextual differences or the diversity of learning styles within our sample. To guide future research, we recommend further exploring how personalized AI-based approaches can be adapted to heterogeneous groups of learners. New evaluation methods could also be developed to more finely measure the impact of these interventions on the learning of different styles. Taking into account the feedback from the evaluators and the results of our study, it is clear that further research is needed to deepen our understanding of the dynamics between artificial intelligence and learning styles in physics.

In conclusion, the use of artificial intelligence (AI)-based applications allows the creation of educational resources and activities adapted to each learning style, thus promoting a better understanding and greater engagement of students. These adaptations are in line with the characteristics of learning styles proposed by Kolb. This test aims to assess a student's tendency to adopt a particular style while exploring some aspects related to Kolb's learning styles. It is crucial to recognize that students may manifest combinations of several learning styles. In addition, learning preferences may evolve and vary according to contexts and personal experiences.

VI. Conclusions and Implications

Our study findings highlight the critical importance of addressing the challenges that many students face in learning physics. We propose two sets of solutions to address these challenges. The first is for curriculum designers, who should streamline course content and better identify students' needs in terms of prior knowledge and learning styles. The second targets teachers, suggesting tailored support lessons, progressive presentation of concepts, and a focus on experimentation and conceptual understanding over simple memorization. The integration of artificial intelligence (AI) tools is also essential to boost student engagement and motivation. AI can adapt physics learning to the different learning styles defined by Kolb. For divergents, interactive virtual experiences and stimulating problem situations promote exploration. Assimilators benefit from interactive presentations and personalized online resources, while convergers benefit from virtual labs and AI-assisted engineering projects. Finally, accommodators have access to guided hands-on experiments and real-world case studies. By combining AI with learning styles, we can create responsive learning environments that not only enhance the understanding of physics concepts but also foster greater learner engagement. These personalized, AI-powered methods aim to deliver tailored content, interactive experiences, and individualized assessments, contributing to a rich learning experience.

In conclusion, artificial intelligence is transforming physics education by simplifying complex concepts and opening new avenues for learning and scientific exploration. By embracing these innovations, educators can provide more personalized learning experiences that meet the diverse needs of their students. This fusion of AI and physics represents an exciting shift for education, promising to enrich our scientific understanding and significantly improve learner engagement..

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