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ENHANCING MATHEMATICS EDUCATION: LEVERAGING GRAPHIC TOOLS FOR INSTRUCTION

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Abstract- Because of the positive effects it has on students' learning and, more importantly, their skill development, the incorporation of digital technologies into classroom is a need. The objective of this research is to compare the impact of the use of graphic tablet and that of slide shows on the level of students in mathematics. *Method*: The study includes eighty high school students for the 2022/2023 school year. The course in question focuses on the'' limits and continuities of functions''. Exercises for the first chapter, "Limits and Continuity at a Point," are dealt with using slide shows, while those for the second chapter, "Continuity over an Interval and the Intermediate value theorem," are treated using graphic tablet. The evaluation takes place in two times: a test immediately after the correction of the exercises, and another will be proposed 4 weeks later. T-test is used to analyze student averages. *Results*: Student averages are higher when the exercises are corrected using the graphic tablet. This is confirmed not only right after the correction, but even 4 weeks later. The students showed their satisfaction with this digital tool. Conclusion: the graphics tablet is a digital tool for enhancing students' mathematical skills. This tool can be considered as a digital version of the blackboard. However, teachers still need training on how to use this tool effectively in the classroom.

Keywords: Mathematics Teaching, Secondary School, Handwriting, Graphics Tablet, Slide Show.

1. INTRODUCTION

The world has seen a remarkable transformation in the realm of information technology and digital fields; thus, educational institutions must adapt this change in order to benefit from their valuable advantages and to keep the face of the ever-changing contemporary world [1]. This fact explains why most countries employ ICT in the educational sector. This shift on the digital plane has prompted researchers to deploy their efforts to develop teachers' professional practices and implement strategies that serve to make better use of these new digital technologies, all while respecting the main objective of arousing learners' interest and developing their skills.

In this perspective, Tablets and smart mobile devices have recently joined the extensive array of technological advancements that are thought to aid and improve both the teaching and learning processes [2]. Research on the utilization of graphic tablets in higher education has primarily concentrated on topics such as: Art [3], Anatomy [4], Linear algebra [5], Discrete mathematics courses [6], These studies demonstrate the positive impact of this innovative technology on student learning, and criticize other didactic tools such as the blackboard, whiteboard, and PowerPoint®. To foster the development of mathematical thinking in educational settings dedicated to teaching mathematics, it is imperative that these environments incorporate technologies that facilitate real-time writing [7].

That is why math teachers prefer to use blackboard in teaching, as it encourages handwriting and interaction with learners. in fact; more than in any other subject, the construction of mathematical knowledge hinges on the teacher's oral language explanations and interactions [8]. First criterion that must justify the choice of this digital tool is its relevance to the specificities of the mathematical subject. This means that any innovative approaches to teaching mathematics must support handwriting. The graphic tablet is a digital tool that enables teachers to combine handwritten practice and an oral explanation of the lesson. This contrasts with the use of Power Point, which is considered only as a tool for presenting work, since it does not promote exchange between learners and the teacher. Indeed, the courses are prepared in advance by the teachers with the detailed solutions of the exercises and can only be modified through manipulation by mouse and keyboard, this method therefore takes time and is unreliable for the smooth running of the session.

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The teacher will then analyze the tool to be used using indicators such as pedagogical relevance, to know if it is legitimate to use it in the school setting. Article 33 of Framework Law No. 51-17 on Morocco's education, training, and scientific research system, enacted on August 9, 2019, underscores the commitment to enhance the integration of information and communication technologies to enhance the quality of learning and boost its effectiveness. Furthermore, it outlines the gradual incorporation of e-learning with the aim of making it more widespread. This entails the integration of digital resources into the educational framework, aligning them with pedagogical strategies designed to achieve educational goals and facilitate the acquisition of general or specialized skills, in line with the requirements and guidelines of modern curriculum programs. The scenario leads to the development of a project, which entails a specific learning activity that utilizes Internet resources, and potentially incorporates print materials, online radio, internet-based television, or multimedia components [9]. Teachers can use any digital tools by basing their decisions on criteria like relevance, reliability, and coherence with the topic being taught.

2. METHOD

Eighty second-year baccalaureate students from Othman Ibn Affane high school in Taounate, Morocco participated in this study during the 2022-2023 school year. Participating students had an average age of 17.2 years and 67.5% were female. The course concerned focuses on Limits and Continuity of Functions. The course is presented to students over a period of 15 hours using the blackboard and covers the following chapters: limits, the continuity of a numerical function, image of an interval by a continuous function, reciprocal functions, and nth root function.

The correction of exercises relating to the chapter: limits and continuity of a function at a point is done using the slide shows. Indeed, students take the time to do the exercises themselves. Then, after analyzing their answers, the solutions were presented to them in the form of slide shows, while explaining the steps and tips of the solution. Note that it is possible to modify the solution or add notes to slideshows during correction. The exercises in the chapter: continuity over an interval and image of an interval by a continuous function are corrected using the graphic tablet (Gaomon S620 6.5×4 Digital Graphic Tablet) (Figure 1). Students complete the exercises themselves, and after analyzing their answers, they interact and take part in the collective correction.

The evaluation is done in two moments: immediately after correcting the exercises and 4 weeks later (before the first assignment). The test consists of ten questions (5 questions for each section) during 30 min. Figures 2 and 3 show the different questions chosen in the test. Students' comments are considered by answering the following two questions: 1- How satisfied were you with the use of this new educational tool in the classroom? (Satisfied, neither satisfied nor dissatisfied, Dissatisfied), 2- Briefly express how you rate this new digital tool, specifying its advantages and disadvantages. Data are entered into Excel and analyzed by SPSS (version 23). The T-test is used to compare student averages (paired samples T-test), with a significance level of 0.05. The calculation of the P-value is essential to assess the validity of the results.

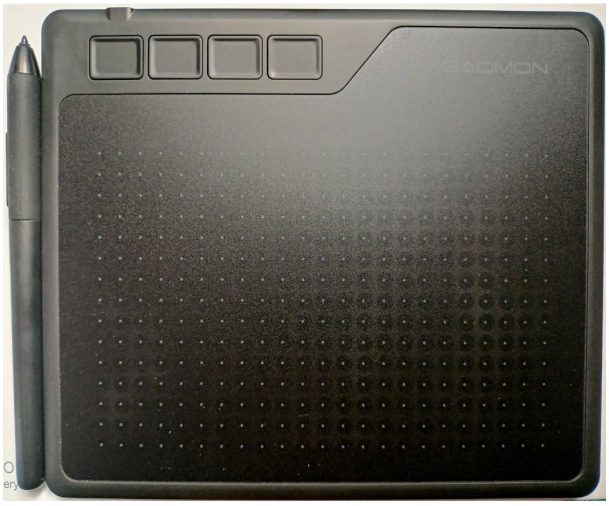

Figure 1. Graphic tablet device used in class; The different questions proposed in the first test, The first four questions concern the calculation of limits and the definition of continuity at a point, Question 5, on the other hand, concerns the statement of the Continuous Extension theorem

1) Calculate the following limit: $\lim_{x\to 3}\dfrac{x^2-9}{x-3}$

2) Calculate the following limit: $\lim_{x\to+\infty}\sqrt{x^4+x^2-x}-2x$

3) Let f be the function defined by:

$$\begin{cases} f(x)=\dfrac{\sqrt{x+1}-1}{x}; x\neq 0 \\ f(0)=\dfrac{1}{2} \end{cases}$$

Verify that f is continuous at a=0

4) Let f be the function defined by:

$$\begin{cases} f(x)=\dfrac{x+7}{x+1}; x\geq 1 \\ f(x)=\dfrac{x^2+2x-3}{x-1}; x<1 \end{cases}$$

Determine if this function is continuous at a=1.

5) Let f be the function defined on $\mathbb{R}^*$, when can we say that f can be extended continuously at 0?

The different questions proposed in the second test. The first two questions concern the study of the continuity of a function over an interval. Questions 8 and 9 concern the calculation of the image of an interval by a continuous function. The last question (question 10) concerns the statement of Intermediate value theorem.

6) Study the continuity of the function f on the interval I such that: $f(x)=\sin(x)+\dfrac{x^2+6}{x-1}; I=\mathbb{R}-\{1\}$

7) Let g be the function defined on $\mathbb{R}$ by: $g(x)=\sqrt{x^2+x+1}$

Study the continuity of the function g on $\mathbb{R}$

8) Let be f the function defined on $\mathbb{R}-\{-1\}$ by:

$$f(x)=\frac{2x-3}{x+1}$$

a) Construct the table of variations of f

b) Find the image of interval $[2;+\infty]$ by f

9) Let f be the function defined on $\mathbb{R}$ by:

$f(x)=x^2-2x$

Find $f(]-\infty;1])$

10) State the intermediate value theorem.

3. RESULTS

The T-test requires the assumption of normality to be used. The Kolmogorov-Smirnov normality test performed with SPSS shows that the P value displays two values: 0.200 and 0.196. The first value indicates student averages using slide shows, while the second value represents student averages using the graphics tablet. Both of these values exceed 0.05, which leads to the acceptance of the null hypothesis affirming the normality of the data. The diagnostic test is distributed to students at the beginning of the school year, it covers all the necessary prerequisites including the calculation of limits. The averages of students' grades on the five limit calculation questions are 0.42. This finding proves that the way students are taught is responsible for any improvement in their grades.

Students have an average score of 0.4044 on the first five questions (PowerPoint®) and 0.7150 on the last five questions (graphic tablet). The difference between the students' averages is significant (P-value=0.0001<0.05), which makes it possible to accept the alternative hypothesis H_1: $m_1 \neq m_2$ ($m_1 < m_2$). Based on these findings, we can confidently state that differences between the students' averages are not the result of chance, but to the choice of tool used during the correction of the exercises. After 4 weeks, the students were evaluated a second time on the same chapters but with different questions (without revision). The student averages for the first five questions and the last five questions are 0.3658 and 0.6543, respectively. The P-value is: 0.0001. This again shows that the difference between students' averages is significant.

The results show that most students are very satisfied with the use of the graphics tablet (85% Very satisfied, 12% Neither satisfied nor dissatisfied, 3% dissatisfied). Table 1 details the average scores obtained by students for each test question. They were better able to answer the question concerning the statement of the intermediate value theorem, unlike the other questions, which require a mathematical sequence and a precise demonstration based on the propositions of the course.

Table 1. Average of students' scores for each question in tests immediately after and 4 weeks after the correction of exercises

Questions	Average student's score immediately after the correction of exercises	Average student's score 4 weeks later
1. Calculate a limit (using the technique of factorization by a remarkable identity)	0.64	0.50
2. Calculate a limit (the factorization technique by x^2)	0.53	0.32
3. Study the continuity of a function at a point (function is defined on an interval)	0.47	0.55
4. Study the continuity of a function on the right and left at a point (function defined on two intervals)	0.34	0.30
5. Continuous Extension theorem	0.40	0.21
6. Continuity over an interval (case of the sum of two usual functions)	0.78	0.54
7. Continuity over an interval (case of a function of type $\sqrt{f}$)	0.87	0.66
8. Image of an interval by a continuous function (case of an increasing function on an interval)	0.8	0.67
9. Image of an interval by a continuous function (case of a descending function on an interval)	0.7	0.65
10. Intermediate value theorem	0.9	0.78

4. DISCUSSION

Many instructors across subject areas have come to rely on PowerPoint presentations to introduce their lessons and lectures, but majority of studies show that use of Power point is not associated with a significant improvement in student grades [10], which means that slide shows are still a way of presenting the course, but do not encourage teaching based on the development of students' skills. In this respect, mathematics teachers prefer to use the blackboard as a support that allows verbal and non-verbal communication between the class group. Student's interactions with technology have been found helpful in making decisions and collaborations with one another [11-13]. In doing so, we must think about integrating new digital and technological tools into the teaching-learning process. Results show that students' performance improves when using graphic tablet; this means it can be used in place of the traditional blackboard. In fact, the tablet's screen stands in for the chalkboard and the stylus takes the place of the chalk; this allows for more fluid writing of demonstrations, explanations, and detailed solutions to exercises without interrupting the teacher's interactions with students.

It is impossible for a teacher to anticipate all the students' observations and ideas and include them into their work in advance when constructing lessons or exercise corrections in the form of slide shows. The modification of slides during the session is not always accessible because of the difficulties related to the writing of mathematical symbols and diagrams with the mouse or keyboard (integral, limit, summation, product, union, intersection...), which leads to a considerable waste of time.

We should also note that the students do not contribute to the learning process, as a result, they are

considered passive as far as they are unable to share their ideas and responses with their peers. Radford concluded that mathematical thinking doesn't solely take place in one's mind; rather, it emerges through a complex semiotic coordination involving speech, body language, gestures, symbols, and tools [14], by using the graphic tablet, the teacher can teach math's without difficulty, while respecting the essential factors for the construction of mathematical knowledge. In addition, the teacher is now in front of the class, he can manage the course and the students simultaneously.

Teachers can use any type of graphics tablets that are distinguished just by screen size or by touch options that play the role of keyboard shortcuts. At the same time, graphic tablet must be attached to the Microsoft OneNote software supplied as part of the Microsoft Office package or use other similar handwritten note-taking software (Xournal++®, Microsoft Whiteboard®, PowerPoint by integrating the Class Point® software). OneNote is a software that includes several options and benefits such as: the ability to switch between different display modes (Normal Mode or full page), different types of background, add images to the working space (course documents, excerpts from the digital textbook, exercise excerpts), several colors, highlight important signs. The usefulness of tablet graphics is wider than what we have emphasized before, but it can have various uses such as modifying PDFs or a PowerPoint presentation. In fact, it is preferable in certain cases to show the work of a learner in front of the others: add remarks, signs, or corrections, keep these modifications, and then share the final product with the learners via email.

Learner motivation is an essential factor that needs to be considered before choosing such a pedagogical innovation, because Student motivation is a crucial factor in reaching course learning objectives and achieving success. Motivation is commonly recognized as being shaped by a combination of personal traits and environmental factors within the educational context [15]. Students are motivated while correcting exercises thanks to graphic tablet, which allows them to assess the stylus and visualize their writing on the screen. The students were extremely excited about using the graphics tablet in the classroom. They found it to be very intuitive and easy to use. Here are some advantages and disadvantages of using a graphic tablet from the student's point of view.

Advantages:

- Visualize mathematical concepts in an obvious way.
- Write mathematical symbols simply.
- Increase students' motivation and desire to learn.
- The fluidity of manipulating the stylus is better than working with chalk or markers.
- Cleanliness in the classroom by eliminating the use of chalk.
- Convenient to use thanks to its reduced size and weight.
- keep students' attention.
- Collective work to solve exercises.
- Writing on the screen is easy to understand.
- A wide choice of colors and highlighters to present ideas more clearly.
- Use technology in teaching!

Disadvantages:

- Some students waste a reasonable amount of time familiarizing themselves with the stylus.
- Concentration on the PC screen has health effects such as eyestrain and stress.
- Some students write badly on the screen (large handwriting, misaligned handwriting).

Several studies suggest considering Information and Communication Technologies (ICT) in general as a solution for introducing certain multidisciplinary concepts [16]. The graphic tablet appears to be intriguing for developing new approaches that contribute to a clearer definition of these concepts (Benkenza, et al., 2023). In our experience, this tool has drawbacks. The teacher should practice using this tool flexibly; it is difficult at first to write on the tablet screen while keeping eyes fixed on the PC screen. This reduces non-verbal communication between teachers and students. In addition, the teacher needs to be familiar with the options of OneNote or a similar program.

Among the limitations of our work is that the number of learners participating in this study is small, and the test covers just one course in the program. In doing so, future work needs to take a large sample and address diverse topics. The intention is to inspire others to contemplate incorporating this technology into their teaching setup and to raise their awareness of its potential benefits [5]. The graphic tablet is also proving its effectiveness in distance learning, enabling the teacher to make more improvements to the courses given; students prefer that the teacher writes and explains as he progresses, let alone present the chapters in the form of slideshows or explain using paper. Because of current changes (for example, Covid 19), educational stakeholders are increasingly being pressured to embrace e-learning, and teachers can take advantage of this new digital tool (graphic tablet) by making instructional videos. Students are taught in French, so questions proposed in test were in this language.

5. CONCLUSION

In conclusion, the incorporation of pedagogical innovations in mathematics teaching is a vital endeavor, and the integration of handwriting into this process is of paramount importance. Graphic tablets emerge as a promising tool in this context, effectively serving as digital chalk on a modern-day blackboard. The outcomes of our study underscore the significant positive impact that graphic tablets can have on student learning, enhancing their mathematical comprehension and engagement. Our research underscores the adaptability of graphic tablets in the educational landscape. By addressing challenges in mathematics instruction, we inadvertently unlock a tool that holds promise in overcoming difficulties encountered in teaching diverse subjects. The interactive and dynamic nature of graphic tablets provides a platform that transcends disciplinary boundaries, offering a unique approach to tackle educational hurdles [17].

Nevertheless, for this potential to be fully realized, it is imperative for educators to embark on a journey of

familiarization and mastery with this innovative tool and the associated software. Teachers must recognize the need to adapt to this new educational landscape, embracing the opportunities presented by digital tools to enrich the learning experiences of their students. As with any transformative change in pedagogy, professional development and ongoing training are essential to maximize the benefits of graphic tablets in mathematics instruction. In a world where technology continues to shape the way we learn and teach, the integration of graphic tablets into mathematics education is not merely a suggestion but a necessity. By harnessing the power of these devices, educators can better prepare their students for the challenges of the 21st century, where digital literacy and mathematical proficiency are intertwined. The evidence is clear: the future of mathematics teaching is intertwined with technology, and graphic tablets represent a promising path forward. As we move forward, we encourage educators to embrace this transformative tool and to continually hone their skills in its application, ensuring a brighter and more digitally enhanced future for mathematics education.

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