The Impact of Using Computer Simulation in Industrial Technology Learning on Student Outcomes

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***Abstract*—Computer simulation-based learning techniques can significantly enhance teaching methods by improving both the learning experience and digital educational processes. This method has become one of the most effective approaches for diverse student groups, enabling them to make data-driven decisions that optimize learning and contribute to better academic outcomes. This study aims to examine the impact of integrating computer simulation-based learning techniques into the learning of electronic circuits within industrial technology education. The research was conducted with a sample of 112 students (aged 13 to 16) from three classes. A descriptive correlational approach was used to explore the relationship between simulation-based learning and student performance. Pearson's correlation coefficient was applied to analyze students' results in a circuit manipulation test using simulation software and their responses to a questionnaire assessing their learning progress. Data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS). The findings highlight the potential benefits of incorporating simulation techniques into electronic circuit education, reinforcing students' motivation and engagement. However, several obstacles to the integration of simulations were identified, including the lack of teacher training, the need for complex manipulations, and the time required to prepare each session. Additionally, implementing simulations often requires smaller student groups, which may limit their use in larger classes. Despite these challenges, the results suggest that the widespread adoption of digital simulation in electrical technology education is beneficial, and we advocate for its integration into teaching methodologies to enhance student learning experiences and outcomes.**

***Keywords*—techniques simulation, computer simulation, artificial intelligence, e-learning**

I. Introduction

The world is witnessing unprecedented technological advancements, with simulation-based learning techniques emerging as key tools in education [1–4]. The increasing accessibility of Artificial Intelligence (AI) has accelerated the development of simulation techniques [2, 5], revolutionizing how complex concepts are taught and understood. This technological evolution has not only optimized learning processes but also eliminated barriers related to time, effort, and geographical constraints [6], making education more accessible and efficient.

In the field of education, computer-based simulation techniques have proven to be highly effective [7], particularly in science and technology learning. Their success depends largely on the accuracy of their programming and their ability to engage students in interactive, constructivist-based learning experiences. These techniques function as dynamic, computer-generated models [8], simplifying complex theories and offering a more intuitive representation of real-world phenomena.

Simulation-based learning plays a crucial role in fostering essential skills by providing hands-on experimentation [7, 8], delivering immediate feedback, and creating an adaptable and risk-free learning environment [9–11]. In this study, we focus specifically on the learning of electronic circuits within industrial technology education. Students interact with simulation tools to overcome comprehension challenges related to circuit analysis and manipulation. In this study, the term "computer simulation" refers to the use of Crocodile Clips software to virtually construct and test electronic circuits. This tool allows students to manipulate components such as resistors, LEDs, and sensors in a safe, digital environment, providing immediate visual feedback without the risk of damaging real hardware.

The preliminary findings from this study suggest a strong positive correlation between simulation-based education and student outcomes, indicating significant potential for enhancing student comprehension and engagement. To further explore the effectiveness of these interactive techniques, this research also gathered feedback from nine teachers—three from industrial technology, three from physics, and three from biology—regarding their experience with integrating simulations into their teaching practices. Teachers generally expressed positive views on how simulations enhance student engagement and motivation. However, they also identified certain challenges, such as the need for additional training to use simulation tools effectively, preparation time before each session, and logistical difficulties when managing large student groups. These insights underscore the importance of incorporating educators' perspectives into the broader discussion on the integration of digital tools in education. This article presents our research findings, highlighting the transformative impact of simulation-based learning techniques in the teaching of electronic circuits.

As we explore the integration of simulation techniques into electronic circuit education, it becomes evident that this technological approach has the potential to reshape the educational landscape. The combination of AI-driven simulations and pedagogical methodologies opens new

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opportunities for more effective, engaging, and efficient learning experiences [12–14]. This article presents our research findings, emphasizing the transformative impact of simulation-based learning techniques in the teaching of electronic circuits on.

II. Materials and Methods

The present research was conducted over a period of 4 months at a public school in the city of Sidi Slimane, involving 3 groups of third-year students. A questionnaire was distributed to 112 students to measure the results of integrating computer simulation into the learning process.

Four tests were applied to students in each group, with the groups being taught using simulation activities on Crocodile Clips simulation software for one hour each week. Simulating electronic circuits with software like Crocodile Clips offers a versatile and effective way to learn, experiment, and design electronic circuits. It provides a safe, accessible, and interactive platform for students to develop their electronic knowledge and skills while facilitating collaboration and real-world applications.

The students were organized into pairs, with each pair sharing a computer. The computer room had a total of 18 computers, and a video projector, linked to the teacher's computer, was used to assist and guide students in building their understanding while addressing any technical inquiries they had.

In analyzing the results of the questionnaire distributed to the students, we made sure to include not only positive responses but also neutral and negative ones. This ensures that the data reflects a comprehensive view of the students' perceptions regarding the use of simulations in their learning process. While the majority of respondents expressed favorable views, a significant proportion provided neutral or negative responses, particularly regarding the effectiveness of simulations in protecting electronic components. This range of opinions was carefully considered and presented in the interpretation of the results.

This approach allows for a more accurate representation of student perceptions, acknowledging the full spectrum of opinions, from highly positive to more reserved ones. Therefore, the interpretation of the results takes into account not only the favorable responses but also the neutral or critical ones, ensuring a complete and balanced analysis of the data.

The data gathered underwent analysis using IBM SPSS.

A. Gander of Sample

Table 1 presents the number of participants in the three groups which contain 59 girls (52.7%) and 53 boys (47.3%).

Table 1. Gender distribution of sample

Category		Frequency (F)	Percentage (%)	Valid Percentage (%) (V.P)	Cumulative Percentage (%) (C.P)
	M	53	47.3	47.3	47.3
V	F	59	52.7	52.7	100.0
	T	112	100.0	100.0	

Table 2 shows that in Group A we have a participation of 23 girls and 15 boys with a majority of girls compared to boys. 20 girls and 17 boys in Group B with a slight majority of girls compared to boys, and, we have the participants of Group C which are composed of 16 girls and 21 boys but with a majority of boys compared to girls.

Table 2. Gender distribution in sample Groups A, B and C

Group	Gender		Total
	M	F	
A	15	23	38
B	17	20	37
C	21	16	37
Total			112

B. Sample of Test Simulation

Figs. 1 and 2 show examples of simulation circuits created using Crocodile Clip software. In Fig. 1, it is a switching circuit controlled by a switch. In this activity, students are responsible for drawing the circuit on the software, and controlling the switch, opening and closing it, and then analyzing its operation.

Fig. 2 is also a switching circuit, but this time it incorporates a transistor. The objective is to allow students to discover the role of the transistor in controlling an LED. They must take into account the specific properties of the transistor, such as the choice of resistors in relation to the operation of the transistor, and analyze the control results of the LED.

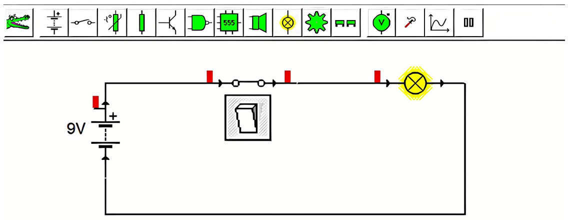

Fig. 1. Simulation switching function.

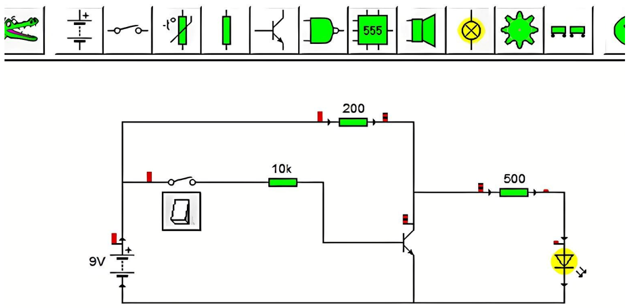

Fig. 2. Simulation switching function transistor.

III. Results

A. Research Procedure and Data Analysis

Figs. 3–5 present the average student scores obtained in each of the four tests for groups A, B, and C, respectively. These figures clearly demonstrate a progressive improvement in student performance across the four tests. Each group underwent an increasing number of simulations prior to each corresponding test, and this progression is reflected in their scores. The data indicate a consistent upward trend throughout the testing sequence.

As the number of simulations increased, so did the students' performance, suggesting that the simulations had a positive and measurable impact on learning outcomes. This aligns with active learning theories, which emphasize hands-on, experiential engagement as a catalyst for deeper understanding.

The results underscore the beneficial role of simulations in reinforcing students' understanding and technical skills. The gradual improvement in average scores suggests that repeated exposure to simulations helped consolidate knowledge and enhance mastery of the subject matter. Moreover, the positive trend supports the idea that repetition, when implemented through meaningful simulation activities, strengthens both retention and conceptual grasp.

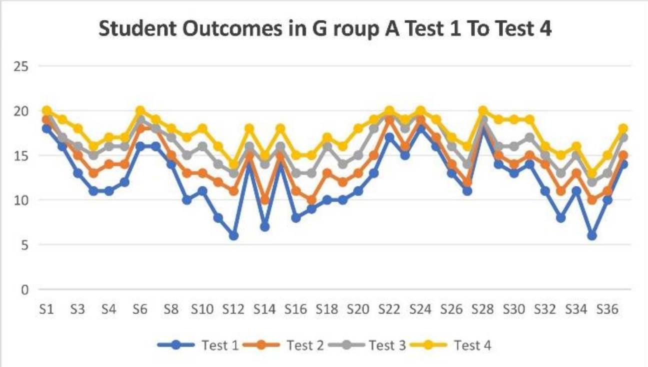

Fig. 3. Student outcomes in Group A from Test 1 to Test 4.

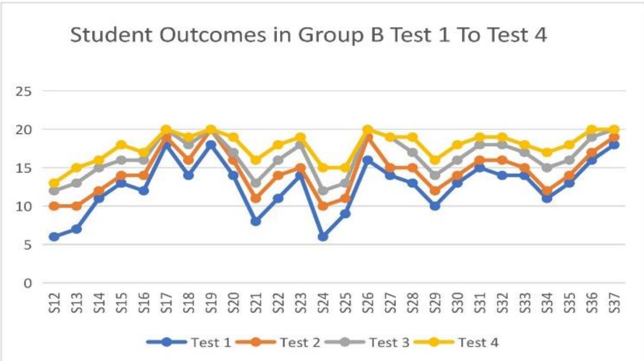

Fig. 4. Student outcomes in Group B from Test 1 to Test 4.

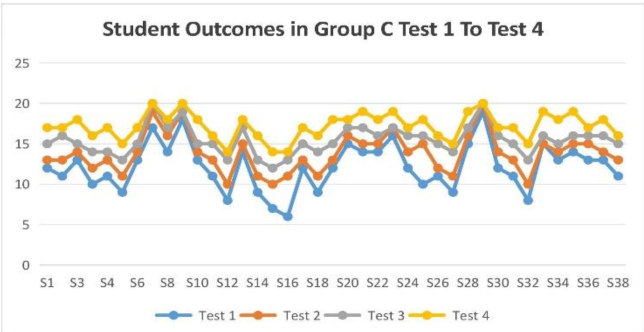

Fig. 5. Student outcomes in Group C from Test 1 to Test 4.

It is also worth noting that the differences in performance between the groups highlight the importance not only of frequency, but also of the quality and design of the simulation sessions. The simulations appear to be more effective when students are given sufficient time and interactive opportunities to engage with the material. While the current trend is promising, further research would be needed to determine whether performance continues to improve beyond three simulation sessions or if it eventually reaches a plateau

B. The Descriptive Statistics of the Student's Outcomes

In Table 3, the mean represents the typical score of test participants, while the standard deviation indicates the dispersion or variability of the results relative to the mean.

A higher standard deviation suggests greater dispersion of results, which may indicate significant variability among participants' performances.

A lower standard deviation suggests less dispersion, indicating higher consistency among participants' performances.

Table 3. Descriptive statistics of student performance across simulation tests (Test 1 to Test 4)

Statistic	Test 1	Test 2	Test 3	Test 4
Mean	12.28	14.19	15.94	17.44
Max	19.00	20.00	20.00	20.00
Min	6.00	10.00	12.00	13.00
Raoundd Mean	13.00	14.00	16.00	18.00
Mode	11.00	15.00	16.00	18.00
Std. Dev	3.13	2.60	2.12	1.76
C.V	0.25	0.18	0.13	0.10

1) For the first test (no simulation)

The mean score of 13 indicates that student performance is centered around this value. However, the standard deviation of 3.130 suggests significant dispersion in student performance. This means that there is considerable variation in scores, with some students scoring much higher or lower than the average, indicating a heterogeneous understanding of the material prior to the integration of simulations.

2) For the second test (one simulation before answering)

The mean score of 14 reflects a slight improvement in student performance after completing a simulation. The standard deviation of 2.601 suggests moderate variability in the results. While the average performance is 14, this indicates that scores are somewhat spread around this value, but with less dispersion compared to the first test. This could suggest that exposure to the simulation helped to standardize students' understanding to some extent

3) For the third test (two simulations before answering)

The mean of 16 indicates further improvement in performance. The standard deviation of 2.124 is lower than the previous tests, suggesting that students' scores are becoming more clustered around the mean. This indicates that multiple simulations have likely contributed to a more uniform understanding of the material.

4) Last test (three simulations)

The mean of 18 suggests that student performance continued to improve. The standard deviation of 1.755 is the lowest of all tests, indicating that performance is now more consistent across students. The closer clustering of scores around the mean suggests that repeated simulation exposure has had a stabilizing effect on student learning.

The Coefficient of Variation (C.V.) is calculated as the ratio of the standard deviation to the mean. This provides a sense of relative dispersion, allowing comparisons across tests:

- Tests 1: C.V. = 0.254
- Tests 2: C.V. = 0.183
- Tests 3: C.V. = 0.133
- Tests 4: C.V. = 0.100

As the C.V. decreases from Tests 1 to Tests 4, this further supports the idea that the more simulations students experience, the more consistent their performance becomes.

The results show a clear progression in student performance across the tests. Tests 1 reveals high variability, indicating diverse performance before simulations. Tests 2 shows some improvement with moderate variability, suggesting that the first simulation had a positive but limited impact. Tests 3 exhibits further improvement and more consistent performance, while Tests 4 demonstrates the most consistent results, with the lowest standard deviation. This progression underscores the benefits of repeated exposure to simulations, which helps students grasp the material more effectively and consistently.

These findings confirm that repeated exposure to simulations not only improves average student performance but also reduces performance variability. In the final test, where students completed three simulations beforehand, the results were more tightly clustered around the mean score of 18, reflecting greater consistency among learners. This suggests that simulations helped bridge the gap between high and low performers, promoting a more uniform understanding. Overall, the integration of active learning through simulations positively influenced students' comprehension and mastery of electronic circuits by making learning more interactive, structured, and accessible to all.

5) The descriptive statistics of the student's responses to the questionnaire

The descriptive statistics of the students' responses to the questionnaire revealed that the highest average was awarded to Question 5: (Does simulation give you more motivation to learn technology?) with a mean of 4.42 and a standard deviation of 0.653. This indicates that, on average, students strongly agreed that simulations significantly increased their motivation to learn technology. The relatively low standard deviation of 0.653 suggests that there was a strong consensus among the students, with most participants sharing this positive perception of the motivating effect of simulations.

Following this, Question 3: (Simulation makes it possible to check the results of the operation of the system and make changes in the event of an error?) received a mean of 4.40 and a standard deviation of 0.703, indicating a similarly positive perception but with slightly more variation in responses. Question 1: (The simulation makes it possible to visualize in real time the result of the phenomenon) had a mean of 4.35 and a standard deviation of 0.707, reflecting a strong, though slightly more varied, agreement among students regarding the value of real-time visualization in simulations.

The other questions, including Question 4: (Simulation keeps the equipment protected through visualization with the simulator?) with a mean of 4.27 and standard deviation of 0.759, and Question 2: (Does simulation lead to good control of properties and components?) with a mean of 4.25 and standard deviation of 0.741, also showed high mean scores, demonstrating that students consistently viewed simulations as a valuable learning tool across various aspects.

The weighted average of all questionnaire responses was 4.338, and the overall standard deviation was 0.7126. This result is categorized as a high level of perception, reflecting a strong, positive overall evaluation of the simulations as effective tools for enhancing motivation, understanding, and control in learning technology.

- low level : [1–2.59]
- Moderate: level [2.60–3.39]
- High level: [3.40–5]

The survey results, as shown in Fig. 6, indicate that 50.9% of respondents strongly agree and 40.2% agree with the idea that simulation allows for effective control of properties and components. These percentages reveal a strong consensus among students regarding the utility of simulations in mastering and understanding electronic properties. Approximately 91% of participants expressed a positive opinion, suggesting a high level of confidence in the effectiveness of simulations for controlling electronic components. The neutral responses, representing 7.1% of respondents, indicate that a few students remain more reserved, but overall, there is a clear agreement that simulations are an excellent tool for learning electronic properties.

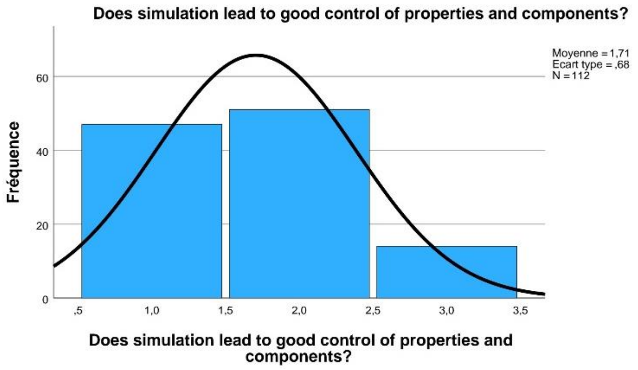

Fig. 6. Control of components through simulation.

In Fig. 7, the responses to this aspect of simulation-based learning are noteworthy. A significant 50.9% of the respondents strongly agreed, and 40.2% agreed with the idea that simulations allow for effective real-time visualizations of outcomes. These results highlight a strong consensus among students regarding the effectiveness of simulations in providing real-time feedback and insights into the phenomena they are studying.

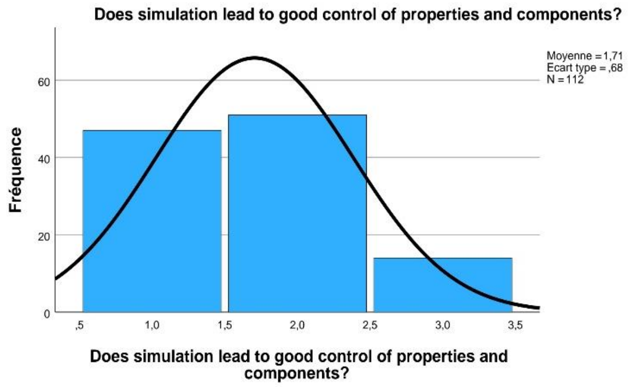

Fig. 7. Simulation and real-time visualization of results.

Additionally, 7.1% of respondents remained neutral on this point, while only a small portion, 1.8%, disagreed. This suggests that while most students recognize the value of real-time visualization, there are a few who either had no strong opinion or felt differently. Nevertheless, the 91.1% agreement rate (combining "strongly agree" and "agree") demonstrates that simulations are widely considered effective tools for providing real-time data, reinforcing the value of dynamic and interactive learning experiences.

Fig. 8 presents the questionnaire results concerning circuit implementation tasks, providing valuable insights into the effectiveness of simulations as an educational tool, particularly for understanding the impact of values such as resistance, capacitance, and voltage in electronic circuits. One of the key skills in learning about electronic circuits is the ability to adjust the values of specific components to ensure a schematic operates correctly. This skill is fundamental for anyone pursuing a career in electronics, as it forms the foundation for troubleshooting and optimizing circuit designs. Simulations, with their interactive and dynamic nature, offer an ideal platform for enabling students to effectively master these concepts.

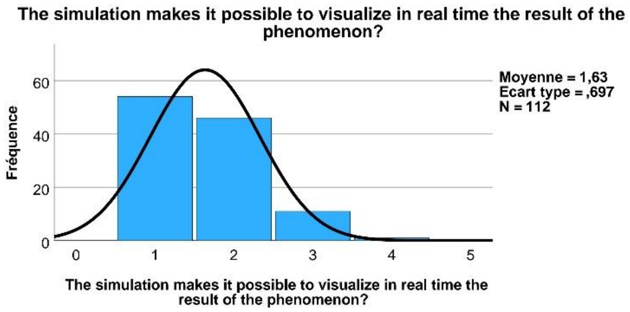

Fig. 8. Simulation and change of values.

The survey results are significant. A substantial 71.1% of respondents (combining 50.9% strongly agree and 40.2% agree) confirmed that simulations allow for examining system operation results and making adjustments when errors occur. This strong agreement highlights the essential role that simulations play in providing students with a practical and meaningful way to interact with circuits. Simulations offer a dynamic environment where students can experiment, observe outcomes, and make adjustments in real time, which mirrors the real-world process of circuit design and troubleshooting.

Additionally, 7.1% of respondents expressed a neutral opinion, suggesting that while the majority of students recognize the value of simulations for understanding circuit behavior, a small portion remains uncertain or indifferent. This finding further supports the idea that, although simulations may not always be the primary method of learning, they play a valuable supplementary role in enhancing students' understanding of electronic circuits.

Fig. 9 presents the survey results concerning the question about the role of simulations in preventing the degradation of electronic components, revealing a notably positive response among students. A significant 48.2% of respondents agreed, while an impressive 41.1% strongly agreed with the statement, highlighting that nearly 90% of the students either agreed or strongly agreed that simulations effectively serve as a means of protecting electronic components from degradation. This widespread agreement emphasizes the strong recognition of simulations as a valuable educational tool.

The overwhelming support for this approach suggests that students highly appreciate the benefits of simulations. By providing a risk-free environment, simulations allow students to address errors and malfunctions without the fear of damaging costly electronic components. This proactive learning environment encourages students to experiment, troubleshoot, and learn from mistakes in a safe and controlled setting.

The high percentage of students who strongly agree underscores the enthusiasm with which they perceive simulations as protective tools for electronic components. This enthusiastic endorsement not only reflects their confidence in the effectiveness of simulations but also signals their readiness to actively engage with this educational method.

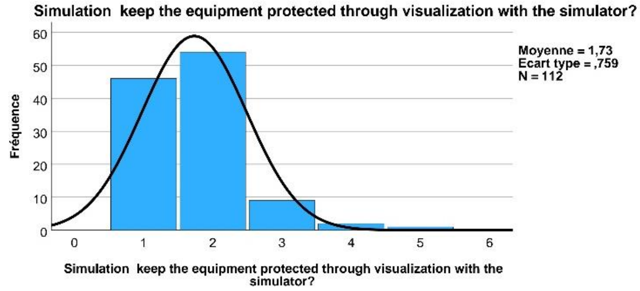

Fig. 9. Simulation and protection of components.

Fig. 10 presents the responses to the final question, revealing significant insights into the impact of simulations on students' motivation to learn technology. A remarkable 50.9% of respondents strongly agreed with the statement, indicating that a substantial majority of the participants are highly motivated by simulations in their technology-related learning. This highlights the powerful effect that simulations have on students' enthusiasm for technology education.

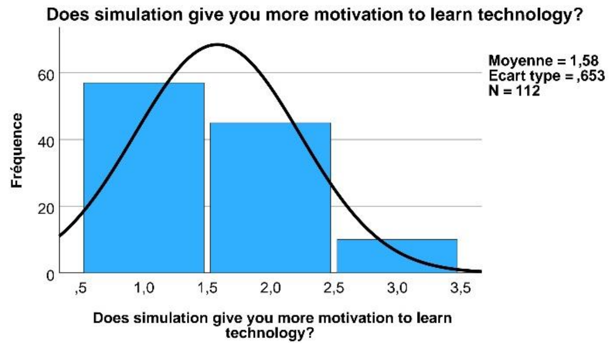

Fig. 10. Simulation and learner motivation.

In addition, 40.2% of respondents expressed agreement, demonstrating that a considerable portion of students, though not as emphatic as the first group, still recognize the positive influence of simulations on their motivation to learn technology. This indicates that simulations have a broad appeal, motivating a wide range of students and enhancing their engagement with the subject.

The purpose of the question was to assess how simulations influence students' motivation in the context of technology education. The collective responses strongly suggest that simulations serve as an effective motivator for many students, leading to a more active and enthusiastic approach to learning technology.

Feedback from nine teachers across Industrial Technology, Physics, and Life Sciences (SVT) highlighted that simulations were generally well-received for enhancing student engagement and understanding, particularly in subjects like electronic circuits (teachers of Technology and Physics) and scientific phenomena.

However, teachers reported challenges, including lack of preparation time, technical issues, and difficulties managing large groups. Despite these challenges, most teachers agreed that simulations had a positive impact on student learning, allowing for safe, hands-on experimentation.

Teachers emphasized that the availability of tools played a crucial role in the effectiveness of the simulations. They noted a significant difference in student comprehension and manipulation of the simulations between those who had access to the necessary tools and those who did not. The lack of access was often tied to socioeconomic factors, which created disparities in student engagement and learning outcomes. Teachers observed that students with access to the required tools were more confident and engaged in the simulation activities, while others struggled to grasp the concepts due to limited resources.

In terms of adjustments, teachers emphasized the need for better time management, individualized support, and training to make simulations more effective. They also recommended broader integration of simulations, particularly in technical subjects, but underlined the importance of adequate equipment and preparation time.

IV. Discussion

In Table 4, we explore the correlation between two variables: Test 1 and Test 4 scores. The Pearson correlation coefficient (r) ranges from −1 to 1:

Table 4. Descriptive statistics for S.Test 1 and S.Test 4

Descriptive statistics	Mean	std. deviation	N
S.Test1	12.28	3.130	115
S.Test4	17.44	1.755	114

- An r close to 1 indicates a strong positive relationship (as one variable increases, the other does as well).
- An r close to −1 indicates a strong negative relationship.
- An r close to 0 suggests a weak or no linear relationship.

The Pearson correlation coefficient between Test 1 and Test 4 is 0.933, indicating a strong positive relationship between the use of computer simulations and students' academic performance. This suggests that greater engagement with simulations is linked to higher achievement.

Table 5 illustrates the relationship between student performance in Simulation Test 1 and Simulation Test 4, based on the Pearson correlation coefficient. The coefficient obtained, $r = 0.933$, indicates a very strong positive correlation between the two sets of scores. In statistical terms, this means that as students progressed through additional simulation sessions, their performance tended to improve consistently. The significance value ($p < 0.001$, two-tailed) confirms that this correlation is statistically significant and highly unlikely to be due to chance.

Table 5. Pearson correlation coefficients between S.Test 1 and S.Test 4

	Correlation	S.Test 1	S.Test 4
S.T1	The Pearson Correlation	1	0.933**
	Sig. (bilatérale)		<0.001
	N	115	114
S.T4	The Pearson Correlation	0.933**	1
	Sig. (bilateral)	<0.001	
	N	114	114

This result suggests that repeated exposure to simulation activities is closely associated with better academic performance. Specifically, students who engaged more frequently with simulations demonstrated greater understanding and application of the concepts evaluated in the tests.

Simulations offer dynamic, interactive learning environments that support comprehension and retention. Key benefits observed in this study include:

- **Enhanced Concept Understanding**: Complex technical functions became more accessible through visual and interactive representations.
- **Increased Engagement and Motivation**: Students reported higher motivation due to the gamified and exploratory nature of the activities.
- **Safe Learning Space**: Simulations allowed students to test hypotheses without real-world risks.
- **Instant Feedback**: Immediate responses helped correct misconceptions and reinforce learning.
- **Personalized Learning**: Students advanced at their own pace, enabling differentiated instruction.

These findings were further validated by students' positive feedback in the questionnaire, highlighting simulations as an effective tool for both knowledge acquisition and the development of transversal skills such as teamwork, communication, and problem-solving.

In conclusion, the strong correlation between simulation use and improved performance underscores the pedagogical value of integrating simulation into the learning process. It not only improves academic outcomes but also prepares students more effectively for real-world technical challenges.

A. Context and Literature

In a similar study conducted by Ouahi *et al.* in Morocco, the use of computer simulations in teaching science showed a significant improvement in students' performance. The findings of this study align with those of the current research, reinforcing the value of integrating technology into the learning process [15–22]. In the study, the experimental group using simulations demonstrated better results compared to the control group. Additionally, Demba [17] examined the impact of computer simulations on understanding physics concepts in classroom settings in Côte d'Ivoire. His study, which focused on an oscilloscope simulator, demonstrated positive effects on knowledge retention, attention, concentration, and motivation to learn.

B. Study Limitations and Perspectives

A limitation of this study is the absence of a control group, which limits the generalizability of the findings. The main objective of this research was to examine the evolution of students' performance based on the number of simulations conducted. However, to more thoroughly assess the impact of simulations on student learning, a subsequent study, including a control group, is underway [21–23].

Additionally, the sample size of 112 students from a single school also limits the generalization of the results. Future research should include a larger sample around 320 students from various public and private schools to strengthen the validity and representativeness of the conclusions. The results of this supplementary study will be published in future work [24–29].

Moreover, one important limitation not fully addressed in this study is the potential over-reliance on technology in the learning process [30–34]. While simulations provide a highly interactive and engaging experience, there is a risk that excessive use of digital tools could lead to a decrease in students' ability to engage in traditional learning methods or to critically evaluate information without digital assistance. Additionally, the digital divide remains a significant challenge [35]. Not all students have equal access to necessary technological resources, such as reliable internet connections, computers, or the required simulation software. This inequality may exclude certain students, leading to disparities in learning outcomes. Future studies should explore ways to balance technology-based learning with traditional methods, ensuring that all students, regardless of their access to technology, can benefit equally from educational innovations [36, 37].

V. Conclusions

The simulations had a beneficial influence on student achievement, leading to significant improvements in their performance. This immersive pedagogical approach enables students to acquire knowledge and practical skills more effectively compared to traditional teaching methods. Simulations provide an interactive learning environment where students can experiment, make decisions, and solve problems while safely learning from their mistakes, reinforcing their understanding.

The integration of simulations into education provides various cognitive and practical benefits. One of the key advantages is enhanced information retention, as students tend to remember concepts better when engaging in simulated learning experiences. This improved retention is due to the interactive and immersive nature of simulations, which encourages active participation. Moreover, simulations effectively bridge the gap between theory and practice, enabling students to apply their knowledge in real-world contexts, thereby enhancing comprehension and retention. This approach not only improves academic performance but also equips students with essential problem-solving skills for future challenges.

Furthermore, simulations play a crucial role in fostering self-confidence. When students can experiment and observe the consequences of their actions in a risk-free environment, they become more assured in their abilities. Additionally, many simulations are designed to promote collaboration, requiring students to work together to solve complex problems, which enhances teamwork and communication skills essential for the modern workforce.

The integration of simulations into the educational curriculum serves as an effective strategy for enhancing teaching quality. However, it is essential to maintain a balanced approach, ensuring that simulations complement rather than replace traditional teaching methods. A well-structured combination of innovative digital tools and conventional pedagogical practices provides an optimal learning experience for students.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

M.B. conceived the study, conducted the experiments, and drafted the manuscript. H.B. analyzed the data and prepared the figures. All authors reviewed and approved the final version of the manuscript.

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