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Utilization of Adapted Cartesian Plane for Visually-Impaired Students

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Abstract *– This study aims to utilize an adapted Cartesian Plane to teach mathematics topics to visually-impaired students. Utilizing a quasi-experimental design, this research employed a purposive sampling technique. Visually-impaired students in the mainstream served as the subjects of the study. Hypotheses of no significant relationship between the profile of the respondents and their performance in Mathematics; no significant difference between the performance of the respondents in their pretest and posttest; and no significant effect of using Adapted Cartesian Plane to the subjects of the study were tested. The following conclusions were drawn after the analysis: there is no significant relationship between the profile of the respondents and their performance in Mathematics except in terms of their age; there is a significant difference between the pretest and posttest of the respondents; and the degree of effect of using Adapted Cartesian Plane in delivering Mathematics lessons to visually-impaired students is large.*

Keywords *– Adapted Cartesian Plane, Mainstream, Visually-Impaired Students, Mathematics*

INTRODUCTION

Tactile materials are essential tools in the teaching-learning process for visually-impaired learners. Lack of these materials is a severe obstacle for visually-impaired students at all levels of those learners who are schooling today. Based on World Health Organization's report (2019), about 2.2 billion people are suffering from vision impairment or blindness across the globe in which about 45% of them could have been saved, or has yet to be given treatment. Among these cases, cataracts lead the cause of blindness in developing countries. In the Philippines, the Magna Carta for Disabled Persons stipulated the same rights of disabled persons as other people to take place in the society. Similarly, the K-12 curriculum to provide quality education for Filipinos, to equip individuals, to be globally competitive, to develop individuals holistically, and to develop skills and ability to pace to lift us to another country or its development. Republic Act 10533 stated that there are seven learning areas under the core curriculum. These are Languages, Literature, Communication, Mathematics, Philosophy, Natural Sciences, and Arts. Mathematics is challenging for some students; fear in this subject happens when a person has to answer real-life applications; this is observable even from the sighted ones. Most of the math problems require several steps before conclusion. There are strategies, and practical techniques teachers can use to assist students' comprehension about their meaningful learning. It is a tough subject for sighted learners, but how much more for the visually-impaired?

Learning strategies vary by subject matters, learning styles of students, instruction styles, among others. Most strategies flow across subjects and techniques, while others fit for one particular area of study (Entwistle, 2013).

This research is concerned with developing competencies such as the addition and subtraction of integers, plotting of points, and graphing linear equations and its applications. The Graphing of linear equation includes skills like plotting of points in the Cartesian coordinate plane, identifying the slope of a line, x-intercept and y-intercept, and many others. K-12 curriculum aims that learners with visual impairment shall be allowed to be included in the mainstream. However, teachers find difficulties in teaching visually-impaired learners with different intellectual variabilities, competencies, and interests, especially in a regular classroom setting. This situation calls for teachers to create lessons adapted for the blind. As educators, the researchers were motivated to conduct this research on utilizing adapted Cartesian plane in teaching Mathematics.

OBJECTIVES OF THE STUDY

To help the visually-impaired students enrolled in the mainstream learn some lessons about Cartesian Plane by the use of the tool which they can touch for effective teaching-learning process, to prove the

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effectiveness of Adapted Cartesian Plane made by Resources for the Blinds, Inc. by identifying the degree of effect in utilizing the tool in the performance of the respondents in Mathematics before and after the intervention.

MATERIALS AND METHODS

This research used the quasi-experimental design, and purposive sampling was employed. Visually-impaired students enrolled in public schools in the Fourth Congressional District of Laguna are the respondents of the study. The materials used in the study were; Adapted Cartesian Plane with pins, questionnaires, set of braille with rubber bands. Mathematics teachers of the school where the researchers teach validated the questionnaires. The study is quantitative research design. The competencies in the questionnaires are addition and subtraction of integers, plotting/locating of points, the slope of a line, quadrilaterals, and distance between two points, which are included in the K-12 curriculum. Mean and standard deviation were used to determine the level of performance of the visually-impaired and their classification. At the same time, a paired t-test was employed to calculate the significant difference in the mean scores of pretest and posttests. Spearman Rho was used to determine the significant relationship between the respondents' profile and their performance in Mathematics. The data were collected, tabulated, analyzed, and interpreted.

Research Design

A Quasi-experimental design was used in the study. White, H., & Sabarwal, S. (2014) stated that this design identifies a comparison group that is similar as possible to the intervention group with respect to the pre-intervention characteristics. In contrast to the true experimental design, quasi-experimental design lacks randomization. However, in a situation like the present study, the use of purposive sampling is more advantageous than probabilistic sampling.

Participants/Respondents

Visually-impaired learners enrolled in selected secondary public schools in the Fourth Congressional District of Laguna were the respondents of the study. Specifically, three respondents from the District of Cavinti, one respondent from the District of Sta. Cruz and one respondent from the District of Paete. Purposive sampling technique was employed since there are only a few visually-impaired students included in the mainstream.

Instrumentation

Questionnaires were used explicitly used; pretest to tell the performance of the blinds before the utilization of adapted Cartesian plane, and posttest was used to determine the changes in their performances after the Adapted Cartesian Plane was utilized. Mathematics teachers of the school where the researchers are assigned validated the questionnaires, and was approved by the experts. Adapted Cartesian Plane was used as an intervention. It is a tool made by the Resources for the Blinds, Inc. It is a three-dimensional printed tool having x-axis, y-axis, quadrants one to four. Pins are inserted in the holes in the plane that represents the coordinates of a point. Braille writing slate and Braille writing paper were used to record the answers of the respondents in their pretest and posttest.

Data Collection Procedure

A preliminary survey was conducted at different schools to determine the available number of respondents. Permission to do the study was asked from the Division Office of Laguna, from their parents/guardians, from the principal of the school where these students are enrolled, the researchers personally distributed letters of request to respondents together with the questionnaire checklist and examination. The principal gave a schedule for the researchers to conduct the study; the pretest was administered, lectures using Adapted Cartesian Plane were presented, followed by assessments. Finally, the posttest was answered in the last session. The Resources for the Blinds, Inc. granted their permission to use the tool during the research conduct. Mathematics teachers of One Secondary School in Laguna validated the questionnaires. Addition and subtraction of integers, plotting, and locating coordinates of points, the slope of a line, quadrilaterals, and distance between two points are the competencies presented. The respondents use the x-axis as a number line for addition and subtraction of integers, the tool as a whole for plotting and locating coordinates of points using the pins inserted to its holes. The slope of a line was taught by counting how many times the pin rises and moves to the right or left towards the second pin. Quadrilaterals were taught by connecting the pins by rubber bands that represent the sides of the polygon mentioned.

Finally, the distance between two points was taught by counting the distance between two pins

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manually and using distance formula if the line is diagonal. Each respondent was instructed with four topics for within a week. The pretest and posttest were given on the first day, and the last day of the sessions respectively. Quizzes were administered after every lecture. The researcher read the questions, and the respondents wrote their answer on a Braille paper. Data were gathered, were encoded, and classified according to variables described, tabulated and analyzed according to appropriate statistical tools described in this chapter.

Ethical Consideration

The researcher submitted letters of permission to conduct the study in the Schools Division Office of the schools where the study was conducted. Approval from the parents was also sought through letters and home visitation. The researcher also ask permission from the respondents' parents for him to secure their Clinical Low-Vision Assessment Form signed by a professional ophthalmologist. The data in this form were treated will utmost care so that the information remain confidential.

Data Analysis

The scores of both pretest and posttest were taken, and statistically treated using the mean, standard deviation, chi-square, and t-test of significant difference. Mean and standard deviation were used to determine the level of performance of the visually-impaired and their classification. A Paired t-test was employed to determine the significant difference in the mean scores of pretest and posttests. Spearman Rho was used to calculate the significant relationship between the respondents' profile and their performance in Mathematics.

RESULTS AND DISCUSSION

Profile of the Respondents

Table 1 shows there were five respondents took part in the study. Respondent 1 is 18 years old, male, middle child, of high financial status, and loves to use his cellphone during free time. Respondent 2 is 20 years of age, female, eldest among the siblings, average financial condition, and spends most of her time using her cellphone when out-of-school hours. Respondent number 3 is 22 years of age, female, youngest among the siblings, of low financial status, and loves to weave leaves for additional income. Respondent 4 is 17 years of age, female, middle among three children, low economic situation, and loves to write inspirational stories during free time. And respondent 5 is 23 years of age, female, 5th among six siblings, of low financial status, and loves to watch/hear Youtube even though her vision is weak

Table 1. Profile of the Respondents

R	A	Sex	SP	FS	Interest
1	18	male	2nd	high	cellphone
2	20	female	eldest	ave-rage	cellphone
3	22	female	young est	low	weaving
4	17	female	2nd	low	writing inspiration-al stories
5	23	female	5th among 6	low	watching Youtube

Legend
*R - Respondent
*A – Age
*SP – Sibling Position
*FS – Financial Status

Level of Performance of the Respondents in their Pretest.

Table 2 shows the level of performance of the respondents in their pretest. The first respondent got a very satisfactory performance with a score of 30 out of 40. The second respondent also had a very satisfying performance with a score of 31 out of 40. The third respondent had a reasonably satisfactory performance with a score of 10 out of 40. The fourth respondent performed satisfactorily with a score of 24 out of 40. And the fifth respondent also performed successfully with a score of 18 out of 40. Overall, the respondents performed successfully in the pretest with a mean score of 22.600 and a standard deviation of 8.764. Rezat (2011) concluded that the optimal strategy applied to situations containing negations was the transformation into similar situations with natural numbers using the law of addition and the law of subtraction of integers. Learners should know how to plot coordinates of points and locate its position in the Cartesian Coordinate Plane.

Laundal (2017) stated that the coordinate systems are essentials at ionospheric altitudes that are non-orthogonal. These show about handling vectors in

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coordinates and explains the appearance of systematic errors if not done properly and correctly. The slope of a line is also an essential topic in Mathematics. It is a prerequisite skill for understanding steepness as well as the rate of change.

Teuscher et al. (2010) mentioned in their paper that the rate of change is one of the important topics in mathematics that students should understand for it progresses into higher mathematics concepts. The linear rate of chance is one of the baseline concepts introduced and encountered in the high school.

Table 2. Level of Performance of the Respondents in their Pretest

Respondent Number	Pre-Test	Verbal Interpretation
1	30	Very Satisfactory
2	31	Very Satisfactory
3	10	Fairly Satisfactory
4	24	Satisfactory
5	18	Satisfactory
Mean	22.600	
Standard deviation	8.764	
Verbal Interpretation	Satisfactory	

Level of Performance of the Respondents as Reflected on their Formative Assessments

Table 3 shows the level of performance of the respondents during the conduct of the study. These are the scores of the respondents in their quizzes after the lectures using the Adapted Cartesian Plane as an intervention. The data show that all the five respondents showed excellent performance during the first assessment, where they scored 10, 10, 9, 10, and 7, respectively, with a mean score of 9.20 and a standard deviation of 1.30. In their second assessment, the five respondents obtained a score of 10, 7, 9, 6, and 6, respectively, with a mean score of 7.60 and a standard deviation of 1.82, which is evident in their very satisfactory performance. In their third assessment, the five respondents showed excellent performance, as shown in their scores of 10, 10, 5, 10, and 9, respectively, with a mean score of 8.80 and a standard deviation of 2.17. The fourth assessment also revealed the excellent performance of the five students, they got a score of 10, 10, 9, 10, and 5, respectively, with a mean score of 8.80 and a standard deviation of 2.17. The first lesson is about the addition of integers where the respondents use the Adapted Cartesian Plane as a number line. From the origin, they move to the right if the integer is positive, otherwise, to the left. The second lesson presented to the respondents is the subtraction of integers. The same concept was used after they change the sign of the subtrahend then proceed to add, that is why addition must be presented first, and it made their skills more efficient. The third lesson presented to respondents is plotting/locating points in the Adapted Cartesian Plane. It was their first time to plot points using the tool, and it made them better in identifying the location of the coordinates of points by inserting pins to the holes in the device. The last lesson presented to the grade 8 respondent was the slope of a line, she used the device in counting how many times the point rises and divide it by how many times it goes to the left or right, in this manner, she does not have to use the formula for the slope of the line. The last lesson presented to Grade 9 respondents was quadrilaterals, where they used the pins inserted in the tool and connect the points by a rubber band that represents the polygon and its sides. The last lesson presented to the grade 10 student was the distance between two points, by only counting the distance between inserted pins if the line is vertical or horizontal. The assessments of the respondents are unique forms of quizzes, for they used the tool as an intervention. The utilization of Adapted Cartesian Plane significantly improved their performance in their daily assessment, as shown in the table. An increase in the performance of the respondents in the 4-day lessons is consistent with the result of the study of Surtamm (2010) who concluded that there are several assessment practices far from the typical assessments which includes journals, questioning, observations, and self-assessment. In order for teachers to examine mathematical thinking of students and provide feedback to students about learning, these practices are being allowed.

The use of Adapted Cartesian Plane, pins, and rubber bands gave way to the respondents to follow the shape of different types of quadrilaterals through their sense of touch. The formula for distance has a lot of real-life applications. Thus, it is necessary to study this topic in high school. Weber (2020) uses the distance formula in calculating the distance between two addresses. Georoute calculates the geo routing distance between two addresses or two geographical points identified by their coordinates. In the first step, addresses are geocoded, and their geographic coordinates (latitude and

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longitude) are obtained. In the second step, the geo routing distance between the two points is obtained.

Table 3. Level of Performance of the Respondents as Reflected on their Formative Assessments.

RN	A1	A2	A3	A4
1	10	10	10	10
2	10	7	10	10
3	9	9	5	9
4	10	6	10	10
5	7	6	9	5
Mean	9.20	7.60	8.80	8.80
SD	1.30	1.82	2.17	2.17
VI	E	VS	E	E

Legend
*RN – Respondent Number
*A1 – Assessment 1
*A2 – Assessment 2
*A3 – Assessment 3
*A4 – Assessment 4
*SD – Standard Deviation
*VI – Verbal Interpretation
*E – Excellent
*VS – Very Satisfactory

Level of Performance of the Respondents in their Posttest

Table 4 shows the level of performance of the respondents in their posttest. The first respondent got scored excellently with 38 out of 40. The second respondent got 35 out of 40, which also shows excellent performance. The third respondent got 25 out of 40, which reveals very satisfactory performance. The fourth respondent likewise performed excellently with a perfect score of 40 out of 40. And the fifth respondent scored 30 out of 40, which provided evidence of very satisfactory performance. Overall, the respondents showed excellent performance in the posttest, in which they obtained a mean score of 33.600 and a standard deviation of 6.107. The utilization of Adapted Cartesian Plane improved the posttest of the *respondents using tactile materials, which are of great help, especially for visually-impaired students. The improved performance of the respondents in their posttest is consistent with the result of to the study of Nool N.R. (2012) that the use of improvised tools/abacus significantly reduces the errors of learners and improve the performance and retention of skills in the addition of integers and students' confidence in learning lessons in Mathematics.

Table 4. Level of Performance of the Respondents in their Posttest

Respondent No.	Post-Test	Verbal Interpretation
1	38	Excellent
2	35	Excellent
3	25	Very Satisfactory
4	40	Excellent
5	30	Very Satisfactory
Mean	33.600	
Standard deviation	6.107	
Verbal Interpretation	Excellent	

Relationship of the Profile of the Respondents in their Performance in Mathematics

Table 5 shows the relationship between the profile of the respondents and their performance in Mathematics. Age correlated in their pretest had an rs-value 0f -0.500, which means moderate negative and p-value of 0.391. Sibling position showed a high negative correlation with their pretest with an rs-value 0f -0.872 and a p-value of 0.054. The financial status also showed a high negative correlation with their pretest with an rs-value of -0.783 and a p-value of 0.118. The data likewise show that there is no significant relationship between the profile of the respondents and their performance in the pretest. Age showed a very high negative correlation with their posttest with an rs-value of -0.900 and a p-value of 0.037, which means there is a significant relationship between the age of the respondents and their performance in the posttest. If r is negative, it means that as one gets larger, the other gets smaller, it is called inverse correlation. The result is consistent with the study of Clark et al. (2010), who examined connections between children's developing executive function abilities at different ages and concluded that the age of learners affects their achievement in Mathematics. Sibling position revealed a moderate negative correlation with their posttest with an rs-value of -0.564 and a p-value of 0.322. It means there is no significant relationship between the sibling position of the respondents and their performance in the posttest. Financial status revealed a low negative correlation with their pretest with an rs-value 0f -0.335 and a p-value of 0.581. It means there is no significant relationship between the financial status of the respondents and their

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performance in the posttest. Finally, age manifested a very low negative correlation with the difference of their pretest and posttest that had an rs-value 0f -0.200 and a p-value of 0.747. Sibling position depicted a weak positive relationship with the difference of their pretest and posttest that had an rs-value of 0.462 and a p-value of 0.434. Financial status showed a high positive relationship with the difference of their pretest and posttest that had an rs-value 0f 0.783, which means high positive and p-value of 0.118. It revealed that there is no significant relationship between the profile of the respondents and their performance in the difference of their pretest and posttest. The data on sex and interest were not analyzed due to the insufficiency of the number of respondents.

Table 5. Relationship of the Profile of the Respondents in their Performance in Mathematics

Profile	P	rs-value	Correlation	p-value	Decision	I
Age	Pre-test	-0.500	Moderate Negative	0.391	Failed to Reject Ho	NS
SP		-0.872	High Negative	0.054	Failed to Reject Ho	NS
FS		-0.783	High Negative	0.118	Failed to Reject Ho	NS
Age	Post-test	-0.900	Very High Negative	0.037	Reject Ho	S
SP		-0.564	Moderate Negative	0.322	Failed to Re ject Ho	NS
FS		-0.335	Low Negative	0.581	Failed to Reject Ho	NS
Age	Difference	-0.200	Very Low Negative	0.747	Failed to Reject Ho	NS
SP		0.462	Low Positive	0.434	Failed to Reject Ho	NS
FS		0.783	High Positive	0.118	Failed to Reject Ho	NS

Legend
*SP – Sibling Position
*FS – Financial Status
*S – Significant
*NS – Not Significant
*P - Performance
*I – Interpretation

Difference between the Performance of the Respondents in their Pretest and Posttest

The next table shows the difference between the performance of the respondents in their pretest and posttest. Their pretest had a mean of 22.6 and a standard deviation of 8.764. In contrast, their posttest had a mean of 33.6 and a standard deviation of 6.107, t-value of 4.919, and a p-value of 0.008, which rejected the null hypothesis. It means that there is a significant difference between the pretest and posttest scores of the respondents, and the use of Adapted Cartesian Plane as an intervention is effective. Also, it is evident that the performance of the respondents improved by an average of 11 or 48.67%. The result of assessments 1,2,3 and 4 given to the respondents during the research conduct are excellent, very satisfactory, and excellent and excellent respectively, this outcome is consistent with the result of their improved posttest compared to their performance in the pretest. It concluded that experiential learning theory is of great help in the teaching-learning process, making sense of direct experiences whereby knowledge is constructed through the transfiguration of experience. Similarly, scaffolding helped the learners in their lessons by using Adapted Cartesian Plane in a different form of instruction. Eyyam et al. (2014) revealed that the Mathematics posttest results of the students who were instructed using interventions were significantly higher than the posttest results of the groups who were instructed without intervention/technology. In their study, they use technology as the intervention, and the respondents' performance improved. In relation to this study, it revealed that the Adapted Cartesian Plane an as intervention is effective and efficient. Hodges (2013) suggests that it is important to mediate in the social development of people with visual impairments before they attend higher education and to help them overcome such walls as peers' discomfort with them in social circumstances and challenges in life.

Table 6. Difference between the Performance of the Respondents in their Pretest and Posttest

Test	Mean	SD	T-value	p-value	D	Interpretation
Pre	22.6	8.764				

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Post	33.6	6.107	4.919	0.008	Re ject Ho	**Signi ficant**
Diffe rence	11.00 (48.67% increase)					

Legend
*SD – Standard Deviation
*D – Decision

Degree of Effect of Using Adapted Cartesian Plane

Table 7 shows the degree of effect of using Adapted Cartesian Plane in their performance in Mathematics with a t-value of 4.919, a p-value of 0.008, and Cohen's D of 2.200, which means that using Adapted Cartesian Plane as an intervention is significant and has a substantial effect. It implies that the utilization of Adapted Cartesian Plane as an intervention to deliver the lessons to the respondents greatly improved their performance in Mathematics. It also means that visually-impaired students learn more in tactile materials, and their sense of touch is one of the keys for them to learn efficiently.

Table 7. Degree of Effect of Using Adapted Cartesian Plane

Test	t-value	P-value	Cohen's D	Interpre tation
Pre Post	4.919	0.008	2.200	Large Effect

According to Krackov, S. K. (2013), feedback is an essential component of the teaching and learning process.

Table 8 shows the feedbacks of the respondents regarding the sessions where the Adapted Cartesian Plane was used. They affirmed that they enjoyed the sessions and found the use of Adapted Cartesian Plane helpful. They also said that it is fun, great, and easy to learn the lessons. Likewise, they said that they get to understand the topics presented better. Also, they said that it is good because they learned about the x-axis and y-axis and the location of those quadrants. Based on the respondents' feedback, the utilization of adapted Cartesian Planes made them feel pleased while learning. Specifically, respondent number 1 viewed the adapted Cartesian plane as a tool that makes learning mathematics more enjoyable among students, especially among the visually-impaired. Similarly, respondent number 2 found learning mathematics fun, great, and easy. Hence, the use of adapted Cartesian plane makes visually- impaired students understand easily the mathematical topics presented to them by the teacher. Also, respondent number 3 said that he understood the given topics better. The result implies that the utilization of adapted Cartesian Plane makes learning more achievable than merely presenting the mathematics topics to the students. The use of adapted Cartesian Plane is also applicable in introducing a new lesson to the students as revealed by the response of respondent numbers 4 and 5 who learned the concept of x and y axes and location of quadrants through the use of adapted Cartesian Plane.

Table 8. Feedbacks from Respondents in Utilizing Adapted Cartesian Plane

Respondents	Feedbacks
1	I enjoyed the sessions, Adapted Cartesian helps.
2	It is fun, great and easy to learn the lessons.
3	I now understand the presented topics better.
4	It is good because I learn the x and y axes.
5	I learned the locations of those quadrants.

CONCLUSION AND RECOMMENDATION

The following conclusions are drawn from the result of the study. There is no significant relationship between the profile of the respondents and their performance in Mathematics except in their age and posttest. There is a significant difference between the pretest and posttest of the respondents. The performance of the respondents in their posttest improved with the use of tactile material, specifically the Adapted Cartesian Plane. The degree of effect of using Adapted Cartesian Plane in delivering Mathematics lessons to visually-impaired students is large. The study is limited to the number of visually-impaired students enrolled in the mainstream.

Recommendations

The researchers highly recommend that scaffolding should always be considered when teaching in a regular classroom setting whenever visually-

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impaired students are included; always use of tactile materials in teaching visually-impaired students for their sense of touch in the most efficient way for them to learn; use Adapted Cartesian Plane in teaching the visually-impaired learners in their Mathematics lessons; and similar studies should be conducted, giving considerations to other disciplines.

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