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USE OF COMPUTER ASSISTED INSTRUCTION (CAI) TO ENHANCE MATHS LEARNING IN STUDENTS WITH MATHS DIFFICULTIES

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ABSTRACT

Students with difficulties in maths learning form a sizeable school population and maths learning difficulties are exhibited in various forms. Predominantly math is taught using explaining and modeling modalities. Using ICT in imparting maths education is documented to produce positive learning outcomes. The current experimental research aimed to study the effectiveness of computer assisted instruction (CAI) package as measured by math achievement in 44 students following Pratham Level A curriculum and having maths difficulty. The CAI package developed by researchers followed linear programming and used the drill and practice mode. The analysis of data collected during the study supported the hypothesis that students taught using CAI along with traditional method performed statistically significantly better than students taught using traditional instructional method alone. The paper describes the tools used in the research, the methodology of research, and the data analysis procedures. The research results are discussed in light of use of ICT in classrooms to further inclusive education efforts.

Key words: *ICT, Computer Assisted Instruction (CAI), Maths difficulty*

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INTRODUCTION

In India, the Right to Education Act (2009) has highlighted the idea of education of all the students including those from the various marginalized sections of society. This marginalization was defined in terms of socio-cultural, economic, gender or disability sections. These ideas have led to the development of curricula to cater to individual learners, development of teaching learning material and assistive technology for them, and also use of numerous tools to represent information, keep the students engaged and provide opportunities to express their learning. The proliferation of information and communication technology (ICT) is witnessing the propulsion of the educators to embrace the pedagogies of technology.

Challenges in Math Learning

The classrooms of today consist of diverse learners having different abilities and this learner diversity is seen in maths learning as well. Some students struggling to cope with challenges of learning maths are found in every class (Kroesbergen & Van Luit, 2003). The difficulties observed in these students are of various types ranging from fleeting difficulties in one domain while severe difficulties in many other domains.The difficulties faced by these students may be due to deficits in memory, problem solving and generalization o even merely inadequate opportunities for maths learning. Thus, a considerable amount of gap exists between low and high performers. These students require special help and some type of maths intervention. One of the most important goals of resolving the issue of struggling maths students should be to develop the students' understanding of basic mathematicalconcepts and procedures. The idea should be to equip them with knowledge and skills that will enable the students to solve maths-related problems that they encounter at home and at future work situations on a consistent basis. All students must have a strong foundation in math in order to function successfully in the modern world. Mathematical skills are an essential prerequisite for both school achievement and success in the workplace. Without mathematical skills, individuals will not be able to hold gainful employment or manage their personal finances (Abraham, Slate, Saxon, & Barnes, 2014).

Computer Assisted Instruction (CAI)

The use of computers as a part of the instructional procedure was presented by B.F. Skinner way back in 1958. Computer-delivered instruction was considered an effective teaching methodology throughout the 1980s and 1990s (Christmann & Badgett, 2000) and it is equally important even today. The method most used for computer-delivered instruction is called Computer

Assisted Instruction (CAI) or Computer Managed Instruction (CMI). The Association for Education Communication and Technology define CAI as "an instructional method used with students where the instructional design is used to teach, guide, and test the student until a desired proficiency level is reached" (Jenks & Springer, 2002). CAI is most often drill-and-practice, tutorial, or simulation activities offered as a supplement to teacher-directed instruction, traditional method instruction, or the aforementioned activities by themselves.

Benefits of using CAI

According to numerous studies, the use of ICTs in teaching can help to bridge the gap between diverse learners. Many studies examine the teaching and learning of maths, and more specifically, how technologies such as Computer Assisted Instruction (CAI) can be used to enhance maths instruction (Heid & Blume, 2008; Jenks & Springer, 2002; Ku, Harter, Liu, Thompson, & Cheng, 2007; Slavin & Lake, 2008; Zbiek, Heid, & Dick, 2007) and ascertain that ICT plays an important role in aiding teaching and learning processes at all levels, and all academic fields (DuPaul & Stoner, 2003) including learning in children with mathematical learning difficulties (Küçükalkan, Beyazsaçlı, & Öz, 2019). The use of computers gives students real time feedback and monitors their progress (Godfrey, 2001), helps students learn more in lesser time (Hasselbring, Lott & Zydney,2005), and when a computer is integrated as a tutor giving real time feedback, it offers an enjoyable experience for students with learning disabilities (Smaldino, Lowther and Russell,2008). CAI is also found to be an effective instructional strategy on mathematical operations' performance either of students with ADHD or typical ones in an individualised 'working at home' educational set up (Botsas, 2015). A meta-analytic study (Ran, Kasli, & Secada, 2021) on effect of computer technology on maths achievement in low performing students revealed that there are statistically positive effects on maths achievement when students learn using various forms of computer technology. On similar lines, another meta-analysis revealed that using digital-based interventions benefit students with mathematical difficulties (Benavides-Varela, et al., 2020) as compared to regular classroom teaching.

Need and Significance of the Study

Technology is a great equalizer for students with learning difficulties and this holds true for students with maths learning difficulties too. Technology serves as a kind cognitive prosthesis to overcome or compensate for differences among learners. The use of CAI in the classroom has become widespread,

especially visible in the maths classroom. Many in the educational field have considered that somewhere in between traditional instruction and computer-assisted instruction lays a healthy balance for instruction. This would be the type of classroom where computers are integrated into the curriculum, but there would still be face-to-face time with the instructor (Gesbecker, 2011).

Children with learning difficulties, school drop outs, those living in institutional set ups, and those who have difficulty attending formal schools for various reasons attend open schools. In India, these students appear for exams conducted by the National Institute of Open Schooling (NIOS) to complete their secondary and higher secondary education. Pratham, a well-known NGO in the educational sector has created a curriculum for open basic education programme to prepare students for NIOS (Pratham Mumbai Education Initiative, n.d.). Thus, Pratham offers the curriculum at three levels – Pratham level A, Pratham level B, and Pratham level C. The three levels correspond to Maharashtra State Board curriculum for grades I to III, grades IV to VI, and grades VII and VIII respectively. Institutes for teaching students to appear for Pratham and NIOS exams are functioning in many places in Mumbai. The profile of student diversity in these institutes is tremendous -there are students with learning difficulties, learning disabilities or simply students who need flexibility offered by the NIOS board. As would be the case with any educational set up or school, some students here too have difficulties in learning maths.

In the present study, an attempt was made to teach the students studying for Pratham level A exam a maths topic (division) using CAI along with traditional method of instruction and compare the performance of these students with those who were taught the same topic using the traditional method of instruction alone. A study of this nature will provide insights into whether the use of CAI along with tradition instructional method will benefit students studying maths. On the basis of this, schools offering the open school Pratham and NIOS curriculum may be recommended to use CAI in addition to traditional method of instruction to teach maths. This technology integration will immensely benefit the students.

METHODOLOGY

Research Design

The research employed a pretest-posttest control group design. The pretests and posttests provided the measures of maths achievement of students studying Pratham A level, prior to and after the intervention. The independent variable was the CAI and the dependent variable was maths achievement.

Sample and Sampling

The sample for the study comprised of 44 students studying Pratham level A curriculum and were from two English medium schools in Mumbai offering the Pratham and NIOS curriculum. Based on the maths performance in their class test, the school teachers identified the students achieving less than 35% of marks. These students were operationally defined as having maths difficulties. From school one, 20 students were identified to be part of the study and from school two, 24 students were identified as having difficulties in learning maths. Half the students from each school were assigned to the experimental group (EG) and half to the control group (CG) using random assignment. Accordingly, from school one there were 10 students in each group. There were 12 students in EG and CG each from school two. Consequently, there were 22 students in the EG and 22 in CG.

A two-stage sampling procedure was followed to select the students for the current study. Thus, purposive sampling was used in stage one to identify the institutes and this was followed by random selection and random assignment of students to the EG and CG. A need to use purposive sampling was experienced in the process of selection of schools for the study because the intervention entailed use of computer assisted instruction (CAI); this required that the chosen schools have a computer facility. It was also essential that the students included in the study were familiar with the use of computer.

Tools for the Study and their Development

For the current study, the researchers developed two tools – tool for measurement and tool for intervention.

Tool for measurement was a Curriculum-Based Achievement Test (CBAT). The content for the CBAT was the topic ‘division’ based on Pratham A level curriculum. As was guided by the school teachers, the textbook of grade 3 (Maharashtra State Board Curriculum) was used to develop the CBAT. For the purpose of collecting pretest and post test data, parallel CBATs were constructed and used. This was done to reduce the effect of familiarity of the test items for the students during posttest. A table of specifications was developed and the items were developed accordingly. The tool had 30 items initially that were reduced to 28 items each after content validation. The maximum attainable score on the CBAT was 54. The content covered in the CBAT was division facts, computation, and problem solving. The CBAT was content validated by teachers and they made suggesting pertaining to reframing the items and inserting brackets for the pictures. The content validated CBAT was pilot tested on six students and on the basis of

the observations, some pictures in the test were rearranged.

Tool for intervention was the CAI developed by the researchers to teach the topic 'division'. The CAI developed using HTML 5, JAVA Script and Flash had a total of 135 slides. The CAI was a self-paced, self-instructional linear programme using the drill and practice mode. Accordingly, there were instructional slides and slides for drill and practice. The CAI included five strands of the topic 'division'. These were meaning of division, terminology of division, using tables for division, dividing numbers (one-digit number by single digit number, two-digit numbers by one-digit number, and three-digit number by one-digit number). The number of slides per strand differed. After every drill and practice slide a smiley would appear and reinforce the student, and lead the student to the next slide. A happy smiley appeared when the student gave a correct response and a sad smiley would appear if an incorrect response was given. The CAI was content validated by maths teachers and was then introduced to the students. Table 1 shows the details of the structure of the CAI package. Out of the total number of slides (135), 107 were drill and practice slides.

Table 1 - Structure of CAI Package

Sr. No.	Content	No. of Instructional Slides	No. of Drill and Practice Slides	Total no. of Slides
1	Introduction	4	-	4
2	Meaning of division	6	4	10
3	Using tables for division	2	9	11
4	Terms used in division	5	7	12
5	Dividing a one-digit no.	4	7	11
6	Division with the help of tables	1	8	9
7	Dividing a two-digit no.	1	12	13
8	Dividing a three-digit no.	2	12	14
9	Word problems	2	25	27
10	Practice sums	-	23	23
11	End	1	-	1
	Total	**28**	**107**	**135**

Data Collection

The research data was collected in three phases – pretest, intervention and posttest. The students were administered the CBAT in the pretest and posttest phase. The time taken to complete the CBAT was 45 minutes. During the intervention phase, the 22 students in EG were introduced to the CAI package which was on a pen drive. The EG used the self-instructional self-paced package for 10 sessions of one-hour duration per day. This was in addition to the classroom teaching by their teacher that followed the traditional method. The CG was instructed by their teacher using the traditional method alone.

RESULTS

The aim of the study was to study the effect of intervention using the CAI on maths achievement of students having maths difficulties. These students were attending Pratham level A. The topic on which the CAI was developed was division. For the study three null hypotheses were developed with the view to understand the gain score for the CG and EG pre and post intervention independently, and identify whether there is any difference in the gain score between the CG and EG post intervention.

Data was analysed using descriptive and inferential statistics. Two-tailed t-test statistic at .05 level of significance was employed to ascertain whether the CG and EG differed significantly after CAI intervention.

The mean as measure of central tendency was computed and standard deviation was calculated to provide a measure of variability for the CG and EG. The table below (Table 2) shows that CG and EG were performing similar at the beginning of the experiment as evident for the mean scores of both the groups (*M* of CG = 7.09 and *M* of EG = 7.00). Likewise, both the groups have similar variability (*SD* of CG = 2.16 and *SD* of EG = 2.12) indicating that the individual differences within the two groups is comparable with regard to the obtained range of scores. The groups have similar heterogeneity. From figure 1, it is also evident that the bar for mean posttest score on CBAT is higher for the EG (*M* = 34.14) as compared to the CG (*M* = 26.05) indicating improved performance after intervention.

Table 2 - Mean Scores and SD obtained by Students in CG and EG on CBAT in Pretest and Posttest

Groups	Pretest Scores				Posttest Scores			
	Minimum obtained	Maximum obtained	Mean	SD	Minimum obtained	Maximum obtained	Mean	SD
CG	3	11	7.09	2.16	13	40	26.05	7.68
EG	3	11	7.00	2.12	22	47	34.14	5.80

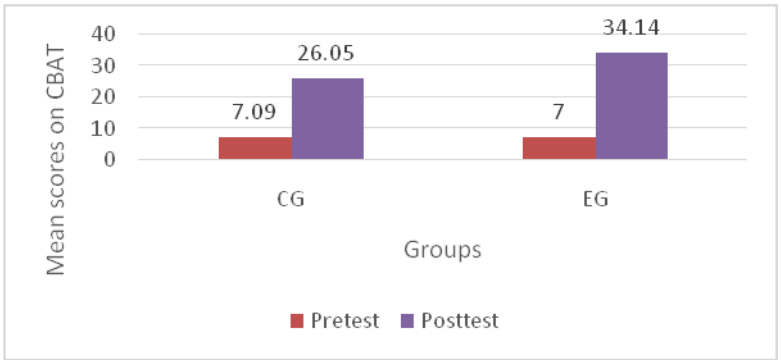

Figure 1 - Mean scores obtained by students in CG and EG on CBAT pre and post intervention

Figure 1 indicates that the mean score of students in CG is higher during posttest as compared to pre-test. In addition, that all students in CG benefitted from receiving instruction using traditional methods is evident from figure 2 which shows the performance of each student pre and post intervention. The scores on posttest are higher than on pretest for all students.

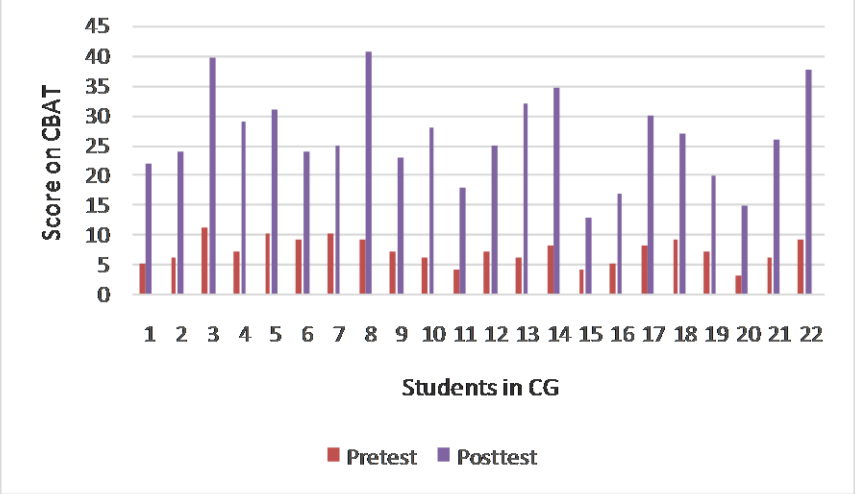

Figure 2- Scores obtained by students in CG on CBAT pre and post intervention

To know whether there was a statistically significant difference in the mean achievement scores on the CBAT obtained by students in the CG before and after being instructed using the traditional method, correlated samples t-test was employed. The results as presented in table 3 indicate that the students in the CG benefitted from being taught the topic division using the traditional method that included explanation and modeling from the teacher. The gain score of 18.96 showed the increase in the mean scores from pretest (M = 7.06, SD = 2.16) to posttest (M = 26.05, SD = 7.68). The difference t (21)

= 14.59, $p<.05$ indicated that use of traditional method for instruction has a significant effect on maths achievement of students with maths difficulties.

Table 3 - Comparison of Mean Scores of Students in CG on CBAT Pre and Post Intervention

Test condition	Mean	SD	n	df	t
Pretest	7.09	2.16	22	21	14.59*
Posttest	26.05	7.68	22		

*Significant at .05 level of significance

With reference to the performance of students in the EG, figure 3 shows that every student in the EG (n = 22) students benefitted from being taught using CAI along with traditional teaching. The scores on CBAT posttest are higher than on CBAT pretest.

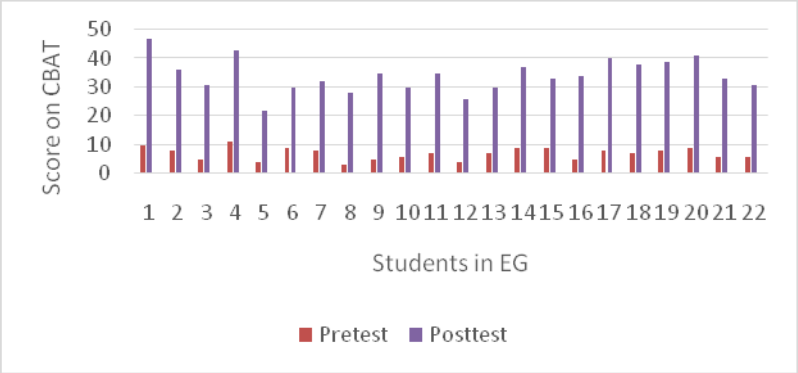

Figure 3- Scores obtained by students in CG on CBAT pre and post intervention

The effect of teaching division to the students in EG using traditional method along with CAI package developed for the purpose was further analysed to comprehend whether the difference in the mean scores was statistically different. The data in table 4 shows that the mean gain for students in EG was 27.14 from pretest (M= 7.00, SD = 2.12) to posttest (M = 34.14, SD = 5.80). This mean gain score was found to be significantly higher indicating the effect of intervention on maths scores,$t(21)$= 28.85, $p<.05$.

Table 4 - Comparison of Mean Scores of Students in EG on CBAT Pre and Post Intervention

Test condition	Mean	SD	n	df	t
Pretest	7.00	2.12	22	21	28.58*
Posttest	34.14	5.80	22		

*Significant at .05 level of significance

Lastly, posttest data on CBAT was analysed using independent samples t-test to ascertain whether the students in CG and EG performed statistically significantly different than each other. It was seen that the performance of EG (M= 34.14, SD = 5.80) was significantly better than CG (M= 26.05, SD = 7.68), $t(42) = 3.72$, $p<.05$ (refer to table 5), thus concluding that the intervention with the help of CAI combined with traditional teaching has caused betterment in maths learning. To ascertain whether this statistically significant difference has any implication for practical use of CAI combined with traditional teaching, the effect size was calculated. The effect size (d = 1.12) was found to exceed Cohen's convention for large effect (d = .80) demonstrating that teaching division to students using CAI in addition to traditional teaching methods will benefit students with maths difficulties immensely.

Table 5 - Comparison of Mean Scores of Students in CG and EG on CBAT Posttest

Group	Mean	SD	n	df	t	d
CG	26.05	7.68	22	42	3.72*	1.12**
EG	34.14	5.80	22			

*Significant at .05 level of significance
**Large effect size

DISCUSSION

Based on the reported data, students receiving intervention through a CAI program, showed significant gains compared to the control group indicating that teaching using CAI was an effective method of intervention for students having difficulties in learning maths. The findings support previous research findings signifying that CAI has a positive effect on student learning.

From the view of use of Differentiated Instruction strategies or Universal Design for Learning framework, CAI offers flexibility and individualized support within their framework; it affords extensive one-to-one practice within classrooms thus reducing the teachers' supervisory time (Basturk, 2005); ensures skill mastery. CAI can be considered important specifically for low achieving students or those with maths difficulties, for who tutorial instruction is found to be effective (O'Byrne, Securro, Jones, and Cadle; 2006) and this is evident in the present study too. Many struggling maths learners need support and scaffolds. Vygotskian theory indicates that ICT can bring difficult tasks within the ZPD (Zone of Proximal Development) because students receive

screen cues that provide scaffolding not available from the teacher at all times. Computer programs are interactive, can illustrate a concept through attractive animation, sound, and demonstration, offer a different type of activity and a change of pace from teacher-led or group instruction (Fuchs et al., 2006). Students are not just passive learners, but they understand the mathematical concepts by doing maths. This interactive feature and user-friendly software provided such an environment where mathematical concepts are presented in virtually concrete forms, activities are interesting and challenging. The CAI package developed by researchers in this study had the features that assisted students in gaining concrete, real-life based and basic knowledge, and also it provided them with the scope to construct their own understanding of division.

CONCLUSION

The study contributes to the field of education as it provides evidence that use of CAI benefits students who struggle with maths learning. Though the study was conducted in institutes that teach Pratham and NIOS curriculum, the results obtained in the study are encouraging and can prompt the conduct of a similar study in inclusive classrooms or special education classrooms that use evidence based inclusive education practices. A study on the long-term gains of the use of the CAI package is essential to determine whether the effects of the intervention would be sustained for a longer duration.

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