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IMPACT OF FLIPPED AND GAME-AIDED INSTRUCTION ON THE MATHEMATICAL ACHIEVEMENT OF SOCIO-ECONOMICALLY MARGINALIZED CHILDREN AT THE PRIMARY SCHOOL LEVEL

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KEYWORDS

Flipped and Game-Aided Instruction; Academic Achievement, Academic Motivation, Socio-economically Marginalized; Mathematics; Primary Level

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ABSTRACT

The mathematical achievement of primary school students, flipping, and game-aided instruction proved as effective in improving the mathematical achievement. However, literature is silent about its impact on the students' motivation. Thus, the effects of flipped and game-aided instruction were investigated for students' mathematical success and motivation, following the true experimental research design, wherein two parallel experimental groups (flipped & Game-aided instruction), used to probe the effectiveness of both instructional methods for the students' motivation. This experiment was confined to whole numbers, mathematical operations, fractions, HCF, and LCM in a mathematics textbook. The students' Pre-test (MAT) scores, students' academic motivation and their socioeconomical indicators were utilized to randomize both flipped & game-aided instruction groups and were taught for six weeks followed by post-test and academic motivation questionnaire. It was revealed that both flipped & game-aided instruction have improved students' mathematical achievement and motivation. Consequently, research study recommended that students' mathematical achievement in marginalized communities can be improved through the application of both the flipped and game-based instruction at the primary school level.

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INTRODUCTION

All scientific fields are rooted in mathematics (Liu, Sun, Sun, Wang & Yu, 2025). Mathematics is a subject with widespread applications in our daily lives (Sharma, 2021), which helps 21st-century learners to equip themselves with the sustainable learning skills (Vintere, 2018). The increasing the technological advancement have improved living standards (Hess, Narteh-Yoe,

Gregorious & Moloi, 2023) and further highlighted people's expectations from the modern educational systems to prepare the learners for sustainable learning skills (Dworak, Rzymełka & Wilk, 2023). Educational institutions are rapidly adjusting to the evolving nature of people's expectations, continuous reforms and curricula changes are an emerging reality in academic circles (Liu et al, 2025). Akbar (2023), further studied the impact of game-aided instruction and collaborative learning on the mathematical achievement at the secondary school level. These reforms and changes extended to the teaching methodologies and learning experiences, from traditional classroom settings, to online/virtual, hybrid, blended (Sosa, Garrido & Delgado, 2025), multidisciplinary and learner-centered classroom teaching methodologies (Allayarova, 2025).

The importance of mathematics as a life subject, rapid technological advancements (Hess et al, 2023), evolving expectations of people, and response of academia has increased the concerns among researchers related to the low mathematical achievement at primary level in Pakistan (Dworak, Rzymełka, & Wilk, 2023; Liu et al, 2025). Studies revealed the low quality of primary education and disheartening condition of primary school students' mathematical achievement (Bhutta, Ahmad, & Ansari, 2025; Ali, Ahmad, & Hussain, 2021). TIMSS (2019) also tested the mathematical achievement of the 4th grade in 64 countries, and Pakistan ranked 63rd. In such scenarios, alongside a long-term nationwide policy intervention, direct intervention within available resources is an amicable solution develop greater confidence and mastery in the mathematics (Bailey, Duncan, Cunha, Foorman, & Yeager, 2020). The provision of the online instructional resources for teachers' self-directed professional learning on classroom teaching techniques and methodology could prove incremental towards desired goals (Lopes & Cunha, 2017).

The local studies, including the study of Akbar (2023), Ali, Ahmad, and Hussain (2021), Ullah (2023) experimentally studied effectiveness of teaching methods for mathematics. He found both instructional effective for improving students mathematical achievement, this study was carried out in urban area of district Swat, Khyber Pakhtunkhwa, another study was conducted Ali, Ahmad and Hussain (2021) on the effectiveness of collaborative learning approach for the teaching of mathematics found it effective for 5th grade students mathematics achievement, this study too was conducted in the urban area of district Swat. For marginalized learners, this model can level playing field in several ways.Likewise, Ullah (2023) studied the effectiveness of the Laboratory Method (LM) in teaching students' higher-order thinking skills and found it effective in developing the students' higher-order mathematical skills in secondary schools in Upper Dir, Khyber Pakhtunkhwa. Thus, even peer tutoring was used and found effective for enhancing the mathematical achievement of hearing-impaired students (Shah, Noor, & Ullah, 2025).

The empirical results conclude that researchers studied game-aided instruction, collaborative learning, and laboratory methods for the students' academic achievement in mathematics (Ali, Ahmad, & Hussain, 2021; Ghani, 2023; Ullah, 2023). Still, these results are associated with risk-oriented factors like contextualized factors (Rubel & McCloskey, 2021), academic motivation of students (Rodríguez, et al., 2017), as these studies are silent about students' socio-economic

background and their motivation for the learning of mathematics after following game-aided, collaborative laboratory methods. In contrast, game-aided instruction embeds mathematical learning within game-like contexts, digital games, board games, manipulatives that simulate real-world problem solving while making abstract concepts tangible, engaging. But, literature is silent about effectiveness of flipped and game-aided instruction in one frame used of socio-marginalized rural area girls' mathematic success, with their academic motivation, along with socio-economically marginalized, there cognitive disabled students who were also part of this experiment.

Study Locale

District Swat is beautiful tourist destination, with a population of 2.687 million and comprises 5337 square kilometers. Being a hilly area, majority of its inhabitants are involved in farming, the hotel industry, and service-oriented jobs. The majority (90%) of them speak Pushto, 08% speak Torwali, Kalami, and Kohistani languages. The educational aspect of this district is not appreciated, only 13.45% female are literate compared to 43.16% male (Khyber Pakhtunkhwa, 2023). Swat from last two decades is in continuous grip of man-made and natural disasters, militancy, floods, cloud outbursts, and earthquakes are worth mentioning (Ahmad et al., 2020, Khan, 2025). These natural and man-made disasters have detrimental effects on socio-cultural dimensions of its inhabitants, evident in educational attainments of children, the demolition of girls' schools during militancy in Swat has long-lasting impacts on girls' education in this region, 13.45% female literacy is significant evidence in this regard (Khan, 2015). The cultural constraints (prohibition of co-education) scattered population located in hills have intensified issue of access to education for socio-culturally marginalized and cognitive disabled families' girls, those who have access were reported as having low academic performance, particularly in mathematics.

Research Objectives

1. To examine effects of flipped classroom instructional intervention on socio-economically marginalized students' achievement and motivation in the mathematics at the primary school level.
2. To examine the effects of game-aided classroom instructional intervention upon socio-economically marginalized students' achievement and motivation in mathematics at the primary level.
3. Compared the effects of flipped and game-aided classroom instructional intervention on socio-economically marginalized student achievement & motivation in mathematics at primary level.

Research Hypotheses

1. The flipped classroom instructional intervention upon socio-economically marginalized students has no significant effects on their mathematical achievement and motivation in particular context.
2. Game-aided classroom instructional intervention on socio-economically marginalized students has no significant effects on their mathematical achievement and motivation in particular context.

LITERATURE REVIEW

Constructivist approach prioritizes students' active participation in knowledge construction, and games provide a way for students to learn new material and incorporate it into what they already know, and they facilitate suitable adjustments to the real-world scenarios (Donaldson, 2023, McLeod, 2019). The games, as abstract representations of reality, provide a platform for participants to share ideas and perspectives actively (Wang, Thompson, Uz-Bilgin & Klopfer, 2021). Games in mathematics have pre-determined cognitive aims, are enjoyable in engaging students with content-oriented aspects, and the application of mathematics rules makes these games unique (Russo, Bragg & Russo, 2021). These games reduce the students' academic stress generated from their inequalities & other temporal constraints, increase their interest towards learning, and provide them with well-organized and socially engaged learning opportunities (Liu, 2023).

Game Aided Instruction

Crocco, Offenholley, and Hernandez (2016) and Wang et al. (2021) caution that the impact of games upon academic learning depends on careful planning and integration with the lesson. Therefore, teachers' role is indispensable to ensure students' active participation, to strive to meet mathematical cognitive goals and content coverage, to foster effective self-competition, to engage students in peer competition on the mathematical content-integrated games, and to make learning fun for students (Heshmati et al., 2018). Such continued teacher engagement can lead to improvements in students' mathematical achievement and academic motivation. In this connection, the empirical evidence on games in mathematics are evolving, initially, it was Dienes (1963) who advocated game-play in the teaching of mathematics, endorsed by the results of the Ernest (1986) claiming that games helps the students comprehend mathematical concepts, improve social skills, enhance student reasoning skills (Olson, 2007), boost problem solving skills among learners, ensure targeted instruction (Clarke & Roche, 2010) and connect school and home environments (Russo, et al, 2018), laconically, there are ample evidences that depicted positive effects of game aided instruction for various mathematical skills as well as achievement.

On the contrary, the dimensions such as less reflection, excessive engagement in games, may undermine the pedagogical approaches and potential learning of the students (Harviainen & Merilainen, 2019), which prioritize mathematical ideas in the gameplay, as players' heuristic application disconnects them from core mathematical concepts (Heshmati et al, 2018). Russo et al. (2021) concluded that teachers do follow gameplay in the mathematics frequently, which rises students' experience of 'flow', where it often contains core mathematical ideas connected to the gameplay in this subject. Thus, in support of this claim, Heshmati and colleagues (2018) monitored the cover-up and uncover fraction games among 5th-grade students and concluded that players navigated with reference to the colors of the pieces rather than their fractional amounts, which is significant evidence of the abstraction of mathematical quantities. Braggs (2012) added that gameplay reduces the pedagogical interactions of students. Heshmati et al (2018) studied 70 video-taped mathematics lessons, where 14 lessons were on Cover-up and

Uncover games, & remaining included alternative learning experiences (problem solving and worksheet).

The theme was the same, that is, fractions and multiplication of fractions, where the quality of student-teacher was examined in game and non-game learning experiences. It was concluded that games were effective for reinforcement and practicing previous mathematical learning, but not for exploring new mathematical concepts. In-game learning experiences, instead of a mathematical concept, focus of interactions was on game rules, turn-taking & game progress. These results among researchers question pedagogical value of games (Crocco, Offenholley, & Hernandez, 2016; Russo et al., 2021; Wang et al., 2021). The latest developments in the last twenty years have appeared in digitalization of almost every aspect of education, including mathematical games. Heshmati et al (2018) studied the effectiveness of the digital games in mathematics. Still, Heshmati et al., (2018) concluded that the teachers need more professional training and orientation as they are the ones who decide when and which games to use more effectively for the classroom learning experiences of the teachers. Another dimension in game-aided instruction is developmental, mechanical & designing aspects of games for mathematics teaching that affecting the students' mathematical skills (Nilsson, 2007; Ramani, & Siegler, 2011).

The study of Nilsson (2007) on the students' reasoning skills while playing games (probability games) where they worked in pairs as Nilsson design a game following counters and dice, to complete counters through a competitive games among students for completing of probability counters and he was mainly concerned about the effects of games variations, and structured rules for supporting the students' thinking around probability, concluded that it has multiple worthy notes for the instructional designing characteristics. They concluded that, along with positive effects on students' mathematical achievement, these games also have adverse effects on the student-teacher pedagogical interactions, on the student learning of new mathematical concepts, and on the players' excessive engagement in game-oriented activities rather than mathematics. Jabbar and Felicia (2015) concluded that digital games do impact students' mathematical learning positively due to the students' engagement, interest, and persistence. The findings of Pareto (2012) revealed that the student interactions with mathematical digital games increase their motivation, confidence, and interest towards mathematics, as the author concluded that the students were more enthusiastic at the start of and reluctant to end these games.

Flipped Instruction

Flipped instruction, as popularized by Sams (2013), involves conducting educational activities outside lecture halls, emphasizing hands-on, collaborative activities during class. It is part of a broader trend of the blended learning, combining online and in-person training (Mushtaq & Iqbal, 2024). This method aims to use the internet technology to enhance classroom activities, fostering students' interaction and critical thinking (Pang, 2022). A dynamic and introspective learning environment is produced by the three phases of flipped learning: before, during, and after session (Birgili et al., 2021; EI Miedany, 2018). The concept was introduced by Northern Colorado University, where students see educational films prior to class, enabling project-

based and participatory learning in classroom (Akçayır, & Akçayır, 2018). This method aims to offer learners with real educational experience while helping ownership of learning (Smith et al., 2021). Active flipped teaching classroom model covers integrating technology, attention-grabbing models, relevant material, reflection, time and location consideration (Doğan et al., 2023).

The technological integration into classroom learning experiences helps the teaching in the individualized instruction of students (Ruggiero, & Mong, 2015), ensures students' interest, academic motivation (Pang, 2022), and enhances students' academic performances (Silva, et al., 2020). Students' attention & provision of relevant materials streamline classroom learning, which can be further enlarged through reflective learning experiences, and flipped classrooms are well-equipped with these factors. Along with the benefits of flipped instruction, various pitfalls have detrimental effects on students' educational satisfaction. Students of weak socio-economic background are lacking portable digital gadgets, experiencing problems of access to the internet for downloading videos, and some students don't have access at home to watch and prepare for pre-classroom assignment. The switch from traditional instruction to flipped instruction may also instill resistant behavior among students for pre-classroom learning activities, which are considered additional learning burden on them. Most literature explains the benefits of flipped classroom instruction, but these dimensions have detrimental effects on the output results upon the students' academics, resource utilization, as well as the academic satisfaction.

Students' Academic Motivation

Students' academic motivation in a subject is closely associated with their prior performance. Aunola et al. (2010) call it the cumulative developmental cycle. Trujillo-Torres et al (2020) concluded that motivation is always a concern in the teaching of mathematics, even among its teachers. The way they teach mathematics reflects their low motivation. Akbar (2023) added that academic motivation works as the catalyst, continuous feedback, innovative instructional techniques, hands-on practices, and teachers' attitude positively add to the students' academic motivation. Aunola et al, (2010) added that students' motivation at primary closely associated with incremental learning, it's teacher who contributes to students' interest, self-motivation, and confidence or vice versa. All these pre-classroom activities have unfavorable effects on classroom teaching and on learners' hands-on practice during classroom instruction. Students' initial mathematical learning success increases their confidence, enhances interest in subject and leads toward academic motivation. Gohar (2025) believed that among socio-economic backward students' mathematics teaching is a tough course of action, but related to their own social life experiences, adding the element of games and technology has significantly positive results.

Theoretical Framework

The game-aided and flipped instruction are innovative teaching methods in the teaching of mathematics. Sociocultural Theory of Cognitive Development (STCD) of Vygotsky (1978) and Constructivist Learning Theory of Piaget (1970) explain that children interact with learning

concepts twice, initially at societal level and later at individual level. Learning mathematics where they experience the learning realities within their social interactions and flipped, and game-aided instruction provides them with interactional, hands-on learning experiences at the classroom level and leads toward knowledge construction. There are multiple factors that hinder this process, but teachers, technology, and active engagement enable them to overcome the hindrances and reach the desired targets. These theories provide a basis for understanding of interactional effects of game-aided, flipped instruction on student learning of mathematics. Davis (1989) Technology Acceptance Model (TAM) viewed that effectiveness of technology integration into the teaching learning process and procedures depends on its usefulness and convenience.

Davis has supported the technological aspect of flipped instruction through TAM. Deci and Ryan (2011) in their Self-determination Theory (SDT) elaborated motivation the combination of autonomy, competency, and relatedness of learners to learning concepts. Game aided and flipped instruction empower learners with corrective and immediate feedback (Ferriz-Valero, et al., 2025), improving their learning competence through hand-on practices (Sams, 2013), as both these instructional practices immensely depend upon the first-hand leaning experiences (Heshmati, 2018), and the integration of local games, videos, pictures, and diagrams of flipped and game aided instruction contextualize learning concepts for students. Sociocultural theory of cognitive development, constructionist learning theory, technology acceptance model, and self-determination theory were used to examine effects of flipped and game-aided instruction on student outcomes for socially marginalized/cognitive disabled children at primary school level.

RESEARCH METHODOLOGY

Post-positivist research clearly depicted learning reality of students in learning mathematics following empirical control observations, experiments, testing of null hypotheses & collecting data from two groups: flipped instruction (Group-A) and game-aided Instruction (Group-B) through the Mathematical Achievement Test (MAT) and the Students' Academic Motivation questionnaire (SAMQ). The true-experimental pre-test and post-test equivalent group design was followed; both the groups were equalized based on the pre-test scores on the MAT test and the SAM questionnaire on 5th grade students at the Government Girls Primary Kalkata, District Swat. Fraenkel et al., (2019) identified true experimental equivalent group design as an effective experimental design due to its internal validity, randomized assignment to groups and manipulation of subjects in the experiment. This design was recently used by Akbar (2023), Ali et al., (2021), other researchers for such studies, therefore, this research design was adopted.

Table 1

Group Distributions

SN	Groups	Observations	Experiment	Observation
1	Group-A (Flipped Instruction)	RO1	X	O2
2	Group-B (Game Aided Instruction)	RO1	X	O2

Note: R = Randomized, O = Observation (Test), X1 = Flipped Instruction, X2 = Game Aided Instruction

The students of this school were selected because all the students in the school belong to lower socio-economic families and is situated in the remote area of Kalkata, tehsil Charbagh, district Swat, KP, Pakistan. Besides, there were students with mental disabilities, which also became a strong justification for selection of this school. A total of forty students of grade 5th enrolled in GGPS Kalkata were employed in this study, who were divided into flipped and game-aided instruction groups (A&B) after the pre-tests, aiming to equate both groups. Before the pre-test, the MAT and the SAM questionnaires were validated (content validity) through a committee of four experts, who conducted a pilot test on sixty-eight 5th-grade students of GGPS Labor Colony and GGPS Manglawar. The item analysis (difficulty and discrimination indices) of MAT was conducted to develop a test (MAT) that is more reflective and suitable for different cognitive processes along with the multiple intelligence levels of students (Bennett & Davier, 2017).

MAT was comprised of sixty-three items but after item analysis, eighteen items were dropped due to a lower/higher level of the difficulty index (p range for items = 30% to 70%) and lower discrimination index (DI = less than 30%) and a final forty-five-item MAT was used for the pre-test and post-test. The reliability coefficient of MAT was than measured following the KR-20 formula (Tan, 2009) and rKR-20 = .81 however, the reliability of the SAM questionnaire was measured through the Cronbach alpha method (Digon, & Alvarado, 2025) and it was α = 85 both these values were in acceptable range, therefore, both MAT and SAM questionnaire were used for data collection. The teachers of both groups were trained for flipped and game-aided instruction, and lesson plans were prepared to teach both the groups accordingly. The formal permission for the experiment in the school was obtained from the Parent Teacher Council (PTC) (Annexture-IV), as well as an ethical review certificate (Annexture-V) was granted by the Graduate Study Committee (GSC) of the Centre for Education & Staff Training, University of Swat.

After the formation of flipped and game-aided experimental groups and completion of the preparation arrangements, the experiment was launched, which lasted for six weeks. Thus, the Khyber Pakhtunkhwa Mathematics Textbook's Board grade 5th basic mathematics course, which included fractions, HCF and LCM, whole numbers, and operations, was utilized in this experiment. Given the marginalized and disabled nature of students in flipped instruction, five Android mobile phones, two tablets, and one laptop were provided to provide ample pre-class opportunities for students to watch the videos and other associated materials required in flipped classrooms. Similarly, for game-aided instruction, the local games, materials available in the school from the sports room, and some additional puzzles were utilized. The data were collected from both groups following true experimental research twice; the MAT and SAM questionnaires were administered for data collection (pre-test & post-test). The data collected were analyzed following mean score (X), standard deviation, t-test analysis techniques were utilized.

RESULTS OF STUDY

The results of current study are produced in this section to systematically present the leading outcoms.

Table 1
Results of Pre-Tests for Education Using Game-Aided and Flip Learning Methods

Learning Parameters	Group	Mean	S.D	df	t value	Sig
Students Knowledge	Game Aided	5.5500	2.16370	38	.144	.886
	Flipped	5.6500	2.23077			
Students Comprehension	Game Aided	10.1500	3.03098	38	.053	.958
	Flipped	10.1000	2.88189			
Skills Application	Game Aided	.9000	.71818	38	.216	.830
	Flipped	.8500	.74516			

Both groups illustrate similar performance on MAT test taken before the experiment, and no significant difference found in all three domains (knowledge, understanding & application) of learning. Slight differences in mean scores were found, which were not significant as reflected from the t values and significance value of table. Results revealed low academic performance of students in groups, and both groups were equalized in an effective way based on pre-test scores.

Table 2
Results of Post-Tests for Education Using Game-Aided and Flip Learning Methods

Learning Parameters	Group	Mean	S.D	Df	t value	Sig
Students Knowledge	Game aided	9.5500	1.43178	38	3.066	.004
	Flipped	8.3000	1.12858			
Students Comprehension	Game aided	26.4000	3.58946	38	2.668	.011
	Flipped	23.3000	3.75710			
Skills Application	Game aided	1.4000	.59824	38	.588	.560
	Flipped	1.3000	.47016			

Table 2 shows that the flipped group's students had an average knowledge score of 8.3000, it is 9.5500 for those in game-aided group. This suggests that, on average, students in the game-assisted group did better in terms of knowledge than students in flipped group. The standard deviation measures how data varies or is dispersed. There is some variation in knowledge scores between two groups, group that used the game assistance had slightly greater standard deviation (1.43178) than group that used flip technique (1.12858). An indication of difference in averages in relation to group variability is t-value of 3.066. More significant differences are generally indicated by bigger t-values. In this instance, two groups' knowledge ratings differ noticeably, as indicated by t-value of 3.066. The study's sample size is likely related to degree of freedom (df), which is 38. The generally recognized threshold of 0.05 is exceeded by the level of significance (Sig) of 0.004. According to this, meaningful difference has been found amid two groups' knowledge scores. Put another way, it is highly unlikely that it happened by chance.

Similarly, the results suggest that two groups' assessments of knowledge varied significantly. With a significance level of 0.011 and a t value of 2.668. The t-test indicates that the observed

mean difference is unlikely to have occurred by chance. Consequently, it seems sense to draw the conclusion that the teaching strategy (flipped or game-aided) significantly influences how well students understand the material. The positive t- value indicates that, on average, the comprehension performance of game-aided group was superior to that of the flipped group. Additionally, the mean application skills score for the game-based group is 1.4000, whereas the average score for the group that was flipped is 1.3000. The standard deviation quantifies the degree of variance or variation in the scores for each category. In statistics, the values of number that are susceptible to variation in the final calculation is represented by the freedom of the degrees (df). The difference among the groups about the variation within each group is quantified by t-value. To assess whether the observed variations are statistically important, the significance (Sig) level of 0.560 is frequently compared to the relevance threshold (such as 0.05).

Table 3

Students' Academic Motivation Taught Using Flipped & Game-Aided Methods of Instruction

Component of Academic Motivation	Group	Mean	SD	Df	t Value	Sig
Direction as an Element of Academic Motivation	Game Aided	41.7000	3.58506	38	1.161	.253
	Flipped	40.3000	4.02754			
Persistence as an Element of Academic Motivation	Game Aided	30.6500	3.45307	38	.862	.394
	Flipped	29.7500	3.14350			
Intensity as an Element of Academic Motivation	Game Aided	48.7500	3.73990	38	1.877	.068
	Flipped	46.6000	3.50038			

Table 3 displays the standard deviation (3.58506) and average Direction score (41.7000) for the group that received game assistance. While the Flipped group's mean is marginally lower at 40.3,000, the standard deviation is higher at 4.02754. The t-value of 1.161 and p value of.253 are obtained from 38-degree-of-freedom t-test. Direction component of academic motivation does not differ statistically substantially among flipped and game-based groups, as indicated by the p-value, which is not significant. Comparably, with the standard deviation of 3.45307, The average Persistence score for the group that received game assistance is the 30.6500. The Flipped group's mean is 29.7500, while its standard deviation is 3.14350, which is slightly less value.

A t-value of 0.862 and p-value of.394 are obtained from t-test with 38 degrees of freedom. The game-based and flipped groups do not differ statistically significantly in terms of persistence component of academic motivation, according to non-significant p-value. Additionally, with an average deviation of 3.73990, mean intensity value for Game-based is 48.7500. A slightly below 3.50038 group average, the Flipped group's mean is 46.6000. The 38-degree-of-freedom t-test yields 1.877 and p-value of.068. Though it does not satisfy standard criteria, the p-value of.068 does suggest a tendency to relevance. A bigger sample size or additional research may be required to substantiate possibility that degree of academic motivation varies between two groups.

DISCUSSION

The study's goal was to find out how students' academic motivation and learning outcomes were impacted by flipped and game-aided instruction, particularly when it came to teaching mathematics. Key findings include that both flipped and game-aided instructions improved students' achievement scores. According to study of Lo and Hew (2020), student interviews indicate that peer relationships within the flipped classroom, rather than the gamification and online learning resources, were crucial in fostering students' mathematical proficiency and cognitive engagement. Game-aided instruction was found to be more effective than flipped instruction in enhancing knowledge, comprehension, and application skills. In a variety of subject areas and educational levels, game-based learning increased student motivation, engagement, and achievement. While the study of Holbrey (2020) reports that results indicate there were no technical challenges encountered when integrating synchronous online learning into lecture halls and that gaming was an effective means of encouraging active engagement and interactive learning. The knowledge, comprehension, and application skills of the pupils were much improved by both creative teaching strategies. Positive attitudes towards their academic efforts, hopes for the future, as well as personal growth were demonstrated by the students.

According to Chen and colleagues (2020), they contend that the incorporation of educational games into the classroom can improve students' cognitive and non-cognitive skills while also influencing their learning experiences and results. A promising strategy for the contemporary education, integration of games into classroom can reduce student learning fatigue and, when done properly, address cognitive, social, emotional and environmental elements of learning (Griepl et al., 2020). Furthermore, the flipped instruction unlike traditional instruction inspire learning preemptively (Bergmann, & Sams, 2015), the teachers design learning materials in the form of short video (5 to10 minutes) and disseminate one day before the teaching, for which the teachers use numerous educational games, social media, TED talk, educational YouTude channels and the Khan Academy, iTune University and multimedia etc (Omar et al, 2016) to orient learners with new lesson and engagement students with classroom discussion (Bishop & Verleger, 2013), and resultantly it contribute into sustainable learning according to students own pace and style (Elian & Hamaidi, 2021). This pedagogical approach also helps students fast-forward, taking notes, reviewing previous learning, boosting their productivity, learning satisfaction, passion, eliminating boredom, anxiety and feelings of lagging behind in peers. To foster holistic development, the study emphasized the significance of a supportive learning environment as well as an awareness of students' self-perceived skills and social-emotional components.

CONCLUSION

Flipped instruction provides enough and multiple opportunities for socio-economically and disabled students to improve their mathematical achievement. As the students were satisfied and their interest was increased, they liked to spend more time in flipped materials learning, watching videos, asking questions, and discussing content with each other in the classroom. Likewise, the game-aided instruction was also found interesting for these students; they were

found more inclined towards games, but the time factor and classroom discipline were issues for classroom management for the teachers. Similarly, with respect to comparison, game-aided instruction was found to be more effective for increasing students' mathematical achievement as compared to flipped instruction. In this connection, the academic motivation of game-aided instruction was thus found to be higher than that of the flipped instruction, and the reason was that students were involved more practically in game-aided instruction, together with the hands-on diverse opportunities that were effectively capitalized on as compared to the flipped instruction.

Recommendations

1. The study's conclusions led to the recommendation of several approaches to increase the efficacy of flipped & game-based mathematics instruction. First, as both approaches have been demonstrated to greatly improve student achievement, it was recommended that pre-service teachers be trained in both approaches. Equipment required for these teaching methods should be provided by school administrators through PTC or local government money.
2. It was suggested that public-private partnerships be used to encourage the use of game-aided learning and flipped learning in elementary schools. Also, study recommended including these techniques into mathematics textbooks to boost students' knowledge, comprehension, and application skills, as well as to put them into practice to improve learning outcomes.
3. It has been particularly suggested that using games in the classroom can help students learn more efficiently and stay interested in a variety of disciplines. In this linking, the teachers of mathematics have been encouraged to develop the dynamic and attractive learning environments by employing game-based and flipped learning to sustain the desired outcomes.
4. Overall, study emphasized the transformative potential of these contemporary teaching techniques while highlighting necessity of thorough training, sufficient funding, and cooperation amid all parties involved in education. By using these modern techniques, supportive learning environment and accommodation for variety of learning styles can help students succeed.

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