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Digital Games and Co-Curricular Activities as the Influential Factors of Problem Solving Ability in Mathematics of Senior Secondary Students

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Authors' contributions

This work was carried out in collaboration between both authors. Author MV managed the literature, preformed the statistical analysis and wrote the first draft of the manuscript. Author VJ reviewed the draft and given it final shape. Both authors read and approved the final manuscript.

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ABSTRACT

This study aims to investigate digital games and co-curricular activities as the influential factors of problem solving ability in mathematics of senior secondary students. 200 students of 12th class studying mathematics were selected in sample. For the selection of sample simple random sampling was used. Data was analyzed by two-way ANOVA. The study revealed that digital games and co-curricular activities had main significant effect on mathematics problem solving ability of senior secondary students. This also revealed that there was significant interaction effect of digital games and co-curricular activities on mathematics problem solving ability. Thus, students' mathematical problem solving ability was positively influenced by digital games and co-curricular activities. Mathematics related digital games improved mathematics problem solving ability. Digital games and co-curricular activities can be useful to develop interest and participation of the students in solving mathematics problems. So, their inclusion with interest significantly improved the delivery of instructions in mathematics.

Keywords: Digital games; co-curricular activities and problem solving in mathematics.

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1. INTRODUCTION

We live today in a world of ever increasing complexities. In the present scenario we faced many problems which need to be solved quickly and effectively. Success in present time depends on ability to solving problems. Therefore, it is essential that we should develop our problem solving ability to such an extent that solutions come naturally to us. Today's computational skills are not sufficient for mathematics; it requires ability to think and reflects mathematically to learn new thoughts and to find the solution of new problems that will be face by students in future.

Mathematical problem solving ability is not a topic but also a tool applied as not only to help in the development of thinking ability in students but it is also helpful in the development of their basic skills of solving the daily life problems. The goal of mathematics teaching and learning is that the students became able to solve problems of subject as well as in daily life [1]. Problem solving ability is a heart of mathematics learning [2,3,4,5]. National Council of Teachers of Mathematics (NCTM) [6] suggested for modification in the mathematics education from content to problem solving abilities. [7] reported that mathematics is a subject of reasoning, not memorization. Problem solving gives opportunities to students to gain understanding and explain the processes used to provide the solutions in place of remembering and applying a set of procedures. In these abilities students gain a deeper understanding of concepts of mathematics and appreciate the significance and usefulness of mathematics. Thus, problem solving plays a significant role in mathematics learning.

Problem solving is a higher order cognitive process which uses facts and principles to explain new situation or predict consequences from known conditions. In problem solving task solvers use analysis of facts, prediction to explain cause and effect relationship in given situation [8,9]. This is a process in which learner use previous knowledge, understanding and skills to fulfill the requirements of unknown situations. In this process learner must synthesize what he knows and use it to find the solution in new situation [10].

Digital game refers to an interactive program that can be played by one or more peoples on electronic devices such as computers and mobiles. Digital games improved creativity, reflective thinking and problem solving skills of persons with its features that enable persons to have active experiences, gives solutions in problematic environments and gives immediate feedback [11]. Digital games transform learning from a rote process to conceptual understanding.

Without co-curricular activities the curriculum might not be sufficient for overall development of students. The holistic growth as well as to develop the various domain of mind and personality of students classroom teaching should be supplemented with co-curricular activities. Co-curricular activities are those which facilitate to supplement or complement the curricular or main syllabi activities. These activities take place outside of the classroom but attached to the classroom curriculum [12]. Co-curricular activities play an important role in the development of various domains such as cognitive, moral, social, cultural, emotional and physical of students.

1.1 Literature Review

Computer programming, different types of co-curricular activities [9] learning style [13] self-esteem, teachers' behavior, motivation, self-efficacy and attitude towards mathematics [14] were influential factors of problem solving ability. Computer programming and co-curricular activities enhanced this ability. [15] found in her study that jigsaw method of cooperative learning was also an enhancing factor of problem solving skills. Gender, locality, extra coaching, community, parental education and occupation were affects the problem solving ability but these abilities not affected by type of schools [3]. [16] reported that mathematical problem solving ability affected by locality, type of schools and subject group but not influenced by gender. Problem solving ability was positively affected by life style education [17]. [18] reported that these skills positively related with working memory. The study of [19] revealed that senior secondary students differ significantly on their problem solving ability on the basis of cognitive style and gender. Male students performed better than female on problem solving ability, but according to [20] there was no gender difference in this ability of senior secondary students. Their problem solving ability was differs on the basis of stream. Science and commerce stream students had high level of problem solving ability than students of art stream. Under graduate students present difference in their problem solving ability

regarding to gender, type of institutions and mothers' education but no difference on the basis of fathers' education [21]. Secondary students differs on problem solving ability with respect to locality, gender [22] parental income and fathers' education but they have same level of this ability with respect to status of family, mothers' education and parental occupation [23]. [24] found that incapability in mathematical skills such as information skill, visual spatial skills and missing of cognitive abilities were difficulties faced by students in solving mathematical problems.

According to a study conducted by [25] students and teachers preferred and supported to use of digital games in mathematics learning. But parents did not support to use of digital games in learning, they accepted that communication and socialization are important factors in learning. Computer games or digital games were effective in the development of problem solving skills in students [11,26,27,28,29,30,31].

Students who were involved in co-curricular activities performed better in mathematics and reading skills rather than students who were not involved in co-curricular activities. This indicates that co-curricular activities had positive effect on mathematics learning and reading ability [32].

1.2 Objectives

1. To study the effect of digital games on mathematics problem solving ability of senior secondary students.
2. To study the effect of co-curricular activities on mathematics problem solving ability of senior secondary students.
3. To study the interaction effect of digital games and co-curricular activities on mathematics problem solving ability of senior secondary students.

1.3 Hypotheses

1. There will be no significant effect of digital games on mathematics problem solving ability of senior secondary students.
2. There will be no significant effect of co-curricular activities on mathematics problem solving ability of senior secondary students.
3. There will be no significant interaction effect of digital games and co-curricular activities on mathematics problem solving ability of senior secondary students.

2. METHODOLOGY

2.1 Method

The focus of this study is to find the existing present status of the variable (mathematics problem solving ability). For this purpose a survey was conducted on selected sample to collect the information about the variable. Hence, descriptive survey method has been used in the present study.

2.2 Sample

In this study, a sample consisting of 200 students of mathematics studying in the 12^{th} class selected from seven schools of Meerut District. Lottery method was used to select the schools from the list of schools of Meerut district. All students of 12^{th} class in mathematics section in these schools have been considered in the sample.

2.3 Tool Used

Mathematical Problem Solving Ability Test (MPSAT) constructed and standardized by the researcher was used to assess the problem solving ability in mathematics of senior secondary students. This test consists of 20 multiple choice items. The reliability of this test was 0.78, which was established by Test-Retest method. The validity of MPSAT test was calculated by finding the correlation of scores with the standardized test. The correlation coefficient was found to be 0.72.

2.4 Statistical Technique Used

Mean and SD was used on the scores of mathematical problem solving ability of senior secondary students under this study. Analysis of variance (ANOVA) with 2x2 factorial design was applied to identify the main effects and interaction effect of two independent variables (digital games and co-curricular activities) on dependent variable (problem solving ability in mathematics).

2.5 Data Analysis

In order to study the main effect and interaction effect of two independent variables on one dependent variable 2X2 factorial design was applied. In this section, the independent variable

as digital games (A) was varied into two groups as mathematics related digital games (A_1) and other digital games (A_2). The second independent variable as co-curricular activities (B) was varied into two groups as participated in co-curricular activities (B_1) and not participated (B_2) in co-curricular activities. A layout of factorial design for variables has been showed in Fig. 1.

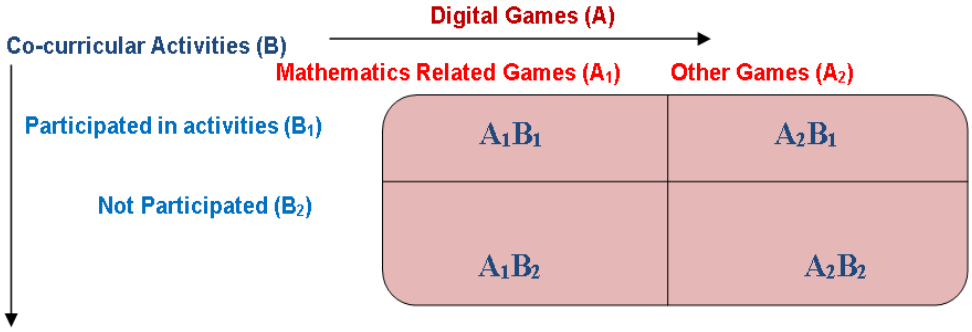

Fig. 1. Layout of 2X2 factorial design for variables

Table 1. Summary of two-way analysis of variance for mathematics problem solving ability with respect to digital games and co-curricular activities

Sources of Variance	df	Sum of squares SS	Mean squares MS	F-ratio	Level of significance
Between Digital games (A)	1	391	391	27.92	Significant at 0.01
Between Co-curricular Activities (B)	1	374	374	26.71	Significant at 0.01
Interaction AXB	1	463	463	33.07	Significant at 0.01
Within	196	2744	14		
Total	199	3972			

2.5.1 Main effect

The description of main effect of independent variables (digital games and co-curricular activities) on dependent variable (mathematics problem solving ability) is shown as follows:

2.5.2 Digital games (A)

It is clear from Table 1 that the calculated value of F-ratio for the effect of digital games on mathematics problem solving ability of senior secondary students is 27.92, which is greater than the Table value (6.81) of F-ratio at 0.01 level. Thus, the null hypothesis rejected at 0.01 level. This means that there was significant impact of digital games on problem solving skills in mathematics. Hence, digital game is influential factor of problem solving ability.

t- value has been further calculated to support the result and has been given in Table 2.

Table 2. t- value for mathematics problem solving ability with regarding to digital games

Variable digital games	N	Mean	SD	t-value	Significance at 0.01
Mathematics Related Games	99	15.14	4.27		
Other Games	101	8.09	3.80	12.37	Significant

The Table 2 indicates that t-value is 12.37; it is significant at 0.01 level. This shows that both groups of students one in which students play mathematics related games and the other group in which students play other digital games differ significantly on scores of mathematical problem solving ability. After comparing the mean scores, it was found that students who play mathematics related digital games have high problem solving ability as compared to students who play other digital games.

2.5.3 Co-curricular activities (B)

From Table 1 the calculated F- value for the effect of co-curricular activities in mathematics problem solving ability of senior secondary students is 26.71, which is greater than table value (6.81) at 0.01 level. Thus, the null hypothesis rejected at 0.01 level. This shows that co-curricular activities are affected factor of mathematics problem solving ability. This means that these abilities influenced by co-curricular activities. For support the result t- test has been further applied and calculated value presented in the Table 3.

Table 3. t- Value for mathematics problem solving ability with regarding to co-curricular activities

Variable co-curricular activities	N	Mean	SD	t-value	Significance at 0.01
Participated in activities	93	13.47	5.17		
Not Participated	107	9.79	4.85	5.27	Significant

It can be seen from Table 3 t-value is 5.27; it is significant at 0.01 level. This indicates that two groups of students one group of students who participates in co-curricular activities and other group of students do not participate in any type of co-curricular activities have significant difference on mathematics problem solving ability. After comparing mean scores it can be said that students participate in co-curricular activities have high mathematical problem solving ability rather than the students do not participate in activities.

2.5.4 Interaction effect of digital games and co-curricular activities (AXB)

It can be seen from Table 1 the value of F-ratio for the interaction effect of digital games and co-curricular activities of senior secondary students is 33.07, which is greater than table value 6.81. Thus, the null hypothesis rejected at 0.01 level. It indicates that significant interaction effect of digital games and co-curricular activities on mathematics problem solving ability exist.

3. RESULTS AND DISCUSSION

The result of this study shows that problem solving ability in mathematics of senior secondary students positively influenced by digital games. Mathematics related digital games improve mathematical problem solving ability at senior secondary level. This result is similar with the work of [31,33] which revealed that computer games had effect on problem solving ability. Similar results of [11] that digital games improve problem solving ability of students because they have experiences with its features, digital games provide solutions in problematic environment and gives immediate feedback. Result if this study also supported by results of [26,27,28,29] which shows that features of digital games as a strategy focused on attention and trying to develop problem solving ability. In addition students who play digital games improved their mathematics learning, had positive attitude towards mathematics [34].

From findings based on objective-2, it indicates that co-curricular activities have positive effect on mathematics problem solving ability. This is also in line with the finding of [35] which indicates that student's involvement in extra-curricular in any types of sports, drama and literacy activities had positive effects on mathematics performance. Findings of this study also supported by the work of [32] co-curricular activities had positive effect on mathematics learning and reading ability and similar the results of [36] found that students performance positively affected by co-curricular activities. This finding of the study oppose to the findings of [37,38,39], found that all co-curricular activities are not help to students achievement, some improve performance but others obstacle in academic performance. Result of the study based on objective-3, revealed that digital games and co-curricular activities have interaction effect on mathematics problem solving ability.

4. CONCLUSION

The study concluded that problem solving ability in mathematics of senior secondary students is positively affected by digital games. Students play mathematics related digital games performed better as compared to students play other games. Study also concluded that student's participation in co-curricular activities also influencing factor of the mathematics problem solving ability. Students involved in any kind of co-curricular activity gain high scores on mathematics problem solving ability. The study

also exposed that mathematics problem solving ability influenced by interaction of digital games with co-curricular activities. It is desirable that teachers should organize problem solving environment and competitions in classroom. The students should be encouraged to participate in these activities which will certainly improve problem solving skills. Parents should arrange mathematics related digital games for their children to improve mathematics performance and to develop problem solving ability. Teachers should use effective strategies for foster problem solving ability. Teacher should be design game system in digital mode based on constructivist learning in which generate problems, producing and implementing solutions with systematic steps in order to defeat the obstacles for the development of problem solving skills. As a future research, studies can be conducted to find out the impact of digital games and co-curricular activities in learning outcomes in various subjects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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