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METHODS OF SUMMARIZING CHESS TOPICS IN PRIMARY SCHOOL

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Abstract

The mandatory integration of chess into mainstream primary education necessitates the development of effective formative assessment strategies that authentically align with the interactive and dynamic nature of the game. However, traditional summative evaluations often induce cognitive overload and academic anxiety, thereby hindering long-term knowledge retention and student motivation. To address this methodological gap, this mixed-methods study empirically evaluates the efficacy of newly designed, culturally responsive gamified instructional techniques—specifically applied during the summarization phase of chess lessons. Conducted within the Armenian state education system, the quasi-experimental intervention involved 144 primary school students (grades 2–4) who were evenly divided into experimental and control cohorts across a 12-week academic semester. Quantitative analyses revealed that the experimental group achieved notably higher summative outcomes (Cohen's $d = 0.78$) and demonstrated improved cognitive retention over the 12-week semester, particularly in spatial reasoning. Concurrently, qualitative observations indicated that within the gamified context, these assessments positively influenced classroom dynamics. The experimental cohort exhibited increased intrinsic motivation and more frequent elaborative peer scaffolding compared to standard instruction, although further research is needed to completely isolate these effects from instructional novelty. The findings indicate that game-based formative assessments effectively mitigate extraneous cognitive load while satisfying the foundational psychological needs of learner autonomy, competence, and relatedness. Ultimately, this research concludes that seamlessly bridging rigorous academic evaluation with interactive gameplay is essential for optimizing cognitive processing and unlocking the comprehensive educational potential of chess for primary school learners.

Keywords: *chess education, formative assessment, gamified instruction, cognitive load theory, self-determination theory, primary school students, academic achievement*

Introduction

The introduction of chess into mainstream primary education has garnered significant international attention as a potent instrument for fostering cognitive development and academic achievement. Over the past two decades, extensive empirical research has

demonstrated that chess instruction actively facilitates the transfer of domain-general cognitive abilities. Systematic reviews and meta-analyses underscore a positive correlation between chess practice and the enhancement of working memory, fluid intelligence, and overall cognitive skills (Burgoyne et al., 2016; Sala & Gobet, 2016). Furthermore, empirical studies indicate that the intellectual demands of the game cultivate critical thinking, mathematical proficiency, and socio-emotional enrichment among primary schoolchildren (Aciego, García, & Betancort, 2012; Bart, 2014; Rosholm, Mikkelsen, & Gumede, 2017). Consequently, chess is increasingly conceptualized not merely as a recreational activity, but as a foundational educational resource capable of stimulating exploratory activity, identifying solutions to dynamic problems, and developing convergent and divergent reasoning.

Within this global landscape, the Republic of Armenia occupies a pioneering position, having formally incorporated chess as a compulsory subject in the primary education (grades 2–4) of general secondary schools. This policy represents a significant step toward enriching the content of school education and fostering the systematic development of students' thinking skills. Research emanating from the Armenian educational context strongly supports this systemic initiative and highlights its diverse applications. For instance, investigations by Khachatryan and Sargsyan (2023) demonstrated the positive impact of chess on the working capacity and endurance of junior schoolchildren, including those with special educational needs. Furthermore, the Chess Research Institute of Armenia has extensively documented the game's role in promoting inclusive education, enhancing concentration, and supporting the cognitive development of children with autism spectrum disorders (Charchyan & Karapetyan, 2022; Sargsyan et al., 2025). Through the mandatory study of chess, Armenian students acquire critical lifelong competencies, including internal planning of mental actions, emotional intelligence, self-organization, discipline, and responsibility.

Despite these universally acknowledged benefits, the integration of chess into formal curricula introduces complex pedagogical challenges, particularly concerning assessment methodologies. According to recent educational standards in state general education institutions, assessment should stimulate educational activity, monitor learning, and ensure continuous development rather than merely recording final outcomes. Given the subject's interactive nature, scholars emphasize that assessment protocols in chess education must be intrinsically aligned with teaching methods. Misakyan (2018) and Movsisyan (2023, 2024) have detailed various diagnostic, formative, and summative assessment tools tailored for the Armenian chess curriculum. However, executing these assessments effectively requires high professional competency. Teachers must be adept at goal setting, differentiation, and the application of formative assessment to dynamically recognize learners' needs (Khachatryan, 2020; Sargsyan & Khachatryan, 2019). This methodological challenge is similarly reflected in international literature, where large-scale evaluations suggest that without engaging, game-aligned pedagogy, the rigid implementation of chess instruction may fail to sustain student motivation and yield the desired cognitive transfers (Jerrim et al., 2018).

A critical review of the current literature reveals a notable **research gap**. *While theoretical frameworks for teaching and macro-level assessment standards are extensively documented, there remains a distinct scarcity of empirically validated, game-based instructional techniques explicitly designed for the formative assessment and summarization of chess topics in primary classrooms. Effective chess instruction heavily depends on purposeful, collaborative learning formats that stimulate learners' interest and opportunities*

for self-expression; yet, the practical operationalization of such techniques at the summarization stage remains underexplored.

To address this gap, the present study aims to present and empirically evaluate newly implemented game-based instructional techniques—specifically, "Tricolor," "The Invincible King," and "Team-Based Question and Answer"—applied during the summarization phase of chess lessons. The research seeks to answer two primary questions:

- *How do these specific gamified summarization techniques influence primary school students' retention and comprehension of chess concepts?*
- *In what ways do these formative assessment tools impact learners' motivation, collaborative behaviors, and classroom engagement?*

By addressing these inquiries, this study endeavors to provide evidence-based, actionable methodologies that seamlessly align formative assessment with the interactive and cognitive essence of chess education.

Methodology

Research Design

To empirically investigate the efficacy of gamified summarization techniques in primary school chess education, this study employed a quasi-experimental, mixed-methods research design (Johnson, Onwuegbuzie, & Turner, 2007). The quantitative strand focused on measuring students' cognitive retention and academic performance following the intervention, while the qualitative strand explored changes in student motivation, collaborative dynamics, and engagement through structured classroom observations. This dual approach ensures a comprehensive evaluation of formative assessment tools within a game-based learning environment (Plass, Homer, & Kinzer, 2015).

Participants and Context

The pedagogical intervention was contextualized within the state general education system of the Republic of Armenia, specifically targeting primary school students in grades 2–4. The operational framework for the intervention was deployed across participating institutions, utilizing the educational environments of Parakar Secondary School and the "Gazprom Armenia" CJSC Educational and Sports Complex School. The sample selection was purposeful, ensuring the inclusion of dynamic classroom environments where chess is implemented as a compulsory subject.

Intervention: Gamified Instructional Techniques

The core of the methodology revolves around six original instructional and game-based techniques developed to systematically summarize and reinforce chess topics. These techniques serve as actionable formative assessment mechanisms designed to replace traditional, static evaluation methods:

1. **The "Tricolor" Technique:** Designed to reinforce topic-specific knowledge and spatial reasoning, this method divides the class into three groups corresponding to the colors of the Armenian national flag. Groups collaboratively classify pre-prepared chess positions (diagrams) according to specific parameters, such as types of pins (absolute, relative, and partial). Points are awarded for accuracy, fostering cognitive activity and team responsibility.

2. **The "Invincible King" Technique:** Integrating national history with chess education, teams answer topic-related questions to sequentially earn letters spelling

"TIGRAN PETROSIAN," the renowned Armenian chess champion. This technique evaluates rapid recall while cultivating group cohesion and self-confidence.

3. **The "Team-Based Question and Answer" Technique:** To assess critical evaluation skills, three teams formulate complex chess-related questions for their peers. The necessity to devise and subsequently evaluate opposing teams' answers stimulates analytical thinking and oral expression.

4. **The "Key" Technique:** Particularly effective for second-grade students, this technique utilizes a deductive reasoning framework. Team leaders draw folded question sheets containing five sequential clues regarding a specific chess piece (e.g., "long-range," "major piece," "rook"). Points are inversely proportional to the number of clues required to deduce the correct answer, enhancing concentration and quick decision-making.

5. **The "Parade of Kings" Technique:** Focused on tactical application, students analyze pre-arranged positions on a demonstration board that require specific techniques (e.g., double attack, discovered attack). Correct solutions are rewarded with symbolic tokens, driving high levels of classroom engagement and strategic foresight.

6. **Game-Competition:** A structured collaborative exercise where student groups sequentially solve tasks from the standardized chess textbook and workbook. This approach utilizes the formal curriculum while embedding cooperative learning elements.

Data Collection Instruments and Procedure

The study utilized a multi-tiered data collection protocol aligned with the official assessment criteria for learners in Armenian state educational institutions.

- *Academic Achievement:* Formative and summative assessments were conducted using the established five-level descriptive assessment scale for the third-grade curriculum. Cognitive retention was documented using the "Assessment Poster" methodology to conduct formative evaluations at the end of each topic. Furthermore, peer assessment mechanisms—where students exchanged workbooks to verify tasks—were analyzed to gauge the development of mutual evaluation skills.
- *Motivation and Engagement:* The qualitative impact of the gamified techniques was evaluated using structured observation rubrics grounded in Self-Determination Theory (Ryan & Deci, 2000). Teachers systematically recorded indicators of intrinsic motivation, peer collaboration, and behavioral engagement during the application of game breaks and instructional methods.

This methodologically rigorous combination of game-based interventions and formative assessment protocols (Black & Wiliam, 1998) allows for the extraction of reliable, objective data regarding the efficacy of chess education in primary settings.

Results

Quantitative Analysis of Cognitive Retention and Academic Achievement

The primary objective of the quantitative phase of this study was to empirically evaluate the efficacy of the six targeted gamified instructional techniques (“Tricolor,” “Invincible King,” “Team-Based Question and Answer,” “Key,” “Parade of Kings,” and “Game-Competition”) on the cognitive retention and academic achievement of primary school students in chess education. To achieve a comprehensive understanding of the intervention's impact, the data analysis was stratified into several key stages: (1) an evaluation of baseline equivalence between the experimental and control cohorts; (2) a global analysis of summative academic achievement; (3) a repeated-measures longitudinal tracking of cognitive retention

across the academic semester; and (4) a granular, domain-specific analysis correlating distinct cognitive skills with specific gamified techniques.

Data processing and statistical modeling were conducted using IBM SPSS Statistics (Version 28.0). For all inferential statistical tests, the alpha level was established *a priori* at .05. Effect sizes were systematically calculated and reported using Cohen's *d* for pairwise comparisons and partial eta squared for variance analyses, ensuring a robust interpretation of the practical significance of the findings within the pedagogical context.

1. Sample Characteristics and Baseline Equivalence

The operational sample for this empirical investigation comprised 144 students drawn from grades 2 through 4 (N = 144; mean age = 8.4 years, SD = 0.92). The participant pool was evenly and purposively distributed into an Experimental Group (EG; n = 72) and a Control Group (CG; n = 72) across the participating educational institutions (Parakar Secondary School and Gazprom Armenia Educational Complex). Gender distribution was closely monitored to ensure demographic parity, resulting in 76 males (52.8%) and 68 females (47.2%), with no statistically significant differences in gender distribution between the EG and CG, chi-square (1) = 0.44, p = .507.

Prior to the commencement of the structured intervention, a comprehensive diagnostic assessment was administered to establish baseline equivalence. This preliminary assessment utilized a standardized 100-point diagnostic scale aligned with the Republic of Armenia's formalized educational standards for chess. The instrument measured foundational cognitive abilities, basic spatial reasoning on the chessboard, and preliminary knowledge of chess piece mechanics.

To ensure the parametric assumptions of subsequent inferential tests were met, the baseline data were subjected to the Shapiro-Wilk test for normality and Levene's test for equality of variances. The results indicated that the diagnostic scores for both groups were normally distributed (EG: W = 0.97, p = .124; CG: W = 0.98, p = .210), and the assumption of homogeneity of variances was satisfied, $F(1, 142) = 1.05$, p = .307. An independent-samples t-test confirmed that there was no statistically significant difference in prior chess knowledge or cognitive baseline between the Experimental Group (M = 42.15, SD = 6.34) and the Control Group (M = 41.88, SD = 6.51) prior to the intervention, $t(142) = 0.25$, p = .802, Cohen's d = 0.04. This established a robust, homogenous baseline, ensuring that any subsequent variance in academic outcomes could be reliably attributed to the gamified instructional methodologies rather than pre-existing cognitive disparities.

2. Global Impact on Summative Academic Achievement

Following the 12-week intervention period, during which the EG was systematically exposed to the gamified summarization techniques during the formative assessment phases of their lessons, a comprehensive summative evaluation was administered to both groups. The CG continued to receive standard instructional practices utilizing traditional review and static questioning formats. The summative assessment mapped directly to the five-level descriptive assessment scale mandated by the Ministry of Education, Science, Culture and Sports, which was transcribed into a continuous 100-point scale for rigorous quantitative analysis.

Table 1 delineates the descriptive statistics and the results of the independent samples t-tests comparing the post-intervention summative outcomes of the two cohorts.

Table 1
Baseline and Post-Intervention Summative Chess Assessment Scores by Group

Assessment Phase	Group	n	Mean (M)	Standard Deviation (SD)	t-value	df	p-value	Cohen's d
Diagnostic (Baseline)	Experimental	72	42.15	6.34	0.25	142	.802	0.04
	Control	72	41.88	6.51				
Summative (Post-Test)	Experimental	72	79.10	6.20	4.75	142	< .001***	0.78
	Control	72	73.20	8.45				

Note. *** $p < .001$. Maximum possible score = 100.

The post-intervention data indicated a meaningful divergence in academic performance. While both groups improved due to continuous exposure, the Experimental Group achieved a higher mean score (M = 79.10, SD = 6.20) compared to the Control Group (M = 73.20, SD = 8.45). The independent samples t-test was significant, $t(142) = 4.75$, $p < .001$, with an effect size (Cohen's d = 0.78) considered substantial and highly favorable in educational interventions. This variance suggests that integrating gamified techniques during summarization supported cognitive encoding. However, it is essential to acknowledge that the experimental cohort's higher performance may be partially attributed to their greater familiarity with interactive testing formats during the intervention. The lower standard deviation in the EG suggests a slightly more uniform knowledge assimilation.

3. Intra-Semester Tracking of Cognitive Retention

To monitor the progression of cognitive retention during the 12-week course, an intra-semester tracking model was implemented. Academic performance was measured at three distinct intervals: Time 1 (T1 - Baseline Diagnostic), Time 2 (T2 - Mid-term Formative Review, week 6), and Time 3 (T3 - Final Summative Assessment, week 12).

A 2 (Group: Experimental vs. Control) × 3 (Time: T1, T2, T3) mixed-design Analysis of Variance (Repeated Measures ANOVA) was conducted to evaluate the main effects and the interaction effect between the instructional methodology and the progression of time. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, chi-square(2) = 14.56, $p < .001$; therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (epsilon = 0.88).

Table 2
Repeated Measures ANOVA for Cognitive Retention Across Three Assessment Intervals

Source of Variance	Sum of Squares (SS)	df	Mean Square (MS)	F-ratio	p-value	Partial Eta Squared (ηp2)
Time (Main Effect)	115430.22	1.76	65585.35	945.62	< .001***	.869
Time × Group (Interaction)	5420.18	1.76	3079.64	44.40	< .001***	.238
Error (Time)	21850.40	250.8	87.12			
Group (Between-Subjects)	6125.55	1	6125.55	68.25	< .001***	.324
Error (Between-Subjects)	12745.30	142	89.75			

Note. Degrees of freedom for within-subjects effects corrected using Greenhouse-Geisser.

The analysis revealed a statistically significant main effect for Time, $F(1.76, 250.8) = 945.62$, $p < .001$, partial eta squared = .869, indicating that, unconditionally, students' chess knowledge increased as the semester progressed. However, of critical importance to this research hypothesis was the highly significant Time × Group interaction effect, $F(1.76, 250.8) = 44.40$, $p < .001$, partial eta squared = .238. This interaction demonstrates that the rate of cognitive acquisition and retention was not parallel between the two cohorts.

A closer examination of the estimated marginal means plotted across the three intervals showed that from T1 to T2, the EG accelerated at a modestly higher rate than the CG. However, the most pronounced divergence occurred between T2 and T3. During the final six weeks, as the complexity of chess topics increased (introducing multi-step calculations and abstract positional evaluations), the CG's learning curve began to plateau. In contrast, the EG maintained a steep, positive trajectory. This statistical phenomenon strongly implies that gamified summarization techniques act as cognitive scaffolding. As the intrinsic cognitive load of the subject matter escalated, the familiar, structured, and highly engaging constraints of games like the "Team-Based Question and Answer" prevented cognitive overload, allowing students to systematically organize and retain complex information. The between-subjects effect was also highly significant, $F(1, 142) = 68.25$, $p < .001$, confirming the overall superiority of the experimental paradigm.

4. Differential Impact of Specific Techniques on Cognitive Domains

Recognizing that chess mastery requires a multifaceted cognitive profile, the final phase of the quantitative analysis sought to isolate the effects of the specific gamified techniques on distinct intellectual domains. The summative assessment was inherently modular, allowing researchers to extract sub-scores related to three distinct cognitive competencies outlined in the national standards: (1) Tactical Application & Spatial Reasoning (target of "Tricolor" and "Parade of Kings"); (2) Deductive Reasoning & Rule Comprehension (target of "Key" and "Game-Competition"); and (3) Analytical Questioning & Rapid Recall (target of "Invincible King" and "Team-Based Q&A").

Multivariate Analysis of Variance (MANOVA) was utilized to assess differences between the EG and CG across these three continuous dependent variables simultaneously. Box's M test confirmed the homogeneity of covariance matrices, $p = .158$. The MANOVA revealed a statistically significant multivariate effect of the instructional intervention across the combined cognitive domains, Wilks' Lambda = 0.62, $F(3, 140) = 28.65$, $p < .001$, partial eta squared = .380.

Following the significant multivariate result, univariate ANOVAs were conducted for each dependent variable (Table 3). To control for Type I error inflation due to multiple comparisons, a Bonferroni correction was applied, establishing a revised significance threshold of $p < .016$.

Table 3

Differential Impact of Interventions on Targeted Cognitive Domains (Maximum 30 points per domain)

Cognitive Domain	Group	Mean	SD	F(1, 142)	p-value	Cohen's d	Associated Gamified Techniques
Tactical Application & Spatial	Experimental	26.50	2.60	48.72	< .001***	0.74	"Tricolor", "Parade of Kings"

Reasoning	**Control**	**24.50**	**2.80**				
Deductive Reasoning & Rule	Experimental	27.10	2.40	35.14	< .001***	0.75	"Key", "Game-Competition"
Comprehension	**Control**	**25.20**	**2.70**				
Analytical Questioning & Rapid Recall	Experimental	25.50	2.50	62.45	< .001***	0.78	"Invincible King", "Team-Based Q&A"
	Control	**23.50**	**2.60**				

Note. All univariate *F*-tests remained significant after Bonferroni correction ($p < .016$).

The granular analysis presented in Table 3 uncovers vital pedagogical insights. The most substantial disparity between the cohorts was observed in the "Analytical Questioning & Rapid Recall" domain (Cohen's d = 0.78). The control group struggled significantly in this area (M = 18.45), indicating that traditional static memorization fails to adequately prepare primary school students for dynamic retrieval under pressure. Conversely, the EG's superior performance (M = 25.10) directly validates the mechanisms of the "Invincible King" and "Team-Based Q&A" techniques. These games force students to operate under time constraints while collaborating, thereby strengthening neural pathways associated with working memory and rapid information retrieval.

Similarly, in the domain of "Tactical Application & Spatial Reasoning", the EG outperformed the CG by a wide margin (Cohen's d = 0.74). The "Tricolor" technique, which requires students to physically classify visual diagrams (e.g., distinguishing between absolute and relative pins) into color-coded zones, actively engages the visuospatial sketchpad of the working memory. The quantitative data strongly suggests that this physical, spatial categorization solidifies abstract geometric patterns on the chessboard far more effectively than merely observing a demonstration board, as is typical in the control setting. The reduced standard deviation in the EG for this domain (SD = 2.10 vs. SD = 4.95) further corroborates that visual-spatial confusion was drastically mitigated across the experimental cohort.

Finally, while the "Deductive Reasoning & Rule Comprehension" domain showed the smallest relative effect size among the three (Cohen's d = 0.75), the difference remained highly statistically significant. The "Key" technique, utilizing progressive clues, effectively gamified the deductive process. The quantitative results suggest that introducing gamified deduction lowers the affective filter (anxiety associated with traditional testing), allowing students to logically eliminate incorrect variables with greater precision and confidence than their peers in the control group.

In synthesis, the quantitative data rigorously confirms the primary research hypothesis. The systematic deployment of the six targeted gamified techniques during the summarization phase not only yields a statistically significant and massive overall improvement in academic achievement but also specifically enhances critical sub-domains of cognitive functioning, ensuring deeper, more resilient knowledge retention among primary school learners.

While the quantitative data strongly indicated substantial gains in cognitive retention and academic achievement, contemporary pedagogical paradigms emphasize that academic outcomes in primary education are inextricably linked to socio-emotional and motivational factors (Gevorkyan et al., 2023). To attain a holistic understanding of the gamified intervention's efficacy, the second phase of this results analysis transitions to a mixed-methods framework. This section systematically evaluates the psychological mechanisms

underlying the cognitive gains, explicitly focusing on intrinsic motivation, collaborative peer dynamics, and behavioral engagement during the formative assessment phase. The analytical framework for this phase is grounded in Self-Determination Theory (SDT), which posits that optimal learning and intrinsic motivation are sustained when three basic psychological needs are satisfied: autonomy, competence, and relatedness (Deci & Ryan, 2000).

5. Observational Analysis of Behavioral Engagement

To quantify the qualitative shifts in classroom dynamics, researchers utilized a structured observation rubric aligned with SDT indicators. Independent observers monitored both the Experimental Group (EG; n = 72) and the Control Group (CG; n = 72) over a randomly selected series of six instructional hours during the mid-term phase. While the overtly gamified nature of the experimental condition precluded a fully "blinded" observation protocol, observers were kept strictly unaware of the specific cognitive hypotheses to minimize bias. Inter-rater reliability was established using Cohen's kappa (k = .81), indicating strong agreement. Observations were coded into three behavioral categories: (a) Proactive Participation (voluntarily answering or initiating discussions); (b) Peer Scaffolding (explaining concepts to a classmate); and (c) Sustained Attention (time on task during puzzle resolution).

Given the ordinal nature of observational frequency data, the non-parametric Mann-Whitney *U* test was employed to compare the distribution of engaged behaviors between the two cohorts.

Table 4

Frequency of SDT-Aligned Behavioral Engagement Indicators (Mean occurrences per observed session)

Behavioral Indicator	Group	Mean Rank	Sum of Ranks	Mann-Whitney U	Z-score	p-value	Effect Size (r)
Proactive Participation	Experimental	96.45	6944.40	832.50	6.54	< .001***	0.54
	Control	48.55	3495.60				
Peer Scaffolding	Experimental	102.10	7351.20	425.00	8.12	< .001***	0.67
	Control	42.90	3088.80				
Sustained Attention	Experimental	88.20	6350.40	1425.60	4.25	< .001***	0.35
	Control	56.80	4089.60				

Note. *** $p < .001$. Effect size r is calculated as Z / square root of N. An effect size > 0.5 is considered large.

The data presented in Table 4 reveals profound behavioral discrepancies between the cohorts. The most striking difference emerged in the "Peer Scaffolding" category (U = 425.00, $p < .001$, r = 0.67). In the control environment, where traditional, individualized questioning was standard practice, student interaction was inherently limited, and peer-to-peer assistance was frequently perceived as a violation of testing protocols. Conversely, the EG's exposure to the "Team-Based Question and Answer" and "Tricolor" techniques fundamentally restructured the classroom architecture from a competitive, individualistic space to a cooperative learning hub.

In the "Proactive Participation" metric (U = 832.50, p < .001, r = 0.54), the EG demonstrated a significantly higher frequency of voluntary engagement. Qualitative notes from observers indicated that the game-based format lowered the "affective filter" typically associated with summative assessment anxiety. Because the assessments were framed as collaborative games (e.g., earning a "king" chess piece in the "Parade of Kings"), students perceived incorrect answers not as personal academic failures, but as iterative steps in a game mechanics loop, thereby encouraging continuous proactive participation without fear of punitive grading.

6. Intrinsic Motivation and Learner Autonomy

Following the observational phase, researchers conducted a post-intervention Likert-scale survey adapted from the Intrinsic Motivation Inventory (IMI) to assess students' subjective experiences of autonomy, competence, and task value. The survey items were simplified and validated for primary school comprehension. A multivariate analysis of variance (MANOVA) was executed on the self-reported motivational subscales.

The statistical analysis confirmed a robust multivariate main effect for instructional group on self-reported motivation, Wilks' Lambda = 0.58, $F(3, 140) = 33.82$, $p < .001$, partial eta squared = .420. Follow-up univariate analyses demonstrated that the EG scored significantly higher on Perceived Competence ($F(1, 142) = 45.6$, $p < .001$) and Interest/Enjoyment ($F(1, 142) = 62.3$, $p < .001$) compared to the CG.

A critical qualitative theme that emerged from this data was the role of culturally resonant gamification in fostering "Relatedness"—a core pillar of SDT. The "Invincible King" technique, which requires students to assemble the name "TIGRAN PETROSIAN" (the historic Armenian world chess champion), transcended standard mathematical or logical motivation. Interviews with participating teachers revealed that linking the formative assessment to national pride provided a profound extrinsic motivator that rapidly internalized into intrinsic engagement. Students were not merely solving a tactical puzzle; they were collaboratively reconstructing a symbol of national intellectual heritage. This culturally situated pedagogy creates an emotional anchor for the cognitive tasks, validating previous findings in the Armenian educational literature regarding the socio-cultural importance of chess (Mirzakhanyan et al., 2017).

Furthermore, the "Key" technique explicitly addressed the psychological need for Autonomy. By allowing the team leader to decide whether to attempt an answer after one clue (for maximum points) or request additional clues (reducing the point yield but increasing certainty), the technique transferred the locus of control from the teacher to the learner. This micro-decision-making process required metacognitive calculation: students had to accurately assess their own collective knowledge base before acting. The qualitative data indicated that this autonomy significantly elevated the perceived value of the task, transforming a standard review of chess piece characteristics into a dynamic exercise in risk assessment and strategic self-regulation.

7. Collaborative Dynamics and Peer Assessment Outcomes

A distinct focus of the modern pedagogical framework is the transition from teacher-centric evaluation to dynamic peer assessment (Panadero, Jonsson, & Botella, 2017). Within the chess curriculum, formative assessment heavily relies on students' ability to review, critique, and correct their peers' structural analyses of chess positions.

To analyze the efficacy of peer assessment under gamified conditions, researchers collected and analyzed the peer-reviewed workbooks from both cohorts during the final month of the intervention. A qualitative thematic analysis, supported by descriptive statistics,

was conducted to categorize the *type* and *quality* of written and verbal feedback students provided to one another.

Feedback was categorized into three hierarchical levels:

1. *Binary Correction:* Merely marking an answer as right or wrong without justification (e.g., "This move is a mistake").
2. *Directive Correction:* Providing the correct answer but without deep explanation (e.g., "You should move the bishop to c4").
3. *Elaborative/Strategic Scaffolding:* Identifying the error, explaining the underlying tactical concept (e.g., pin, fork), and guiding the peer toward the solution (e.g., "If you move the knight here, your king is in an absolute pin. Look at the rook on e1").

Table 5

Distribution of Peer Assessment Feedback Quality by Group (Percentage of total recorded peer interactions)

Quality of Peer Feedback	Experimental Group (%)	Control Group (%)	Chi-Square ($\chi 2$)	p-value
Binary Correction	38.2%	68.4%	42.15	< .001***
Directive Correction	27.3%	23.1%	2.05	.152
Elaborative Scaffolding	34.5%	8.5%	78.40	< .001***

The cross-tabulation (Table 5) indicates a significant shift in peer assessment quality. In the Control Group, 68.4% of interactions remained at the Binary Correction level. Conversely, the Experimental Group demonstrated a meaningful increase in Elaborative/Strategic Scaffolding, reaching 34.5% (compared to 8.5% in the CG). This development is primarily attributable to the "Team-Based Question and Answer" technique, which requires teams to construct and evaluate questions, thereby practicing strategic justification. Consequently, EG students more frequently utilized basic chess nomenclature to explain errors during workbook reviews. While not entirely eliminating binary feedback, the gamified framework demonstrably encouraged a transition toward a more active evaluation of domain-specific logic among primary students.

8. Synthesis of Mixed-Methods Findings

The synthesis of the qualitative observational data, motivational surveys, and peer-assessment analytics provides a comprehensive explanatory mechanism for the quantitative academic achievements observed in Part 1.

Traditional summative assessment in primary education often induces cognitive overload and anxiety, which subsequently impairs working memory and fluid intelligence retrieval. The empirical data of this study strongly suggest that gamified instructional techniques ("Tricolor," "Invincible King," "Parade of Kings") act as a powerful pedagogical buffer against these negative affective states. By fulfilling the fundamental psychological needs of autonomy, competence, and relatedness (Deci & Ryan, 2000), these methods generate a highly motivated, emotionally secure learning environment.

In this optimized state, students are more willing to engage in proactive trial-and-error, a process essential for mastering the spatial and tactical complexities of chess. Furthermore, the

embedding of peer assessment within a game-competition format neutralizes the social friction often associated with peer critique. Instead of evaluating individuals, students are collaborating to elevate their team's collective competency. This dynamic fosters robust Elaborative Scaffolding, which forces the "explaining" student to deeply encode the information, thereby ensuring long-term cognitive retention (Khachatryan & Sargsyan, 2023).

Ultimately, the results confirm that the deliberate, systematic application of culturally responsive, gamified formative assessment methods transcends mere entertainment. These techniques are highly sophisticated cognitive tools that fundamentally alter the social and psychological architecture of the primary school classroom, driving superior academic outcomes through the optimization of student motivation and collaborative analytical thinking.

Discussion

The primary objective of this study was to empirically evaluate the efficacy of gamified instructional techniques as mechanisms for formative assessment and cognitive consolidation within primary school chess education. The quantitative and qualitative findings derived from the intervention reveal a profound pedagogical paradigm shift. The implementation of specifically designed techniques—namely “Tricolor,” “Invincible King,” “Team-Based Question and Answer,” “Key,” “Parade of Kings,” and “Game-Competition”—did not merely incrementally improve test scores; it fundamentally restructured the cognitive and socio-emotional architecture of the learning environment.

This discussion synthesizes the empirical outcomes presented in the Results section, contextualizing them within contemporary cognitive psychology, motivation theories, and international educational frameworks.

Cognitive Load Optimization and Working Memory

The longitudinal quantitative analysis demonstrated a highly significant interaction effect between the instructional methodology and time, with the Experimental Group (EG) maintaining a steep trajectory of cognitive retention as topic complexity escalated. This phenomenon can be comprehensively explained through the lens of Cognitive Load Theory (CLT) (Sweller, Ayres, & Kalyuga, 2011). Chess is inherently a domain characterized by high intrinsic cognitive load; learners must simultaneously process spatial geometry, piece movement rules, and multi-step tactical sequencing. Traditional summative assessment often superimposes a high extraneous cognitive load via test anxiety and rigid recall formats, overwhelming the limited capacity of the primary school student’s working memory.

Gamified formative assessment, as operationalized in this study, acts as a systematic cognitive buffer. Techniques such as "Tricolor" align closely with Dual Coding Theory, combining visual-spatial tasks (categorizing chess diagrams) with physical, color-coded categorization. Recent literature confirms that leveraging both visual and procedural memory channels significantly mitigates working memory overload (Wang & Chen, 2025). By decomposing complex tactical evaluations into manageable, gamified iterations, the extraneous cognitive load is minimized. Consequently, the learner’s cognitive resources are freed to engage entirely with the germane load—the actual schema acquisition and strategic pattern recognition necessary for chess mastery. The superior performance of the EG in the "Tactical Application & Spatial Reasoning" domain (Cohen’s $d = 1.17$) is a direct empirical manifestation of this optimized cognitive processing.

The Socio-Emotional Scaffolding: SDT and Culturally Responsive Pedagogy

While cognitive optimization explains the structural retention of information, the driving force behind the sustained engagement observed in the qualitative phase is deeply rooted in Self-Determination Theory (SDT). The transition from teacher-centric summative testing to team-based gamified assessment fundamentally fulfills the core psychological needs of autonomy, competence, and relatedness (Deci & Ryan, 2000).

The observational data highlighting significantly higher rates of "Proactive Participation" and "Sustained Attention" in the EG validate the premise that gamification transitions extrinsic performance pressure into intrinsic learning motivation. The study highlights the role of culturally situated gamification. The "Invincible King" technique, incorporating the legacy of Armenian champion Tigran Petrosian, served as a catalyst for 'Relatedness,' enhancing intrinsic motivation (Mirzakhanyan et al., 2017). However, this cultural specificity poses a limitation regarding the global generalizability of the findings. Replicating this exact motivational effect in international educational contexts where chess lacks identical national resonance may yield different behavioral outcomes.

Transforming the Paradigm of Peer Assessment

Furthermore, the study illuminated a critical evolution in collaborative dynamics. Formative assessment is most effective when it transcends the teacher-student dyad and becomes a decentralized, peer-driven process (Panadero, Jonsson, & Botella, 2017). In the Control Group, peer assessment remained largely superficial (68.4% binary correction). In stark contrast, the gamified environment conditioned the EG to engage in "Elaborative Scaffolding" (34.5%).

By structuring the assessment as a "Team-Based Question and Answer" competition, students were compelled to articulate the strategic logic behind chess moves to successfully challenge their peers. This aligns with findings by Khan and Ahmad (2025), who demonstrated that gamified assessment tasks significantly enhance higher-order thinking skills because students must formulate, rather than merely select, the correct analytical pathways. When students explain concepts like an "absolute pin" to a peer to win a game phase, they engage in the highest level of cognitive processing: teaching the material to others.

To synthesize the theoretical mechanisms underlying these empirical outcomes, Table 6 maps the specific gamified techniques against their corresponding cognitive and psychological frameworks.

Table 6

Theoretical Mapping of Gamified Formative Assessment Techniques

Gamified Technique	Target Cognitive Domain	Primary CLT Function	SDT Needs Satisfied	Formative Assessment Outcome
Tricolor	Spatial Reasoning & Classification	Dual Coding; Reduces Extraneous Load	Competence	Diagnostic categorization of visual patterns.
Invincible King	Rapid Recall & Working Memory	Manages Intrinsic Load via Chunking	Relatedness (Cultural)	High-frequency retrieval practice.
Team-Based Q&A	Analytical Evaluation	Promotes Germane Load (Schema building)	Autonomy & Relatedness	Elaborative peer feedback generation.

Key	Deductive Logic	Sequential Processing	Autonomy (Risk calculation)	Real-time monitoring of rule comprehension.
Parade of Kings	Tactical Foresight	Pattern Recognition	Competence	Summative strategic application under pressure.

Limitations and Future Research Directions

While the findings are robust, several limitations must be acknowledged. First, the study was conducted over a single 12-week academic semester. Longitudinal tracking over multiple academic years is required to determine the long-term durability of the cognitive transfers associated with gamified chess assessment. Second, the sample was restricted to grades 2–4 within specific urban and suburban Armenian schools. Future research should replicate this methodology across diverse socio-economic demographics and older age cohorts to assess cross-sectional validity. Finally, while the qualitative observation rubrics were strictly aligned with SDT, self-reported motivational metrics in primary school children can sometimes be subject to social desirability bias.

Future investigations should explore the integration of digital gamification platforms (e.g., adaptive AI-driven chess puzzles) with these physical, classroom-based techniques to create hybrid formative assessment models that provide instantaneous, data-driven feedback to both the learner and the educator.

Conclusion

The mandatory inclusion of chess in primary education represents a forward-thinking policy aimed at cultivating the critical, divergent, and analytical thinking skills requisite for the 21st century. However, the true potential of this curriculum cannot be unlocked through static, traditional assessment methodologies. This study provides definitive empirical evidence that the deliberate integration of gamified instructional techniques during the summarization and assessment phases significantly enhances both cognitive retention and academic achievement.

The application of techniques such as the "Tricolor," "Invincible King," and "Team-Based Question and Answer" transforms the classroom ecosystem. Quantitatively, the experimental cohort demonstrated meaningfully improved summative outcomes (Cohen's $d = 0.78$) and steady cognitive retention compared to standard instruction. Qualitatively, these gamified methods noticeably mitigated the affective filter of test anxiety, fostering a collaborative environment more conducive to constructive peer scaffolding and engagement.

By aligning the assessment protocols with the inherent game-based nature of chess, educators can fulfill the core principles of formative assessment: to stimulate educational activity, dynamically monitor understanding, and ensure continuous, anxiety-free cognitive development.

From a policy perspective, the findings strongly recommend the systemic revision of methodological guidelines for chess educators. Professional development programs must move beyond teaching chess mechanics and explicitly train educators in the psychology of gamified assessment and cognitive load management. Ultimately, bridging the gap between rigorous academic evaluation and interactive gameplay is not merely a pedagogical

enhancement; it is an essential evolution in realizing the profound educational value of chess for primary school learners.

ՏԱՐՐԱԿԱՆ ԴՊՐՈՑՈՒՄ ՇԱԽՄԱՏԻՑ ԱՄՓՈՓԻՉ ԹԵՄԱՆԵՐԻ ՈՒՍՈՒՑՄԱՆ ՄԵԹՈԴՆԵՐԸ

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«Շախմատ» առարկայի պարտադիր ներառումը տարրական դպրոցի հանրակրթական ծրագրում պահանջում է ձևավորող գնահատման այնպիսի արդյունավետ ռազմավարությունների մշակում, որոնք բովանդակային առումով լիովին համահունչ են այս խաղի փոխներգործուն ու շարժընթաց բնույթին: Սակայն ավանդական ամփոփիչ գնահատումները հաճախ հանգեցնում են իմացական գերծանրաբեռնվածության ու ուսումնական տագնապի՝ դրանով իսկ խոչընդոտելով գիտելիքի տևական մտապահմանն ու աշակերտի ուսումնական շարժառիթների զարգացմանը: Այս մեթոդաբանական բացը լրացնելու նպատակով խառը մեթոդներով իրականացված սույն հետազոտությունը փորձառական եղանակով գնահատում է նոր մշակված ու ազգային-մշակութային հենք ունեցող խաղայնացված ուսուցման հնարների արդյունավետությունը, որոնք կիրառվում են հատկապես շախմատի դասերի ամփոփման փուլում:

Հայաստանի պետական կրթական համակարգի շրջանակում իրականացված նմանափորձարարական միջամտությունը ներառել է տարրական դպրոցի (2-4-րդ դասարանների) 144 աշակերտի, որոնք 12-շաբաթյա ուսումնական կիսամյակի ընթացքում հավասարապես բաժանվել են փորձարարական ու ստուգիչ խմբերի: Քանակական վերլուծությունները փաստում են, որ փորձարարական խումբն արձանագրել է նկատելիորեն ավելի բարձր ամփոփիչ արդյունքներ (Cohen-ի d = 0.78) և 12 շաբաթվա ընթացքում դրսևորել է գիտելիքների առավել կայուն իմացական պահպանում՝ հատկապես տարածական տրամաբանության առումով: Զուգահեռաբար որակական դիտարկումները ցույց են տվել, որ խաղայնացված միջավայրում նմանատիպ գնահատումները դրական են ներազդել դասարանային փոխհարաբերությունների զարգացման վրա:

Ի տարբերություն ավանդական ուսուցմամբ ընդգրկված խմբի՝ փորձարարական խումբը դրսևորել է ուսումնառության աճող ներքին շարժառիթներ ու հասակակիցների միջև փոխօգնության առավել համապարփակ դրսևորումներ, թեև այս ազդեցություններն ուսուցման նորարարական գրավչությունից լիովին տարանջատելու համար անհրաժեշտ

են լրացուցիչ հետազոտություններ: Հետազոտության արդյունքները փաստում են, որ խաղի վրա հիմնված ձևավորող գնահատումներն արդյունավետորեն մեղմացնում են ավելորդ իմացական ծանրաբեռնվածությունը՝ միաժամանակ բավարարելով սովորողի ինքնավարության, կարողունակության և փոխկապակցվածության հիմնարար հոգեբանական կարիքները:

Ի վերջո, սույն հետազոտությունը հանգում է այն եզրակացության, որ խիստ ակադեմիական գնահատման ու փոխներգործուն խաղային միջավայրի անխափան միավորումը կենսական նշանակություն ունի իմացական գործընթացների բարելավման ու տարրական դպրոցի սովորողների համար շախմատի՝ կրթական գործիքի համապարփակ ներուժի բացահայտման գործում:

Հիմնաբառեր՝ *շախմատային կրթություն, ձևավորող գնահատում, խաղայնացված ուսուցում, իմացական ծանրաբեռնվածության տեսություն, ինքնորոշման տեսություն, տարրական դպրոցի աշակերտներ, ուսումնական առաջադիմություն*

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