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Effectiveness of Cabri II Plus software in enhancing academic achievement and motivation in learning right triangles and Pythagorean theorem among second-grade middle school students

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Abstract

This study aimed to determine the impact of using the Cabri II Plus software on students' achievement and motivation. A quasi-experimental research design was employed to investigate the effects of learning with Cabri II Plus software on the achievement and motivation of second-grade middle school students in the module covering right triangles and the Pythagorean theorem. The study comprised 70 participants, who were divided into two groups: experimental and control. Each group consisted of 35 participants. The study utilized two main tools: a student achievement test and a math motivation questionnaire. The experimental group used interactive activities with Cabri II Plus software, while the control group used existing activities from a textbook provided by the Moroccan Ministry of Education. Thus, the pre- and post-tests on the achievement and motivation scores were carried out for both groups. Analysis of covariance revealed a significant difference in favor of the experimental group in terms of the academic achievement scores ($F [1, 67] = 52.12$, $p = .00 < .05$) and the motivation scores ($F [1, 67] = 94.08$, $p = .00 < .05$). Thus, the students who used the Cabri II Plus program obtained higher motivation and achievement than their counterparts who did not use Cabri II Plus to learn the test module. The study's findings also showed a strong, statistically significant positive relationship between academic achievement and motivation among the experimental group students in the post-tests and a moderate, statistically significant relationship between these variables among the control group students. Thus, the teaching method using the Cabri II Plus program has a greater positive impact on the relationship between academic achievement and motivation than traditional teaching methods. Based on the findings, integrating Cabri II Plus into the teaching process effectively improves students' educational outcomes and fosters a more engaged and motivated learning environment.

Keywords: Cabri II Plus software, right triangle and Pythagorean theorem, experimental and control groups, covariance analysis, achievement and motivation

INTRODUCTION

During the past two decades, Morocco has participated in various international studies, like trends in international mathematics and science study (TIMSS), the program for international student assessment, and progress in international reading literacy study (OECD, 2023; Mullis et al., 2020). These studies aim to evaluate the efficiency of the Moroccan education system in terms of learner performance and to compare it with other

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Contribution to the literature

- This study contributes to the literature by exploring the effectiveness of Cabri II Plus software in enhancing academic achievement and motivation, aligning with current trends in integrating technology into educational settings to improve students' understanding of mathematical concepts.
- The research highlights the role of Cabri II Plus in creating an interactive and visually engaging learning environment, offering new insights into how technology can deepen students' understanding of mathematical concepts, particularly in geometry.
- The study explores the relationship between motivation and academic achievement, offering new perspectives on how technology can boost student engagement. It highlights Cabri II Plus's potential to positively influence motivation and learning outcomes, contributing to a broader understanding of how digital tools impact student success.

participating countries' education systems. In particular, the Moroccan student's results were below the international average in mathematics and science. Based on these studies and findings, it has emerged that the Moroccan education system requires reform to keep pace with the modern developments in the education field. In this context, Morocco has reformed its education system (Bourqia, 2016). During this reform, numerous education systems of leading countries in the education field, such as Singapore and Finland, were studied. As a result, the Moroccan ministry of education has introduced several changes to the education system. Most of these changes aim to place the learner at the center of the educational process, making them the central actors in constructing their knowledge while considering the teacher as their guide (Elwarraki et al., 2023). Regarding information and communication technologies (ICT), the pedagogical guidelines for Moroccan mathematics encourage using these technologies in the teaching process. Although many educational experts have proven the effectiveness of using modern technology in mathematics education (Zakaria & Khalid, 2016), Some local studies have revealed that teachers in Morocco have almost limited the use of modern technologies in mathematics teaching (Ismaili, 2020; Nejjari & Bakkali, 2017).

Geometry is one of the most important branches of mathematics, owing to its significant role in equipping learners with practical skills such as using measurement tools and geometric constructions. It also plays a crucial role in developing students' visual thinking skills and ability to reason, connect data and results, and solve problems (Alghtani & Abdulhamied, 2010). Thus, geometry serves as a means for mathematics to apply innovative forms of learning that we aim for in future education. Teaching geometric concepts to young students can be challenging due to the complexity of the problems and the challenges associated with visualizing abstract concepts (Barut & Retnawati, 2020). These difficulties can arise from inappropriate pedagogy, complex content, a lack of clarity in content presentation, relevance to learners' needs, or a combination of these elements (Gafoor & Kurukkan, 2015).

The current study seeks to determine the effectiveness of Cabri II Plus software in enhancing academic achievement and motivation in learning right triangles and the Pythagorean theorem among second-grade middle school students and to examine the relationship between motivation and academic achievement.

Research Problem

Despite geometry's growing importance in modern times, many students still need help learning it. At the same time, mathematics teachers face obstacles in teaching geometry. So, most pupils perceive learning geometry as arduous, and many need more interest and enthusiasm. This can be seen in how pupils feel when faced with a simple geometric problem (Barut & Retnawati, 2020; Juman et al., 2022). The traditional mathematics teaching method, which relies on the teacher's direct presentation through reading and explanation, has led to negative attitudes among students toward learning geometry. Relying on memorization, giving examples, and then doing geometry practice exercises without understanding them has led students to lose interest in geometry classes, reducing their motivation to learn it (Adolphus, 2011). Mathematics education specialists have associated students' weakness in mathematics, particularly in geometry, with the above factors, in addition to the rare use of technology in teaching and reliance solely on the textbook (Pepin et al., 2021). Several previous studies and research have shown that ICT use in mathematics learning increases students' motivation and improves their scientific level (Abi Saab, 2011; Akinoso, 2023; Bhagat & Chang, 2015; Harris & Bataineh, 2016; Idris, 2007; Klemer & Rapoport, 2020; Tamur et al., 2022).

Data analysis on mathematics teaching in Moroccan second-grade students' middle school schools revealed that students' performance in mathematics is low. Their motivation to learn is also low, and they lack modern teaching methods (Ismaili, 2020; Nejjari & Bakkali, 2017). These local challenges are further reflected in Morocco's performance on an international scale. In May 2019, Morocco participated in the TIMSS alongside 39 other countries (Mullis et al., 2020). On a scale of 1,000,

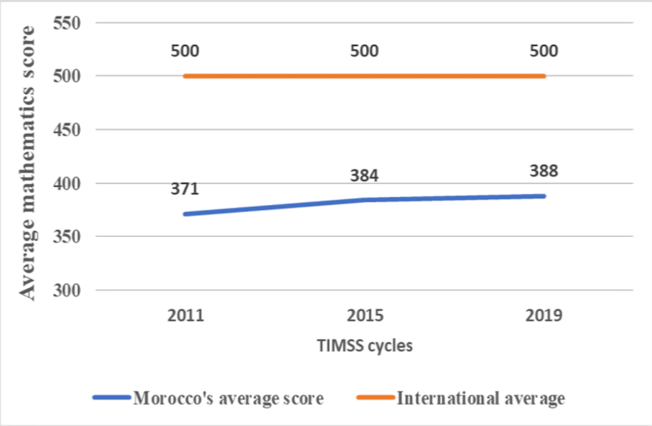

Figure 1. Trends in the average mathematics score of Moroccan second-grade students in middle school (TIMSS, 2019)

Moroccan students scored 388 points in mathematics, placing them at the bottom of the ranking. In contrast, the top positions were occupied by Singapore (with 616 points), Chinese Taipei (612 points), and the Republic of Korea (607 points).

With this result, Moroccan second-grade middle school students could not reach the international mean score of 500. The gap from this score is statistically significant. Regarding the evolution of performance over the last three TIMSS cycles, we observe a slight upward trend. However, it remains significantly below the international average, as shown in **Figure 1**.

From 2015 to 2019, second-grade middle school students recorded a gain of 4 points, which helped reduce the gap between their performance and the international mean score (500 points) from -116 to -112 points. However, despite this improvement, their performance remains significantly below the international average, with a considerable gap persisting.

Research Questions

Given the lack of use of dynamic geometry programs in geometry learning by students in Morocco, despite their educational value in enhancing students' mathematics learning, improving their success rates and motivation, and addressing the difficulties they face. This research aims to study the effect of using Cabri II Plus software on second-grade middle school students' achievement and motivation in learning the right triangle and the Pythagorean theorem, compared to traditional teaching methods. This study seeks to answer the following main questions:

1. What is the effectiveness of Cabri II Plus software on second-grade middle school students' achievement in learning the right triangle and the Pythagorean theorem?
2. What is the effectiveness of Cabri II Plus software on second-grade middle school students' motivation to learn the right triangle and the Pythagorean theorem?
3. What is the relationship between academic achievement and motivation to learn mathematics among second-year middle school students?

Research Hypotheses

The current study sought to verify the validity of the following hypotheses:

Hypothesis 1. There are no statistically significant differences at the level of $\alpha \leq 0.05$ between the means of the two groups (experimental and control) in the academic achievement of second-year middle school students related to the teaching method.

Hypothesis 2. There are no statistically significant differences at the level of $\alpha \leq 0.05$ between the means of the two groups in the motivation of the second-year middle school students linked to the teaching method.

Hypothesis 3. There is not a statistically significant correlation at the level of $\alpha \leq 0.05$ between academic achievement and second-year middle school student's motivation toward learning mathematics.

Research Objectives

This study aims to investigate the impact of using the Cabri II Plus software on academic achievement and motivation among second-year middle school students in mathematics and to examine the relationship between motivation and academic achievement when using the software compared to not using it.

Importance of the Research

This study's importance lies in providing empirical insights to guide educators, curriculum designers, and policymakers in making informed decisions regarding using interactive geometry software, such as Cabri II Plus, to enhance academic achievement and motivation in mathematics learning. The study seeks to understand how these technological tools impact student learning and motivation in mathematics, thereby contributing to developing innovative teaching strategies that meet the needs of 21st century students. The findings of this study could contribute to improving mathematics education in Morocco and diverse educational contexts worldwide by promoting educational technology to motivate students and achieve better learning outcomes.

LITERATURE REVIEW

Use of Modern Technology in Mathematics Education

In the current context, the world faces many changes that affect all aspects of life, including education. Therefore, it is essential to use modern tools and technologies to meet the challenges of our time. These modern technologies help us to overcome life and education problems. Integrating modern technologies enriches teaching with practical experiences and skills that enhance success. These technologies also provide the necessary support to address future problems and challenges based on systematic scientific thinking (Alneyadi et al., 2023; Bedada & Machaba, 2022; Qurat-ul-Ain et al., 2019). Therefore, improving education is critical in enabling each individual to assume responsibility for societal development (Raja & Nagasubramani, 2018). Upon examining modern educational tools, it is clear that they enhance the learning process. They are not merely the means used to accomplish the specific functions of the teaching and learning process, but they also embody the tools that have kept pace with developments in the modern era, thereby contributing to the teaching evolution and the learning styles (Ghory & Ghafory, 2021; Marange & Tatira, 2023). Today, the computer represents the pinnacle of modern technology and has established itself as an essential educational tool, playing a prominent role in the learning process. It has become inseparable from our daily lives, directly and indirectly affecting our existence (Das, 2019). In the education field, computers have attracted considerable interest from educators. They enable learners to actively participate in the learning process through various educational programs. Moreover, they transform pedagogical situations into concrete experiences, making learning more tangible and practical (Henrie et al., 2015).

Moroccan education specialists have studied using and integrating modern technologies into teacher training and education programs, particularly mathematics (Nejjari & Bakkali, 2017). They have recognized that the digital era provides unprecedented opportunities for improving teaching and learning. In this context, ICT has been identified in the educational guidelines as an essential tool to facilitate access to information, promote collaboration, and stimulate pedagogical innovation (Ismaili, 2020). Notably, technology and mathematics are closely intertwined because math poses a challenge for many students at various education levels due to their limited understanding of its concepts, theories, and laws (Chinn, 2016). For this reason, technology can play a critical role by providing interactive and visual tools that can demystify complex mathematical concepts and make learning more engaging and effective (Drijvers et al., 2016; Kotu & Weldeyesus, 2022; Zulnaidi & Syed Zamri, 2017). Mathematics teaching has evolved with computers' advent and capabilities and their integration into education. This evolution aims to teach students correct thinking methods (Abramovich, 2013). Computers equipped with specialized programs are designed to solve mathematical problems and teach algorithms (Benton et al., 2017). Consequently, mathematics learning has become more accessible, and innovative teaching methods encourage exploration, discovery, and hands-on learning (Cunska & Savicka, 2012). The National Council of Teachers of Mathematics (NCTM) underscores the significance of leveraging current technologies for mathematics education. These technologies are widely acknowledged for their positive impact, enabling students to focus on ideas and concepts while simplifying problem-solving (NCTM, 2000). In geometry education, specific computer programs, known as dynamic geometry, have significantly transformed this discipline's teaching. These innovative tools have made a meaningful contribution to geometry education in schools and universities (Villa-Ochoa & Suárez-Téllez, 2021). They stand out due to several features, including the ability to explore various categories of geometric shapes and their properties (González & Herbst, 2009). Furthermore, they allow students to create, configure, move, reshape, stretch, and shrink geometric figures, modify angle measurements, and rotate these shapes (Straesser, 2002). Numerous studies have confirmed that dynamic geometry software significantly improves students' thinking (Daher, 2021; Maarif et al., 2018; Marrades & Gutiérrez, 2000). Indeed, these tools provide a dynamic conceptual environment that strengthens their conceptualization and reasoning skills by encouraging them to tackle more complex problems (Adelabu et al., 2019; Crompton et al., 2018).

Technology on Student's Mathematics Achievement and Motivation

A major challenge that educators encounter in classrooms is the consistent lack of student motivation (Rone et al., 2023). Studies indicate that students who exhibit higher levels of motivation tend to achieve better academic performance (Froiland & Worrell, 2016). Recent studies indicate that students' perceptions of mathematics can be crucial in shaping their motivation and willingness to engage in mathematical academic activities (Xia et al., 2022). Students' achievement in mathematics is significantly influenced by their motivation to learn the subject (Tran & Nguyen, 2021). When motivated to learn mathematics, students are more likely to pay attention in class, participate actively, and engage in self-study. This heightened engagement can lead to a better understanding of the material, improved problem-solving skills, and increased levels of achievement (Hellín et al., 2023). Research indicates that motivated students are more likely to engage in mathematics learning and, consequently, achieve higher results in mathematics (Iyamuremye et al., 2023). Conversely, students with low motivation or negative emotions, such as stress, may find it challenging to attain good mathematics achievement levels (Valiente et al., 2012). When motivated to learn mathematics, students are more likely to pay attention in class, participate actively, and engage in self-study. This heightened engagement can lead to a better understanding of the material, improved problem-solving skills, and increased levels of achievement (Tella, 2007). Furthermore, students motivated to learn mathematics are more inclined to seek additional learning opportunities and practice outside the classroom, such as participating in math clubs or competitions, which further enhance their performance (Bright et al., 2024). Conversely, students who lack motivation may struggle with learning mathematics, resulting in lower achievement levels (Chand et al., 2021). Other studies have found that students who perform poorly in mathematics tend to develop less motivation for learning the subject (Chand et al., 2021). Thus, students' motivation to learn mathematics is a crucial predictor of their mathematical achievement.

Research shows that integrating technology into mathematics education can significantly enhance students' achievements and motivation (Poçan et al., 2023). Technology allows students to visualize abstract mathematical concepts, forge connections between different mathematical ideas, and engage more actively with the material (Bright et al., 2024). For instance, interactive software applications and simulations offer visually rich and immersive experiences, making mathematics more engaging and motivating for students (Weis et al., 2024). Additionally, technology can provide students with more personalized learning opportunities, enabling them to progress at their own pace based on their levels of understanding (Major et al., 2021).

This positive impact of technology on learning is supported by various studies examining its effects on mathematical achievement and motivation. For instance, research conducted by Özçakır et al. (2015) on using dynamic geometry activities with eighth-grade students demonstrated that instruction supported by dynamic geometry improved students' performance in triangle estimation. Similarly, the study by Rahmadani et al. (2023) on the impact of modern technology on ninth-grade students' mathematics achievement in Indonesia revealed that technology significantly improved students' mathematics scores and effectively facilitated the attainment of specified educational objectives. Shurygin et al. (2023) conducted research comparing the effects of traditional mathematics teaching methods with those of the MalMath app on students' academic performance, focusing on conceptual and procedural knowledge, problem-solving abilities, and motivation levels. The study found that students in the experimental group who used the MalMath app achieved more academic success than those in the control group. Furthermore, using the app also increased students' motivation to learn. The research conducted by Birgin and Topuz (2021) examined the effects of using GeoGebra in a computer-supported collaborative learning (CSCL) environment on seventh-grade students' achievement in geometry, their retention of learning, and their attitudes toward geometry. The study found that CSCL with GeoGebra significantly improved students' geometry achievement and learning retention compared to textbook-based instruction. Additionally, the CSCL environment using GeoGebra notably enhanced students' attitudes toward geometry. Similarly, Lankford (2021) explored technology-based learning environments to help teachers integrate successfully. The study concluded that technology-based learning environments allowed teachers to focus their expertise on developing students' knowledge, leading to improved mathematics achievement among their students. The research conducted by Öztop (2022), which examined previous studies on the impact of using digital technology in mathematics instruction on mathematics through meta-analysis techniques, found that using digital technology in mathematics teaching has a moderate effect on increasing motivation toward mathematics. Finally, the research conducted by Hartuti and Hikmah (2021), which studied mathematics learning outcomes on the topic of flat shapes using the Cabri 2D learning tool compared to traditional methods and analyzed students' motivation for learning, showed that the average scores of students who used the Cabri 2D software were higher than those of students who studied using traditional methods. The results also indicated that students with higher motivation performed better than those with lower motivation.

Learning Geometry With Cabri II Plus

Geometry is crucial in education due to its importance in various everyday contexts. It helps to develop students' cognitive abilities and enhance their spatial skills for better environmental perception (Nagy-Kondor, 2017). Contemporary teaching methods notably enrich this learning. In this context, dynamic geometry software has significantly transformed geometry teaching in schools and universities (Clark-Wilson et al., 2020).

Cabri II Plus and GeoGebra offer interactive tools enabling students to explore, create, manipulate, and reshape geometric shapes, significantly enhancing their understanding of geometric principles. Cabri II Plus fosters a more profound comprehension of geometry through its interactive features, allowing hands-on experimentation with geometric figures (Arzarello et al., 2002; Kordaki & Balomenou, 2006). This approach not only enhances academic performance by cultivating critical thinking and problem-solving skills (Maarif et al., 2018; Yilmaz, 2015) but also boosts motivation for learning through engaging interfaces that provide direct interaction with geometric concepts, enriching the educational experience (Akhirni & Mahmudi, 2015; Jaya & Suparman, 2021). Similarly, GeoGebra equips students with tools to investigate and manipulate geometric shapes, improving their grasp of geometric concepts (Ziatdinov & Valles, 2022). GeoGebra also supports academic success by offering interactive learning environments that nurture critical thinking and problem-solving abilities (Zulnaidi & Syed Zamri, 2017; Zulnaidi et al., 2020). Moreover, GeoGebra enhances learner motivation through its interactive features and direct engagement with geometric principles, making the learning process dynamic and stimulating (Akhirni & Mahmudi, 2015; Bedada & Machaba, 2022).

In Morocco, the ministry of national education has provided various educational programs to enrich contemporary teaching and learning methods in mathematics, including the Cabri II Plus software. Given that Cabri II Plus specializes more in the field of geometry than other areas, its design includes menus and icons that facilitate the creation and modification of geometric shapes by students who are in the early stages of engaging with such programs; the ministry has trained teachers on how to use it in the teaching and learning process within specific units of the mathematics curriculum. In this research, Cabri II Plus was selected to study its effectiveness in enhancing academic achievement and motivation in learning right-angled triangles and the Pythagorean theorem among second-grade middle school students. This choice was based on the teachers' ability to use the software due to the training provided. Additionally, the program provides interactive activities that align with various curricula and are designed to cover a range of fundamental geometric concepts. Computers with an activated version of Cabri II Plus are available in educational institutions' laboratories.

METHOD

Research Design

A quasi-experimental design involving pre- and post-tests for the two groups (the control and the experimental) was used to investigate the achievement and motivation of second-grade students in middle school. The study's control group received traditional learning. In opposition, the experimental group was taught using a learning method that included the Cabri II Plus software. The tested lesson from the geometry module included the right triangle and the Pythagorean theorem, taken from the mathematics subject. The chosen mathematics textbook was "Al Moufid in mathematics" for second-grade middle school students, used in the Moroccan educational program during the 2022-2023 school year. This module was chosen due to its appropriateness for the study's objectives and methodology, the difficulties students encountered in understanding, and their low achievement. In the current investigation, the teaching method was the independent variable (Traditional learning, learning geometry using Cabri II Plus). In contrast, the dependent variables were the student achievement test (SAT) and math motivation questionnaire (MMQ). The design of the research study is set out in **Figure 2**.

EG:	O1	O2	X	O1	O2	Experimental group (Learning geometry using Cabri)
CG:	O1	O2	_	O1	O2	Control group (Traditional learning)

EG: Experimental group
CG: Control group
O1: Test de réussite des élèves
O2: Math Motivation Questionnaire
X: Treatment with Cabri II lus
_: Not treated

Figure 2. The study's research design (Source: Authors' own elaboration)

Participants

The participants of this study were 70 second-grade students of an Al-Nahda middle school in a suburban district of Sidi Slimane, Morocco. The socioeconomic status of the students attending the school was similar, with the majority of the students coming from low- to middle-class families. At the school, there were six second-year middle school classes taught by three teachers, each responsible for teaching two mathematics classes. Two classes taught by the same teacher were randomly selected for inclusion in the research study. One of these classes was designated as the experimental group, while the other was defined as the control group. The experimental group comprised 35 students, including 17 girls and 18 boys, while the control group comprised 35 students, with 17 girls and 18 boys. The ages of the students in both groups ranged from 13 to 14 years.

Al-Nahda middle school was selected for our study based on its representation of a model that reflects the general characteristics of middle schools in Morocco. This choice was based on a comparative analysis of education indicators provided by the directorate of strategy, statistics, and planning of the Ministry of National Education (MEN), which demonstrated the alignment of Al-Nahda's education indicators with those of middle schools across Morocco (MEN, 2023). **Table 1** presents the relevant education indicators.

Table 1 shows that Al-Nahda middle school closely matches the educational indicators of middle schools in Morocco. This similarity in indicators ensures that the results of our study can be generalized to other middle schools in Morocco.

Instruments

In this research, an experimental approach was employed to investigate the effects of the Cabri II Plus software on the academic performance and motivation of second-grade middle school students regarding the right triangle module and the Pythagorean theorem. The study aims to validate or invalidate its hypotheses statistically (Johnson & Christensen, 2024). The experimental method is a research approach designed to examine the effects of an independent (experimental) variable, which the researcher intentionally alters while

Table 1. Educational indicators at Al-Nahda Middle School and middle schools in Morocco (Source: MEN)

Education indicators	Al-Nahda Middle School	Middle schools in Morocco
Student-to-teacher ratio	28.20	27.60
Student-to-class ratio	37.50	36.90
Proportion of classes with 36 students or fewer	41.30%	40.30%
Passed the 3rd-year middle secondary examination	65.30%	64.40%
Schools with internet for educational purposes	80,00%	77,90%
Schools with computers for educational purposes	78.00%	77.10%
Proportion of schools connected to electricity	100%	98.60%
Proportion of schools with potable water	100%	85.90%

keeping all other factors constant. By contrasting the experimental group with the control group, the impact of the independent variable can be identified (Jonassen et al., 2007). The SAT and the MMQ were used in the study to collect data.

Student Achievement Test (SAT Pre-Test)

The SAT pre-test is a test that assesses students' achievement in mathematics before proceeding to the unit on right triangles and the Pythagorean theorem, where students undergo a diagnostic assessment of their previous knowledge in mathematics (triangles, area, and forces). The SAT pre-test includes 18 multiple-choice questions. This test is taken from the book "Al Moufid in mathematics" for the second year of middle school. It is an approved test to assess knowledge in mathematics before teaching the module on right triangles and the Pythagorean theorem. Elements of the SAT pre-test questions in mathematics are in **Appendix A**.

Student Achievement Test (SAT Post-Test)

To evaluate the student's achievement on the right triangle and the Pythagorean theorem module, the SAT post-test was developed based on the ministerial note that supervises the continuous assessment process in mathematics at the middle school, as well as the objectives set out in the pedagogical directives (El Hadri, 2021). The SAT post-test consisted of 18 questions, with 13 multiple-choice questions and five open-ended questions. Its validity was confirmed by presenting it to experts, including the thesis supervisor, the educational inspector for mathematics in the Sidi Slimane directorate, and three mathematics teachers from the middle school where the study was conducted. Based on their observations, certain adjustments were made, and an exploratory study was carried out to check the question's clarity, the test reliability, and the question selection according to the discrimination and difficulty coefficients of the final version of the test. The exploratory study applied the test to 20 students in the third year of middle school. The responses that were obtained were analyzed using SPSS software. The statistics relating to the questions and the reliability test for the preliminary version of the SAT post-test are presented in **Table 2**. It found that the mean score was 12.30, with a standard deviation of 4.08. In addition, it is remarked that the discrimination coefficients for all questions range from 0.10 to 0.60, and the mean discrimination coefficient is about 0.37. Thus, the difficulty coefficients for all the questions range from 0.05 to 0.95, and the difficulty coefficient mean is 0.51. The reliability value of the test questions (Cronbach's alpha coefficient) was 0.81.

Table 2. The statistics related to the preliminary version of the SAT post-test

No	Discrimination coefficient	Difficulty coefficient
Q1	0.20	0.20
Q2	0.30	0.25
Q3	0.30	0.25
Q4	0.30	0.35
Q5	0.40	0.70
Q6	0.10	0.05
Q7	0.50	0.25
Q8	0.60	0.40
Q9	0.50	0.25
Q10	0.40	0.70
Q11	0.60	0.40
Q12	0.50	0.65
Q13	0.40	0.80
Q14	0.40	0.70
Q15	0.40	0.70
Q16	0.10	0.95
Q17	0.30	0.75
Q18	0.40	0.80

Note. Mean score = 12.30; Standard deviation = 4.08; Mean discrimination coefficient = 0.37; Mean difficulty coefficient = 0.51; & Cronbach's alpha = 0.81

When the final questions for the SAT post-test were selected, the questions with a discrimination coefficient of less than 0.20 were eliminated from the study. Consequently, two questions (6 and 16) were removed from the SAT post-test, and the test statistics were recalculated for the remaining 16 questions. The discrimination coefficients for the questions ranged from 0.20 to 0.60, with the mean discrimination coefficient increasing to 0.41. The final reliability of the test, measured by Cronbach's alpha, proves to be 0.83. These values demonstrate that the SAT post-test is a valid and reliable tool for data collection in this investigation. Elements of the SAT post-test questions in mathematics are in **Appendix B**.

Math Motivation Questionnaire

The MMQ was adapted from the science motivation questionnaire (SMQ) by Glynn et al. (2009). In this study, we replaced “science” with “math” in each item to evaluate students’ motivation in mathematics, thereby assessing their engagement with the field.

The original SMQ was developed by Glynn and Koballa (2006), who suggested its applicability across all scientific disciplines. Taasoobshirazi and Glynn (2009) noted that the items in the SMQ could be adapted to incorporate terms such as “biology,” “chemistry,” or “mathematics” instead of the general term “science.” Designed to assess undergraduate students’ motivation in science, the SMQ explores why students are motivated to learn science, the intensity of their effort, and the emotions and feelings they experience during the learning process (Glynn et al., 2009). Through a series of studies, Glynn et al. (2009, 2011) defined the preliminary factor structure of the SMQ, providing supporting evidence for its validity based on data from both science and non-science undergraduates. Their initial analysis of non-science undergraduates revealed a five-factor structure, which included motivation driven by grades, motivation linked to career aspirations, intrinsic motivation with personal relevance, self-determination, and a factor encompassing both self-efficacy and assessment anxiety. The SMQ was selected for this study due to its extensive use by researchers in over 70 countries, demonstrating its adaptability across various cultural contexts (Chow & Yong, 2013). Additionally, the SMQ has been employed in studies across secondary schools and other disciplines to measure student motivation (Kwon, 2016). Widely regarded as one of the highest-quality instruments in its field, it is considered one of the most commonly used tools in science education research for measuring motivation (Komperda et al., 2020; Toma et al., 2023; You et al., 2018).

The MMQ consists of 30 items divided into six dimensions: intrinsically motivated dimension (5 items), extrinsically motivated dimension (5 items), personal importance dimension (5 items), self-determination dimension (5 items), self-efficacy dimension (5 items), and low math-related anxiety dimension (5 items). The correspondence between the MMQ items and the motivational dimensions is in **Appendix C**. The possible scores for each subscale range from one (never) to five (always), with higher scores representing the most positive attitudes. The items assessing anxiety related to math assessments were scored in reverse, meaning higher scores indicated lower anxiety within this specific subset. The exploratory study was conducted on 40 third-year middle school students. The responses that were obtained were analyzed using SPSS software. Cronbach’s alpha coefficients were calculated for each dimension and the overall dimensions, as presented in **Table 3**. These values demonstrate that the MMQ is a valid and reliable tool for data collection in this investigation.

Table 3. Reliability coefficients (Cronbach’s alphas) for the MMQ

Dimensions	Cronbach’s alphas
Intrinsically motivated dimension	0.79
Extrinsically motivated dimension	0.89
Personal Importance dimension	0.84
Self-determination dimension	0.84
Self-efficacy dimension	0.80
Low math-related anxiety dimension	0.88
Overall dimensions	0.86

Procedure

The experimental group studied the module on the right triangle and the Pythagorean theorem using an innovative instructional method that incorporated interactive activities in the Cabri II Plus program. Before the study, the searcher developed these activities and reviewed them with a mathematics education inspector and three mathematics teachers to ensure their suitability for educational objectives. In addition, the control group used a traditional teaching textbook-based method to study the same module. Four weeks (sixteen teaching hours) were allocated for the delivery of the module.

Before the study, the experimental group students trained using Cabri II Plus and its essential tools, and they completed some basic constructions using it over three study hours. Following the training, the pre-tests of SAT and MMQ were administered to both student groups before the start of the module. After completing the module, the post-tests SAT and MMQ were also administered to both groups. **Figure 3** illustrates the visual representation of the study.

The innovative teaching method of the experimental group includes digital activities in Cabri II Plus. It was uploaded to the computers in the media room before the beginning unit. At the start of each lesson, the teacher provided introductory information about the targeted activity, and the students began to work in pairs, where they dynamically created, dragged, and resized shapes, observing the changes resulting from their movements and manipulations. In this group, the students were more engaged, active, and interactive during the learning sessions. They brought their ideas to life through creativity, good communication, investigation, debate, and clear expression.

The teacher’s role was limited to helping students develop, express, discuss, and critique their ideas. At the end of the module, the teacher assessed the students’ understanding by reviewing their achievements. **Figure 4** presents an example of a sample activity the student completed using Cabri II Plus.

For the control group, the students learned the same module using a traditional textbook-based instructional method. The teacher explained the concepts and definitions during the learning sessions without using

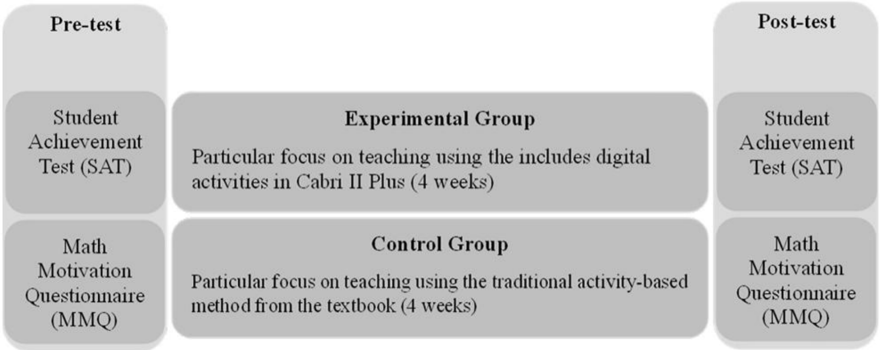

Figure 3. Treatment design (Source: Authors' own elaboration)

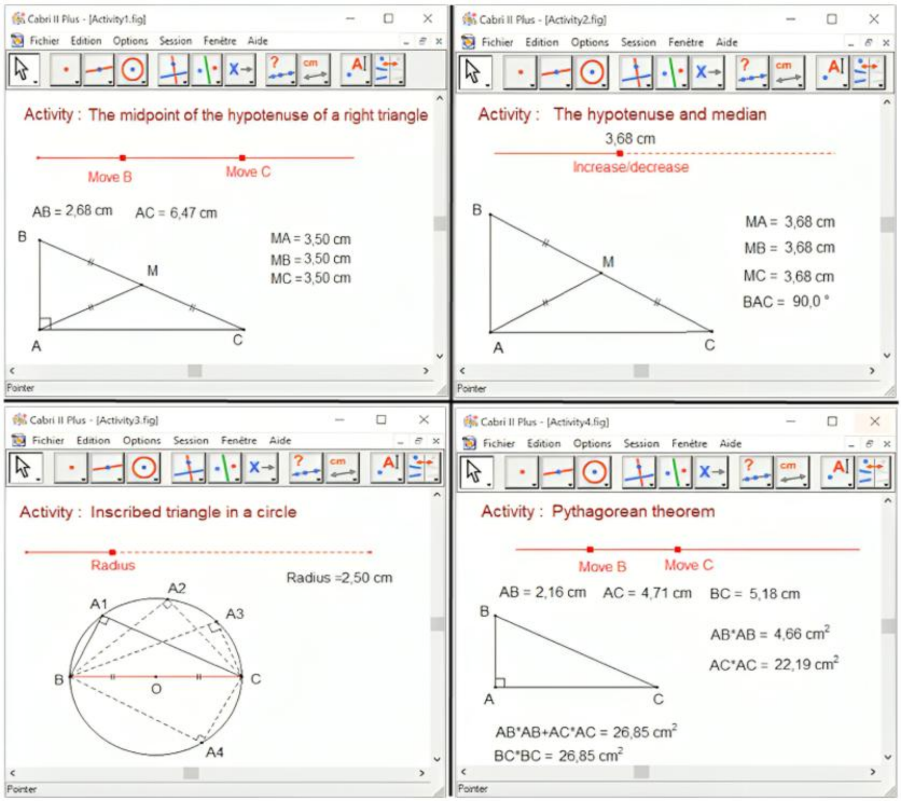

Figure 4. Examples of the student activities using Cabri II Plus (Source: Authors' own elaboration)

technological tools. At the beginning of each lesson, the teacher outlined the target activity from the textbook, then explained the lesson and solved the exercises on the board while the students would take notes in their notebooks. During these sessions, they were mainly passive. Thus, their work is limited to taking notes, listening to the teacher, and asking questions without being able to find the answers themselves. Additionally, their participation and interactions in the discussions were very restricted.

Analysis of Data

In this study, data analysis was performed using SPSS 26.0. Shapiro-Wilk tests were applied to determine if the SAT and MMQ results followed a normal distribution. The SAT achievement scores and MMQ motivation scores from the two groups' pre-tests were compared using an independent samples t-test. Analysis of covariance (ANCOVA) was employed to assess the significance of differences in SAT achievement scores and MMQ motivation scores between the two studied groups in the post-test. The relationship between achievement and motivation scores on the experimental and control groups post-tests was assessed using Pearson's correlation coefficient. The hypotheses, used primarily in educational studies, were tested at a significance level of 0.05.

RESEARCH RESULTS

Descriptive Statistics for the Pre- and Post-Test Scores of SAT and MMQ

Descriptive statistics were used to summarize the pre- and post-test SAT and MMQ scores for the experimental and control groups.

Table 4. Descriptive statistical results related to pre- and post-test of SAT and MMQ

Variable	Group	n	Mean	SD	Skewness	Kurtosis	Shapiro-Wilk
Pre-SAT	EG	35	8.66	2.74	-0.13	-0.05	0.99
	CG	35	8.50	2.79	-0.03	0.14	0.98
Post-SAT	EG	35	15.53	2.43	-0.28	-0.25	0.81
	CG	35	10.97	2.52	-0.11	0.17	0.99
Pre-MMQ	EG	35	2.80	0.52	-0.08	-0.91	0.38
	CG	35	2.81	0.51	-0.11	-0.97	0.35
Post-MMQ	EG	35	3.96	0.50	0.02	-0.99	0.48
	CG	35	2.82	0.49	-0.03	-0.99	0.30

Table 5. Results of the ANCOVA for the post-test SAT scores with pre-test SAT as the covariate

Source of variation	Sum square	df	Mean square	F	Sig.	η^2
SAT pre-test	0.09	1	0.09	0.01	0.91	0.00
Teaching method	362.80	1	362.80	52.12	0.00	0.44
Error	466.35	67	6.96			
Total	829.87	69				

Note. df: Degrees of freedom; F: F-test; Sig.: Significance; & η^2: Partial eta squared

The findings are detailed in **Table 4**. Both groups' SAT and MMQ scores exhibited skewness and kurtosis values ranging between -1 and +1 in both pre- and post-tests. The Shapiro-Wilk test confirmed that these scores follow a normal distribution.

According to **Table 4**, the achievement and motivation scores for students in the experimental group increased significantly following the intervention. The average achievement scores for the experimental group rose from 8.66 in the pre-SAT to 15.53 in the post-SAT, while their average motivation scores improved from 2.80 in the pre-MMQ to 3.96 in the post-MMQ. In contrast, the control group demonstrated a smaller increase in both areas: their mean achievement scores increased from 8.50 in the pre-SAT to 10.97 in the post-SAT, and their mean motivation scores only slightly rose from 2.81 in the pre-MMQ to 2.82 in the post-MMQ. These findings indicate that the experimental group experienced a more substantial improvement in achievement and motivation scores than the control group.

The independent t-test was used to compare the pre-test scores of the SAT and MMQ between the experimental and control groups. The results indicated no significant differences in either pre-SAT scores ($t [68] = 0.23$, $p = 0.81$) or pre-MMQ scores ($t [68] = 0.06$, $p = 0.95$) between the two groups.

Results Related to the First Question of the Research

To answer the first question of the research, which states the following: "What is the effectiveness of Cabri II Plus software on second-grade middle school students' achievement in learning the right triangle and the Pythagorean theorem?" The first hypothesis of the research provides for: "There are no statistically significant differences at the level of $\alpha \leq 0.05$ between the means of the two groups (experimental and control) in the academic achievement of second-year middle school students related to the teaching method", was verified.

To verify this hypothesis, we conducted an ANCOVA with pre-test SAT scores included as a covariate. This analysis aimed to control initial differences and accurately assess the method's impact on the results. Regarding the pre-test SAT scores, it was verified that the variances are equal in the context of the ANCOVA test assumptions ($F [1, 68] = 0.06$, $p = 0.81$). For the assumption of slope homogeneity, the pre-test SAT scores were treated as a covariate, and the interaction between these scores and the groups was analyzed. The analysis indicated that the interaction between the pre-test SAT scores, and the groups did not reach statistical significance ($F [1, 66] = 0.16$, $p = 0.69$), thus satisfying the assumption of equal slopes. These findings indicated that conducting an ANCOVA is feasible. The results obtained from this analysis are shown in **Table 5**.

Table 5 shows a statistically significant difference between the experimental group's and the control group's average achievement scores at the post-test ($F [1, 67] = 52.12$, Sig. = 0.00, $\eta^2 = 0.44$). This difference was attributed to the used teaching method. It is remarked also that the experimental group, which followed a teaching method using Cabri II Plus software to study the right-angled triangle unit and the Pythagorean theorem, outperformed the control group, which followed a traditional textbook-based teaching method. According to Cohen's (1988) evaluation of the effect size (partial eta squared $\eta^2 = 0.44$), it can be concluded that the use of Cabri II Plus software by the experimental group had a large impact on the achievement scores for the second-year middle school students.

Results Related to the Second Question of the Research

To answer the second question of the research, which states the following: "What is the effectiveness of Cabri II Plus software on second-grade middle school students' motivation to learn the right triangle and the Pythagorean theorem?" The second hypothesis of the research, which provides for: " There are no statistically

Table 6. Results of the ANCOVA for the post-test MMQ scores with pre-test MMQ as the covariate

Source of variation	Sum square	df	Mean square	F	Sig.	η^2
MMQ pre-test	0.45	1	0.45	1.88	0.18	0.03
Teaching method	22.74	1	22.74	94.08	0.00	0.58
Error	16.19	67	0.24			
Total	39.35	69				

Note. df: Degrees of freedom; F: F-test; Sig.: Significance; & η^2: Partial eta squared

Table 7. Correlation result between students' motivation and academic achievement in post-tests for the experimental and control groups

		Experimental group		Control group	
		Achievement	Motivation	Achievement	Motivation
Achievement	Pearson correlation	1	.72**	1	.37*
	Sig. (2-tailed)		.00		.03
	N	35	35	35	35
Motivation	Pearson correlation	.72**	1	.37*	1
	Sig. (2-tailed)	.00		.03	
	N	35	35	35	35

Note. *p < .05; **p < .01

significant differences at the level of $\alpha \leq 0.05$ between the means of the two groups in the motivation of the second-year middle school students linked to the teaching method", was verified.

To verify this hypothesis, we conducted an ANCOVA with pre-test MMQ scores included as a covariate. This analysis aimed to control initial differences and accurately assess the method's impact on the results. Regarding the pre-test MMQ scores, it was verified that the variances are equal in the context of the ANCOVA test assumptions (F [1, 68] = 0.00, p = 0.96). For the assumption of slope homogeneity, the pre-test MMQ scores were treated as a covariate, and the interaction between these scores and the groups was analyzed. The analysis indicated that the interaction between the pre-test MMQ scores and the groups did not reach statistical significance (F [1, 66] = 0.72, p = 0.40), thus satisfying the assumption of equal slopes. These findings indicated that conducting an ANCOVA is feasible. The results obtained from this analysis are shown in **Table 6**.

Table 6 shows a statistically significant difference between the experimental group's and the control group's average motivation scores at the post-test (F [1, 67] = 94.08, Sig. = 0.00, η^2 = 0.58). This difference was attributed to the employed teaching method. The experimental group, which took the right triangle and the Pythagorean theorem module using Cabri II Plus software, outperformed the control group, who took it using the traditional textbook-based teaching method. According to Cohen's (1988) evaluation of the effect size (partial eta squared η^2 = 0.58), it can be concluded that the experimental group using Cabri II Plus software had a large effect on the motivation scores of the second-grade middle school students.

Results Related to the Third Question of the Research

To answer the third question of the research, which states the following: "What is the relationship between academic achievement and motivation to learn mathematics among second-year middle school students?" The third hypothesis of the research, which provides for: "There is not a statistically significant correlation at the level of $\alpha \leq 0.05$ between academic achievement and second-year middle school student's motivation toward learning mathematics", was verified.

To verify this hypothesis, we calculated Pearson's coefficient to determine the correlation between students' motivation and academic achievement in post-tests tests for the experimental and control groups. The results obtained from this analysis are shown in **Table 7**.

Table 7 reveals a significant positive correlation between student motivation and academic achievement in post-tests for the experimental and control groups. In the experimental group, the correlation coefficient is r = .72 with a significance level of p = .00 (p < .01), indicating a statistically strong association, as categorized by Cohen (1988). In the control group, the correlation coefficient is r = .37 with a significance level of p = .03 (p < .05), showing a statistically moderate correlation as defined by Cohen (1988). These findings suggest a meaningful relationship between motivation and academic achievement across both groups, with a stronger correlation in the experimental group.

Furthermore, a scatterplot was used to illustrate the connection between motivation and academic achievement in post-tests for both the experimental and control groups, as shown in **Figure 5** and **Figure 6**.

Figure 5 and **Figure 6** illustrate the varying relationships between student motivation and academic achievement in post-tests for the experimental and control groups, respectively. **Figure 5** highlights a strong relationship for the experimental group (r = .72), with the scatterplot displaying data points closely aligned along

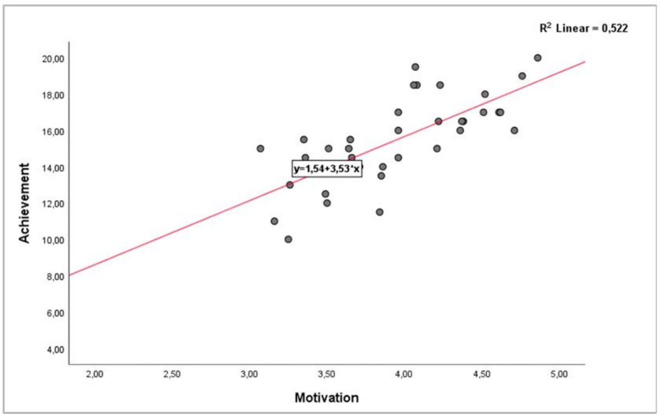

Figure 5. Scatterplot illustrating the relationship between students' motivation and academic achievement in post-tests for the experimental group (Source: Authors' own elaboration)

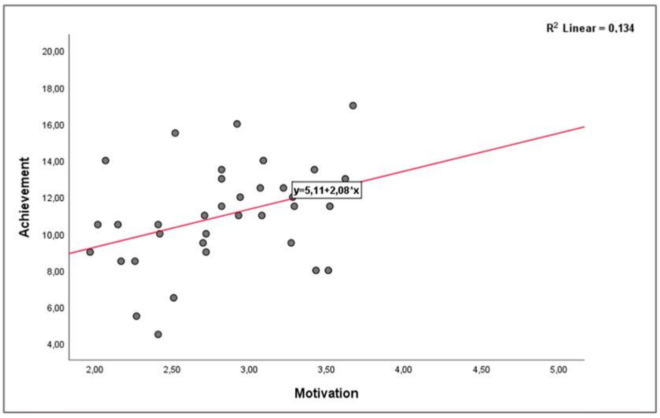

Figure 6. Scatterplot illustrating the relationship between students' motivation and academic achievement in post-tests for the control group (Source: Authors' own elaboration, using SPSS version 26)

a nearly straight line. This alignment underscores a substantial link between motivation and academic achievement, suggesting that higher levels of student motivation are associated with greater academic success. In contrast, **Figure 6** shows a moderate relationship for the control group (r = .37), where data points are less aligned along a straight line than the experimental group. This reduced alignment indicates a weaker correlation between motivation and academic achievement, with lower student motivation associated with lower educational outcomes.

DISCUSSION

The main objective of this study is to investigate how the use of Cabri II Plus software affects academic achievement and to examine the relationship between motivation and academic achievement when using the software compared to not using it. By focusing on the module right triangle and the Pythagorean theorem, this study contributes to the existing literature by exploring the effect of Cabri II Plus software on student academic achievement and motivation in this area.

The findings of this study show a significant difference in the academic achievement of topics on the right triangle and the Pythagorean theorem between students who used the Cabri II Plus software and those taught using the conventional method and for the benefit of students who used the Cabri II Plus software in learning the right triangle unit and the Pythagorean theorem. This positive effect on students' academic achievement is attributed generally to the program's characteristics in teaching branches of the mathematics module, particularly in geometry lessons. The dynamic nature of the program allowed students to learn geometric concepts, explore relationships, and visualize them easily. The Cabri II Plus software is based on learning through practice, as geometry requires extensive training to master its skills, understand its concepts, and connect them (Mackrell et al., 2013). This program enables students to visualize geometric shapes, which enhances their understanding of geometric concepts (Jaya & Suparman, 2021). The teacher's familiarity with the Cabri II Plus program, which is reinforced by specialized training in the integration of ICT in mathematics teaching provided by the MEN, has enabled the teacher to enhance their teaching abilities and improve their skills in delivering content interactively and effectively, this makes the lessons more attractive and exciting for students. The program allows students to choose activities that match their abilities, interests, and desires. This aspect has captured students' attention and motivated them to persevere and be diligent. Its active role in strengthening social interaction and cooperation within the class has increased students' interest in mathematics and their desire to engage in the classroom. Additionally, it made education student-centered by allowing them to solve geometric problems independently and discover new geometric relationships that deepen their knowledge of the subject. It also allows learners to solve questions and exercises more broadly than the traditional method. These findings align with several studies demonstrating the effectiveness of dynamic geometry software in enhancing academic achievement and understanding of geometric concepts. For instance, Yazlik and Ardahan (2012) found that using Cabri Geometry Plus II positively impacted seventh-grade students' learning of transformational geometry, showing significant improvement in academic performance in the experimental group compared to the control group. This supports the notion that technological learning tools can enhance academic achievement. Similarly, Jaya and Suparman (2021) found that Cabri II Plus software significantly improved students' understanding of geometric concepts and academic achievement. Their meta-analysis revealed that using CABRI positively affected students' comprehension of geometry. This reinforces the benefits of such technological tools in education. Additionally, Yilmaz (2015) confirmed that

Cabri II Plus effectively improved students' achievement in transformational geometry compared to traditional methods, suggesting that technology-enhanced learning can significantly boost academic performance. The study by Erbas and Yenmez (2011) also revealed the impact of using a dynamic geometry environment (DGE) on the achievements of sixth-grade students in various topics, including polygons, congruency, and similarity of polygons, and showed that using the DGE significantly improved students' performance. Moreover, the study's results align with numerous previous studies investigating the effectiveness of using GeoGebra in enhancing students' academic achievement. For instance, Hidayat et al. (2023) found that students who were taught using GeoGebra achieved higher levels of academic performance and engagement than those taught using traditional methods in the context of polygon topics. Similarly, Zulnaidi and Syed Zamri (2017) revealed that students who utilized GeoGebra to learn about functions demonstrated higher conceptual and procedural knowledge than those who learned through conventional methods. Additionally, Uwurukundo et al. (2022) confirmed that implementing GeoGebra in Rwandan secondary schools for teaching and learning geometric concepts showed that students who used GeoGebra outperformed those who did not.

The findings of this study show a significant difference in the motivation to learn the right triangle and the Pythagorean theorem between students who used the Cabri II Plus software and those taught using the conventional method and for the benefit of students who used the Cabri II Plus software in learning the right triangle unit and the Pythagorean theorem. This positive effect on students' motivation to learn geometry is attributed to the fact that the program has some exciting features in terms of displaying shapes with movement and colors. In addition, the program offers students the ability to manipulate points and straight lines, change the figure's colors, control the thickness of each element, and even change the background. It can also enlarge and reduce shapes by clicking and dragging. These interactive features motivate the pupils to learn geometry and encourage them to discover new geometric problems. Additionally, the program's capacity to solve simple and complex problems, including exercises and examples presented in class, captured the students' attention and heightened their motivation to learn geometry. This is especially significant as they were introduced to a novel learning method that enhanced their motivation to learn this module (Laborde, 2002). Moreover, the student's inclination towards computers and their programs, as well as their desire to learn mathematics through this medium, has increased their motivation for learning geometry; this is significant because it aligns the learning process with their interests, making it more effective and enjoyable (Rachmavita, 2020). Furthermore, students' autonomy, developed by solving mathematical problems independently through trials and experiments involving drawing shapes and comprehending their properties, increased their motivation to learn geometry (Maarif et al., 2018; Mariotti, 2012). On the other hand, the Cabri II Plus has enabled students to acquire a fresh perspective of geometry based on practical and interactive applications rather than solely relying on abstract views grounded on theories and proofs (Suratno, 2020). These findings align with numerous studies examining the impact of technology on student motivation in learning mathematics. For instance, Hikmah and Hartuti (2018) found that students using the Cabri II Plus software exhibited higher motivation than those following traditional learning methods. Similarly, Akinoso (2023) noted that integrating ICT into education enhances student motivation by improving performance expectations and providing a more stimulating learning environment. Erbas and Yenmez (2011) also reported that a DGE significantly increased students' interest and motivation in mathematics compared to traditional methods. Moreover, the study's results align with numerous previous studies investigating the effectiveness of using GeoGebra in enhancing students' learning motivation. For instance, Abdullah et al. (2020) demonstrated that using an inductive reasoning strategy supported by GeoGebra significantly enhanced students' motivation toward the topic of graphical representation of functions. Similarly, Machromah et al. (2019) found that learning calculus through GeoGebra substantially increased student motivation and made the learning process more enjoyable. Finally, Hosseini et al. (2022) revealed that students in the experimental group who used GeoGebra achieved significantly higher academic and motivation scores than those in the control group.

The research findings revealed that the teacher provided positive feedback on using Cabri II Plus in teaching the right triangle and the Pythagorean theorem. The teacher found the software easy to use and beneficial for explaining geometric concepts and creating accurate geometric figures. Cabri II Plus helped the teacher effectively demonstrate geometric properties and supported students in mastering the concepts and solving related problems. This result was consistent with Maarif et al. (2018), who noted that dynamic learning environments, like Cabri II Plus, serve as valuable technological tools that facilitate students' understanding of complex mathematics concepts. The software's ability to create precise visual representations eased students' difficulties in learning and enhanced their motivation. Cabri II Plus also allowed the teacher to explore various teaching methods and adapt materials to suit their educational approach better, as Laborde (2003) emphasized. The software expanded the learning environment by providing interactive tools and representations that bridged classroom learning with real-world applications, thus improving students' comprehension. According to Jaya and Suparman (2021), Cabri II Plus enabled students to visualize abstract geometric concepts and connect them to their mathematical knowledge, fostering greater interest and cognitive development. This experience reinforced Cabri II Plus's effectiveness in supporting student achievement and motivation in mathematics. Overall, Cabri II Plus significantly contributed to the teacher's ability to deliver a more effective and motivating learning experience in mathematics.

The findings of this study reveal a strong positive correlation between student motivation and academic achievement in post-tests for the experimental group that utilized the Cabri II Plus software to study the right-angled triangle and the Pythagorean theorem. This significant relationship highlights the crucial role of technology in enhancing student motivation and fostering academic achievement. Interactive programs like Cabri II Plus allow students to engage directly with mathematical content through animations and dynamic simulations, giving them a deeper understanding of mathematical concepts (Hillmayr et al., 2020). Such digital educational tools promote active participation in the learning process, encouraging students to explore and solve problems independently and enhancing their motivation and academic performance (Li et al., 2024). Mayer (2014) similarly emphasized that integrating technology into teaching improves student engagement and interaction, ultimately boosting their academic success. In contrast, the control group that used traditional textbook-based methods demonstrated a moderate positive correlation between motivation and academic achievement. This suggests that traditional methods may offer less interactivity than technological approaches, leading to a more limited impact on student motivation and academic performance (Hassidov, 2017). The absence of technology in education can result in lower student engagement, as many activities are confined to passive listening and information receipt, thus restricting direct interaction with mathematical concepts (Alessa, 2023). This lack of interactivity may reduce student motivation and engagement levels (Alsswey et al., 2024; Mulqueeny et al., 2015). While traditional methods focus on transmitting information from teacher to student, technological tools create a rich and diverse environment that promotes critical thinking and encourages students to engage with information innovatively (Abdulrahaman et al., 2020).

The findings of this study significantly support the idea of technology's positive impact on student's academic achievement and motivation across various educational contexts. Poçan et al. (2023) demonstrated that students who learn using technology show higher motivation and academic achievement levels than those who follow traditional teaching methods. In line with this, recent research indicates that learning with interactive software enhances problem-solving and thinking skills, positively affecting academic performance (Shurygin et al., 2023). Conversely, traditional methods may hinder the development of these skills, resulting in lower academic outcomes (Zhang et al., 2020). Additionally, using technology strengthens students' ability to learn independently. It fosters the development of research and innovation skills, leading to increased motivation and improved academic success in mathematics. For example, Emeri (2022) found that using technology in classrooms in the Ikorodu Local Government Area of Lagos State significantly enhances students' academic performance and learning motivation. Ziden et al. (2022) showed that augmented reality notably improves students' achievement and motivation, with a positive correlation between motivation and achievement. Supporting these findings, a systematic review by Higgins et al. (2019) confirmed the positive influence of technology on students' academic performance, motivation, and attitudes toward learning. Furthermore, Paino (2024) affirmed that technology boosts student achievement and motivation in mathematics education. Hosseini et al. (2022) also demonstrated that using GeoGebra with the ARCS (attention, relevance, confidence, and satisfaction) model led to statistically significant improvements in academic achievement and motivation. In addition, studies such as those by Xia et al. (2022) and Herges et al. (2017) found that increased learning motivation significantly improved academic performance among students, with positive relationships between motivation and achievement in various educational settings. Agustina et al. (2021) and Wilkesmann et al. (2021) further emphasized that motivation is positively and significantly related to academic performance. These studies highlight the importance of integrating modern technology and interactive activities into the educational process to enhance students' academic outcomes and motivation.

CONCLUSIONS

This study investigated the effects of teaching using Cabri II Plus software on students' academic achievement and motivation in learning about right triangles and the Pythagorean theorem. The findings proved that Cabri II Plus significantly enhances students' academic achievement and motivation compared to traditional teaching methods. Results demonstrated that students who used Cabri II Plus achieved higher scores and displayed greater motivation to learn the right triangle and Pythagorean theorem. The study's findings also showed a strong, statistically significant positive relationship between academic achievement and motivation among the experimental group students in the post-tests and a moderate, statistically significant relationship between these variables among the control group students. Thus, the teaching method using the Cabri II Plus program has a greater positive impact on the relationship between academic achievement and motivation than traditional teaching methods. Based on these results, it is evident that using Cabri II Plus in the teaching process is an effective strategy for enhancing students' educational outcomes and promoting a more engaging and motivating learning environment.

Recommendations

According to the study's findings, it is recommended that Cabri II Plus be integrated into the curriculum as an effective tool for enhancing the interactive learning experience in mathematics education. Additionally, a training manual for teachers should be developed, including instructional strategies supported by practical examples to facilitate the effective incorporation of the program into classrooms. The study also recommends providing continuous professional development programs for teachers to familiarize them with dynamic geometry tools and their applications, thereby improving teaching practices and motivating students. Furthermore, it suggests developing digital educational resources, such as worksheets and activities supported by Cabri II Plus, to enhance students' practical understanding of mathematical concepts. Finally, the study emphasizes encouraging collaboration among teachers and educational institutions to exchange experiences and best practices, thereby improving teaching processes and expanding modern educational technologies.

Future Research

This study used interactive Cabri II Plus software activities to teach second-year middle school students right-angled triangles and the Pythagorean theorem. It investigated the impact of this approach on their academic achievement and motivation to learn mathematics. However, the study had certain limitations, particularly regarding the sample size and representativeness, which may affect the generalizability of the findings. Future research should expand the sample to include a more extensive and diverse group of middle and high school students to enhance the results' reliability and applicability. Additionally, the effectiveness of Cabri II Plus in developing skills such as mathematical thinking, spatial abilities, proof skills, and enhancing levels of geometric thinking should be further investigated in accordance with the Van Hiele model. Ultimately, the study suggests further research on teachers' beliefs and attitudes towards using other dynamic geometry software, such as Cabri 3D and GeoGebra, to evaluate their effectiveness in enhancing the quality of mathematics education.

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Ethical statement: Authors stated that, prior to conducting the study at Al-Nahda Secondary School in the Sidi Slimane Directorate, the researchers obtained permission from the school principal to carry out the research. Full respect for the privacy and identity of the participants was maintained throughout the study. Additionally, written informed consent was obtained from all participants in accordance with the ethical standards for scientific research.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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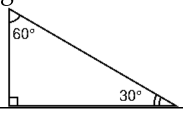
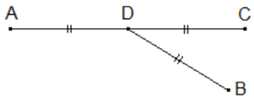
APPENDIX A

Table A1. Student achievement test (SAT pre-test) (for each question, check the correct answer)

No	Questions	Answers		
1	In the figure: ABC is a triangle ... 	Equilateral ☐	Isosceles ☐	Right ☐
2	Point M is the midpoint of segment [BC]. Therefore, ...	$MB = MC$ ☐	$MC = \frac{BC}{2}$ ☐	$MB = 2BC$ ☐
3	The hypotenuse of a right triangle ABC, with a right angle at B, is ...	[AB] ☐	[AC] ☐	[BC] ☐
4	ABC is a triangle where: $AB = 4$ et $AC = 5$. Therefore ...	$BC > 9$ ☐	$BC = 9$ ☐	$0 < BC < 9$ ☐
5	In the following figure:  Compared to D, C is the symmetrical of ...	B ☐	D ☐	A ☐
6	M is a point on the perpendicular bisector of segment [AB]. Therefore, ...	MAB is an equilateral triangle. ☐	$MA = MB$ ☐	MAB is a right triangle. ☐
7	ABCD is a rectangle with a center O. Therefore, ...	A, B, C, and D belong to a circle with center O. ☐	ODC is a right triangle. ☐	(BD) is the axis of symmetry of ABCD. ☐
8	The center of the circumscribed circle of a triangle is the point of intersection of the ...	Perpendicular bisectors ☐	Medians ☐	Altitudes ☐
9	The square of 15 is equal to ...	30 ☐	225 ☐	7.5 ☐
10	The area of a square is 64 m^2. Its side measures ...	8 m ☐	128 m ☐	32 m ☐
11	If $x^2 = 100$, then …	$x = 50$ ☐	$x = 10$ ☐	$x = 10$ ou $x = -10$ ☐
12	The area of triangle MAN with height AH is ...	$\frac{AH \times MH}{2}$ ☐	$\frac{AH \times MN}{2}$ ☐	$\frac{AH \times MN}{2}$ ☐
13	If ABC is a triangle, then ...	$AB + AC > BC$ ☐	$AB + AC < BC$ ☐	$AB + AC = BC$ ☐
14	IF $AB + AC = BC$, then …	ABC is a triangle. ☐	$B \in [AC]$ ☐	$A \in [AC]$ ☐
15	If ABC is a right triangle at A, then ...	$AB + AC = BC$ ☐	$AC > BC$ ☐	$AB < BC$ ☐
16	If EFG is a right triangle at F, then its hypotenuse is the side ...	[EF] ☐	[EG] ☐	[FG] ☐
17	$6^2 + 8^2$ is equal to ...	$(6 + 8)^2$ ☐	$12 + 16$ ☐	100 ☐
18	The equation $25 = x + 9$ has the solution ...	$\frac{25}{9}$ ☐	$25 - 9$ ☐	$9 - 25$ ☐

APPENDIX B

Table B1. Student achievement test (SAT post-test) (for multiple-choice questions, check the correct answer)

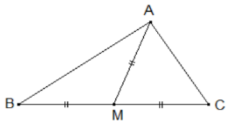
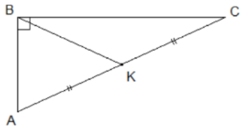
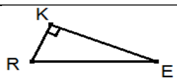
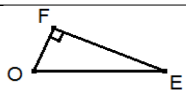
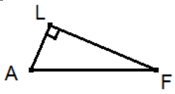
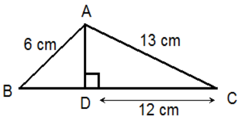
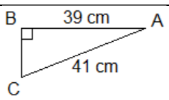
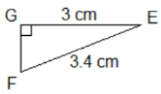
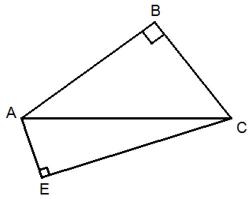
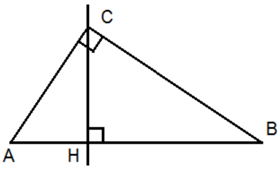
No	Questions	Answers		
	For questions 1 and 2, we use the figure shown here: 			
1	The triangle ABC is: …	Isosceles ☐	Right ☐	Equilateral ☐
2	The center of the circumcircle of triangle ABC is: …	B ☐	C ☐	M ☐
	For questions 3 to 6, we use the figure shown here: 			
3	If BK = 2, then …	AC = 2 ☐	AC = 3 ☐	AC = 4 ☐
4	If AK = 2, then …	BK = 2 ☐	BK = 3 ☐	BK = 4 ☐
5	If AB = 3 and AB = 4, then …	AC = 13 ☐	AC = 7 ☐	AC = 5 ☐
6	The circumcircle of triangle ABC has its center at: ...	A ☐	K ☐	B ☐
7	 RKE is a right triangle at K, therefore ...	$RK^2 = RE^2 + EK^2$ ☐	$EK^2 = ER^2 + EK^2$ ☐	$RE^2 = RK^2 + EK^2$ ☐
8	 EOF is a right triangle at F, with OF = 2.03 cm and EF = 3.96 cm, therefore ...	OE = 19.8025 cm ☐	OE = 4.45 cm ☐	OE = 5.99 cm ☐
9	 FAL is a right triangle at L, therefore ...	$AL^2 = AF^2 - LF^2$ ☐	$LF^2 - LA^2 = AF^2$ ☐	$LF^2 = LA^2 - AF^2$ ☐
10	 (AD) is an altitude of triangle ABC, thus ...	AD = 6 cm ☐	AD = 5 cm ☐	AD = 12 cm ☐
11	 ABC is a right triangle at B, therefore ...	BC = 40 cm ☐	BC = $\sqrt{160}$ cm ☐	BC = 12 cm ☐
12	 EFG is a right triangle at G, therefore ...	GF = 1.6 cm ☐	GF = 1.7 cm ☐	GF = 2 cm ☐

Table B1 (Continued). Student achievement test (SAT post-test) (for multiple-choice questions, check the correct answer)

No	Questions	Answers
	For questions 13 and 14, we use the figure shown here: ACE is a right triangle at E, and ABC is a right triangle at B. AE = 2.5 cm; CE = 6 cm; AB = 5.6 cm 	
13	Calculate AC: …………………………………………………………………	
14	Calculate BC: …………………………………………………………………	
	For questions 15 and 16, we use the figure shown here: ABC is a right triangle at C. (CH) is the altitude from C to triangle ABC, and H is on segment [BC]. AC = 3.6 cm; BC = 4.8 cm. 	
15	Calculate AB and CH: …………………………………………………………	
16	Calculate HA and HB: …………………………………………………………	

APPENDIX C: MATH MOTIVATION QUESTIONNAIRE (MMQ)

MMQ was adapted from the validated science motivation questionnaire (SMQ) developed by Glynn et al. (2009) by replacing the term "science" with "math" in each item.

In order to better understand what you think and feel about your college math courses, please respond to each of the following statements from the perspective of: ''When I am in a college math course …'')

1. I enjoy learning math.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

2. The math I learn relates to my personal goals.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

3. I like to do better than the other students on the math tests.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

4. I am nervous about how I will do on the math tests.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

5. If I am having trouble learning the math, I try to figure out why.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

6. I become anxious when it is time to take a math test.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

7. Earning a good math grade is important to me.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

8. I put enough effort into learning the math.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

9. I use strategies that ensure I learn math well.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

10. I think about how learning math can help me get a good job.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

11. I think about how the math I learn will be helpful to me.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

12. I expect to do as well as or better than other students in the math course.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

13. I worry about failing math tests.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

14. I am concerned that the other students are better in math.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

15. I think about how my math grade will affect my overall grade point average.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

16. The math I learn is more important to me than the grade I receive.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

17. I think about how learning math can help my career.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

18. I hate taking the math tests.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

19. I think about how I will use math I learn.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

20. It is my fault if I do not understand math.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

21. I am confident I will do well on math assignments and projects.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

22. I find learning math interesting.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

23. The math I learn is relevant to my life.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

24. I believe I can master the knowledge and skills in the math course.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

25. The math I learn has practical value for me.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

26. I prepare well for math tests and quizzes.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

27. I like math that challenges me.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

28. I am confident I will do well on math tests.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

29. I believe I can earn a grade of "A" in the math course.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

30. Understanding math gives me a sense of accomplishment.

○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always

Table C1. Specific items are divided into the six dimensions of the MMQ

MMQ dimensions	Items	Frequency
Intrinsically motivated dimension	1, 16, 22, 27, & 30	5
Extrinsically motivated dimension	3, 7, 10, 15, & 17	5
Personal importance dimension	2, 11, 19, 23, & 25	5
Self-determination dimension	5, 8, 9, 20, & 26	5
Self-efficacy dimension	12, 21, 24, 28, & 29	5
Low math-related anxiety dimension	4, 6, 13, 14, & 18	5
Total		30