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Impact of the Integration of GeoGebra on Teaching the Notion of Radian

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ABSTRACT

The aim of this study is to evaluate the impact of the dynamic geometry software GeoGebra on student achievement in teaching of trigonometry, especially measuring an angle with Radian. the population for this investigation included 48 students of 1st year of high school scientific, splitted into two groups. The experimental group was given the task of integrating GeoGebra software. However, constructivist teaching was used to present the notion (Radian) for the control group. The application of ANNOVA analysis and Tukey test showed that the experimental group outscored the control group. We concluded that using GeoGebra helps students become more adept at understanding notion of radian.

Keywords: GeoGebra; Teaching; Trigonometry; Radian; Constructivist.

INTRODUCTION

Mathematics is a progressive and cumulative science; the mathematical notions are constructed upon one another. According to (Baki, A., 2014) mathematical notions acquire value when they are treated in connection with other notions. The function of trigonometry in the high school mathematics curriculum is to establish connections between mathematical notions. trigonometry connects algebraic and geometric thinking in mathematics education, and many discipline like physics, architecture, and engineering need knowledge of trigonometry.

"Trigonometry" comes according to the Greek terms "trigono" referring to "triangle" and metro, which indicates "measure". trigonometry is the study of triangles and the relationships between their sides and angles.

Comprehending the trigonometric relational system is a challenging subject in mathematics education. Its fundamental concepts are the angle, the unit circle, and the trigonometric functions (Martín-Fernández, E., Rico, L., & Ruiz-Hidalgo, J. F., 2022). These three ideas and their connections play a role in the interpretation and comprehension of trigonometric topics.

While Babylons used the degree angle unit, the radian is a rather recent addition. In the 1870s, physicist James Thomson and Thomas Muir debated the requirement for an angular measurement unit that did not depend on dividing a full circle into a certain number of equal parts (National Council of Teaching of Mathematics, 1971). In a paper published in 1873, Thomson presented the notion of "radian" as "the ratio of the length of the arc faced by central angle to the length of the radius of the circle" (figure 1), this ratio remains constant across all circles (National Council of Teaching of Mathematics, 1971).

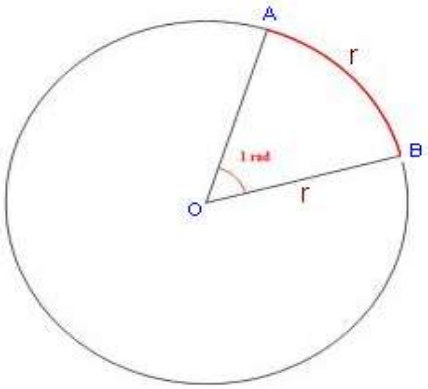

Figure 1: Definition of Radian

The foundation of trigonometry proficiency is an understanding of angle measurement units, especially Radian. Most students find it difficult to measure an angle using Radian. (Yavuz Mumcu, H., & Aktürk, T., 2020) make reference to the idea of a radian as something that students cannot visually understand. To overcome students' difficulties, many teachers use technological tools, specifically GeoGebra for geometrical concepts (Mosese, N, & Ogbonnaya, U. I., 2021). GeoGebra is a dynamic geometry software that is open-source and gives learners an interactive space for learning, it combines the potential of both computer algebra and dynamic geometry. Furthermore, GeoGebra receives inputs in geometry, algebra, and calculus and can connect several representations.

LITERATURE REVIEW

Trigonometry is the study of triangles, the relationships between their sides and angles, the functions of sine and cosine, tangent and cotangent, secant and cosecant, and the graphs of these functions. It also involves deriving conclusions about the characteristics and connections between all of the aforementioned concepts (Richard Walsh, Olivia Fitzmaurice & John O'Donoghue, 2017). Trigonometry is too esoteric for lower performing students; only those with higher achievement levels can cognitively understand it (Ofsted, 2012). Students confirm that trigonometry is a very challenging mathematical topic. They largely rely on rote learning from textbooks and perceive trigonometric notions to be excessively abstract (Renana Altman & Ivy Kidron, 2016). They do not comprehend the basic ideas of trigonometry. Students in the secondary school have frequently demonstrated conceptual misconceptions related to trigonometric ratios, trigonometric functions, solving trigonometric equations, as well as inadequate visualisation abilities. It has also been demonstrated that when students are solving trigonometric problems, they follow procedural methods (Richard Walsh, Olivia Fitzmaurice & John O'Donoghue, 2017). According to (Tuna, A., 2013), students frequently complete activities involving radians procedurally without comprehending the idea of radian, and they have a worse grasp of radian compared to degree.

Based on (Ngcobo, A.Z., Madonsela, S.P., & Brijlall, D., 2019) study, students' first challenges in trigonometry are caused by a lack of comprehension of fundamental ideas like angles, measuring angles, right triangles, and the unit circle. Furthermore, (Melike Yiğit Koyunkaya, 2016) suggested that pupils can comprehend trigonometry provided they develop an appropriate comprehension of angle measures. However, students will find it difficult to comprehend trigonometry if they have not developed such fundamental understanding.

According to this study (Maknun C.L., Rosjanuardi R., Jupri A., 2022), students often link a trigonometric value with a specific angle, such as, they may find it difficult to use an angle in radians or to understand the value of π. Additionally, they frequently change angles from radians to degrees and vice versa by following the formal procedures without understanding how the formula is put together. They struggle to determine the value of the trigonometric function, particularly when it comes to angle in the quadrant and coordinates of a point trigonometry graph, which are mostly associated with the radian unit. Students' comprehension of more complex notions, such trigonometric functions, is impacted by their lack of

knowledge of the radian concept (Yavuz Mumcu, H., & Aktürk, T., 2020).

Teachers were demonstrated to have a limited ingrained, and constrained comprehension of trigonometry. (Melike Yiğit Koyunkaya, 2016) noted that the teachers teach trigonometry using right triangles in lieu of the unit circle technique, because they found it hard to create trigonometry presentations centred around the functions of angle measurements. The results of the study showed that most of the teachers' challenges stemmed from their basic trigonometry understanding. Their ideas of angle measures depended only on measurements in degrees, and they appeared to possess little of a unit circle. The findings of (Martín-Fernández, E., Rico, L., & Ruiz-Hidalgo, J. F., 2022) show that there is a lack of understanding between the goniometric and analytical representation systems among pre-service math teachers. (Fi, C., 2003) found that while pre-service teachers could translate radians to degrees or the other way around, they were incapable to identify a radian as a ratio of two lengths and needed a thorough comprehension of what a radian measure was.

Numerous studies indicate that one reason why students display understanding difficulties is due to bad teaching (Weber, K., 2005) (Richard Walsh, Olivia Fitzmaurice & John O'Donoghue, 2017). If trigonometric content is presented solely through traditional approach, students will see it as being highly abstract. When it comes to grasping trigonometric content, the traditional style is rather restricted. For the trigonometric content to appear more tangible, it must be visualized. Students will find the notion of trigonometric periods or angles in different quadrants simple to comprehend if trigonometry is presented in a tangible way (D Fahrudin, & al., 2019).

Trigonometric ideas must be reinforced through the implementation of suitable instructional resources (Kuswari Hernawati, & Herman Dwi Surjono, 2019). GeoGebra is an educational resource that help students better grasp geometry-related subjects. In school or at home, students can use GeoGebra to better understand experiments and work through math challenges (Y Zengin, 2012). Likewise, GeoGebra may help students visualize and comprehend a variety of mathematical concepts (Mosese, N, & Ogbonnaya, U. I., 2021).

According to the work of (Orhani, S. ,2024), innovative pedagogic strategies that incorporate collaborative techniques and technology are more successful than conventional ones. The findings demonstrate also that employing technology raises student enthusiasm and commitment. Teachers may employ GeoGebra to visualize trigonometric content. Notions are better understood by student when they are seen or shown (Maria Cortas Nordlander, 2021).

Students' comprehension of trigonometric notions has grown more profound and detailed because to the employment of interactive software (Smith, M. T., & Johnson, R. 2023). (Lee, S., & Kim, J., 2021) affirms that utilizing software for presenting trigonometric functions has greatly improved students' comprehension of the notions of periodicity and graphical representation. (Garcia, A., & Fernandez, M., 2021) demonstrate how employing augmented reality apps has helped students do better on trigonometry exams by giving them a more tangible way to see theoretical notions.

The development of technology has made visuals more than just immobile; they can now be animated visualizations that help pupils acquire strong and durable learning. (Bornstein, N., 2020) affirmed that the ability of computer technology to represent geometric shapes, like those needed for trigonometry, has been demonstrated to be useful. (Orhani, S., 2022) highlighted that the beneficial impact that Information and Communication Technology has had on encouraging students to complete assignments when trigonometric functions are shown graphically.

MATERIALS & METHODS

The aim of this study is to evaluate the impact of the dynamic geometry software GeoGebra on student achievement in teaching of trigonometry, especially measuring an angle with Radian. The study sample included 48 students of 1st year of high school scientific, were chosen from TARIK BEN ZYAD High School in Marrakech, Morocco, in the 2023–2024 academic year. This sample are splitted into two groups: the experimental group (G1: 24 students) was given the task of integrating GeoGebra software. However, constructivist teaching was used to present the notion (Radian) for the control group (G2: 24 students). For the first group (G1): each student installed GeoGebra on his laptop, and then we used a practical work. While for the control group (G2) we taught our notion adopting as usual the constructivist approach and using the activity in the textbook (ALMOUFID).

RESULT

In order to accomplish our goals, we are curious to assess the averages that the two groups in the current study produced. Then, we have decided to employ the ANOVA test.

Group	Control test average	Evaluation test average
G1	11.651	18.469
G2	10.792	15.258

Table 1: Distribution the averages of control test and evaluation test for the two groups

The table 1 Displays, for both groups, the average score of the control and the evaluation test. The table 1 reveals that the highest marks are achieved by students in the experimental group G1. They obtained 11.651 in the control test and 18.469, out of 20 points, in the evaluation test

Test	DDL	F	Pr > F
Control	3	F=11.176	p<0.001
Evaluation	3	F=173.915	p<0.0001

Table 2: Analysis of variance

Table 2 shows the analysis of variance by ANOVA. Based on the results of the F statistic and p-value that either for the control test (F=11.176, p<0.001, ddl=3) or the evaluation test (F=173.915, p<0.0001, ddl=3), there is considerable variation between the groups. It is clear that the chosen teaching strategy has a big influence on the students' learning.

Test	Contrast	Difference	Standardized difference	Critical value	Pr >Diff	Significant
Diagnostic	G1 vs G2	0.589	1.054	2.025	0.286	No
Control	G1 vs G2	1.978	3.582	2.025	<0.001	Yes
Evaluation	G1 vs G2	3.397	12.845	2.025	<0.0001	Yes

Table 3: Comparison of diagnostic tests' results, control test and evaluation test for two groups

To ascertain the degree to which the experimental group (G1) varied substantially from the control group (G2). We employed the Tukey test, which enables them to examine any pair of averages. Since the diagnostic test's p-value (table 3) is p=0.286, which is not considered important, we may conclude that the groups under investigation did not vary significantly.

The control and the evaluation test (table 3) indicate that G1 exhibits substantial variance in comparison to G2 (p<0.001 between G1 and G2). This outcome demonstrates that, in comparison to the pupils in the control group G2, the experimental group's performance improved by a considerable margin. These results show that GeoGebra significantly improved student performance in the teaching of Radian.

DISCUSSION

The findings show that the experimental group outscored the control group. At this

point we can conclude that using GeoGebra helps students become more adept at understanding notion of radian. Numerous research has been conducted to examine how various methods affect the performance and attitudes of students in trigonometry (Korntreff, 2018) (Spangenberg, E. D., 2021). Learning is improved by creating an engaging setting where students can take part in the lesson (Olteanu, C., 2017). The GeoGebra program is capable of being employed as a teaching and learning support for mathematics, especially for understanding notion of radian.

A number of researchers have found that GeoGebra has a positive impact on student learning, ensuring that learning is more meaningful, contextualised and sustainable, and opening up further opportunities and possibilities for students' futures (Hidayat W, Rohaeti EE, Hamidah I and Putri RII, 2023). In the (Mosese, N, & Ogbonnaya, U. I., 2021) study, the learners became active thanks to the use of GeoGebra in their learning, they took the initiative to learn, and made a major effort to solve problems, to find original solutions, by following relevant methods of analysis. Significant use of GeoGebra by teachers in the classroom is likely to improve the quality of learning in a rapid and effective manner (Tola Bekene Bedada & France Machaba, 2022).

Through the implementation of technology, the learner was able to progress from an intuitive to a functional and, ultimately, a practical phase of cognitive procedures (Bornstein, N., 2020). The capacity to switch between abstract and tangible illustrations of mathematical items is necessary for a thorough comprehension of trigonometry (Garcia, A., & Fernandez, M., 2021). If students are able to connect their geometrical results with their numerical, they will acquire trigonometric notions more effectively and creatively (Maria Cortas Nordlander, 2021). The effective and genuine implementation of GeoGebra to teach geometrical notions will provide dynamic educational settings that enhance students' mathematical reasoning (Tola Bekene Bedada & France Machaba, 2022).

Today's learners are accustomed to new digital technologies in their daily lives, so teachers need to exploit this advantage to promote learning in the classroom (Orhani, S., 2022). ICT is not suited to the principles of traditional pedagogy, but it is an aid to modern pedagogy (Lee, S., & Kim, J., 2021). When implementing digital technology to teach mathematics, it is important to offer students the tools they need to develop ideas. To do this, it is essential to offer them the environment they need to formulate, test, and externalize hypotheses that support problem-solving, conceptual understanding, and thinking structure (Hidayat W, Rohaeti EE, Hamidah I and Putri RII, 2023). In order to provide this type of support, it is undoubtedly necessary for a math teacher to understand the potential and constraints of every educational software program for every area of mathematics (Smith, M. T., & Johnson, R. 2023).

CONCLUSION

There are two main justifications why our investigation is important. First and foremost, the investigation was motivated by the desire to discover a different method of teaching mathematics in order to raise student achievement. The Moroccan school is under pressure to improve learning results in fields that are in high demand, including science and mathematics. The purpose of this investigation was to assess GeoGebra's potential impact on trigonometric function instruction and learning. Second, however radian has frequently been described as a challenging notion for students, very few research has examined the efficacy of utilizing ICT in their teaching and learning.

The current education system has undergone remarkable improvement and development thanks to the pedagogical integration of ICT into the activities of both teachers and learners. Promoting the integration of technology to improve the quality of education, especially in the methodological

approach to education as a whole, as well as in the skills targeted and the teaching methods used. when ICT is integrated to promote teaching, the effect is simple, but when ICT is integrated to promote learning, the effect is significant. This already makes it possible to qualify the effect of integrating ICT between teaching and learning. The use of new technologies for learning and teaching is nowadays a necessary condition for enabling learners and teachers to be more successful in the educational context, and more broadly, in the knowledge society to which we belong.

Declaration by Authors

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