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**APPENDIX - I**  
**PERSONAL DATA SHEET**

1. Name of the Student :
2. Class :
3. Gender :
4. Age :
5. Name of the School :
6. Medium of Instruction :
7. Phone number :
8. Address for Communication :

## APPENDIX - II

## Assessment of Acquisition of Concepts of Cartesian Plane

S.No	Concepts of Cartesian Plane	Yes	No
1.	Able to identify x-axis		
2.	Able to identify y axis		
3.	Able to identify origin		
4.	Able to name the first quadrant		
5.	Able to name the second quadrant		
6.	Able to name the third quadrant		
7.	Able to name the fourth quadrant		
8.	Able to set the scale		
9.	Able to identify the values of First quadrant		
10.	Able to identify the values of second quadrant		
11.	Able to identify the values of third quadrant		
12.	Able to identify the values of fourth quadrant		
13.	Able to identify the positive and negative numbers of x axis		
14.	Able to identify the positive and negative numbers of y axis		

## APPENDIX - III

## Assessment of Performance of Graph skills on the Cartesian Plane

S.No	Graph skills	Yes	No
	<b>Plotting points on Quadrants</b>		
1	Plot a point (4,5)		
2	Plot a point (-7,3)		
3	Plot a point (-2,-6)		
4	Plot a point(3,-8)		
	<b>Finding points on Quadrants</b>		
5	Find a point (2,4)		
6	Find a point(-5,3)		
7	Find a point(-6,-4)		
8	Find a point(9,-3)		
	<b>Plotting Points on Axes</b>		
9	Plot a point (0,-4)		
10	Plot a point(0,5)		
11	Plot a point(-3,0)		
12	Plot a point(6,0)		
	<b>Finding Points on Axes</b>		
13	Find a point(0,7)		
14	Find a point(-4,0)		
15	Find a point (3,0)		
16	Find a point (0,-5)		

:

## APPENDIX - IV

## RATING SCALE TO ASSESS THE COMPUTER ASSISTED CARTESIAN PLANE SYSTEM

SA –Strongly Agree    A- Agree    DA – Disagree    SDA – Strongly Disagree

S.No		SA	A	DA	SDA
	<b>Identification of Basic Cartesian Plane concepts</b>				
1	Computer Assisted Cartesian Plane helps to identify x- and y-axis without orientation to Tactile graph.				
2	Computer Assisted Cartesian Plane helps to identify the origin without orientation to tactile graph.				
3	Computer Assisted Cartesian Plane helps to identify the positive and negative values of x axis and y axis without orientation to tactile graph.				
4	Computer Assisted Cartesian Plane helps to identify the quadrants without orientation to tactile graph.				
5	Computer Assisted Cartesian Plane helps to identify the form of the quadrants without orientation to tactile graph				
	<b>Self Learning Tool</b>				
6	Computer Assisted Cartesian Plane helps to identify the x- and y -axis				
7	Computer Assisted Cartesian Plane helps to identify the origin easily.				
8	Computer Assisted Cartesian Plane helps to identify the positive and negative values of x axis and y axis				
9	Computer Assisted Cartesian Plane helps to identify the quadrants				
10	Computer Assisted Cartesian Plane helps to identify the forms of the quadrants.				
11	Computer Assisted Cartesian Plane helps to find a point in the respective quadrant				
12	Computer Assisted Cartesian Plane helps to find a point in the respective axis				
13	Computer Assisted Cartesian Plane helps to plot a point in the respective quadrant				
14	Computer Assisted Cartesian Plane helps to plot a point in the respective axis				
	<b>Advantages</b>				
15	Students can practise more problems using this tool than tactile aid				
16	Computer Assisted Cartesian Plane motivates students to learn individually.				

S.No		SA	A	DA	SDA
17	Computer Assisted Cartesian Plane helps students to enhance their knowledge in graphs and increase their performance.				
18	Any time students can practice tool to learn graph				
19	No need for internet connectivity				
20	Minimum computer keys are used to avoid complications.				
	<b>Usability</b>				
21	Computer Assisted Cartesian Plane is self instructional in nature				
22	Computer Assisted Cartesian Plane helps to meet the objectives of learning the Cartesian plane concept				
23	The time taken to perform a graph problem by the sighted students using print and visually impaired students using this tool is almost the same.				
24	Teaching graph using this tool is easier than using tactile aid				
25	Computer Assisted Cartesian Plane act as a supplementary tool to tactile aid to learn Cartesian plane concept.				
	<b>Scope for Teaching</b>				
26	Computer Assisted Cartesian Plane helps parents to teach their students with visual impairment				
27	Computer Assisted Cartesian Plane helps regular teacher to teach graph in the Cartesian plane to students with visual impairment				
28	Students with visual impairment can teach other students with visual impairment using this tool				
29	Students with visual impairment can guide sighted students using this tool				
30	Computer Assisted Cartesian Plane helps students with visual impairment for hierarchical learning of graphs				
	<b>Challenges</b>				
31	Basic computer knowledge is required to learn Computer Assisted Cartesian Plane system				
32	Distraction to the audio				
33	Computer Assisted Cartesian Plane is one way communication				
34	Less of Communication with the peer group and special teachers				
35	Limits the tactual mode of learning.				

**APPENDIX - V**  
**INSTITUTIONAL HUMAN ETHICAL COMMITTEE CLEARANCE**  
**CERTIFICATE**

**INSTITUTIONAL HUMAN ETHICS COMMITTEE**



***Avinashilingam***

Institute for Home Science and Higher Education for Women  
 (Deemed to be University under Category 'A' by MHRD, Estd. u/s 3  
 of UGC Act 1956) Re-accredited with 'A+' Grade by NAAC.  
 Recognised by UGC Under Section 12 B  
 Coimbatore-641 043, Tamil Nadu, India

15<sup>th</sup> December, 2021

**Chairman**

Dr. Sudha Ramalingam  
 Director-Research & Innovation,  
 Professor-Community Medicine,  
 PSG Institute of Medical Sciences  
 & Research, Coimbatore

**Member Secretary**

Dr.S.Uma Mageshwari  
 Professor and Head,  
 Department of Food Service  
 Management & Dietetics

**Members**

Mr. K.Arulmoli (Legal Expert)  
 Dr.Subhashini K. Sripathi  
 Dr.A.Saraswathy (Medical Officer)  
 Ms.D.Kavitha  
 Dr.A.R.Sudamani Ramasamy  
 Dr.G.Victoria Naomi  
 Dr. Judith Justin  
 Dr.Anitha Subash

To

Ms/Mrs. Rajeswari B  
 Department of Special Education  
 Avinashilingam Institute for Home Science and  
 Higher Education for Women  
 Coimbatore – 641 043

Dear Rajeswari B,

Ref: Your proposal No. IHEC/20-21/SPED/03 entitled  
 "Developing Computer Assisted Cartesian Plane to Enhance  
 Graph Skills of Students with Visual Impairment" submitted for  
 approval of IHEC.

The Institutional Human Ethics Committee of our University  
 hereby grants approval to your research proposal No. IHEC/20-  
 21/SPED/03 entitled "Developing Computer Assisted Cartesian  
 Plane to Enhance Graph Skills of Students with Visual  
 Impairment" submitted by you. The Approval number for the  
 same is AUW/IHEC/SPED-20-21/XPD-03.

We wish you all the best in your research endeavours.

Regards,

*Dr. Uma Mageshwari*  
 Dr.S.Uma Mageshwari  
 Member Secretary



## APPENDIX - VI

## PLAGIARISM REPORT



**Avinashilingam Institute for Home Science and Higher Education for Women**  
 (Deemed to be University under Category 'A' by MHRD, Estd. u/s 3 of UGC Act 1956)  
 Re-accredited with 'A+' Grade by NAAC. Recognised by UGC Under Section 12 B  
 Coimbatore - 641 043., Tamil Nadu, India

**PLAGIARISM CHECK REPORT (THESES)**

1.	Name of the Research Scholar	B. Rajeswari
2.	Roll No. and Year of Registration	16PHSEP001, 2016
3.	Department	Special Education
4.	Name of the Research Guide	Dr. G. Victoria Naomi
5.	Title of the Thesis / Dissertation	Developing Computer Assisted Cartesian Plane to Enhance Graph Skills of Students with Visual Impairment
6.	Similarity Content (%) Identified	<b>8%</b>
7.	Software Used	Turnitin
8.	Date of Verification	15-02-2022


**Note :** The report is excluding 14 Consecutive words, Review of Literature and Quoted Materials.

Checked by :

  
15/2/22  
**Information Scientist**

  
15.02.2022  
**Research Scholar**

  
15.02.2022  
**Assistant Librarian**

  
15.2.2022  
**Research Guide**

Date: 15-02-2022

## TEACHING GRAPHS TO STUDENTS WITH VISUAL IMPAIRMENT IN INCLUSIVE SCHOOLS

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### Abstract

This present study aimed to explore the level of performance of graphs skills among students with visual impairment. Here in this study, the performance was measured in terms of plotting and finding points in the Cartesian plane using tactile/ any other graphing aid. In addition, this study attempted to find out the method of answering to graph questions in the tests/ exams. This survey study comprised of 30 special teachers. The tool used in the study was a questionnaire containing 20 questions focussing on level of performance of graph skills among students with visual impairment, plotting and finding points in the Cartesian plane using tactile / any other graphing aid and the method of answering to graph questions in the tests/exams. The results revealed that there were scanty number of aids/ devices to perform graphs and all the students with visual impairment used scribe to answering graph question in the test/ exam.

**Keywords:** *graph skills, Cartesian plane, plotting points, finding points*

### Introduction

The mathematical curriculum for visually impaired students involves the same content areas as for the sighted students. The acquisition of mathematical skills can be more difficult for students with visual impairments due to the abstract nature of many essential concepts and the highly visual presentation of the subject. These difficulties include gaining information about the given problem, the formula to use, the calculations part and the visual presentation of the given problem. Few Portions in mathematics like Geometry, Graphs, Coordinate geometry, Venn Diagrams are highly visual in nature where the visually impaired students require different formats to access materials. Tactile graphics are typically used today. However, tactile graphics are not compatible with computers, require Braille reading skills, and are not used later in employment environments.

Graphs are drawings that show mathematical information with lines, shapes, and colours. Graphs are also known as charts. People use graphs to compare amounts of things or other numbers. Graphs are useful because they can be easier to understand than numbers and words alone. Commonly students with visual impairments learn graphs through tactile graphics. It represents a variety of print illustrations that contain information given in graphic formats.

In addition to providing tactile graphics for their students, it is necessary that Teachers of students with visual impairments teach students how to read and make sense of tactile graphics in mathematics instruction. In order to teach students with visual impairments to be successful in handling and interpreting a variety of tactile graphics, Teachers of students with visual impairment should use a sequence for introduction of tactile graphics (Koenig & Holbrook, 2000). Teachers of students with visual impairment could first present students

with opportunities to handle real objects, transition to the use of models, and finally implement two dimensional representations. The successful reading of tactile graphics requires knowledge of spatial and geographic concepts and strategies for exploring and interpreting the displays (Kapperman et al., 2000). This study concentrate on how the teachers teach the graph skills, the way they offer practice and evaluation of performance of visually impaired students.

### **Review of literature**

**Ashley Nichole Nashleanas (2018)** in his study “Graph accessibility and comprehension for the blind: A Challenge of its own kind” The Time and Performance and Verbal and Tactile Cues constructs were examined, and no statistically significant differences were found with respect to formal mathematics training. Descriptive analyses of the collective responses indicated that SVI require more time than their peers with vision when completing homework assignments and exams with graphical information.

**Spindler, Richard (2006)** on their study Teaching Mathematics to a Student Who Is Blind Teaching Mathematics and Its Applications found there are important similarities and also differences as compared to sighted students in teaching strategies, including proper verbal wording of formulas, using simple manipulatives, and repetition. Challenges encountered include instructor resistance, higher dimensional problems, and mental fatigue.

**Kim T. Zebehazy and Adam P. Wilton (2014)** on their study Charting Success: The Experience of Teachers of Students with Visual Impairments in Promoting Student Use of Graphics investigated the perceptions and practices of teachers of students with visual impairments in Canada and the United States regarding graphics (both tactile and print) that are used by students with visual impairments. Questions focused on quality, importance, and instruction in the use of graphics. Fewer than 50% of the respondents felt that graphics were appropriately adapted on large-scale assessments, that there was sufficient instruction in the use of graphics in mainstream classrooms, or that there was an adequate amount of instructional time to teach the use of graphics. Findings highlighted a need to gain insight into effective teaching strategies that help students gather information from both tactile and print graphics. Attention to students with low vision using print graphics needs to be part of future investigations.

### **Need of the Study**

The purpose of the study is to explore the performance of graph skills among students with vision impairment under inclusive and special school setup .This helps to sort out the problems faced by the special teachers and students with visual impairment while learning graphs particularly performing in Cartesian coordinate system.

Accessing graphs in an inclusive and special school setup have been identified to be problematic for blind students partly due to the lack of teaching resources available and personnel type, support and sufficiency. Hence a survey has been done to find out teaching and evaluation of graph to the students with visual impairment. This study may have a scope of developing a technology based teaching and evaluation of performance of graph to students with visual impairment.

### **Objectives of the study**

The specific objectives of the study were:

- To explore the level of performance of graph skills among students with visual impairment.
- To find out the skills acquired in plotting point in the Cartesian plane using tactile/ any other graphing aid.
- To identify the skills in finding points in the Cartesian plane in the graph using tactile aid
- To examine the mode of answering graph questions in the test and examinations.

### **Method of the Study**

The study was survey in nature. The sample comprised of 30 special teachers from Inclusive schools. The sample was selected using purposive sampling method meaning selecting teachers for the students with visual impairment. The questionnaire was developed based on literature survey and opinions of the experts. The questionnaire aimed to measure the comprehension level of graph concept (i.e.) plotting and finding a point in the Cartesian plane.

#### **Tool of the study**

The questionnaire consists of 20 questions and it is subdivided into four parts. Each part contains five questions. First part consists of questions regarding the awareness about the graphs and its types. The second part consists of questions regarding the different parts of the graph. The third part consists of questions regarding the plotting and finding a point in the Cartesian plane. The fourth part consists of questions regarding the mode of answering graph questions in the test/ examinations. The study was conducted in Coimbatore, Chennai and Salem Districts of Tamil Nadu.

#### **Results and Discussion:**

This study shows that the 43% of the special teachers were having graphic aid / tactile diagram to teach graph concepts to visually impaired students and others are teaching orally.

A less number of the special teachers taught Bar chart to the visually impaired students, 20% of the special teachers taught Histogram to visually impaired students, 10 % of the special teachers taught Frequency polygon and 36 % of the special teachers taught Pie chart to visually impaired students.

The result shows that 37% of students with visual impairment were identified x and y axis in the Cartesian plane and 27 % of them identifies the origin and the names of the quadrants , 16 % of them able to state the forms of each quadrant and only 7% of them were able to set the scale.

The result shows that only 23% of students with visual impairment were identified the Cartesian plane correctly and only 10 % people were able to find and plot a point in the Cartesian plane.

Nearly 43% of the special teachers responded that tactile graphs are more reliable to teach the basic concepts on the Cartesian plane.

Pertaining to evaluation of graph skills in the tests/exams, all the students with visual impairment used only scribe to plot and finding points in the Cartesian Plane.

#### **Conclusion**

The study reported the current situation of how the students with visual impairment learning graph skills. It also found out the method of evaluating their knowledge and skills in performing graph. There were scanty numbers of graphic aid and supplementary aids to teach graph. This study envisages a need to teach graph skills using technology which is the reality in today's context.

#### **References:**

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3. Zebehazy, K. T., & Wilton, A. P. (2014). Charting success: The experience of teachers of students with visual impairments in promoting graphic use by students. *Journal of Visual Impairment & Blindness*, 108(4), 263–274.

## **CURRENT STATUS OF GRAPHING IN CARTESIAN PLANE BY STUDENTS WITH VISUAL IMPAIRMENT**

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### **Abstract**

This present study aimed to find the current status of graphing in the Cartesian plane by students with visual impairment when learning graphs in higher secondary inclusive schools. The objectives of the study were to find the current status of graphing in the Cartesian plane by the students with visual impairment in learning graphs, while handling tactile / graphic aid in learning graphs and to compare the current status of graphing in the Cartesian plane by students with low vision and total vision impairment in learning graphs. Descriptive survey method was used and purposive sampling technique was applied to identify the students with visual impairment within the study location. The targeted sample comprised of thirty students with low vision and twenty students with total visual impairment were selected from Coimbatore, Tirupur and Dindugal districts in Tamil Nadu, India. The data was collected, coded and summarized on the basis of objectives of the study. The study found that both the students with low vision and total vision impairment faced major difficulties in understanding quadrant forms, plotting and finding points in the second, third and the fourth quadrants. The study recommended that the maximum training should be given to the students with visual impairment for better understanding of Cartesian plane concept.

**Keywords:** Students with visual impairment, Inclusive schools, Tactile aid, Graphs, Cartesian plane

### **Introduction**

Mathematics is abstract science that is hard to be learned (Retnawati, Prajitno & Hermanto, 2015). In Mathematics, a graph is defined as a chart with statistical data, which are represented in the form of curves or lines drawn across the coordinate point plotted on its surface. Graph literacy is the ability to identify important features of graphs and relate those features to the context of the graphs. A Cartesian graph is one that shows numerical relationships by drawing points, lines, curves, or geometric shapes on the Cartesian plane. Tactile graphics are the traditional mediums for learning graphs for learners who are visually impaired. While graphing principles can be represented using this medium, producing tactile graphs requires specialized equipment and knowledge about how to effectively convey graph components through tactile means. Examples of tactile graphics include push-pins and rubber bands on foam boards, specialized building blocks imprinted with Braille, and embossed paper graphs. Graphics are extensively prevalent as part of a learning curriculum in all school subjects, not only in mathematics. The consideration when using graphics with students with visual impairment is ensuring that the information is presented in a comprehensible way, especially since many graphics have multiple parts and labels. This means that care must be taken when producing these graphs. Lack of access to graphical materials significantly impacted study and career choices of vision-impaired students. A number of other technologies for providing accessible graphics have been developed in the last decade, although none are yet in widespread use. These include sonification (e.g., Brown & Brewster, 2003); haptic feedback (e.g., Darrah, 2013); integrated eBook delivery on touch screen (Goncu & Marriott, 2015) and 3D-printed tactile models (e.g., Grice, Christian, Nota, & Greenfield, 2015; Kolitsky, 2014)

### **Review of literature**

**Marlon A. Macawili , Adriel G. Roman (2020)**, on their study “Utilization of Adapted Cartesian Plane for Visually-Impaired Students” found that 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.

**Ashley Nichole Nashleanas (2018)** in his study “Graph accessibility and comprehension for the blind: A Challenge of its own kind”, the time and Performance and Verbal and Tactile Cues constructs were examined, and no statistically significant differences were found with respect to formal mathematics training. Descriptive analyses of the collective responses indicated that SVI require more time than their peers with vision when completing homework assignments and exams with graphical information.

**Kim T. Zebehazy and Adam P. Wilton (2014)** on their study “Charting Success: The Experience of Teachers of Students with Visual Impairments in Promoting Student Use of Graphics” investigated the perceptions and practices of teachers of students with visual impairments in Canada and the United States regarding graphics (both tactile and print) that are used by students with visual impairments. Questions focused on quality, importance, and instruction in the use of graphics. Fewer than 50% of the respondents felt that graphics were appropriately adapted on large-scale assessments, that there was sufficient instruction in the use of graphics in mainstream classrooms, or that there was an adequate amount of instructional time to teach the use of graphics. Findings highlighted a need to gain insight into effective teaching strategies that help students gather information from both tactile and print graphics. Attention to students with low vision using print graphics needs to be part of future investigations.

**Benjamin K. Davison (2012)** in his study on “understanding how visually impaired students demonstrate graph literacy with accessible auditory graphs” found that blind adults can use mice for point estimation, building a system that could answer questions based on the standards and evaluated the system in classroom and testing situations.

**Benjamin K. Davison (2013)** in his study on “Universal graph literacy: Understanding how blind and low vision students can satisfy the common core standards with Accessible Auditory graphs” found that active point estimation with sonification enables people to solve graphing problems, regardless of their visual impairment. He also has shown that active point estimation with sonification is possible, relates to graphing standards in the sixth grade common core standards for mathematics and has similar benefits as paper formats.

### **Rationale for the study**

While mathematics education is easily accessible to fully sighted children, it is less accessible to students with vision impairment since many of its concepts are presented graphically, and there are many concepts that cannot be explored by touch and are put across through visual observation. The curriculum in regular schools is also designed for fully sighted children and is delivered largely through sight related tasks. Students with visual impairment should not be left from learning a graph concept due to lack or limited vision. Not only they can graph with the right tools, they can often do so better than their sighted peers. Educators have made coordinate graphs a core component of primary and secondary mathematics education. The emphasis of graphic literacy can be seen in many education standards. Students with visual impairment should know how to plot coordinates of points and locate its position in the Cartesian plane. Yet there is scanty number of systematic study that has encountered by these students with visual impairment in learning graphs. There is need therefore to identify the difficulties encountered by students with visual impairment while learning graphs in regular secondary schools. Rajewari, B and Victoria Naomi,G (2021) on their study on teaching graphs to visually impaired students in inclusive schools resulted that due to scanty numbers of graphic aid and supplementary aids to teach graph leads to poor performance of the Graph.

### **Objectives of the study**

The specific objectives of the study were

- To find the current status of graphing in Cartesian plane by the students with low vision and total vision impairment in learning graphs.

- To find the current status of graphing in the Cartesian plane by the students with low vision and total vision impairment in learning graphs while using the tactile/ graphic aid
- To compare the current status of graphing in the Cartesian plane by the students with low vision and total vision impairment in learning graphs.

### Method of study

The study used descriptive survey to explore the problems that students with low vision and total vision impairment faced when learning graphs in higher secondary inclusive schools. The target sample comprised of thirty students with Low vision and twenty students with total vision impairment within the study location from Coimbatore, Tirupur and Dindugal districts in Tamil Nadu, India. The sample was selected using purposive sampling method. The data was collected using questionnaire which was developed based on literature survey and opinions of the experts. The questionnaire comprised of forty questions which were aimed to find the current status of graphing in the Cartesian plane by the students with visual impairment about fundamental graph reading skills, their learning experience and the concept of Cartesian plane in small steps, with each new step building upon previous ones.

### Data collection procedure

Data collection is defined as the procedure of collecting, measuring and analyzing accurate insights for research using standard validated techniques. A researcher can evaluate their hypothesis on the basis of collected data. In most cases, data collection is the primary and most important step for research, irrespective of the field of research. The approach of data collection is different for different fields of study, depending on the required information.

**Table 1 Distribution of the samples**

Grade	9		10		11		12		Total
Gender	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	
Total vision impairment	1	2	7	1	2	2	2	2	19
Low vision	3	4	3	4	4	4	6	3	31
Total	4	6	10	5	6	6	8	5	50

### Analysis and interpretation

#### 1. Current status of graphing in the Cartesian plane by the students with total vision impairment in learning graphs

The study investigated the current status of graphing in the Cartesian plane by the students with total vision impairment in learning graphs. The findings were presented below.

1. All the students with total vision impairment reported that they are interested in learning graphs. Nearly 85% of students with total vision impairment had difficulty to understand concepts of quadrants in the Cartesian plane and (85%) of them faced problem to plot points in the second, third and fourth quadrants.
2. It can be said that about 80% of students with total vision impairment reported to face difficulty in getting proper instructions to learn graphs.
3. About 75% of students with total vision impairment had difficulty to differentiate between axes in the graph sheet with other grid lines, problems in finding points in the second, third and fourth quadrants, finding points and plotting points in the y axis.
4. More than 50% of students with total vision impairment had difficulty to understand the concept of Cartesian plane, learning graphs in the regular classroom, identifying positive and negative numbers, identifying the forms of third and fourth quadrants.
5. Less than 50 % of students with total vision impairment had difficulty in understanding the concept of x axis and y axis, sufficient training in learning graphs, handling teaching aid for learning graphs, sufficient time to complete graphs and understanding graph concepts.

## **2. Current status of graphing in the Cartesian plane by the students with low vision in learning graphs**

The study investigated the current status of graphing in the Cartesian plane by the students with low vision in learning graphs. The findings were presented below.

1. All the students with low vision reported that they are interested in learning graphs. About 85% of students with low vision had difficulty to understand concepts of quadrants in the Cartesian plane.
2. It can be said that about 80% of students with low vision reported to face difficulty in handling the teaching aid, identifying the forms of second, third and fourth quadrants, difficulty in finding and plotting points in second, third and fourth quadrants.
3. About 70% of students with low vision had difficulty in exploring the given problem, learning graphs in the regular classroom and difficulty in understanding spatial relations.
4. More than 50% of students with low vision had difficulty to differentiate between axes in the graph sheet, getting proper instructions to learn graphs and understanding the concept of Cartesian plane.
5. Less than 50% of students with low vision had difficulty in understanding the concept of x axis and y axis, sufficient training in learning graphs, handling teaching aid for learning graphs, sufficient time to complete graphs and understanding graph concepts.

## **3. Current status of graphing in the Cartesian plane by students with visual impairment while using the tactile/ graphic aid in learning graphs**

The study investigated the current status of graphing in the Cartesian plane by the students with visual impairment while using the tactile/ graphic aid for learning graphs. The major findings were presented below.

1. About 70% of students with total vision impairment had difficulty in understanding spatial relations whereas 53% of students with low vision had difficulty in understanding spatial relations
2. About 60% of the students with total vision impairment had difficulty in tracking grid lines in the tactile / graphic aid whereas 46% of the students with low vision had difficulty in the same.

## **4. Comparison of the current status of graphing in the Cartesian plane by students with low vision and students' total vision impairment in learning graphs**

The major findings were presented below.

1. This study indicated that while analysing the current status in learning graphs, students with total vision impairment face more difficulty when compare to students with low vision in spatial relations, tracking the grid lines, the concepts of quadrant in the Cartesian plane, plotting points on the x and y axis.
2. This study indicated that while analysing the current status in learning graphs, both students with low vision and total vision impairment had the same level of difficulties in understanding the concept of x and y axis, sufficient training in learning graphs, handling teaching aid for graphs, sufficient time to complete graphs, understanding graph concept, identifying forms of the quadrants, plotting points in the second, third and the fourth quadrants.

## **Conclusion**

This study attempted to determine the current status of graphing in the Cartesian plane by the students with visual impairment. From the findings of the study, it can be concluded that there are some similarities and differences in the current status of graphing in the Cartesian plane by the students with low vision and total vision impairment. It must be noted that they face major difficulties in working on second, third and fourth quadrants. Consideration should be taken into account however with regard to number of problems assigned. It is permissible to shorten the assignment, as long as the student can demonstrate competence in the content area. An opportunity to explore mathematics using different instructional tools in these early years is beneficial to this population of learners as well. Above all this study could inspire the quest to conduct quantitative studies in order to understand the current status of graphing in the Cartesian plane by the students with visual impairment and their needs in the teaching learning process.

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**DEVELOPING GRAPH CONCEPTS RELATED TO CARTESIAN PLANE AMONG STUDENTS WITH VISUAL IMPAIRMENT**

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**Abstract**

This present study aimed to develop graph concepts related to Cartesian plane among students with visual impairment. The objective of the study was to compare the acquisition of graph concepts before and after intervention using Tactile Cartesian Plane. Quasi experimental design was used and purposive sampling technique was applied to identify students with visual impairment within the study location. The targeted people comprised of forty two students with visual impairment were selected from Coimbatore districts in Tamil Nadu, India. The data was collected, coded and summarized on the basis of objective of the study. The study found that the intervention helped in learning the graph concepts related to Cartesian Plane among students with visual impairment. The study recommended that the tactile intervention helped in learning graph concepts for better understanding of Cartesian Plane Concept.

**Keywords:** *Students with visual impairment, Inclusive schools, Cartesian Plane, Plotting Points, Finding Points, Quadrants, Axes, origin, Tactile Cartesian Plane.*

**Introduction**

Vision allows access to information that helps build a conceptual understanding of basic mathematical concepts. Consequently, students with visual impairment tend to face more challenges than their peers without disabilities, even when learning the most basic mathematical concepts (Beal & Shaw, 2008). These difficulties include problem solving, gaining access to the problem information, representing problem information, and calculating the answer. In addition, mathematics is highly visual in nature and often uses graphics to convey important information, presenting an additional obstacle for students with visual impairment (Smith & Smothers, 2012)

Mathematic education contains many abstract concepts and includes graphs, equation, diagrams which are visual in nature. Students with visual impairment require a thorough understanding of mathematics to function in today's society. It is beneficial for mathematics to be presented to students with visual impairment using a combination of the abacus, Braille codes, tactile materials, and concrete materials in order to meet academic goals. Teaching of mathematical concepts through the use of abacus, Braille codes, manipulative, tactile graphics, and hands-on experiences should start in the early years (Amato et. al, 2013). As soon as a child begins to learn Braille, practice in Braille mathematical codes should be given. Experiences have demonstrated that children with visual impairment display resentment to learning mathematical codes when introduced at later stages (Mani et al., 2005). Whenever a sighted student is allowed to use scratch paper for solving problems, the use of the abacus should be permitted for students who are visually impaired (Amato et al., 2013). The abacus can be taught in conjunction with Braille mathematical codes to help students conceptualize concepts in mathematics. It is important for teachers of students with visual impairment to be highly proficient in the use of abacus computation skills, Braille mathematical codes, and tactile graphics and adapting the general education mathematics curriculum to meet individual student needs.

The students with visual impairment, who belong to deprived, marginalized and socio-economically backward sections of the society usually, are not able to make provision of resources and materials for themselves, as they do not have a proper source of income. The parents, belonging to these communities are normally not educated and they do not possess the skills and abilities to enhance learning and education among their children with visual impairment.

With this premise, a survey of literature related to Cartesian Plane was explored in Indian Context. Hence this investigation was focussed to develop graph concepts related to Cartesian Plane among students with visual impairment and the effect of tactile Cartesian Plane was examined with the help of student's participation and performance in developing graph concepts related to Cartesian Plane in this Experimental study.

### Literature Review

**Matthew Butler, Leona Holloway, Kim Marriott and Cagatay Goncu** (2016), on their study on "Understanding the graphical Challenge faced by students with visual impairment in Australian Universities". This study seeks to understand the current state of accessible graphics such as plots, charts, tables and diagrams provision in Australian higher Education. An online survey among 71 university students with visual impairment and semi structured interviews with 44 key stakeholders was conducted. The study revealed the difficulties faced by students with visual impairment in accessing graphical materials.

**Macawili, Marlon & Roman, Adriel.** (2020) conducted a study on "Utilization of Adapted Cartesian Plane for Visually-Impaired Students", aimed to utilize an adapted Cartesian Plane to teach mathematics topics to students with visual impairment. It is a quasi experimental design and the students with visual impairment in the mainstream employed using purposive sampling technique and served as the subjects of the study. 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 students with visual impairment is large.

**Beal and Rosenblum (2018)** found that 43 visually impaired students in grades 4 to 10 required significantly more help from teachers of students with visual impairments when solving math word problems that involved graphics (such as maps, diagrams, and geometric figures) compared to similar math problems that did not include graphics. Of the 16 braille readers in the study, only 5 were independent with the 16 problems that included graphics; the other 11 needed some level of assistance on at least one of the problems. Similar results were reported for the 27 print readers, and only 9 worked independently on all 16 graphics problems. The level of assistance the teachers of visually impaired students provided to the students in this study would not have been permitted on high-stakes tests (Allman, 2009).

### Rationale for the study

The most difficult mathematics lessons learned by visually impaired children are materials that require more visual observation, such as a two-dimensional figure, three-dimensional figure, circumference and volume (Nurmitasari, 2015). These materials make the visually impaired children have more difficulty than other materials, although they also experience difficulties in learning other materials. Students with visual impairment should not be left from learning a graph concept due to lack or limited vision. Not only they can graph with the right tools, they can often do so better than their sighted peer (Kumar et.al 2001). Children who are visually impaired should learn mathematical skills at the same level as their sighted peers (Tindell, 2006). Rajewari, B and Victoria Naomi, G (2021) on their study on teaching graphs to visually impaired students in inclusive schools resulted that due to scanty numbers of graphic aid and supplementary aids to teach graph leads to poor performance of the Graph.

### Objectives

1. Find out the level of acquisition of Basic Concepts related to Cartesian Plane among students with visual impairment before and after introduction of Tactile Cartesian Plane.

### Hypothesis

1. There is no significant difference in the level of acquisition of Basic concepts related to Cartesian Plane among students with visual impairment before and after intervention.

**Method**

To develop the Graph Concepts, 42 students with vision impairment have been selected from Coimbatore schools. The Graph Concepts viz Axes ( $x$ ,  $x^1$ ,  $y$ ,  $y^1$ ), Origin (0, 0), Quadrants (I, II, III & IV) were included. The study was Quasi experimental in nature. The study adopted purposive sampling technique. The sample consists of 42 students with visual impairment. The study was designed on the basis of Pretest and Posttest Design. A Checklist consists of 14 items which include the concept of Axes, Origin, Quadrants and their form was developed by the researcher. A tactile Cartesian Plane was prepared by the researcher and used for the intervention purpose. Pretest was administered using the Checklist. After pretesting, intervention was given to the students using tactile Cartesian plane for a period of one month. Posttest was conducted using the same checklist. Graph concepts were compared before and after intervention using Tactile Cartesian Plane.

**Analysis and Interpretation**

**Table 1. Testing wise Mean, SD, df and t value for graph concepts related to Cartesian Plane with respect to Pretest and Posttest**

Graph Concept	Test	N	df	Mean	SD	t-value
Graph concept related to Cartesian plane	Pretest	42	41	3.29	2.06	29.88**
	Posttest	42	41	12.40	1.58	

**\*\*Significant at 0.01 level**

From the table 1, it is evident that the t-value for Concept of Axes, Origin and Quadrants is **29.88** with  $df = 41$  which is significant at 0.01 level. It indicates that pre and post test tactile score of Concept of Axes, Origin and Quadrants differ significantly. In the light of this, the null hypothesis that *“there is no significant difference in the level of acquisition of Basic concepts related to Cartesian Plane among students with visual impairment before and after intervention”* is rejected. It may therefore be said that the Tactile Cartesian Plane helped in improving the Learning of Graph Concepts related to Cartesian plane among Students with Visual Impairment.

**Conclusion**

Even after teaching students with visual impairment, many remained unaware of suitable strategies and teaching practices. There was little recognition that improvements in accessibility of graphical material, such as improved clarity of diagrams or textual descriptions, could actually benefit all students not just those with vision impairment. Instead, there was a general sense that it is not appropriate to adapt materials or teaching approach for only one student. While some academics made a conscious effort to be more inclusive, some acknowledged that they would forget, particularly when delivering a lecture.

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