

EFFECT OF GAME BASED FORMATIVE ASSESSMENT ON THE COGNITIVE ABILITY OF THE STUDENTS IN GOVT. NON-FORMAL PRIMARY SCHOOLS

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ABSTRACT

Game-based formative assessment is an effective strategy to raise student cognitive ability in non-formal basic education programs. Research highlighted game-based formative assessment's impact on student cognitive development. The purpose of the study to find the effect of GBFA on Cognitive ability of learners of non-formal education which is always reported low. This study is based on positivist paradigm followed by true experimental design having GBFA as independent variable and dependent was cognitive ability. The study consisted of 390 basic literacy schools in Khushab. Pre-test and Post-test was employed to find out their cognitive ability. The assessment tool consists of a 40-item MCQ instrument that originates from the science textbook to determine the cognitive ability on learning focusing on Bloom's Taxonomy's cognitive domain with 1st three subdomains. Objectives of the study were measured through data collection procedure, t-tests and paired sample t-tests was used to analyze pre and after intervention results. The research findings revealed that students participating in game-based formative assessment acquire superior cognitive abilities. The study shows the necessity of adopting interactive teaching tools with government backing to improve student active involvement and learning results in non-formal classrooms. Educators along with policy makers may utilize the study findings to apply game-based formative assessment effectively which maximizes learning benefits in non-formal educational contexts.

Keywords: *Game-based formative assessment, academic performance, non-formal education, cognitive ability, motivation, engagement.*

INTRODUCTION

Cognitive ability is the ability of one's mind processes and faculties that enable individuals to perceive, understand, reason, remember, process information, and solve problems (American Psychological Association, 2025). Within the changing educational context, there has been increased attention on how to use Game-based Formative Assessment to improve student learning, especially in such low-resourced schools as the government non-formal Primary schools. Formative assessment, or continuous assessment of learning, is a well-known factor affecting student achievement (Panadero et al., 2022). These assessments can be combined with game elements to reinforce and objectively measure their thinking skills (Grier et al., 2021). Meta-analytical results confirm that applications have large positive effects on cognitive outcomes, through their ability to create healthy competition, and a high level of interaction (Sailer & Homner., 2020).

The implementation of GBFA for improving cognitive learning outcomes in young learners has gained more interest from educational researchers. GBFA presents learning checks in

interactive and gamified spaces, offering instant feedback, different pacing, and a story-based approach, which are essential for supporting the development of executive functions such as working memory, attention, or problem-solving (Ramos-Galarza et al., 2026). By constantly involving students in quizzes and challenges, teachers maintain the retention of concepts and keep their students motivated. This social aspect of assessments that also involves collaboration or competition tasks, fosters students to learn more from their peers (Licorish et al., 2018). The positive point from game-based formative assessment is two-fold not only do students excel in learning, but they learn in an exciting environment.

Assessment is a cornerstone of effective teaching and learning, yet in many governments non-formal primary schools, assessment practices are often limited to traditional paper-and-pencil tests that primarily measure rote memorization rather than higher-order thinking skills. Such methods provide little timely feedback to students or teachers, making it difficult to address misconceptions or support the development of essential mental behavior such as learning, understanding, and problem-solving. Meanwhile, evidence from recent studies suggests that game-based formative assessment (GBFA) can create engaging, feedback-rich learning environments that improve motivation and enhance both academic and cognitive outcomes. (Nadeem et al., 2023). However, despite the growing global interest in GBFA, there is a lack of physical research exploring its effect on **cognitive ability** within **non-formal primary education settings**, particularly in developing countries where resource constraints and irregular attendance further complicate learning. This gap in the literature underscores the need to investigate whether GBFA can serve as an effective tool to strengthen cognitive development among students in government-run non-formal primary schools.

The purpose of this research is to measure the effects of game-based formative assessment on learners' academic achievement of non-formal learners. It will show if the utilization of game elements in formative assessments will enhance students' understanding of the material taught, stimulate their interest in the course, and achieve higher cognitive abilities than using conventional types of quizzes. The study could give facilitators and instructional designers guidance on how the different technologies may be incorporated to supplement learning and support distance learners. The present study is to find the effect of games based formative assessment on the cognitive abilities of the students enrolled in non-formal schools. This research was based on the objective to investigate the impact of game based formative assessment on students' cognitive ability enrolled in non-formal schools.

On the bases of the objective given following hypothesis have been created

- H₀₁: There is no significant effect of game based formative assessment on the learning of students enrolled in non-formal schools.
- H₀₂: There is no significant effect of game based formative assessment on understanding of students enrolled in non-formal schools.
- H₀₃: There is no significant effect of game based formative assessment on the problem-solving skills of students enrolled in non-formal schools.

LITERATURE REVIEW

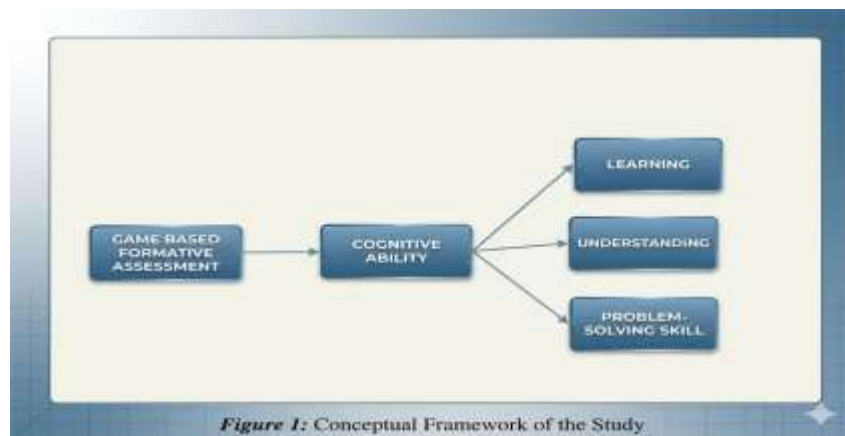
According to the recent literature, game-based formative assessment (GBFA) tools and activities with digitally-mediated combination of gameplay and continuous feedback can favor the cognitive outcomes of the primary age students (Alotaibi, 2024). It is repeatedly mentioned in the literature that well-designed quiz-style platforms can enhance classroom engagement and offer learners quicker corrective feedback which can be formatted by teachers on a formative basis (Wang and Tahir, 2020). Notably, an increasing amount of primary-level experimental studies with randomized work or quasi-experimental work in government schools demonstrates an improvement in the lower-order cognitive outcomes (knowledge, comprehension, application) when gamified formative assessment is administered in addition to regular teaching (Mayer, 2019). Simultaneously, extensive systematic reviews that are dedicated to the domain of primary education specifically warn that the effects are not uniform: some of them report a lack or minimal positive evidence of increased learning outcomes or the detrimental impact of the use of competitive gamification without attention to design (Tsay et al., 2020).

The recent literature suggests that game-based formative assessment (GBFA) tools and activities that combine digitally-mediated gameplay and ongoing feedback may be beneficial to the cognitive performance of the primary age students (Alotaibi, 2024). The literature repeatedly states that properly designed quiz-like platforms can lead to more favorable classroom engagement and provide the learner with faster corrective feedback that can be structured by the teacher on a formative basis (Wang and Tahir, 2020). Interestingly, there is a growing body of experimental work at the primary level using randomized work or quasi-experimental work in government schools that show an improvement of lower-order cognitive outcomes (knowledge, comprehension, application) when gamified formative assessment is added to regular teaching.

At the same time, numerous systematic reviews devoted directly to the field of primary education, in particular, warn that the impact is not universal: some of them find no evidence or rather insignificant positive results of learning outcomes or adverse effects of the application of competitive gamification without paying attention to the design (Tsay et al., 2020). The conceptual framework of the study clearly highlighted the independent and dependent variables of the study. The sub-constructs of dependent variable are also presented here for understanding.

Figure 1

Conceptual Framework



The conceptual frame clearly showed the independent and dependent variable. It showed that the dependent variable has been divided into three sub-construct that is Learning, Understanding and Problem-solving Skills.

The study supports the Mihaly Flow Theory developed by Mihaly Csikszentmihaly in 1970. The flow theory is seen to be a suitably useful paradigm for comprehending how students interact with the study involving game element (Chan et al., 2021). The degree of concentration and immersion experienced when performing a job that is appropriate for one's skill level—not too challenging nor too simple is known as flow. According to Mihály Csikszentmihályi's Flow Theory total absorption and intention in actions results in deep appreciation and novelty alongside high engagement. During flow conditions people experience cognitive engagement when their task demands meet their skill capabilities. It is anticipated that the games that are taught to the pupils would keep them in a processing difficulty zone, which keeps them engaged without causing them to get stressed or bored. Over time, motivation and academic performance improve as a result of this flow experience, which improves learning (Admiraal et al., 2011).

Researchers showed that learning via game improves learning through behavioral (like the intention to participate in learning), cognitive (like cognitive load). According to current research, flow elements including graded difficulty, self-determination, and deep involvement from the game may be best predictors of successful learning through game element (Chan et al., 2021). When someone is engaged in a difficult yet doable task, they experience a state of profound involvement and immersion known as "flow." A common goal of games is to maintain students in their ideal difficulty zone, where they are adequately involved without becoming overwhelmed or disinterested. Over time, this flow experience can improve cognitive ability.

Flow theory successfully demonstrates how people reach their most effective state and develop internal drive. People can increase productivity besides achieving better learning outcomes while improving their overall wellbeing through maintaining balance between skill levels and challenge intensity while keeping their attention focused deeply and remaining free from distracting elements. Research about flow continues to investigate new methods that enhance this experience across different areas of human activity thus establishing it as an essential tool for studying engagement and performance.

METHODOLOGY

An experimental research design was employed to determine whether integrating game-based elements into formative assessments can significantly enhance students' learning outcomes. This study relates to the positivist research paradigm followed by Quantitative approach. The study involved the randomization, intervention of independent variable and measure the effect on dependent variable that's why True experimental design was applied on the bases of suitability. This design allowed researchers to carry a cause-and-effect relationship between GBA and Cognitive ability.

The design was made as:

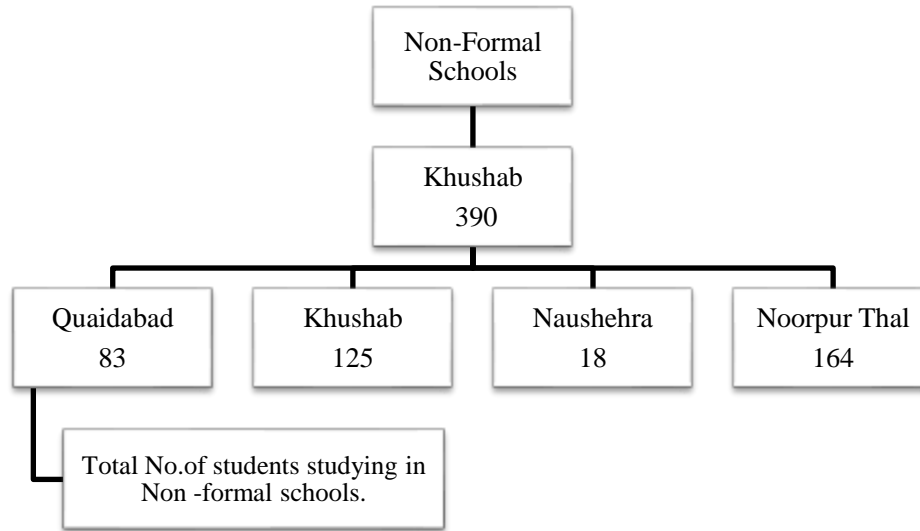
A	P1	X	P2
B	P1	C	P2

A (Experimental Group), B (Control Group), P1 (Pre-test), X (Treatment to Experimental Group), C (Use of traditional method), P2 (Post-test)

The population of this study were the students of 5th grade in non-Formal schools of District Khushab.

Figure 1

Population of the Study



Then researcher randomly selected 01 school out of the population through lottery method. Informed consent was sent to the selected school in which students were requested to attend the study. One school was selected through random selection method out of total population. The selected schools have two section of grade 5. So the students were selected via random selection method in experimental and control group. The sample of the study consisted of 80 students. 40 students were in control group and 40 were in experimental group.

The researcher made a test for intervention to find the cognitive ability of the students. The performance test covered all the learning objectives including cognitive ability, Total eight test were conducted, one per week.

An instrument was created, comprising from first four unit to measure the effect of cognitive ability of 5th grade science students consisting of 40 MCQs. The test consists of 20 knowledge level questions, 12 MCQs are of Understanding level and 8 MCQs are of Application level. Researcher compared the tests of pre-intervention and post intervention result after 8-week game based formative assessment intervention.

RESULTS AND INTERPRETATION

The researcher implemented the Pre-intervention and Post-intervention equivalent group design structure. The researcher applied statistical methods including Mean along with Standard Deviation (SD) for the experimental and control group achievements showed significant differences according to the findings. Researcher applied both t-independent and t-dependent tests for comparing experimental versus control group achievements. When the groups were different the data analysis involved an independent sample t-test because the research included separate experimental and control groups. When the two equivalent assessments included pre-test and post-

test accompanied the use of control groups. The Paired sample t-test was applied in this case. These tests are commonly used to find whether there are significant differences between group means in experimental research (Field, 2018).

Table 1

Experimental Vs Control group in Pre-test

Sub domain	Group	N	Mean	S.D	<i>t</i>	<i>df</i>	<i>p</i>
Knowledge	Experimental Group	40	10.29	2.386	-0.87	78	0.39
	Control Group	40	10.80	2.527			
Understanding	Experimental Group	40	5.23	1.987	1.11	78	0.27
	Control Group	40	4.74	1.686			
Application	Experimental Group	40	3.29	1.274	-0.91	78	0.36
	Control Group	40	3.60	1.557			

The table 1 showed the value of (A) and (B) group in knowledge, understanding and application. In Knowledge the mean value of (A) group is 10.29 and that of (B) group is 10.80 showing no valuable difference between the two groups. High value of p 0.39 shows that there is no difference between the (A) and control (B) before intervention. The mean value of experimental group in comprehension level 5.23 and that of control group is 4.74 showing a minute difference between the two groups. The value of p is 0.27 between the two groups in understanding level showing there is no difference between the two groups. The mean value of experimental group in application level is 3.29 and in control group is 3.60 showing minute difference while high value of p which is 0.36 indicating insignificant difference between experimental and control group before intervention.

Table 2

Experimental Vs Control Group in Post-test

Components	Group	N	Mean	S. D	<i>t</i>	<i>df</i>	M.D	<i>p</i>
Post Knowledge	Experimental	40	15.17	3.785	3.689	78	2.057	0.0005
	Control Group	40	12.11	3.094				
Post Understanding	Experimental	40	8.86	2.264	6.062	78	2.171	<0.0001
	Control Group	40	5.69	2.083				
Post	Experimental	40	5.71	1.759	5.344	78	.371	<0.0001

Application	Control Group	40	3.34	1.955
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The Knowledge, Understanding, and Application levels of the (A) and (B) groups were compared in Table 2. The (A) group improved following the intervention, as evidenced by the mean knowledge score of 15.17 for the (A) group and 12.11 for the (B) group. There is a substantial difference between the two groups, as indicated by the p value of 0.0005. Following the intervention, the experimental group's mean Understanding level score was 8.8, while the mean score of control group was 5.69, indicating that the experimental group's mean score was greater than the control groups. There is a substantial difference in comprehension between the two groups, as indicated by the p value of less than 0.0001. In a similar vein, the experimental group's mean value at the application level is 5.71, whereas the control groups is 5.34. There is a significant difference between the experimental and control groups in all three components, as indicated by the p-value between the two groups being less than 0.0001. This indicates that the experimental group's intervention outperforms the control groups.

SUMMARY, FINDINGS, CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This study's goal is to evaluate how game-based formative assessment (GBFA) affects students' performance in Tehsil Quaidabad District Khushab's Govt. Basic Education non-formal primary school. Fifth-grade kids from Dera Nooraykhail Shimar, a government non-formal primary school, made up the study's sample. Each of the two courses had thirty-five pupils. The experimental group and the control group were designated. For the purpose of educating both groups, the first four chapters of the Punjab Textbook Board's science textbook for five classes were selected.

The following were the main findings drawn from statistical analyses of the data:

1. Prior to the intervention, the mean pre-test scores of all students in the control and experimental groups did not differ significantly in the knowledge component. Every student's knowledge component level was the same (Table 1). When it came to the knowledge component, all of the students in the experimental groups had different mean scores on the pre-test and post-test. Every student in the experimental group demonstrated progress. This improvement exceeded the control group's improvement (Table 2). The findings for the first null hypothesis were disproved.
2. The mean pre-test scores of all students in the experimental and control groups did not significantly differ in the comprehension section. Before the intervention, every student's comprehension level was the same (Table 1). The control group's pre-test and post-test mean scores differed in the comprehension component (Table 2). The pre-test and post-test mean scores of the experimental group differed significantly in the comprehension component. Compared to the control group, this difference was greater (Table 2). The second null hypothesis was disproved.
3. The pre-test mean scores for the experimental and control groups did not differ significantly in the application component (Table 1). The mean post-test scores of the students in the control and experimental groups differed in the application component. Every student made progress. (Table 2). The experimental group outperformed the control group in terms of problem-solving abilities. The pre-test and post-test mean scores for the control group of all students differed in

the application component.

4. Table 2 shows that every student improved their ability to solve problems. Regarding the application component, the mean score of the pre-test and post-test of the experimental group of all students showed a significant difference in the degree of problem-solving abilities. Every student in the experimental group made progress. This improvement exceeded the control group's improvement (Table2).

The current study examined how an instructional intervention affected students' motivation, engagement, cognitive ability, and instant feedback. The results showed that the intervention greatly enhanced the experimental group's learning outcomes in a number of cognitive domains.

5. The pre-test knowledge scores of students in the experimental and control groups did not differ significantly at first, indicating that both groups began with similar baselines (see Table 2). Nonetheless, the experimental group's post-intervention findings demonstrated a statistically significant difference, suggesting that the intervention was successful in improving students' acquisition of knowledge. This is consistent with research by Mayer (2019), who highlighted the value of structured learning environments in fostering meaningful learning.

CONCLUSIONS

The investigation produced the following conclusions

1. Every student in the experimental and control groups had a significantly different mean score on the post-test. The experimental group has improved more than the control group. This indicates that the experimental group's pupils' knowledge improved more than the control groups.
2. The study revealed that the students in the experimental group had a higher level of understanding.
3. Students in the experimental group demonstrated a stronger comprehension of the application that promoted a learner-centered environment through organized and prompt responses.

RECOMMENDATIONS

On the basis of conclusions of the study, the following recommendations have been made:

1. The teachers could implement Game Based Formative Assessment (GBA) techniques such as self-assessment, peer assessment activities in order to strengthen students' remembering, understanding and application abilities of science at the primary level.
2. The teachers may incorporate educational games, quizzes and problem-solving activities into the Science lessons regularly as these make the students to remember well what they have learned, understand and apply scientific concepts in real life situations.
3. Schools can offer opportunities for teachers to plan and develop activities based on the curriculum that encourage students to be active participants and support their lower order thinking processes (remembering, understanding and application).

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