THE IMPACT OF SELF-PACED GEOGEBRA ACTIVITIES ON STUDENTS' UNDERSTANDING OF CORRELATION ANALYSIS IN SENIOR HIGH SCHOOL

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***ABSTRACT*: *Enhancing students' proficiency in mathematics is imperative for their academic advancement. GeoGebra, an advanced digital tool, has demonstrated considerable efficacy as a pedagogical asset in mathematics education. This study investigated the impact of self-directed learning modules utilizing GeoGebra on students' mastery of correlation analysis within the context of the subject "Inquiries, Investigation, and Immersion." The findings revealed a statistically significant enhancement in pretest and posttest scores among students employing GeoGebra, as opposed to those who did not, with a T-test yielding a p-value of .000. These results suggest that GeoGebra's dynamic and visual capabilities facilitate a deeper comprehension of mathematical concepts, streamline complex tasks, and significantly improve mathematical performance. Despite these promising findings, additional research is warranted to explore how variables such as learning styles, prior knowledge, and instructional quality influence these outcomes. This will inform the development of more sophisticated methodologies for integrating GeoGebra and similar technologies into educational practices.*

Keywords: Geogebra, Supplementary learning activities, correlation analysis

INTRODUCTION

The research underscores the pivotal role of technology in augmenting educational outcomes by enhancing academic performance, motivation, and student engagement. Harris [5] provides empirical evidence that the integration of emerging technologies within classroom environments exerts a substantial influence on students' academic performance and motivational levels. Wieking [11] posits that a strategic deployment of technology can significantly elevate both engagement and motivation. Contemporary studies further corroborate the effectiveness of self-directed online learning modalities. For instance, Yang and Wu [12] elucidate the beneficial effects of digital storytelling on academic performance, critical thinking, and learner motivation, while Means et al. [7] delineate effective strategies for optimizing online learning experiences. Additionally, Sung et al. [10] elucidate the advantages of digital game-based and collaborative learning methodologies, and Ma and Lee [6] investigate the transformative potential of online self-paced learning within the context of higher education. Chen et al. [3] further validate these findings by analyzing the positive correlations between technology integration and enhancements in learner motivation and academic performance.

Collectively, these studies emphasize the significant potential and effectiveness of integrating technology and online self-paced learning activities within modern educational frameworks. Research highlights that tools like GeoGebra play a crucial role in advancing mathematics education across various levels and contexts. Empirical studies demonstrate that the incorporation of GeoGebra into instructional practices enhances student performance, deepens understanding, and fosters positive attitudes toward mathematics [1, 2, 4].

Their findings underscore the advantages of integrating GeoGebra and other technological tools into contemporary mathematics education to enhance student outcomes. GeoGebra, in particular, has proven to be a versatile tool that can improve performance, understanding, and attitudes toward mathematics in diverse educational settings. In response to these challenges, educators have increasingly adopted online interactive digital tools as supplementary learning resources to support student learning. This study focuses on the implementation of such tools in an Inquiries, Investigation, and Immersion class for grade 12 students at Nicaan High School. Specifically, it evaluates the effectiveness of using GeoGebra as both an intervention and assessment tool to enhance students' comprehension of correlation analysis, a sophisticated statistical technique.

A pretest-posttest design was employed to assess students' performance and understanding of the lesson on correlation analysis. GeoGebra, a free digital tool, was selected for its interactive capabilities in teaching mathematics and science. By evaluating the effectiveness of this digital tool, the research contributes to the ongoing efforts to address challenges in online learning and to enhance student outcomes during the pandemic and beyond.

FRAMEWORK

GeoGebra, as a supplementary tool, aligns with Jean Piaget's Constructivist Learning Theory [9] by promoting hands-on exploration, facilitating cognitive development, fostering cognitive conflict resolution, and encouraging the co-construction of knowledge through collaborative learning experiences. Its dynamic, multi-representational features empower students to connect new concepts with prior knowledge, enhance their understanding, and actively engage in the learning process.

MATERIAL AND METHODS

The researchers implemented an intervention in the subject *Investigation, Inquiries, and Immersion* utilizing the interactive digital tool GeoGebra. Student performance was evaluated using a pretest-posttest design adapted and modified from Phelps and Brzezinski [8], which demonstrated a split-half reliability coefficient of 0.816, indicating good internal consistency among the test items. The effectiveness of the intervention was assessed by comparing the pretest and posttest results using a t-test to determine if there was a statistically significant difference in performance between the two groups.

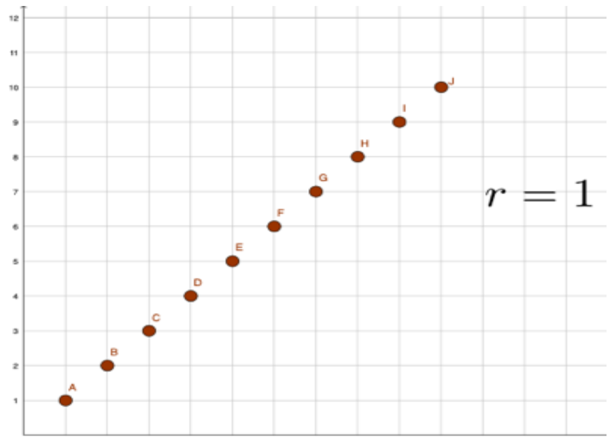

Figure 1. Modified assessment from Phelps and Brzezinski [8]

The activity offers an interactive approach to comprehending correlation coefficients (r) within a geometric framework.

Q1: Modifying the position of point A alters the slope of the regression line, thereby affecting (r). This demonstrates the sensitivity of the correlation coefficient to variations in data points.

Q2: To achieve the maximum correlation coefficient, arrange the points linearly. This configuration yields an extreme (r) value of either +1 or -1, depending on the orientation of the line.

Q3: To minimize (r), position the points symmetrically around the origin. This arrangement results in a minimal correlation coefficient due to the symmetrical distribution of points.

Q4: When points are arranged in a circular pattern, (r) approaches 0. The radius of the circle does not influence (r), as the symmetry of the circular pattern negates any linear correlation.

Q5: Arranging points in a "V" shape yields a negative correlation ($r < 0$). The breadth of the "V" affects the strength of the correlation, with wider "V" shapes corresponding to a lower (r).

Q6: Positioning points along a straight horizontal line results in a maximized positive correlation ($r = +1$).

Q7: A "U" shape configuration induces a positive correlation($r > 0$), analogous to the "V" shape but with reversed values. Expanding the "U" shape decreases the correlation coefficient.

Q8: Arranging points in a square results in no correlation ($r=0$). The size of the square does not impact (r) due to the lack of a linear relationship.

Q9: The correlation coefficient (r) is defined as a measure of the linear relationship between two variables.

RESULTS AND DISCUSSION

In the experimental group, 29 respondents (96.7%) accurately recognized that altering the position of a data point influences the correlation coefficient and underscores the sensitivity of **r** to variations in data points (Q1). This contrasts with 24 respondents (80%) in the control group, who relied solely on calculators for their computations.

For Q2, all respondents (100%) in both the experimental and control groups correctly determined that a positively sloped straight line represents the optimal configuration for maximizing ***r***, where ***r***=+1, indicating that the linear alignment of data points results in a perfect correlationcocient of r=1.0. This demonstrates a comprehensive understanding among all students that a perfectly linear arrangement of observations corresponds to the maximum possible value of the correlation coefficient.

For Q6, which asked, "Place these points on a horizontal line. What is the value of r when the points are positioned linearly?", it is noteworthy that 29 respondents (96.7%) in the experimental group reached the correct conclusion, while none from the control group succeeded. Although there were attempts made by the control group students, none arrived at the correct answer.

For Q9, which asked respondents to define the correlation coefficient **r** based on their experience with the activity, 26 participants (86.7%) in the experimental group provided a robust and accurate definition. In contrast, no respondents in the control group attempted to answer the question.

This demonstrates that utilizing online tools like GeoGebra for solving and exploring exercises in computing significantly accelerates students' computational processes.

This confirms that GeoGebra allows users to visualize data points on a scatter plot, which makes it easier to understand the relationship between two variables. The interactive nature of GeoGebra enables users to adjust data points and immediately see the effect on the correlation coefficient.

GeoGebra can also automatically compute the Pearson correlation coefficient once the data is inputted. This saves time and reduces the risk of calculation errors, making it a convenient tool for quick statistical analysis.

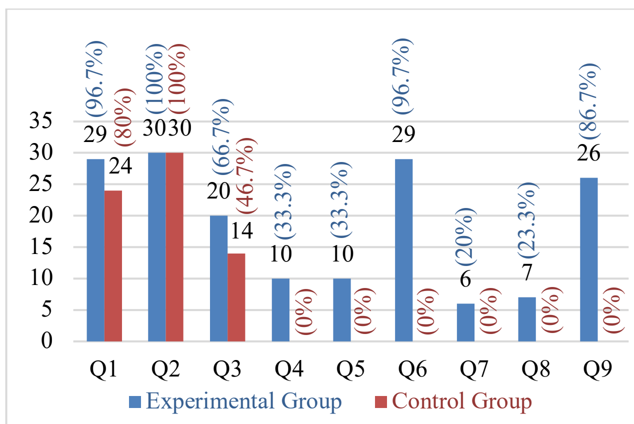

Figure 2. Frequency and percentage distributions forQ1-Q9.

The T-test analysis between the control and experimental groups, who used GeoGebra, revealed a significant difference in both the pretest and posttest scores, with $p<.000$. This indicated that the experimental group using GeoGebra outperformed the control group in terms of their mean scores, suggesting that the GeoGebra tool enhanced their problem-solving and conceptual understanding.

The results are in line with previous studies that emphasize the positive impact of technology integration in education. This finding suggests that the strategic use of tools like GeoGebra in mathematics instruction can result in more engaging and effective learning experiences for students, ultimately leading to improved learning outcomes and a better grasp of mathematical concepts. As previous research highlights, technology integration can have numerous benefits for students, including increased motivation and engagement [11], as well as improved academic achievement [3, 13].

Moreover, this study adds to the body of evidence that supports the value of utilizing technology tools like GeoGebra in mathematics instruction, with a potentially positive impact on student learning outcomes (See Tables 1 and 2 and Figures 1 and 2).

Table 1. T-test on students' pretest and posttest scores between two groups

Variables	Mean	SD	p
Control Group (n=30)			
Pretest	5.70	1.15	
Posttest	6.40	0.77	.000
Experimental Group (n=30)			
Pretest	4.73	1.21	
Posttest	6.86	0.67	.000

*a=0.05

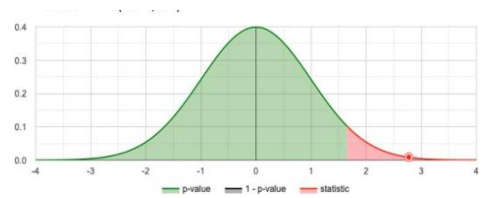

Figure 3. Shapiro-Wilk test on the gain scores of the control group

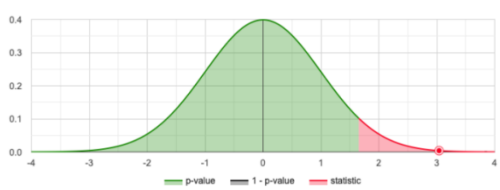

Figure 4. Shapiro-Wilk test on gain scores of The experimental group

Table 2. T-test results on gain scores between groups

Variables	Mean	SD	p
Control Group (n=30)	0.63	1.24	.000
Experimental Group (n=30)	2.33	1.06	

**a=0.05*

The findings suggest that students exposed to GeoGebra manipulation demonstrated noticeably higher scores on the post-test compared to the control group. This outcome further supports the notion that incorporating new technology in educational settings has a considerable impact on students' performance and motivation[5]. Supporting these findings, Chu[4] found that integrating GeoGebra into mathematics education led to enhanced performance in analytical geometry for high school students. Moreover, Abu-Elwan[1] reported improved mathematics achievement and attitudes among university students when GeoGebra was used in their learning. Together, these studies provide evidence that incorporating GeoGebra into mathematics education can significantly affect students' motivation, engagement[11], and overall academic achievement[3, 13].

CONCLUSION

The Geogebra software provides dynamic graphing capabilities, which means that if data points are adjusted, the graph and the correlation coefficient will update in real time. This is particularly useful for teaching and understanding how correlation works, as it allows users to experiment with different data sets and see how changes affect the correlation.

GeoGebra's intuitive interface makes it accessible even to those with limited experience in statistical software. The drag-and-drop features, along with simple input methods, make data entry and analysis straightforward.

The significant difference in pretest-posttest scores between the experimental and control groups suggests that GeoGebra could significantly impact learning outcomes when utilized in supplementary activities as it highlights the potential advantages of incorporating technology-based tools like GeoGebra in mathematics education and tackling problems regarding the time-consuming nature of solving complex problems. GeoGebra's interactive and visual approach to mathematics may contribute to improved understanding and engagement of learners. Integrating such resources can enhance students' learning experiences and provide them with more efficient means of solving complex mathematical problems. However, these preliminary results should be interpreted with caution until further research substantiates their significance. Future studies ought to consider additional influencing factors and employ larger sample sizes to bolster the reliability and generalizability of the findings.

REFERENCES

[1] Abu-Elwan, R. (2016). Using GeoGebra in teaching and learning mathematics at university level: Students' achievement and attitudes. *International Journal of Mathematical Education in Science and Technology*, 47(2),266-277.https://doi.org/10.1080/ 0020739X.2015.1067016

[2] Bütün, O. (2017). The effects of geogebra-aided instruction on sixth grade students' achievement in the topic of "circle". *Balkan Journalof Interdisciplinary Research*, 3(1), 1-10. https://doi.org/10.15228/bjir.v3i1.149

[3] Chen, C. H., Wang, C. Y., & Lin, H. Y. (2019). Analyzing the efficacy of online self-paced learning by examining learners' motivation and academic performance. *Australasian Journal of Educational Technology*, 35(4). https://doi.org/10.14742/ajet.4269

[4] Chu, H. (2015). Effectiveness of GeoGebra-aided teaching on Taiwanese tenth graders' performance in analytical geometry. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(2), 327-344.

[5] Harris, Jennifer L. (2016). One to One Technology and its

Effect on Student Academic Achievement and Motivation. *Contemporary Educational Technology.*

[6] Ma, X., & Lee, S. H. (2019). Online self-paced learning: Outcomes and implications for teaching and learning practice in higher education. *International Journal of Educational Technology in Higher Education*, 16(1), 4. https://doi.org/10.1186/s41239-018-0129-3

[7] Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, 'K. (2010). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. U.S. Department of Education, Officeof Planning, Evaluation, and Policy Development.

[8] Phelps, S., & Brzezinski, T. (2017). Correlation exploration [GeoGebra activity]. https://www.geogebra.org/m/w5q22bzu?cv=1

[9] Piaget, J. (1952). The origins of intelligence in children. *International Universities Press*.

[10] Sung, H. Y., Hwang, G. J., & Chen, C. H. (2014). The effects of digital game-based learning and collaborative learning on learners' scientific concept learning and motivation in a blended learning environment. *International Journal of Educational Technology in Higher Education*,11(1),11-27. https://doi.org/10.7234/IJETHE.11.2014.02

[11]Wieking, B.A. (2016). Technology integration and student learning motivation(Master's thesis, Northwestern College, Orange City, IA). Retrievedfrom http://nwcommons.nwciowa.edu/education_masters/5

[12] Yang, J. C., & Wu, Y. T. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers & Education*, 59(1), 339-352. https://doi.org/10.1016/j.compedu.2011.12.002

[13] Donato,E.&Paleta L.(2024). Enhancing student's correlation analysis skills with online calculators in a blended learning environment. Sci-Int. (Lahore) 36(4),453-456.