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# Effect Of Using Dynamic Graphical Utilities On Students' Achievements And Attitudes To Enhance Mathematics Teaching And Learning At The Elementary Level In Pakistan: Enhancing And Impeding Factors

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## Abstract

Utilizing and integrating technology into teaching practices has become a necessity at all levels to develop students' cognitive in mathematics. This research is a mixed method research to identify differences in the mean scores of teaching with Desmos and GeoGebra graphic utilities with intervention and with no intervention on student's achievement and attitudes to enhance mathematics teaching and learning at the elementary level in Pakistan. Also, to discover the enhancing and impeding factors of using graphical tools in mathematics classrooms by applying a survey questionnaire and asked open-ended questions to obtain information from the participants regarding the factors for using Desmos and Gebgra in Pakistani schools. The findings present that the inclusion of graphical tools in teaching and learning process effected the students understanding positively and significantly. Result showed that pretest and post-test of the experimental group does not imply a significant difference, since the interest shown by the students in using the said dynamic graphical soft wares.

**Keywords:** Desmos, GeoGebra, grade 7, Mathematics, Pakistan, Experimental Design

## Introduction

Nowadays, everybody has digital devices to use for teaching and learning. In any occasion, we can see adults, children, man or woman bring cell phones, tabs, laptops, in their hands and seemed inseparable. In this 21st century, teaching and learning environment cannot be separated from the use of technology (Guggemos, & Seufert, 2021) as it is a basic tool for education. This phenomenon, somehow, challenges the teachers to integrate technology into their teaching to empower students' interest and focus, enhance the classroom environment and overall students' learning experience. That is why this research aimed to identify the effect of Desmos and GeoGebra tools on student's achievement and attitudes at the elementary level for private schools in Pakistan. Also, to determine the enhancing and impeding factors of using the graphical tools in mathematics classrooms and for the purpose, students' and teachers perceptions and experience towards the use of

graphical smart tools were taken. The study was conducted at a private school of Lahore, Pakistan. Over the two decades, teachers and students have access to number of smart tools for teaching and learning mathematics particularly. However, not every teachers integrate technology into their teaching. Good and quality teaching for mathematics mainly depends on the way it is taught and learned (Li, Schoenfeld, 2019). Desmos and GeoGebra are online graphical calculators that are freely available and accessible for everyone. These tools facilitate students to comprehend the concepts conceptually will lead towards students to think and reason more mathematically. Pakistani students face many difficulties in conceptualizing many math concepts. They face problems in understanding, recalling and retaining concepts in mathematics particularly (Ali, 2011). Moreover, in Pakistan, teachers usually fail to instill and nurture critical abilities in students in the subject of math. The use of web-based applications help to reduce learning loss in understanding the content of the subject conceptually.

In our education system, mathematics is a tough subject for teachers and students respectively. Teacher's role in this regard is crucial for implementing the instructional practices for the subject while its effectiveness is measured through the performance of students. To add more, technology positively effects the classroom environment. GeoGebra and Desmos are freely accessible graphical tools and used specifically created to be used for mathematics learning for all types of students.

Technology can play its effective role in teaching and learning the subject to develop conceptual development and even more effective when technology creates interactive classroom environment to successfully complete tasks. According to Huang et, al., 2012, graphical techniques could highly support students' solving processes. Technology concerns about students' understanding of math concepts with graphical web-based tools. Desmos and GeoGebra were used to help students make better link between math concepts and graphical illustrations.

These are used as math practice at different levels and are one of the more popular online graphing utilities. These web-based graphical utilities are available as a website and as an app. Desmos and GeoGebra are a similar online graphing utilities that have many extra options with the ability to plot, solve for a parameter, and explore, calculus, trigonometry, linear algebra and solves equations with intermediate explanations that provide practical information about the topic. Another app 'Symbolab' that gives a user-friendly online graphing utility that shares very similar functionality to Desmos and GeoGebra. Since, there are many practice problems on it, which allow them to practice in different areas such as algebra and calculus. Considerable research on various math topics investigated the effect of using the utilities on different levels of education and assessed the overall performance and attitudes in classroom, learning skills, and students' hand-held written graph-work to measure their conceptual understanding, visualization, problem-solving skills, and reasoning.

In past few decades, these tools have had a broad Impact. The National Council of Mathematics Teachers in 1980 suggested that the students at all levels take advantage of these web-based tools in learning the subject with time, teachers have improved their teaching styles to enhance students learning and designed such activities that help to explore and visualize math concepts. Thus, activities, achievements and their attitudes have changed in today's technological world. Hence, long, time taking and complicated graphical representations can be conceptualized using technology in classroom. The ways that students produce and report graphical analysis can be affected by technology. The main concern of teaching-learning math is to create and develop concept-related images in the minds of students.

For this purpose, graphical soft wares are the best tools that enable them to understand the concept by doing on the screen to support cognitive skills. Through the graphical soft wares, students can draw dynamically as a result different insight graphs of a topics evoke in a meaningful way (Khalil, Farooq, Çakıroğlu, Khalil, & Khan, 2018). Thus, these concept-developmental tools are to formalize the concepts to engage students in the learning process. Technology enhances students' learning as they can discover and construct cognition of different concepts. Utilizing technology in education improves the exploratory potential, abilities and skills of students. For example, using web-based graphing calculators allow them to explore how various functions behave.

The existing research explored the effect of technology based and hand held graphing calculators, 'Desmos and GeoGebra' on students' understanding and organization of paper-pencil work as it relates to their conceptual understanding in the presence of technology is presented.

## Hypothesis

There is a positive relationship between the learning graphs using desmos and GeoGebra tools and the results obtained on the manual way of creating graphs.

## Objectives

- To identify differences in the mean scores of teaching with Desmos and GeoGebra graphical utilities with intervention and with no intervention on student's mathematics achievement and attitudes at the elementary level in Pakistan.
- To identify the effect of Desmos and GeoGebra tools on student's achievement and attitudes at the elementary level in Pakistan.
- To determine the enhancing and impeding factors of using graphical tools in mathematics classrooms at the private schools of Pakistan.

## Research Questions:

- How does dynamic graphical tools effect on students' performance and their attitudes in the mathematics classroom?
- What are the factors that enhance and impede while using dynamic graphical tools of mathematics in Pakistani classrooms?
- How do mathematics students of grade 7 observe enhancing and impeding factors in Pakistani schools?
- What are the impediments of using the desmos and GeoGebra at the elementary level for students in Pakistani classrooms?

## Attitude Terminology

According to Heddy, Danielson, Sinatra, & Graham, (2017), in the context at hand, the terminology 'attitude' can be referred to as perceived behavioral control predict the intention to use technology-related content in instruction. Therefore, attitudes toward technology-mediated teaching implied to as positive evaluation of teaching with digital technologies.

## Achievement Terminology

According to Good, (1973, P-7), achievement means, "Knowledge attained or skills developed in the school subjects usually designed by test scores assigned by teachers"

## Desmos & GeoGebra

GeoGebra is free and multi-platform dynamic software for teaching-learning math (Ramadhani, & Narpila, 2018) whereas Desmos is an innovative and modern online graphing calculator (https://teacher.desmos.com/). Math requires cognitive process that further needs

proper systematic strategy. In mathematics, cognitive process focusses solely on intellectual with no emotional components and places the students and social context in the learning process. Both these graphical soft wares are free, very intuitive and easy to use as students can draw graphs of circles, equation of a line, inequalities and relations. They can use colors and colors are easy to change. These educational soft wares runs in any browser such as Google chrome and students can save their work. Desmos is higher quality, full-featured, 21st century math software as also, offers combination of geometry and algebra up to calculus using sliders with click and drag option created by 'Desmos' (Desmos, 2017). Whereas in GeoGebra, everything is treated geometrical, algebraically and automatically measured https://tube.geogebra.org/ (Sharing area).

## Research Related to GeoGebra and Desmos Aided Instruction

In this technological era, everyone is having technology and various smart tools have been developed being used to support teaching and learning. Features of Desmos and GeoGebra are offering dynamic learning environment, as these are very simple and straightforward in usage. In one study of Erbas and Yenmez (2011) revealed that there is a highly significant effect in achievement, interest and motivation in learning geometry and showed effective result in retention.

Likewise, (Cakir, & Yildirim, 2013) selected pre-service teachers and observed their positive attitude towards integrating technology in classroom setting and resulted in that their positive attitudes are major cause of permanence of knowledge. Wassie, Y., & Zergaw, G., (2019) observed performance groups for treatment whose performance was lower in comparison to the control group whose performance was higher. They showed that results were effective and distinguished of the treatment group using graphical tools along with positive attitude towards learning. To add more, the students on their own activities also achieved the geometrical progression through stages as teachers used Desmos and GeoGebra for teaching mathematics. Considerable research has assessed the effectiveness of using graphing calculators on students' achievement on various mathematical topics. Harvey (1993) collected data from fifty-five schools by comparing the mean scores in pre-calculus test using graphing calculators. Out of which 22 schools considered as control groups and were taught by conventional ways. The remaining schools were taken as treatment and were taught using graphing calculators. The findings of the study revealed that there were significantly positive improvement in the treatment schools on the mean scores over the control groups.

## Methodology

### Participants

As recommended by Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood, (2015), purposive sampling is a useful technique for the implementation of mixed method research and provides useful information to achieve study objectives. Population for the research comprised of all the private schools of Punjab, Pakistan. Thirty students were chosen purposively from a private school in Lahore, Pakistan for the pre-experimental study and out of them 3 students and 2 teachers were taken for the semi-structured interview, constituted the sample of the study. Study has been carried out with a sample of 30 students of grade 7 from 12 to 14 years old for the evaluation of the graphical calculators in math for the treatment group. None of these students had not used the graphical soft wares before. Hence, it is the first time that the treatment group faced the smart tools for drawing graphs in math classroom. It is also descriptive since the intention is also to know their experiences and

opinions on the graphical tools they used in the study. Once the results of the intervention achieved from the participants of the study by the teacher, an interview data was collected from the experiences of the treatment group. The data enabled us to immediately detect possible gaps in the knowledge of content. To clarify the graphs that has been properly learnt by the students, a thinking process based on the analysis of findings is crucial in order to clear doubts. The data analysis obtained from the semi-structured interview enabled the discussion to discover the effect of the graphical tools on students' learning achievement and attitudes in math during the academic year 2022-2023. Two instruments were used to explore the effectiveness of Desmos and GeoGebra on students' learning achievement and their perceptions on the use of the smart tools. A semi-structured interview seeking open-ended answers was administered for the study and the pretest for the intervention was made by the teacher to commensurate the improvement of their performance due to the implementation of the intervention. The participants' experiences were discussed under each question. All six participants were interviewed within the duration of 15 minutes on average.

## Pre-Experimental Design

The existing study focuses on achievement and attitudes of respondents by comparing pretest and posttest of the intervention group, where the tests are multiple choice type items and involved 30 math students. The questions used in the pre-test and post were conceptual based and involved on the conceptual understanding of mathematical graph topics. The experimental group has taken the pre-test to measure their learning prior to the implementation of Desmos and GeoGebra. The post-test was administered after to see the differences of their conceptual understanding of the topics being evaluated. During the analysis, paired sample t-test was administered to compare the significant differences between the pre-test and post-test of the experimental group.

## Achievement test

The mathematics teacher administered the achievement test as an instrument of the study. There were ten questions, designed by the coordinator of the math subject. The topics on the achievement test were graphs of horizontal and vertical line, gradient of a straight line, transformation of a graph, linear and quadratic equations, solving simultaneous equations graphically and its applications in real-world contexts using Desmos and geoGebra apps. Students had more opportunities to use graphing calculators 'Desmos and GeoGebra' for answers. However, ten questions were graphing calculator neutral, and that could be answered with or without graphing calculators.

## Results and Discussion

It was found that the group who involved free software using desmos and geogebra in their teaching and learning pretest and post-test scores were used to measure students' Math learning acquisition.

| Kolmogorov-Smirnov | | | |
|---|---|---|---|
| | Statistics | df | Sig. |
| Pre Test – Experimental Group | .081 | 30 | .200* |
| Post Test – Experimental Group | .103 | 30 | .200* |

*. This is a lower bound of the true significance.

***Test of Normality***

It is evident from the table of normality test for the data that the value of the Kolmogorov–Smirnov Test (KS) is > 0.05, therefore, the data is normal.

The tables below showed that the comparison between the pre and post-tests of the experimental groups. In these tables,

N = 30 → Total No. of students
M = Means
SD = standard deviation
Df → degrees of freedom
t-value → the difference of means
Level of significance is 5%, (0.05)

| | Mean | N | SD | Std. Error Mean |
|---|---|---|---|---|
| Pre Test Experimental Group | 57.33 | 30 | 11.018 | 2.012 |
| Post Test Experimental Group | 76.53 | 30 | 13.390 | 2.445 |

**Paired Samples Statistics**

The table above represents descriptive statistical data of students' comparative score in mean and standard deviation. The two places of the test were pre-test and post-test while in between researcher had given treatment to the students. The result of both the tests were calculated through SPSS ver. 25 which provided that the mean score of the pre-test was 57.33 and the result of post-test was 76.53 among 30 students. The standard deviation was 11.018 for the pre-test and 13.390 for the post-test. The standard error mean was 2.012 for pre-test and 2.445 for the post-test. The results stated that intervention might affect the students' achievement with reference to technological-mediated instruction. The table below represents that the mean score paired difference is 19.200 with a SD of 15.176. It has a standard error mean of 2.771 while with 0.05 confidence interval it has a paired difference of -24.867.

**Paired Differences**

| | | | | 95% Confidence Interval of the Difference | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Std. Error Mean | Lower | Upper | T | df | Sig. (2-tailed) |
| Pre Test Experimental Group | -- | 15.176 | 2.771 | -24.867 | -13.533 | -- | 29 | .000 |
| Post Test Experimental Group | 19.200 | | | | | 6.930 | | |

**Paired Samples Test**

Thus, the difference between the pre-test and post-test scores is significant at (29) degrees of freedom (df) at 5% alpha. The two-tailed significant level is 0.000 < 0.05 which is a significant value for paired sample test. Again, by the rules of quantitative analysis, if p-value < 0.05 the results are not statistically significant, as shown. Overall result confirms that intervention has a positive and significant effect on participants' achievement and attitudes. Use of

graphical smart tools significantly improved their mathematics learning from the pre-test scores to the post-test marks.

## Semi-Structured Interview – Analysis & Results

For the purpose of anonymity of respondents of the present study, the interviews were given codes as student1, student2, student3 respectively for grade 7 students and teacher1 and teacher2 for teachers. The responses of participants and their analysis are given below.

**Qs1. What are the factors to consider that influence or enhance technology-mediated instruction using Desmos & GeoGebra in mathematics classroom at grade 7 level?**

**Teacher1:** I would say that most students felt that technology usage in math classroom was motivating and engaging with the content. Albeit the use of these smart graphical tools, the coursework was completed at a fast and accelerated pace.

### What strategies can be more enhancing within the math classroom for the learners?

As a teacher, I experienced that learning graphs with smart tools improves interaction between students and teacher. We are able to track students' learning easily and in an organized way. According to the needs of the students, these apps solve problems to draw graphs and fully support individual needs of the student. Moreover, these are meaningful educational graphical soft wares to develop conceptual understanding and fluency in the topic.

**Teacher2:** These tools are very convenient learning platforms as these are easily accessible and available in schools that increases motivation. Students learn with conceptual and full understanding with the use of soft wares. However, without these soft wares it takes a lot of time in teaching graphs to students with pen and paper approach for sketching graphs and visualizing concepts.

I also observed that the students were able to better access, learn and practice the topics and they were interested in doing so. I agreed that the use of these apps, of course, increases effective teaching and learning in the classroom.

### Qs2. What are main impediments for implementing this kind of instruction?

**Teacher1:** There are insufficient technical support that may cause us to be less confident about technology-mediated instruction. With this, I mean, smart boards, computer access for every student of the class with smooth internet facility, as there are plethora of additional technology for teaching in a math classroom. To add more, attitudes of teachers and students especially for teaching-learning math to use technology is hesitant.

### Qs3. Do you recommend continuing this kind of technology-mediated instruction? Give one reason.

**Teacher1:** Yes, I recommend continuing these smart tools in math classroom and teachers must continue to innovate and fully embrace technology. Teachers should participate in training of such smart tools in classroom they seem to unable to describe the content based technological knowledge.

**Teacher2:** I would strongly recommend these productive and educational tools; however, school policies should provide suffice amenities, devices and equipment to all students and should support technological integration.

These will definitely be the strongest factor for enhancing math learning. Schools must provide the relevant resources, materials and fast internet facility.

### Teachers' perception – Qualitative Data Analysis

Thus, teachers should consider maximum learning benefits of technological integration in math classroom particularly for overall achievement. With time, they should increase their technological pedagogical content knowledge. Teachers much consider teacher-learner interaction, track learning process and keep records with new trends and advancing professional teaching-learning goals according to the needs of the student. School should also provide teachers with the resources to support and encourage them to increase their confidence to use technology in math classroom and to interact with other teachers.

### Qs1. How do these graphical free soft wares enhance or influence your learning performance and attitude?

**Student1:** We found these smart graphical apps free and easy to use as these are web-based soft wares. These tools help us to understand the math concepts better.

**Student2:** These soft wares are easy to understand, learn and explore as these web-based apps are designed based on simplicity. These smart apps improves communication during the lesson.

**Student3:** Math is a tough subject and especially drawing graphs have always been complicated and difficult topic for us. However, Desmos and GeoGebra offer self-paced learning and more importantly, it produces low stress. It takes much time in conceptualizing and understanding graphs with pen-paper approach. We can access, learn and practice the graphs better. I agreed that the use of these apps is really interesting.

### Qs2. What are some common impediments that make Desmos and GeoGebra possible in the math classroom?

**Student1:** One student said that there should be proper opportunities and resources of using graphing calculators.

**Student2:** Internet facilities must be available all the time to easily browse the data related to mathematics topics.

**Student3:** Some students in math classroom said to the teacher that there should be training courses to teach and learn with these tools.

### Students' Perception – Qualitative Data Analysis

Students found these smart graphical calculators easy to use, explore and learn as these are freely available web-based soft wares. These tools fully support conceptual understanding of the mathematical content. Technically speaking, these graphical apps are consistent with the learning theories as well and can be suitable to use as a part of math curriculum. Teaching and learning with Desmos and GeoGebra help teachers to choose suitable applications for drawing and graphing effectively.

Impeding and enhancement factors for Desmos and GeoGebra mediated instruction and learning are shown in figures below.

***Desmos & GeoGebra Enhanced Learning Platform***



***Impediments implementing GeoGebra & Desmos-Mediated Learning***

## Discussion & Conclusion

The first section addresses pre experimental method for the implementation of technology in math classrooms with students of grade 7. The second data source was a semi-structured interview, which was administered to three students and two teachers that consisted of five open-ended questions. Out of which three questions were shared with the math teachers and two questions with the students. The perceptions of students and teachers about the use of technology-mediated instruction with Desmos and GeoGebra in math classroom at school were documented. ICT tools and techniques are to facilitate students' learning and results declared that the use of Desmos and GeoGebra were found very useful for students' better learning at the elementary level. Teachers were suggested to know how to deliver smoothly and teach smartly with these digital graphical tools in mathematics classroom. The use of graphical apps as educational technology is to support students in their studies and teachers in their profession. Results from analysis revealed that the students could use Desmos, GeoGebra in future as tools to solve math problems easily with complete, and conceptual understanding in less time that they could not solve before. Students perform better if they use these hand-held calculators. The findings from the study demonstrated that math students who used Desmos and GeoGebra to draw and sketch graphs had a better understanding of x and y intercept, equation of horizontal and vertical lines, solving simultaneous equations graphically and finding the point of intersection of linear and quadratic equations. The performance of students using graphical calculators was better than the students without using Desmos and GeoGebra. The students who were taught with free graphical software were able to make a better connection between mathematics topics and their real-world applications. Whereas, the results of the qualitative analysis showed that their experience of using technology in math classroom improved their understanding and in less time, they understand more. All teachers and students recommended continuing the use of the smart approaches for dissemination of mathematical content in the classroom. All participants agreed on usage of these graphic calculators as these had a positive effect on academic achievement and attitudes of students. These smart tools are the fast media and are the effective way to disseminate information and knowledge of the content as technology has a great potential for disseminating math education.

## References


1. Digital Technology, (2018). National Academies of Sciences, Engineering, and Medicine. How People Learn II: Learners, Contexts, and Cultures. Washington, DC: The National Academies Press. https://doi.org/10.17226/24783.
2. Ali, T. (2011). Exploring students' learning difficulties in secondary mathematics classroom in Gilgit-Baltistan and teachers' effort to help students overcome these difficulties. Bulletin of Education and Research, 33(1), 47-69.
3. Cakir, R., & Yildirim, S. (2013). ICT Teachers' Professional Growth Viewed in terms of Perceptions about Teaching and Competencies. Journal of Information Technology Education: Innovations in Practice. 12. 221-237. 10.28945/1889.
4. Desmos, (2017). Desmos user guide: variables and sliders. Retrieved online from https://desmos.s3.amazonaws.com/Desmos_User_Guide.pdf in 14.08.2017.
5. doi.org/10.1016/j.chb.2020.106613

6. Erbas, A. K., & Yenmez, A. A. (2011). The effect of inquiry-based explorations in a dynamic geometry environment on sixth grade students' achievements in polygons. Computers & Education, 57(4), 2462–2475. https://doi.org/10.1016/j.compedu.2011.07.002
7. Good. (1973). Dictionary of education. New York: McGraw Hill Book Company. New York. P. 7, 267.
8. Guggemos, J., Seufert, S., (2021). Teaching with and teaching about technology – Evidence for professional development of in-service teachers. Computers in Human Behavior. 115-0747-5632
9. Harvey, J. G., Ed., Mathematical Association of America Placement Test Newsletter; v1-9 1978-87. Washington, D.C. (p-148).
10. Heddy, B. C., Danielson, R. W., Sinatra, G. M., & Graham, J. (2017). Modifying knowledge, emotions, and attitudes regarding genetically modified foods. The Journal of Experimental Education, 85(3), 513–533. https://doi.org/10.1080/00220973.2016.1260523
11. Khalil, M., Farooq, R. A., Çakıroğlu, E., Khalil, U., & Khan, D. M. (2018). The Development of Mathematical Achievement in Analytic Geometry of Grade-12 Students through GeoGebra Activities. Eurasia Journal of Mathematics, Science and Technology Education, 14(4), 1453-1463. https://doi.org/10.29333/ejmste/83681
12. Li, Y., Schoenfeld, A.H., (2019). Problematizing teaching and learning mathematics as “given” in STEM education. IJ STEM Ed 6, 44. https://doi.org/10.1186/s40594-019-0197-9
13. National Council of Teachers of Mathematics (NCTM) (1980). An agenda for action. Reston, VA: National Council of Teachers of Mathematics.
14. Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. Administration and policy in mental health, 42(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y
15. Ramadhani, R., & Narpila, S.D., (2018). Problem based learning method with geogebra in mathematical learning. International Journal of Engineering and Technology. 7. 774-777.
16. Wassie, Y., & Zergaw, G., (2019). Some of the Potential Affordances, Challenges and Limitations of Using GeoGebra in Mathematics Education. Eurasia Journal of Mathematics, Science and Technology Education. 15. 10.29333/ejmste/108436.

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