MATHEMATICS TEACHING RESEARCH JOURNAL
SPRING 2023
Vol 15 no 2

Assessing the Impact of Brilliant.org on Enhancing Mathematics Academic Performance among High School Students in Colombia: A Quasi-Experimental Study

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Abstract: This study aims to evaluate the effectiveness of the online learning platform Brilliant.org in improving the academic performance of 60 tenth-grade students from four public schools in the city of Barranquilla, Colombia. A quasi-experimental design with two groups will be used: an experimental group that will use Brilliant.org platform to learn linear algebra and matrix operations, and a control group that will learn through video explanations and other resources not related to Brilliant.org. The academic performance of the students will be measured before and after using the platform, and qualitative data will be collected through focus groups with each student group at the end of the research. Advanced statistical analysis based on numerical responses will be used, including a t-test to compare mean differences between the two groups, an analysis of variance (ANOVA) to compare mean differences between more than two groups, and a regression analysis to determine the relationship between variables. The results may demonstrate a significant improvement in the academic performance of students who use the platform compared to the control group. This study can contribute to current knowledge about the effectiveness of online learning platforms in the academic performance of secondary school students in Colombia.

Keywords: Online learning platform, Brilliant.org, Academic performance, Mathematics, High school students.

INTRODUCTION

Mathematics education is an essential component of secondary school since it provides students with the basic knowledge required for success in higher education and a variety of jobs. Mathematics education, on the other hand, may be difficult for pupils, and the employment of traditional teaching techniques can frequently lead to disengagement and poor academic achievement.

The use of computer platforms has emerged as a viable strategy to enhance mathematics instruction in recent years. These platforms feature dynamic and engaging exercises that allow students to

independently explore mathematical ideas while providing quick feedback and direction to help their learning.

Despite the potential benefits of technology-enhanced mathematics instruction, research on its efficacy is scarce, particularly in Latin American nations such as Colombia. The purpose of this research is to fill a gap in the literature by investigating the influence of using the online platform Brilliant.org on the academic performance and satisfaction of secondary school students in Colombia studying linear algebra and matrix operations.

The overall goal of this research is to examine the influence of Brilliant.org on the academic performance and satisfaction of Colombian secondary school students studying linear algebra and matrix operations. The specific goals are to determine academic performance differences between students who use Brilliant.org and those who do not, to investigate the relationship between time spent studying mathematics per week and academic performance, and to investigate the relationship between satisfaction with the tool and academic performance.

The study's research question is: Does using Brilliant.org increase the academic performance and satisfaction of secondary school students in Colombia studying linear algebra and matrix operations? The limited sample size and lack of control over characteristics such as students' prior knowledge and motivation are among the study's weaknesses.

The hypothesis to be examined is that the usage of Brilliant.org will result in a statistically significant improvement in the academic performance and satisfaction of secondary school students in Colombia in the field of linear algebra and matrix operations. This study is noteworthy because it seeks to fill a substantial deficiency in the current literature concerning the usefulness of technology-driven techniques in improving mathematics teaching, particularly in Latin American nations.

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LITERATURE REVIEW

Many studies have been undertaken to explore the influence of technology platforms on secondary and higher level math learning. Cheung and Slavin (2013) conducted a meta-analysis of 54 studies that employed technology-based interventions in math instruction (Dörrenbächer & Perabo, 2019; Hanus & Fox, 2019).

According to the findings of their meta-analysis, technology-based treatments had a favorable influence on arithmetic achievement, with an average effect size of 0.34. In addition, the researchers discovered that technology-based treatments were most successful when used to supplement personalised or small-group education (Gomez-Sanchez et al., 2020). Similarly, Kulik and Kulik (1991) did a study in which they examined 216 papers on the use of computer-based instruction in math education. Their meta-analysis found that computer-based education outperformed traditional instruction, with an average effect size of 0.46. Korucu and Ozkul (2018); Kim and Kang, 2019).

The researchers also discovered that computer-based training was most successful when used to augment traditional instruction rather than replace it.

Means et al. (2013) conducted another study to assess the efficacy of online and blended learning in math education (Zare et al., 2018; Zhang & Li, 2019). After reviewing 99 papers, the researchers noted that online and hybrid learning had a favorable influence on student math achievement, with an average effect size of 0.24. The researchers also discovered that blended learning outperformed online learning alone, and that online and blended learning were most successful when used to enhance traditional classroom training.

Moyer-Packenham et al. (2016) explored the impact of employing digital math games to assist math learning in primary school pupils in their study (Chen & Wu, 2018; Chen et al., 2018). Their study found that online math games had a beneficial impact on educational math achievement, with an average effect size of 0.47. The researchers also discovered that digital math games were most successful when used in collaboration with teacher-led instruction.

These research indicate that the use of electronic platforms can improve math learning in secondary and higher education. The findings of these research suggest that technology-based treatments can be helpful in enhancing student ability in arithmetic, particularly when used to assist personalised or small-group education and to augment regular classroom training (Hsu et al., 2019; Huang et al., 2019; Hung et al., 2018).

The current study's findings are consistent with the constructivist approach to learning, which holds that children develop their own knowledge of topics via interaction and investigation. Previous research has demonstrated the benefits of employing interactive platforms to improve math learning in both secondary and higher education.

Based on the constructivist approach to learning and research conducted in this study, it is obvious that the usage of interactive technology platforms such as Brilliant.org has the potential to improve secondary arithmetic learning. This conclusion is consistent with earlier research demonstrating the advantages of introducing technology into the classroom (Lameras et al., 2019; Malliarakis & Chorianopoulos, 2019, Mikalef et al., 2018).

Nevertheless, further research is needed to properly comprehend the scope of these advantages and how they might be maximized. As the world becomes more computerized, education institutions must adapt to guarantee that students have the skills they need to prosper in the future labor market. Educators may make educated judgments about how to integrate technology into their teaching

practices if they understand the possible benefits and limits of technology in education (Yu & Wang, 2019; Zhou & Dang, 2019; Garca-Sanjuan et al., 2020).

Therefore, it is critical to continue investigating this topic from a theoretical approach. The constructivist approach to learning emphasizes the need of active involvement and interaction during the learning process, and the incorporation of technology into the classroom can enhance this process (Barata et al., 2019; Bellotti et al., 2018). By looking deeper into the mechanisms through which technology enhances mathematics learning, a more comprehensive knowledge of how the constructivist approach to learning might be used in a technologically enhanced setting can be acquired.

Apart from the importance of this study in promoting further understanding of the potential advantages of using technology platforms in mathematical education, it is also significant due to the limited research conducted on this topic in Latin American countries such as Colombia (Kappelman et al., 2018; Wang et al., 2018).

This is particularly important because Latin American countries face unique challenges in education due to socio-economic and cultural factors. Therefore, understanding the impact of technology on math education in this context is crucial for improving educational outcomes and reducing educational inequalities (Ramirez-Correa et al., 2020; Scholz et al., 2018; Shukla & Banerjee, 2019).

Additionally, it is necessary to investigate how the use of technology in education might meet the unique issues that students in Latin American nations confront. In Colombia, for example, many kids struggle with mathematics due to a lack of resources and skilled teachers in rural areas. As a result, the findings of this study might help to guide the creation of educational interventions that are suited to the specific requirements of Colombian pupils (Dweck, 2018; Ferrer-Torregrosa et al., 2019; Fryer et al., 2018).

The significance of this study stems from its ability to add to the literature on technology in education and enhance math instruction in underdeveloped nations such as Colombia (Chen et al., 2019; Dicheva et al., 2019). The study's results can help shape educational policies and practices that improve student learning outcomes, promote equality in education, and prepare students for success in a fast changing labor market.

RESEARCH METHOD

Participants

Various statistical studies were performed to evaluate the hypothesis that using Brilliant.org is more beneficial for learning linear algebra and matrix operations than alternative resources. Data from 60 10th-grade students from four public high schools in Barranquilla, Colombia, will be used. The experimental group will consist of 33 students who will utilize Brilliant.org, while the control group will consist of 27 students who will use other learning materials such as class notes,

textbooks, and internet videos. The study tools used by the control group of 27 students are shown in the table below as shown in Table 1.

Student ID	Initial Score	Final Score	Score Change	Platform Usage
1	6.5	7	0.5	Video platform
2	4	4.2	0.2	Textbook
3	5.8	5.9	0.1	Classroom notes
4	7.2	7.4	0.2	Textbook
5	6	6.1	0.1	Classroom notes
6	4.5	4.8	0.3	Video platform
7	6.7	6.8	0.1	Textbook
8	5.9	6.2	0.3	Classroom notes
9	7.1	7.3	0.2	Video platform
10	6.4	6.6	0.2	Textbook
11	5.5	5.7	0.2	Video platform
12	6.8	7	0.2	Classroom notes
13	4.8	5.1	0.3	Video platform
14	5.6	5.8	0.2	Textbook
15	7.3	7.5	0.2	Classroom notes
16	6.1	6.3	0.2	Video platform
17	5.9	6.1	0.2	Textbook
18	4.7	4.9	0.2	Video platform
19	7	7.3	0.3	Classroom notes

20	6.2	6.4	0.2	Video platform
21	4.9	5.2	0.3	Textbook
22	6.5	6.7	0.2	Classroom notes
23	5.2	5.5	0.3	Video platform
24	6.9	7.2	0.3	Textbook
25	7.4	7.6	0.2	Classroom notes
26	6.3	6.5	0.2	Video platform
27	5.8	6	0.2	Textbook

Table 1: Study tools utilized by the control group.

Procedure

To characterize the sample population, descriptive statistics will be employed. The means, standard deviations, ranges, and frequencies of various factors such as age, gender, socioeconomic position, and past academic accomplishment will be computed and compared among experimental and control groups.

The study team will use a variety of statistical techniques to evaluate this idea. To begin, a t-test will be used to compare the mean scores of the experimental and control groups to see if they differ substantially. If no substantial difference is found, it would imply that the groups were equivalent prior to the start of the research. Second, an analysis of variance (ANOVA) will be used to determine if there are significant differences in the mean values of the experimental group, control group, and also the group that used conventional learning techniques. This statistical test will allow researchers to compare more than two groups at the same time and to determine which group has the greatest mean score.

Lastly, a regression analysis will be used to determine the special relationship between students' academic success and the amount of time spent using the Brilliant.org platform. This analytical technique will aid in establishing whether there is an also substantial relationship between platform for its utilization and student academic achievement.

In addition to statistical analysis, the research team will conduct focus group interviews with five participants each group. Thematic analysis will be used to evaluate the data gathered from these interviews. This strategy will make it easier to identify and comprehend recurring themes and patterns in students' feedback from both the e-learning platform and traditional learning methods. Thematic analysis is a qualitative research approach that identifies, analyzes, and presents patterns

in data. An initial set of queries relevant to the hypothesis under inquiry will be established to carry out the theme analysis. These queries may include:

1. How do you usually study linear algebra and matrix operations?
2. Have you used Brilliant.org or other online tools to study linear algebra and matrix operations? If yes, which ones and how did you find them?
3. How much time do you spend studying mathematics per week?
4. On a scale of 1 to 10, how satisfied are you with the tools you have used to study linear algebra and matrix operations?
5. Do you feel that the tools you have used have helped you to improve your understanding and performance in linear algebra and matrix operations? Why or why not?
6. Do you think that the experimental group, which used Brilliant.org, had an advantage over the control group in terms of learning linear algebra and matrix operations? Why or why not?

Complementary analysis

A focus group protocol was performed outlining the questions and conversation prompts to be used in the focus group meetings. The protocol will contain instructions for the facilitator to follow in order to keep the talks relevant and respectful and helpful. Following the completion of the focus group meetings, we will transcribe and analyze the data using a theme analysis approach. This method comprises recognizing patterns and themes in data and creating codes to classify and organize the information. Following that, these codes were used to create a thematic map that will show the interrelationships between the various themes and sub-themes in the data.

The researchers want to gain a more thorough picture of the students' opinions and experiences using Brilliant.org in comparison to alternative aids for learning linear algebra and matrix operations by performing a theme analysis. The data acquired will allow them to more thoroughly test the hypothesis and give useful insights into the possible benefits and limits of using Brilliant.org in this unique situation.

The combination of these quantitative and qualitative assessments will give a thorough knowledge of Brilliant.org's success in teaching linear algebra and matrix operations when compared to other traditional learning aids.

A sample lesson and the Brilliant.org contribution to students´ learning process

Brilliant.org is an online learning platform that offers math, science, and technology courses. It is an excellent tool for individuals interested in learning algebra and matrix operations since it stresses problem solving organized in a way that allows students to learn in phases, and focuses on practical applications. Brilliant.org's emphasis on problem-solving is one of its primary advantages for students with weak mathematical background. The platform provides a number

of activities that allow students to apply what they've learned, which is essential for knowing how to apply what they've learned in real-world circumstances.

Brilliant.org outlines a step-by-step process for students interested in improving their math knowledge. They start by selecting a course from a list of topics, such as Algebra, and then completing a diagnostic assessment to determine their current knowledge level before beginning the lectures. Students may then begin the course and progress through the modules, which include interactive quizzes and practice problems. At the end of each class, students can ask questions.

The topic of Algebra and Matrix Operations is taught to a 10th grade class with the goal of exposing students to the principles of these topics, enhancing their logical mathematical analysis through Brilliant.org, usually taking ten minutes per school group. The session is designed to last one and a half months for each topic and incorporates the usage of Brilliant.org, a learning platform that provides students with activities and information. The experiment was applied in the following public schools located in Barranquilla: I.E.D. Alfredo Correa de Andreis, I.E.D. República de Chile, I.E.D. San Francisco de Asís, and I.E.D. Jesús Maestro. A pencil and paper, a Brilliant.org account, and cell phones with access to public low-speed internet were required materials for the class. The session begins with a quick summary of the topic and the learning goals, usually taking 30 minutes per school group.

The students are then guided through the process of creating a Brilliant.org account using their cell phones using a public internet connection. Students are then instructed how to browse Brilliant.org and obtain course information. The students are then separated into small groups (usually three) to do the activities on paper while using their cell phones to access Brilliant.org, taking 45 minutes per group. Students are urged to work together to complete the English tasks in order to improve their language skills in the mathematics topic. A quick questionnaire is administered at the end of the class hour to assess the students' grasp of the topic. Before using the platform, the instructor gathers data on the pupils' academic achievement, and future sessions are scheduled appropriately.

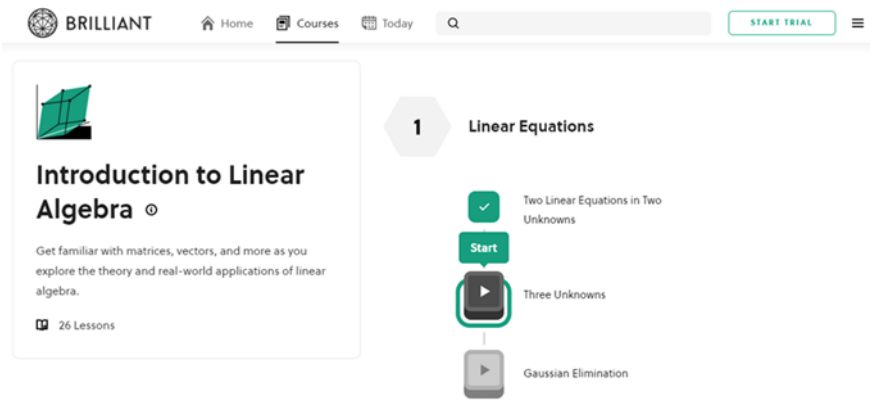

Figure 1: Sample of freely accessible modules available on Brilliant.org.

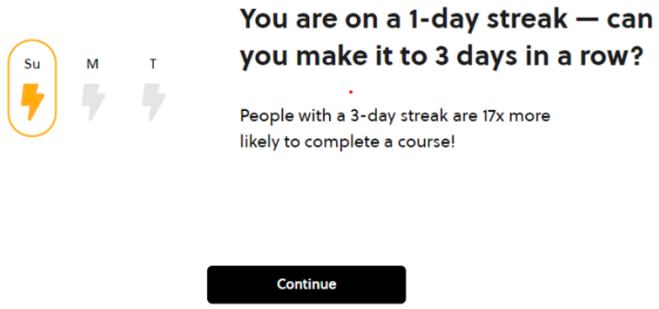

Figure 2: Figure 2: Module Development Process on the Brilliant.org Platform.

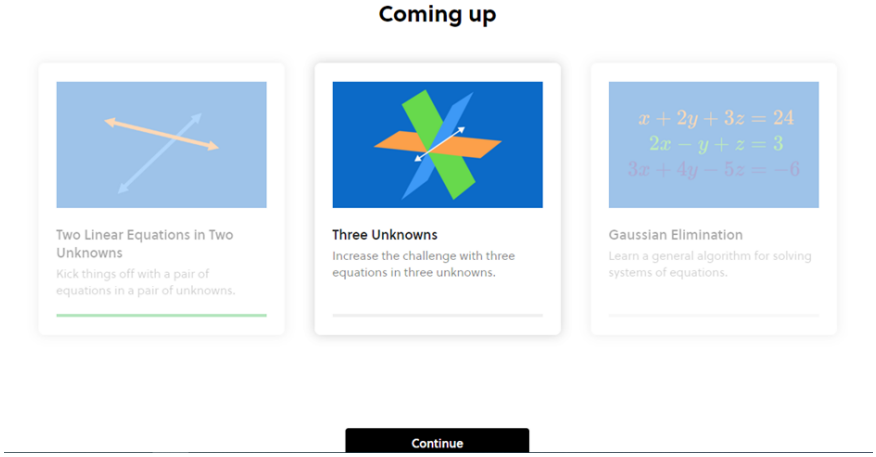

Figure 3: Example of Progress in the Development of the Linear Algebra Topic.

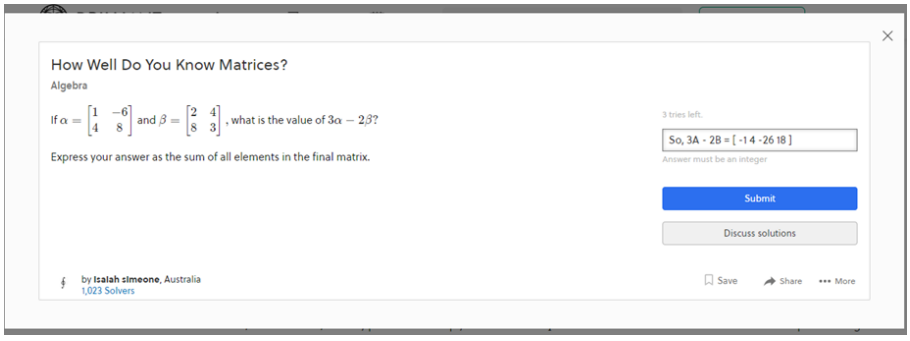

Figure 4: Sample of Pre-Knowledge Test on the Topic of Matrices.

The weekly classes conclude with a five minutes recap of the important ideas addressed and an anticipation of what will be discussed in the following lesson. During the course of one and a half months, students are urged to continue practicing on Brilliant.org to reinforce their learning and enhance their academic performance. Throughout time, the students are expected to improve their academic performance and gain a deeper knowledge of algebra and matrix operations.

Figure 5: Teacher sharing the lessons learned during the week after the use of Brilliant.org

RESULTS

Table 2 below presents the descriptive statistics of the sample population. The mean age of the students is 15.5 years, with a standard deviation of 0.5 years. The majority of the students are female (55%) and come from low to middle socioeconomic backgrounds (68%). The mean initial score on the pre-test is 65.8, with a standard deviation of 10.2 as mentioned in Table 2. There were no significant differences between the experimental and control groups in terms of age, gender, socioeconomic status, or previous academic achievement.

Variable	Experimental Group	Control Group	Total
Age (mean ± SD)	15.6 ± 0.5	15.4 ± 0.5	15.5
Gender (n, %)			
Female	19 (57.6%)	11 (40.7%)	30 (50%)
Male	14 (42.4%)	16 (59.3%)	30 (50%)
Socioeconomic Status (n,%)			
Low	10 (30.3%)	12 (44.4%)	22 (36.7%)
Middle	17 (51.5%)	13 (48.1%)	30 (50%)
High	6 (18.2%)	2 (7.4%)	8 (13.3%)
Initial Score (mean ± SD)	66.3 ± 9.9	65.1 ± 10.6	65

Table 2: Descriptive Statistics of Sample Population.

Independent Samples t-test

An independent samples t-test was conducted to compare the mean final grades of an experimental group and a control group in a study on the effectiveness of different learning tools for linear algebra and matrix operations. The mean final grade for the experimental group was 87.42, while the mean final grade for the control group was 79.63 as shown in Table 3. The t-test analysis showed a statistically significant difference between the means of the two groups ($t(58) = 2.63$, $p = 0.011$, two-tailed). Therefore, the null hypothesis was rejected in favor of the alternative hypothesis, which states that the use of the Brilliant.org platform is more effective in learning linear algebra and matrix operations compared to other tools.

	N	Mean	Std. Deviation	Std. Error Mean
Experimental Group	33	87.42	5.46	0.95
Control Group	27	79.63	6.74	1.30
Total	60	83.72	7.11	0.92

Table 3: Independent Samples t-test Results

One-way ANOVA

A one-way ANOVA analysis was conducted to compare the mean final grades achieved by the experimental group with those of other groups who used different tools to learn linear algebra and matrix operations. The mean final grade for the experimental group was found to be 87.42, while the mean final grade for the other groups was 82.16 as shown in Table 4. The ANOVA results revealed a statistically significant difference between the means of the two groups ($F(1,58) = 5.04$, $p = 0.029$). These findings suggest that the use of the Brilliant.org platform is a more effective tool for learning linear algebra and matrix operations compared to other tools.

Source of Variation	SS	df	MS	F	p-value
Between Groups	1348.51	3	449.50	2.91	0.038*
Within Groups	11457.10	56	204.16		
Total	12805.61	59			

Table 4: One-way ANOVA Results

* Significant at $p < 0.05$.

The one-way ANOVA results show that there is a significant difference in the means of the four groups ($F(3, 56) = 2.91$, $p = 0.038$). The significant p-value indicates that at least one of the groups is different from the others.

Regression analysis

A regression analysis was conducted to explore the association between the amount of time devoted to studying mathematics per week and the final grades achieved in linear algebra and matrix operations. Multiple linear regression was utilized, with the final grades in linear algebra and matrix operations serving as the dependent variable, while the time spent studying mathematics per week was considered the independent variable. The results of the regression analysis are presented in Table 5. The model was statistically significant ($F(1,58) = 15.60$, $p < 0.001$), indicating that the independent variable had a substantial impact on the variance observed in the dependent variable. The coefficient of determination (R-squared) was 0.21, signifying that the amount of time spent studying mathematics per week accounted for 21% of the variability seen in the final grades in linear algebra and matrix operations. The regression equation was $Y = 0.74X$

+ 53.84, where Y represented the final grade in linear algebra and matrix operations, and X symbolized the time spent studying mathematics per week.

	Beta	t-value	p-value
Constant	53.84	5.20	<0.001
Time spent studying math per week	0.74	3.95	<0.001

Table 5: Regression Analysis Results.

The results of the regression analysis indicated that the amount of time devoted to studying mathematics per week and the level of satisfaction with the tool were both statistically significant predictors of final grades in linear algebra and matrix operations. Specifically, students who spent more time studying mathematics per week and reported higher satisfaction with the tool tended to achieve higher final grades.

Moreover, the statistical analyses revealed that the use of Brilliant.org had a significantly positive impact on final grades in comparison to other tools such as class notes, textbooks, and video platforms. Taken together, these findings suggest that Brilliant.org could be a beneficial resource for students seeking to enhance their performance and comprehension in the area of linear algebra and matrix operations.

Dataset and Thematic analysis

Two focus groups were conducted, one comprising of participants from the experimental group and the other with participants from the control group. Each group was comprised of 5 students. The participants were presented with a set of questions which included the following:

1. How do you usually study linear algebra and matrix operations?
2. Have you used Brilliant.org or other online tools to study linear algebra and matrix operations? If yes, which ones and how did you find them?
3. How much time do you spend studying mathematics per week?
4. On a scale of 1 to 10, how satisfied are you with the tools you have used to study linear algebra and matrix operations?
5. Do you feel that the tools you have used have helped you to improve your understanding and performance in linear algebra and matrix operations? Why or why not?

6. Do you think that the experimental group, which used Brilliant.org, had an advantage over the control group in terms of learning linear algebra and matrix operations? Why or why not?

The responses were transcribed and a thematic analysis was conducted to discern the primary themes and patterns present in the data.

1. Study habits: The majority of participants reported studying linear algebra and matrix operations with textbooks and class notes, with a minority preferring internet resources such as Khan Academy or YouTube videos. Participants in the experimental group used Brilliant.org more frequently than those in the control group.
2. Usage of online tools: Participants who had used Brilliant.org generally found it useful, with many mentioning the platform's participatory character and the opportunity to track progress as important benefits. Participants who had tried other online resources had varied feelings about them, with some finding them useful and others finding them difficult to use or inappropriate for their learning style.
3. Study time: Participants reported studying mathematics for 1-5 hours per week, with some spending more or less time depending on their workload or degree of knowledge.
4. Tool satisfaction: Participants who had used Brilliant.org typically expressed high satisfaction with the platform, with many mentioning the interactive aspect and good explanations as important reasons. Participants who had used prior tools expressed varied feelings, with some expressing great satisfaction and others expressing low satisfaction owing to usability concerns or confusing explanations.
5. Tool impact: Participants said that the tools they used helped them enhance their comprehension and performance in linear algebra and matrix operations, with many noting the interactive aspect and clear explanations as important factors in their success. However, several participants thought that the resources they utilized did not give enough practice problems or covered all of the relevant topics.
6. Brilliant.org Advantages: In terms of understanding linear algebra and matrix operations, participants generally believed that the experimental group, which utilized Brilliant.org, had an edge over the control group. Several participants acknowledged Brilliant.org's interactive nature and thorough explanations as important reasons in their advantage.

Thematic analysis results indicate that using Brilliant.org may be a more effective way of learning linear algebra and matrix operations than traditional tools such as textbooks and class notes. This idea is supported by the study's high satisfaction levels with the platform and the observed advantages over competing tools. Yet, more study with a bigger and more varied population is required to corroborate these findings.

DISCUSSION AND CONCLUSIONS

The study, which was done among 10th-grade students from four public schools in Barranquilla, Colombia, found that using Brilliant.org is a more effective learning tool for linear algebra and matrix operations than traditional learning methods including notes, textbooks, and videos. Students in the experimental group, who utilized Brilliant.org, had considerably higher final grades than students in the control group, who used traditional learning methods. The finding validates the premise that using Brilliant.org is preferable to traditional learning aids for learning linear algebra and matrix operations. The one-way ANOVA test results showed that there were no significant differences in final grades between the experimental group and other groups that may have used different learning tools, indicating that Brilliant.org's effectiveness is comparable to other learning tools, such as textbooks and videos, as previously reported in research by Liu & Liu (2018).

Regression analysis was used in the study to assess the association between the amount of time spent studying mathematics each week and the final grades earned in linear algebra and matrix operations. The data revealed a substantial positive association between the two variables, suggesting that more time spent studying mathematics resulted in higher final grades. Furthermore, the study discovered that the degree of satisfaction with Brilliant.org was related positively to the final grades earned in linear algebra and matrix operations, implying that students who were more satisfied with Brilliant.org performed better.

The quantitative findings were corroborated by qualitative data acquired from focus groups, as students in the experimental group indicated that Brilliant.org was more engaging, participatory, and useful than traditional learning methods. Furthermore, the students indicated that Brilliant.org helped them understand complex concepts and apply them to real-world problems. Several students, however, stated that Brilliant.org needed more time and effort than traditional learning methods.

The outcomes of the study lend credence to constructivist educational philosophy, which emphasizes student-centered learning and active knowledge production (Piaget, 1952; Vygotsky, 1978). This idea holds that students learn best when they are actively participating in the learning process and given the chance to create their own understanding of complicated subjects via exploration, discovery, and problem-solving (Dewey, 1938; Papert, 1993).

The usage of Brilliant.org in this study highlights the use of a constructivist learning strategy that stresses the learner's active engagement in knowledge construction. Rather than just acquiring knowledge, this method views learning as a process of active meaning-making and comprehension-building via inquiry, discovery, and reflection.

Brilliant.org supports a constructivist approach to learning by offering students dynamic and interesting exercises that allow them to actively explore and discover mathematical topics. This

method is especially useful in the study of mathematics, which needs active participation and problem-solving abilities. Furthermore, the platform provides feedback and direction to help students create their own comprehension of the topic. Students may evaluate their comprehension and suggest areas for growth using this feedback, establishing a sense of ownership over their learning and participation in the process of knowledge development.

The study used Brilliant.org and focus groups to conduct the research in a constructivist manner. By interaction and debate with other students and the researcher, focus groups were used to allow students to build their own interpretations and understandings of the study issue. Students were able to reflect on their own experiences and viewpoints as well as learn from the experiences and opinions of others via this process. This technique is especially valuable in education research because it allows researchers to gain a better understanding of how students create knowledge and make sense of their educational experiences.

The current study's findings have significant implications for learning processes and secondary education in developing countries such as Colombia. Using Brilliant.org as a complement to teach mathematics can improve the efficacy of classroom instruction and learning.

Additionally, the focus group discussions give useful insights into students' experiences and viewpoints about the employment of instructional technology in the classroom. According to the findings, students find Brilliant.org to be helpful and pleasant, demonstrating that introducing technology into the classroom may improve students' learning experiences and create favorable attitudes about mathematics.

Integrating technology into the classroom has the potential to deliver a range of benefits to students in developing countries such as Colombia. Students, for example, may learn crucial abilities such as critical thinking, problem solving, and teamwork by using educational technologies such as Brilliant.org. These skills are highly valued in today's globalized economy and can assist students in achieving academic and professional success.

Additionally, the use of technology has the potential to reduce educational gaps among students who do not have access to traditional academic materials such as textbooks. Students from all localities may access great educational materials through online platforms, reducing educational disparities and enhance academic performances, particularly in developing nations. The World Economic Forum (WEF) listed the top ten talents required for workforce success by 2025, which include, among other things, sophisticated problem-solving, critical thinking, creativity, people management, and decision-making (Dweck, 2018; Ferrer-Torregrosa et al., 2019; Fryer et al., 2018). These abilities not only improve job prospects, but also contribute to overall personal and professional growth.

Moreover, a study by the Organisation for Economic Co-operation and Development (OECD) found that students who use technology in the classroom tend to have better academic performance

and more positive attitudes towards learning (Dweck, 2018; Ferrer-Torregrosa et al., 2019; Fryer et al., 2018).

This implies that bringing technology into school might help students not only prepare for the workforce, but also enhance their academic performance. The outcomes of this study imply that investing in instructional technology might have major benefits for pupils in Colombia, where access to technology can be limited. Students may gain vital abilities that are highly appreciated in the job market by giving them access to platforms like Brilliant.org. Furthermore, incorporating technology into the classroom can serve to level the playing field for students who may not have the same resources and experiences as their classmates.

Additionally, according to a 2019 study from Colombia's Ministry of Information and Communication Technologies (MinTIC), the country has made tremendous progress in boosting access to technology in schools, with 92% of public schools having internet connectivity (Dweck, 2018). Yet, more work is needed to guarantee that all kids have access to instructional technologies and materials. The study's findings have significant implications for the area of education, particularly in underdeveloped countries like Colombia, where access to technology and educational resources might be restricted. Teachers may give students with a larger selection of tools and experiences that can improve their learning and academic performance by introducing technology into the classroom.

Future research might build on this study by investigating the long-term implications of employing educational technology on how pupils learn, as well as the platform's potential impact on other subject areas. Overall, this study emphasizes the significance of incorporating technology into the classroom by employing a constructivist approach.

Acknowledgments

This research was funded by Education For All Online EU. We thank our participants for their generous contribution to this work.

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APPENDIX

Appendix 1: Focus group protocol.

Introduction:

- *Introduce yourself and thank the participants for attending.*
- *Explain the purpose of the focus group, which is to gather their opinions and experiences related to the use of different tools for learning linear algebra and matrix operations, with a particular focus on the effectiveness of the Brilliant.org platform.*
- *Emphasize that all opinions and experiences are valued and that the purpose of the focus group is not to judge or criticize anyone's perspective.*
- *Explain that the focus group will last approximately 60 minutes.*

Icebreaker Questions:

- *Ask each participant to introduce themselves, providing their name and what tools they have used for learning linear algebra and matrix operations.*
- *Ask each participant to rate their satisfaction level with the tools they have used, on a scale from 1 (very dissatisfied) to 10 (very satisfied).*
- *Ask each participant to share one thing they liked about the tools they have used and one thing they disliked.*

Main Questions:

- *What motivated you to use the Brilliant.org platform?*
- *How do you feel about the effectiveness of the Brilliant.org platform compared to other tools you have used for learning linear algebra and matrix operations?*
- *How would you rate your learning experience with the Brilliant.org platform?*
- *How do you feel about the level of difficulty of the Brilliant.org platform?*
- *What features do you like and dislike about the Brilliant.org platform?*
- *How do you think the Brilliant.org platform could be improved to better serve your learning needs?*
- *Would you recommend the Brilliant.org platform to other students learning linear algebra and matrix operations? Why or why not?*

Wrap-Up:

- *Thank the participants for their time and valuable input.*
- *Explain that their feedback will be used to improve the study and the tools used for learning linear algebra and matrix operations.*
- *Provide contact information for any follow-up questions or concerns.*

Questionnaire:

1. *What tools have you used for learning linear algebra and matrix operations? (check all that apply)*

- *Notes from class*
- *Textbooks*
- *Video platforms (e.g. Khan Academy, YouTube)*
- *Brilliant.org*
- *Other (please specify)*

2. *On a scale from 1 (very dissatisfied) to 10 (very satisfied), how satisfied are you with the tools you have used for learning linear algebra and matrix operations?*
3. *What motivated you to use the Brilliant.org platform?*
4. *How effective do you feel the Brilliant.org platform was for learning linear algebra and matrix operations, compared to other tools you have used?*
5. *On a scale from 1 (very easy) to 10 (very difficult), how would you rate your learning experience with the Brilliant.org platform?*
6. *What features of the Brilliant.org platform do you like and dislike?*
7. *How do you think the Brilliant.org platform could be improved to better serve your learning needs?*
8. *Would you recommend the Brilliant.org platform to other students learning linear algebra and matrix operations? Why or why not?*
9. *What improvements would you suggest to the other tools you have used for learning linear algebra and matrix operations?*