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Research Article

Effects of feedback dynamics and mixed gamification on cognitive underachievement in school

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ABSTRACT

The application of gamification methods is still complex for most Latin American teachers who apply gamified pedagogies. Many confuse their nature with cognitivist classes that are totally confusing when using gamified tools for active learning of their students. The background information states the reduction of academic obstacles for students to perform at a high level, especially when participating in an interactive and combinatorial way with gamification technologies offered by the teacher. We tested the effects of the D-S-$F_{[IR]}$ proposal (dynamics, strategies, feedback, and interactive reinforcement), replicating gamified pedagogical phases with virtual applications, the use of video games in academic underachievement; and a follow-up verbal interactive reinforcement. The method made it possible to develop between 1,600 and 1,800 verbal didactic interactions of knowledge (orientation, questioning, and reassuring). The approach consisted of 60 reinforcement sessions (± 8 months of implementation), for 140 students with low cognitive performance at school ($range_{[age]}$ = 8.5-12.5), who were previously selected and randomly assigned to three comparison groups ($EG_{[1]}$ = 47; $EG_{[2]}$ = 47; CG = 46). The results were evidenced by performance tests, reporting significant improvements in mathematics cognitive performance ($F = 53.316$; $p < 0.05$). A specific analysis of performance in science and communication allowed for significant improvement ($F = 93.119$; $F = 85.770$; $p < 0.05$), although no differentiating effects were evident between the experimental groups. It is important to conclude that mixed gamification was responsible for the reduction of the low level of school cognitive performance.

Keywords: gamified learning, cognitive processes, learning to read, mathematical skills, scientific competences

INTRODUCTION

Face-to-face education was affected globally by COVID-19 between 2020 and 2021, more than 30% of students took virtual classes, 52% of students and teachers used open access software, and 30% did not have access to the Internet (United Nations Children's Fund [UNICEF], 2022). In Spain, less than 50% had digital tablets (UNICEF, 2024), and 90% of Brazilian students learned through video platforms (United Nations Educational Scientific and Cultural Organization [UNESCO], 2023). In addition, more than 400 million children relied on radio and television to educate themselves at home (World Bank, 2022). Although, in 2023, initiatives such as Giga and the UNICEF-ITU Passport helped bridge the education gap for 700,000 students (UNICEF, 2021), more than 90% of Peruvian students aged 6–11 years ended up being educated at home (National Institute of Statistics and Informatics [INEI], 2020).

The 'Aprendo en Casa' program was limited, with only 40% of households having a mobile device without free internet access, forcing teachers to serve students by phone (Andrade & Guerrero / Development Analysis Group [GRADE], 2021; The Office of the Comptroller of the Republic of Peru [GCR], 2021). Moreover, 40–50% of students in the early grades used inadequate educational material (La Rosa Feijoo et al., 2023). However, the Ombudsman's Office (2020) and other political figures continued to push for this continuity without noticing the problems of digital specialization (Ramos García, 2020). In addition, 43.4% of students passed, 30% were promoted by government order (GCR, 2021). Distance education involved the use of Mentimeter, Mural.ly, and Kahoot! However, these applications have been used in sectors with economic possibilities. The TERCE assessment reported deficiencies in Latin American students due to inattentive education of their preferences. Gamification addresses this problem, focusing on academic participation by competing by leveraging collective preferences such as digital storytelling and mini-games (Cattoni et al., 2024; Villalustre-Martinez, 2024), of the enjoyment of serious games in group engagement (Bakhanova et al., 2020; Elisha Ding & Yu, 2024). These games include rewards that provoke academic collaboration (Hong et al., 2024), additionally, delivering them in intuitive environments that foster autonomy and meritocracy (Apascaritei et al., 2024; Grabner-Hagen & Kingsley, 2023; Hardof-Jaffe & Amzalang, 2024).

Evidence reports the social and cultural effects acquired in the family transferring to collective or individualistic activities in the classroom (AlDahdouh, 2021; Delgado et al., 2021; Delprato & Akyeampong, 2019; Susperreguy et al., 2022). Play helps overcome lack of digital connectivity and family illiteracy, develops empathy, and sensory development in coexistence (Cattoni et al., 2024; El Shemy et al., 2025; Navarro-Ávalos et al., 2024; Sun, 2025; Vu et al., 2024). The main difficulty in gamification lies in the lack of expertise in fostering cooperation and adapting game aesthetics (Nazari & Hu, 2024; van Vemde et al., 2022), challenges in developing verbal feedback (Behl et al., 2024; Chen, 2024; Liu et al., 2023; Tamimy et al., 2023), and complications in eliciting interpersonal dynamics without providing verbal instructions (Liu et al., 2023). Therefore, it is crucial to know whether gamified and feedback training improves formal skill development (Elisha Ding & Yu, 2024). Therefore, the study examines the effects of the application of mixed gamification and feedback dynamics on the improvement of school cognitive performance.

Gamification: Dynamism, Interaction, and Feedback

Intergroup dynamics foster a sense of planning and participation through challenges (Arrieta Mier et al., 2023; Bortz & Garrido, 2024; Delgado et al., 2023; Huici, 2019), develop coordination and academic dialogue through competitive rules in gamified environments (Chen et al., 2020), and generate the pursuit of group goals (Aldemir et al., 2018). These environments allow concept building and skill development guided by their classroom goals (Aldemir et al., 2018; Lopez & Tucker, 2017). Young children develop basic motor and cognitive skills in peer competition (Davies et al., 2024), boosting their confidence to express themselves in public. High levels of physical effort have so far been reported in motivational self-assessment dynamics (Quintas et al., 2020). The use of physical and digital interactive materials used by the teacher boosts these dynamics (exercise simulators, virtual reality environments, etc.), or in dance with virtual robots (Sánchez San Blas et al., 2024; Zhenyu, 2025).

In this respect, elements of formative feedback encourage conversational monitoring (Kooloos et al., 2023). Dialogue strengthens confidence and coping with error (Amodia-Bidakowska et al., 2023; Smit et al., 2023). Feedback is categorized into task, process, metacognition and 'I' orientation (Hogan & Payne, 2024). It is further subdivided into verbal and non-verbal. The former includes the teacher-student conversation, whereas the non-verbal one premeditates gestures and body movements to facilitate instruction (Berry et al., 2025; De Carolis et al., 2017). Verbal feedback allows the learner to state his or her position towards other arguments made (Smit et al., 2023). Evidence has explored increasing self-efficacy in reasoning with active, perceived, and reciprocal feedback (Byl & Topping, 2023; Mao et al., 2024; Smit et al., 2023). Each stimulates academic confidence through problem-solving monitoring (Merrick & Fyfe, 2023). That is, guiding the student with verbal interactions to benefit their confidence to succeed (Hagemann & Decius, 2024; Keller et al., 2024; Wu & Schunn, 2023; Zhu et al., 2024).

Feedback accompanied by the use of video games improves academic interest if it includes instructions (Demedts et al., 2024; Liu, 2025), reduces anxiety about complexity if the teacher's pedagogy clarifies learning challenges (Dainer-Best & Rubin, 2024). These needs can be addressed with the use of adaptive technologies (Formosa et al., 2022; Grabner-Hagen & Kingsley, 2023; Johnson et al., 2018; Nebel et al., 2016; Shooken et al., 2024). By addressing these needs, the passion for playful learning is strengthened through verbal feedback. The influence of highly engaging play opens attention in children with cognitive differences (Barata et al., 2017; Contreras et al., 2019), and even develops attitudes in children who have parents who give them feedback (Witte et al., 2024).

Virtual platforms increase group decisions and mutual help among team members (Sun, 2025; Vu et al., 2024). In that sense, teachers try to achieve learning standards with adapted strategies to provoke cognitive assimilation. Findings report the achievement of the specific objectives of contextualized lessons, especially if they include digital platforms (Hervás et al., 2018; Infante-Villagrán et al., 2021; Scolari et al., 2018). It seems that developing participatory verbal exchanges increases receptive capacity, as long as the characteristics of the learner are known (Bacso & Nilsen, 2022). Therefore, more enduring performances are elicited in learners who are recognized by their teachers (Andriani et al. 2019; Christensen et al., 2020; Dalsgaard et al., 2020; Weidlich & Bastiaens, 2019).

Evidence on Gamified Pedagogies

Individualistic and collaborative competences developed in hybrid sessions usually apply an intermittent treatment with gaming platforms (Scolari et al., 2018). In this case, specifically, in the area of mathematics, the effects are more recognized in the use of leisure technologies (Kalogiannakis & Papadakis, 2017; Toda et al., 2019), in the achievement of reading performances, emotional regulation (Ros-Morente et al., 2018; Salemink et al., 2022); and the generation of academic well-being (Nicolaidou et al., 2022; Pimmer et al., 2021). Therefore, gamification processes allow the establishment of direct, aesthetically appealing actions to students through challenges and game imitation activities (Jagušt et al., 2018), as studies support various treatments under theories of self-determination and the fulfilment of academic achievement needs (Tan et al., 2023), students develop attitudinal commitment to compete under the motivational effects of cognitive game play (Xiao & Hew, 2023).

The effects of gamified teaching with platforms and video games have been shown to reduce the slowing of memorization and critical thinking (Zumbach et al., 2019). However, evidence is scarce to determine that gamified games with the use of competing environments and video games develop cognitive abilities to learn. These tools and virtual environments allow the development of massive gamification processes in groups with very particular characteristics in competition. As a pedagogical support process, it is postulated that the sustained practice of interactive actions such as debate and direct conversation reduces cognitive overload (Baydas & Cicek, 2019; Di Giacomo et al., 2017; Duval, 2016; Gokbulut, 2020; Fanari et al, 2017; Holguin-Alvarez et al., 2020; Lupiáñez & Rico, 2015; Wang, 2020), especially in learning contextualized mathematical content (Di Giacomo et al., 2017; Fanari et al., 2017; Huang et al., 2008; Oliveira et al., 2020).

Research Hypothesis

The research tests the effects of the application of two mixed gamification methods on underachievement. This gamification is accompanied by a pedagogical model of the D-S-$F_{[IR]}$ type. Activity 'D' summarizes the development of playful dynamics in class, which are accompanied by strategic gamification activities (S). The final stage of type $F_{[IR]}$ synthesizes the feedback activities with verbal interactive reinforcement from the teacher to the students (conversations enc lase). These three processes work in parallel with the use of video games and virtual platforms. In this sense, the interactive model of Yuan and Zheng (2024) was adapted to a conversational discursive model as cognitive reinforcement. Their evidence suggests classroom simulation as a pedagogical model of live feedback (in a real classroom). On the other hand, it replicates a previous study of mixed gamification in which low-level cognitive skills were developed in students with similar characteristics

(Holguin-Alvarez et al., 2023). The hypothesis posed is: The effects of the application of mixed gamification will demonstrate statistical differences that corroborate the effects on the reduction of low academic performance when accompanied by a pedagogical model: D-S-$F_{[IR]}$.

METHOD

The execution of the study was carried out in experimental design through a controlled trial. The quantification of the results made it possible to compare the data in order to test the central hypothesis. The hypothesis testing was carried out among the subjects distributed in two experimental groups and a control group. The first experimental group, called 'A', included the sequential use of virtual applications, video games and the D-S-$F_{[IR]}$ methodology. The second experimental group, called 'B', included two components: video games + D-S-$F_{[IR]}$ methodology. The activities of groups A and B were developed in parallel. The classes developed allowed the application of activities with virtual applications in the initial phases. The use of video games and feedback dynamics were reproduced in the process and completion phases. A third control group (C) received a constructionist approach methodology without gamification technologies.

In the third group, exogenous variables such as the use of leisure technologies were controlled. In effect, meetings were held with the parents in order to limit the use of these technologies (tablets and mobile phones) during the experiment to one to two hours a day in their homes (limit range). Similarly, it was requested to limit the use of computer games to 30 minutes per day. A daily report through a family diary served as a means for parents to report daily consumption. Students who exceeded this consumption by more than two hours per day for more than one week were removed from the experiment. This prevented the influence on the selectivity of subjects by criteria of experience with leisure ludification, as well as the contamination of cross-effects on the control group's internal dependent variables between cognitive recharge, and attitude towards the use of games.

Data were obtained from two assessment moments, which we refer to as pretest and posttest. The assessments were replicated in both groups. The timing of the application of the tests was eight months after the treatment; however, two more weeks were given to apply the post-test in order to balance intervening memory and forgetting variables. Therefore, the research sought to answer the research question: To what extent can the application of a pedagogical model based on dynamics, strategies and feedback, with differentiated gamification methods, reduce academic cognitive learning if it is accompanied by interactive reinforcement in daily learning?

Participants

We replicated a sampling model with similar characteristics to the sample of the predecessor study (Holguin-Alvarez et al., 2023). Here we considered 140 experimental subjects, who were students from second to fifth grade of primary school in Peru, of Peruvian nationality, residents of the city of Lima and of Spanish language (coastal origin = 75%; Andean origin = 20%; jungle origin = 5%). The study has been conducted during the school year 2023 to 2024. The study was conducted during the school year 2023 to 2024, considering all students in 6 sections of a public educational institution. For the homologation of the samples, the socio-economic level was considered, the type of socio-economic level was 'poor' and 'very poor', and the age distribution. In this sense, the age of the participants was compared with the age ranges established by the Peruvian Ministry of Education (MINEDU, 2022). As they were in the natural range of 8 to 12 years of age, we considered those students who in the school's Institutional Project registered being part of a negative situational diagnosis without demonstrating the fulfilment of the expected performances of academic cycles III, IV, and V.

These parameters underpinned the integration of pupils with low academic performance compared to the age they were expected to demonstrate in the expected grade. This preliminary traceability made it possible to cater for pupils with a certain academic and age lag with respect to the grade they were in (second grade = 8–8.5 years of age; third grade > 8.5–9; fourth grade = 9–10; fifth grade = 11–12.5). Another criterion of choice was based on selecting students with a score equal to or lower than 12 points. The national assessment criteria were considered in deciding the ranking of students: AD (outstanding achievement), A (achievement), B (process), and C (beginning) were considered. This type of qualification was considered for the selection of students with B and C academic performance. That is, students with performance category at the beginning level (low and very low), and the process level (moderate or fair performance) were chosen.

Following the preliminary sample selection, a probabilistic allocation of individuals to each group was developed using a lottery procedure of individuals selected from a general list of students. The drawing of lots was carried out using a ballot box that integrated the total number of tickets of all registered students according to their original classroom. The order number of each pupil in the first classroom was coded together with a letter of origin 'A' (A1, A2, A3, etc.). The order numbers of the students in a second classroom were recorded with the letter 'B' (B1, B2, B3, etc.), and so on, all possible quotas were recorded considering the remaining students. The extraction of each ticket was done by manual withdrawal of each ticket, starting with the first experimental classroom, followed by allocation of the next ticket to the second experimental classroom; and a third allocation to a control classroom. This process was repeated in this order for the remaining allocation.

Once the total number of tickets for each experimental and control classroom had been completed, the latter were letter-coded for follow-up during the execution of the study (GE 1 = A; GE = B; GC = C). The integration of each student was assigned by drawing lots, which involved drawing the student from the general list that was initially organized by surnames and first names (in alphabetical order), to each particular list of groups A, B and C. In terms of age characteristics, these allowed each individual to be integrated as equally as possible into each methodological group ($GA_{[n]}$ = 47; $GB_{[n]}$ = 47; $CG_{[n]}$ = 46). The distribution allowed the three groups to be complemented by all students without interrupting their academic classes in the assigned group, being assumed as academic reinforcement activities.

However, the criterion applied by Holguin-Alvarez et al. (2023) was also considered, regarding the regular attendance of students to their respective sections in the last four months of study at the educational institution, discarding those who did not attend in the months prior to the development of the approach program. Students participated after consent was obtained from their parents, allowing them to opt out of participation during the study if they chose to do so. In any case, the study was carried out in a way that was not emotionally damaging to them, nor did it affect their cognitive integrity or attitudes. These conditions made it possible to comply with the ethical criteria set out in favor of the Declaration of Helsinki, which were reviewed and evaluated by the university's ethics committee: '*Mixed gamification and teaching styles: A study of the effects on pedagogy and school learning*' (Research Support Fund-Phase B, 2024 [PID-3261 / FDH-CE-ID 17070] - Universidad César Vallejo).

Instruments

The assessment involved the use of instruments that measured students' performance scores, the characteristics of their responses and the nature of their resolution. In this sense, it was agreed to use achievement tests that assessed different cognitive components in grades 2, 3, 4, and 5 of primary education in the Peruvian school system. This approach involved assessing nine components of cognitive performance without compromising academic and age selectivity conditions to assess the areas of mathematics, science and communication. This required the researchers to adapt the instruments that teachers used to assess learning, which facilitated the contextualization and adaptation of knowledge (**Table 1**). A total of 90 ordinal scored questions were used (*solved with or without reported answer* = 3 points*; solved/no correct answer* = 2 points*; correct answer/no resolution* = 1*; no answer/no resolution* = 0 points). Each score was awarded for each question answered, the instruments were made up of open-ended questions.

The structure of the instruments was developed by teachers based on the basic education profile and competencies established for levels III, IV, and V in Peru (MINEDU, 2017). The mathematics test was structured in 13 items of its own that represented the performances of the mathematics area established in three components: logical reasoning (sequencing and geometry, etc.), calculation and operations, and problem solving (property problems/problems and operations). In science, nine tasks were set that represented the performances in the area of science and technology in regular basic education (observation, hypothesis, deduction, and verification). In the case of the indicators for reading, writing and oral expression, 13 indicators were established for this area (**Table 1**). This would make it possible to get closer to the low level of performance expected of the students in the grade they were studying.

Table 1. Components, indicators, and reliability indices of the assessment tests

Test	Components	Reliability	Indicators
Mathematics*	Logical reasoning	0.77	*Sequencing of quantities* (1) Completes sequences with three numbers up to three digits. (2) Completes sequences with three numbers up to three digits. *Geometry, deduction, and displacement* (3) Determines locations of groups of elements up to four elements in a plane. (4) Deduces figures from more general ones, pointing them out with specific drawings.
	Calculation and operations	0.76	*Operations and calculation* (5) Solves straightforward operations with numbers up to three digits placed vertically. (6) Solves straightforward operations with numbers up to three digits placed horizontally. (7) Calculates addition and subtraction of elements up to 10 elements per group. *Sequencing and calculation* (8) Divides quantities of elements up to 20 elements per group. (9) Completes sequences from mental arithmetic with quantities up to two digits.
	Problem-solving	0.80	*Problem-solving by property* (10) Solves equality problems. (11) Solves commutation problems. *Problem-solving by type of operation* (12) Solve additive problems with sequential events of up to two additive operations. (13) Solve additive problems with sequential events of up to three additive operations.
Science*	Observation	0.81	*Classification and identification* (14) Classifies data provided by the actions of nature. (15) Extracts characteristics from basic experiments.
	Hypothesis	0.80	*Hypothesis* (16) Establishes causal hypotheses of experimental or chance events. *Probability and solution approach* (17) Poses three probabilities of chance events. (18) Poses solutions as alternative solutions to given problems.
	Deduction and verification	0.79	*Simulated testing* (19) Simulates events resulting from particular events. (20) Deduce results from basic experiments. *Checking in context* (21) Performs basic hypothesis testing with objects (without hints or paths). (22) Performs basic hypothesis testing with objects (with hints or paths).
Communication*	Reading and comprehension	0.77	*Comprehension of short texts* (23) Reads short texts (stories or legends) with ease. (24) Deduce three situations resulting from the narrative. *Inferences and reflection* (25) Infer characteristics of characters. (26) Reflects according to his/her position on the events of the text. (27) Makes an oral or written critique in relation to an opposing position on the text.
	Oral expression	0.75	*Gestures and movement* (28) Gestures when presenting a short text. (29) Performs movements and body movements according to the characteristics of the message to be conveyed. *Transmission of messages* (30) Expresses the message in a complete way or complements it in a substantive way. (31) Responds slowly and with argumentative formulation.
	Text writing	0.78	*Sentence writing* (32) Can write short sentences of up to two sentences. *Coherence and cohesion* (33) Clearly determines the beginning, process and end of a short story of his/her own. (34) Demonstrates cohesion and form in the production of a narrative paragraph. (35) Demonstrates cohesion and form in the production of an informative paragraph.

Notes: Overall reliability = 0,85. * Mathematics (α = 0.11); Science (α = 0.840); Communication (α = 0.804).

The characterization of grading and scoring allowed for an improved approach to assessing both student development and outcomes, although, in the process of item topicalization, tasks were set with a certain complexity according to the grade levels considered. For the mathematics test, completion items (logical reasoning) were established: "*Complete the sequence of numbers: 9, ___, 11, ___, 13, ___, 15*". On the other hand, calculation questions oriented to the application of mental arithmetic were also stipulated, such as: "*Solve: 13 + 20 = ___, 11 + 9 = ____, 32 + 18 =____*". As for the science instrument, questions were posed that verified deduction skills, such as: '*What color can be obtained by mixing black and white paints?* (They observe the process of a mixture by parts in a figure). As for other items of direct and open resolution, items were considered that allowed the evaluation of writing, cohesion and coherence as in the writing of the text, such as: "*Write two sentences describing a figure of your preference: _ sentence 1__. _ sentence 2__*". The indicators proposed made it possible to evaluate the essential features of each dimension, as well as the components considered in the tests as a whole.

The resolution time given was 120 minutes for each of the tests, and they were distributed massively with an extension of up to 15 minutes if the students requested it. Regarding validity, these instruments did not have such a process, so they were developed as instruments for a specific sample and for an unconventional situation (ad hoc). Therefore, content validation was carried out by the judgement of five experts: three were pedagogues, one was a specialist in scientific methodology, and one was a researcher with expertise in gamification. The evaluation criteria were relevance, feasibility and complexity, and linguistic appropriateness. The process was carried out during two months of work, which allowed us to achieve a common agreement of 100% for the mathematics and science tests; and 98.5% for the communication test. The reliability calculations were obtained from the replication carried out by the classroom teachers, each replication was applied at the beginning and at the end of a school day in which the session of each area was developed, reporting the data necessary for the Cronbach's alpha reliability analysis. Thus, 35 indices were involved, which made up the nine components proposed, the reliability values were values greater than 0,70 in the internal consistency index (**Table 1**). The procedure allowed for the evaluation of the initial (pre-test) and final (post-test) conditions.

Procedure

The experimental work allowed the implementation of dynamic feedback methodologies with interactive reinforcement (D-S-$F_{[IR]}$), accompanied by mixed gamification activities. This experimental duality involved comparing two scenarios. The first was applied in experimental group A using cooperative gaming platforms with academic objectives, the use of video games; and the methodology: D-S-$F_{[IR]}$. In the second (experimental group B), video games were used, and the D-S-$F_{[IR]}$ methodology was applied. In the control group, traditional constructivist activities were applied without the use of technological tools. The platforms and collaborative learning environments were: Mura.ly, WhatsApp, Mentimeter, Kahoot, Padlet, Popplet, Zoom, etc. Among the video games, some classics were used such as: Top Gear, Spider-Man, Minecraft, etc.) (**Figure 1**). The classes were developed under a three-phase work scheme: start, process, and exit. Each of the total 60 lessons lasted between 45 and 50 minutes.

The first activities of the experimental group 'A' (mixed gamification) were carried out with participatory games on platforms and applications for the search for prior knowledge (initial phase), which changed to the application of feedback dynamics on new knowledge on the subject: D-S-$F_{[IR]}$ (process phase), and competition between students with video games at the end (exit phase). However, to avoid variables that generate inactivity due to the repetitive use of activities, the internal structure of the activities was exchanged in the remaining 30 sessions. This involved applying video game competition activities at the beginning of the session (start phase), D-S-$F_{[IR]}$ type activities on the central theme; and the exploratory platforms and environments were used to evaluate the end of the class (exit phase). In the experimental group "B" the sessions were applied with the same structure, with the difference that in the start phases of the first 30 classes the video game competitions were used, and these were exchanged for the exit phases in the remaining 30 classes. It should be noted that this group did not involve the use of virtual platforms and applications.

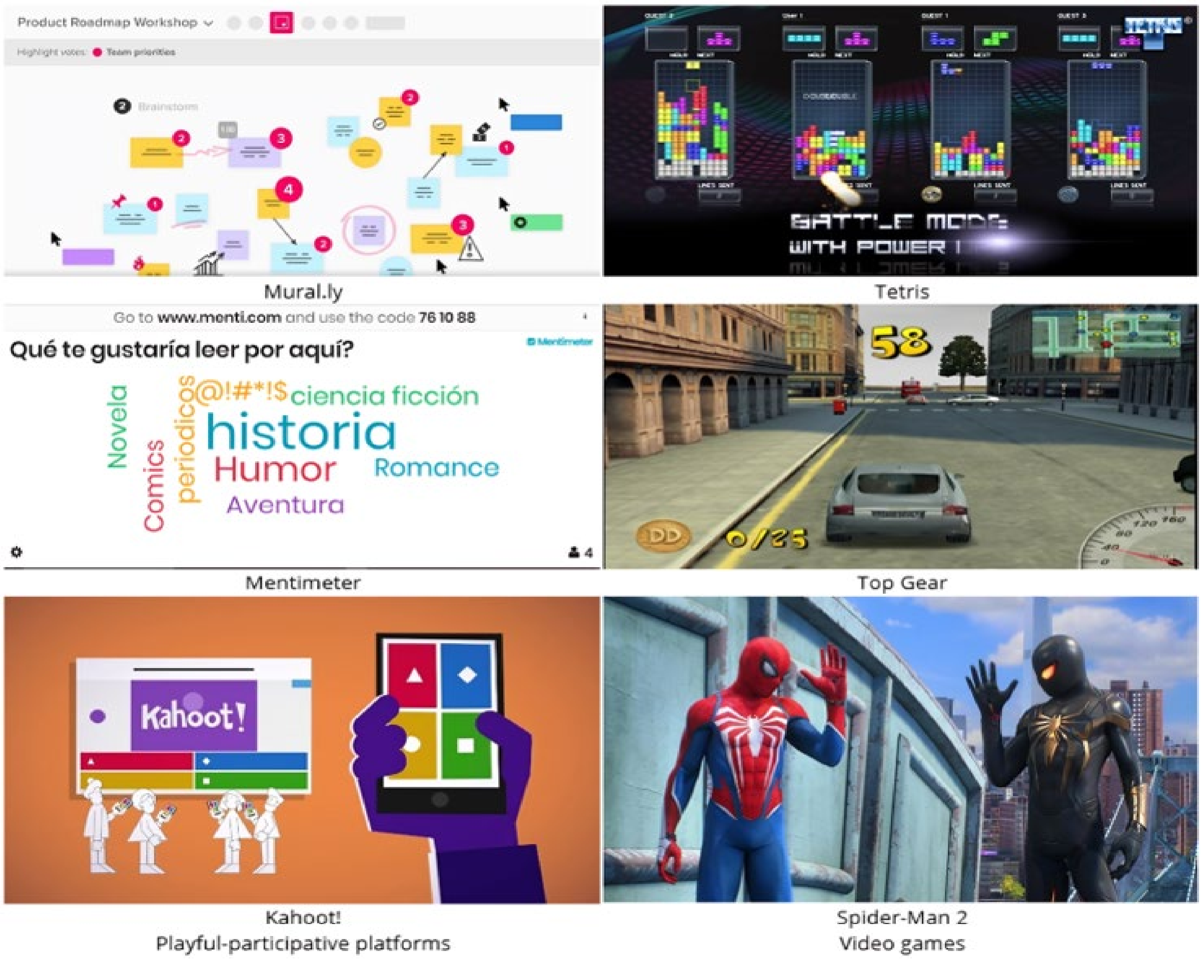

Figure 1. Exemplification of platforms and video games used (Source: Open data sources)

The methodology D-S-F$_{[IR]}$, was developed during 8 months in the school years 2023 and 2024, 60 learning sessions were applied to group A and group B. The sessions included the execution of 800 didactic interactions between teacher and students (**Table 2**). That is, interactional verbalization processes that helped to solve operations or problems on the basis of the teacher's guiding questions, questioning questions, and assuring feedback questions. These didactic interactions were based on interactive reinforcement from preliminary sources (Mao et al., 2024; Yuan & Zheng, 2024), with which the teacher was able to probe prior knowledge (guiding questions), build new knowledge with the student and challenge it (questioning questions) (Byl & Topping, 2023), and subject it to cognitive rigor and permanence (task-assurance questions) (Merrick & Fyfe, 2023). At the end, the teachers executed a total of 1,649 verbal guidance interactions, 1,723 verbal questioning interactions, and 1,789 verbal reassurance and feedback interactions.

The students' progress during each session was recorded in anecdotes kept by the classroom teachers. This made it possible to indicate the qualitative improvement of their knowledge, and to verify whether their participation in class was equitable. On the other hand, this information helped to balance the groups with respect to any absences of students who were unable to attend a session in order to reinforce the work missed in small groups due to repeated absences.

Regarding the implementation of the activities per session, these were applied with a cross distribution, with which to intervene in the groups in the most equitable way possible. In group A, each session was developed with the format: start (application of platforms and applications), process (D-S-F$_{[IR]}$ application), exit (competitive participation in video games). This scheme was respected during the first 30 sessions. In group B it was applied in a different way (start = competitive participation in video games; process = D-S-F$_{[IR]}$ application; exit = application of platforms and applications). In the remaining sessions, the processes were reversed in each group regarding the use of platforms, applications and video games, leaving the application of the D-S-F$_{[IR]}$ method in the process phase. The video games and platforms were used for around 15 to 20

Table 2. Exemplification of interactions and verbal interactive reinforcement*

Session phase	Teacher interaction	Student interaction
Start (guidance questions)	Let's look at this set ... What do you think is happening with the quantities? (He shows two stickers that show the image of cartoon cars interlocked in sets with quantities of 10 and 8, and a car wash house is visualized where the cars are supposed to arrive).	There are several carts ... Some are crossed with each other ... Others are invading other people's fields ... There are 10, but in the other group there are also 8 ...
	What would happen if we took them all home? (The teacher points to the representative drawing of the house).	They could be washed ... They are dirty ...
	And what happens to those who are located in the middle of the two circles? (points to the intersection area).	Parked ... Some are left over, but those in the middle belong to one group and also to the other ...
	What if we count one by one? Can we figure out how many there are or is it not allowed to do that?	Yes, we could, because they are sets ... There would be no problem, they are all like a single set ...
	We can count? (points to each car until reaching the final count).	(Children count ... 1, 2, 3, ...)
	Now, what if we take them home? Could you help me? (He moves the cars, positioning them near the house).	If I want to ... Me too, 1, 2, 3, ...
Process (questioning questions)	But ... if we see, do you think everyone will be able to get in if there are so many cars?	Yes, they can, it's just that it's closed ... They could line up outside to wait ...
	If each car waits outside, how many can be attended to at the wash? (The teacher points to the two windows in the house).	Of course, they could be washed two by two ... They would have to wait for their turns two by two ... They would wait a long time, since there are 18 cars ...
	How many turns will they have to wait if they are waiting in line outside?	How long it takes to get through two rows ... 10 turns ... 9 turns ...8 turns ...
	How can we evaluate shifts? (The teacher orders them while the children point and count).	Arranging them next to each other in a row (children point). By pairs ... In line, in pairs ... Two by two but everyone is in line ...
Exit (security questions)	Can cars be better served by passing two by two?	Yes, because the service is good, you can see two windows ... Of course, there are two windows where two people who wash cars serve in each place ... Yes, because each car enters each space, in the windows you can see that there are spaces ...
	Will cars be washed entirely?	Yeah ...
	New question: when will they all finish?	Yes, but after everyone is finished ... ... When the 9 pairs of cars are finished, that is when they all pass by the house ...
	How did we know that 9 pairs of cars will be able to finish washing when passing by the house?	When we order them in 2 ... By sorting in rows and counting ...
	Will counting be the same as adding?	It's similar if you count one by one ...
	Cross-question: So, what do we do to know that they would finish washing? (The teacher waits ...)	It's similar ... If you count it pair by pair it could be the same ... Count wide until you reach the number 18 ... Count until you finish with the 18 cars to wash ...

* Exemplification of a learning session on the topic of addition of up to two figures

minutes per session, and in the subsequent 30 minutes, pedagogical activities of the D-S-F$_{[IR]}$ type were developed, aimed at the development of participatory activities (group dynamics), playful strategies (development of operations, problems, readings, and questions); and feedback (verbal interactions of questioning and closure).

At the end of the 8th month of treatment, cognitive performance was assessed two weeks after completing the experimental activities in groups A and B (these were developed in parallel); however, 10 classes with similar characteristics were carried out in group C in order to consolidate the delays that could have been caused by the time lag due to non-attendance. This would help to integrate those students who showed weaknesses or who had not participated in the activities carried out in the experimental groups. After extracting the data, measures of normality were calculated using Kolmogorov-Smirnov and Shapiro-Wilk tests. Preliminary results allowed us to decide by parametric ANOVA tests to apply Tukey's post-hoc tests to determine inter-group effects.

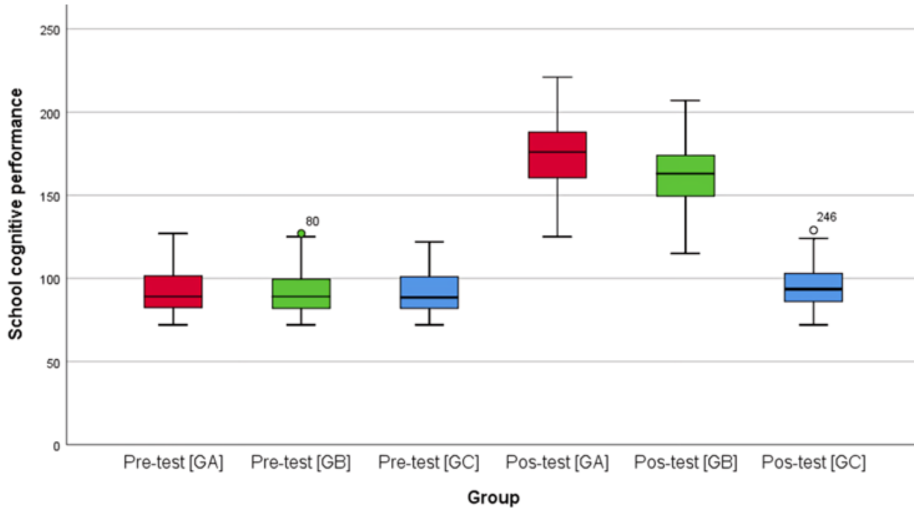

Figure 2. Comparison in school cognitive performance (Source: Authors' research database)

RESULTS

School Cognitive Performance

The pedagogical proposal of the type D-S-$F_{[IR]}$ has allowed us to verify positive effects on low school cognitive performance, as well as on its dimensional components. In principle, scores have been verified that demarcate the stability of intergroup scores (**Figure 2**), without significant differences being determined in the pre-test evaluation ($F = 0.177$; $p > 0.05$), although Tukey's discriminant indices did not show relevant data either (GA = 93.13; GB = 92.06; CG = 91.59).

Once the approach program was developed with mixed gamification methodologies, data were obtained that support the differences favorable to the experimental group of type A against group B ($GA_{[I-J]} = 12.191$; $p < 0.05$), as well as its effects have been greater than those of the control group C ($GA_{[I-J]} = 77.506$; $p < 0.05$). Therefore, the hypothesis that supports that the use of gamifiers with mixed typology accompanied by D-S-$F_{[IR]}$ type methods decreases academic underachievement in contrast to those students in groups B and C is accepted ($F = 249.305$; HSD = 95.222; $p < 0.05$).

Analysis of Dimensions and Performance Indicators

Dimension: Mathematics

In the analysis of pre-test scores on cognitive performance in mathematics, the ANOVA analysis did not present significant intergroup differences ($F = 0.150$; $p > 0.05$). Therefore, the stability between the performance of the subjects in each group was verified (**Figure 3**). Once the pedagogical model D-S-$F_{[IR]}$ was applied, the data showed changes in relation to the two experimental conditions ($F = 53.316$; $p < 0.05$). This has determined the acceptance of the hypothesis of reduced underachievement in groups A and B compared to the control group (C). The effects have shown greater potential in the mixed gamification ($GA_{[I-J]} = 9.362$; $p < 0.05$), compared to condition B. Tukey's test clarified the effects in favor of group A (HSD = 32.39; $p < 0.05$). After conducting the comparative dimensional analysis, we decided to develop a specific analysis of the traits that characterized each performance component.

Specific performances in mathematics

Figure 4 shows indicators of logical reasoning, balanced values were found (group A = 10.34; group B = 10.38; group C = 10.33), as well as between the average scores of the pre-test evaluation on the calculation and operations component (group A = 10.38; group B = 9.79; group C = 9.78). Similarly, higher scores were found in the post-test evaluation for group A (19.57) compared to the other groups. In the ability called calculation and operations the values represent the highest potential for group A (19.83), and in second place for group B (15.11).

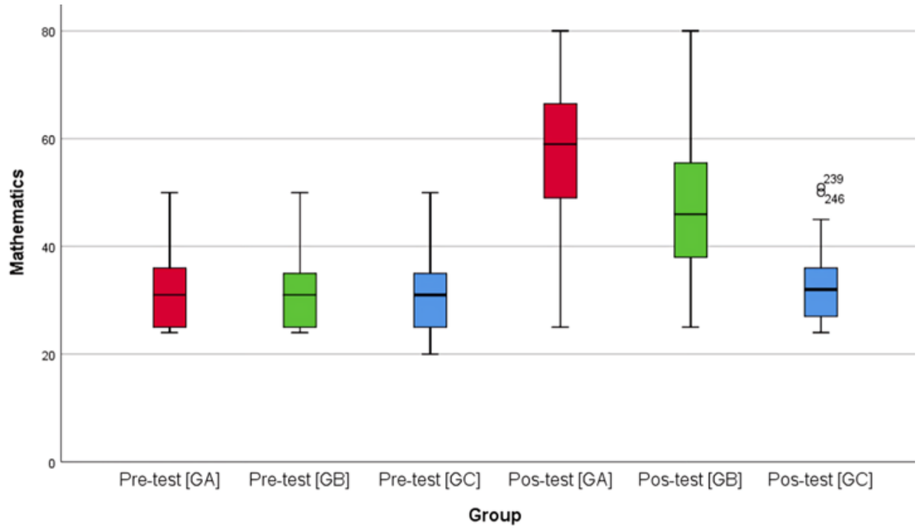

Figure 3. Comparison of scores in the mathematics dimension (Source: Authors' research database)

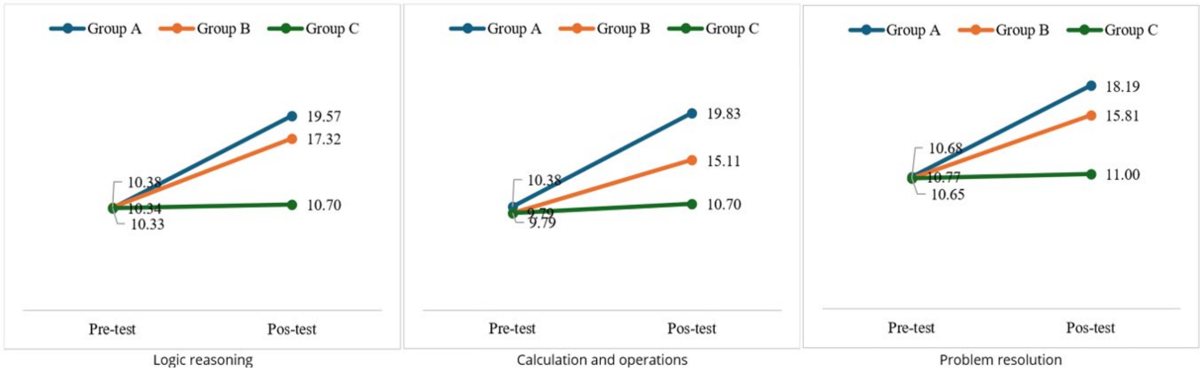

Figure 4. Comparison of mathematics indicators (Source: Authors' research database)

With regard to the problem-solving component, the pre-test scores were higher in group A (10.77) (**Figure 4**). The results of the post-test evaluation showed differences of more than 2 average points in favor of this group (18, 19).

On the other hand, in the logical reasoning performance (**Figure 5**): 'sequencing of quantities', the increase has been achieved in 35% of the total scores at a high level in group A, and 10% at the regular level. This change was significant between groups ($F = 31.101$; $p < 0.05$). In this regard, it should be noted that in group B only 24% obtained a high level, with a greater accumulation of subjects at the regular level (30%). In the performance entitled 'Geometry, deduction and displacement', the improvement of group A has shown an abysmal difference with that of group B at the low and very low level (10 and 45%), with respect to the post-test evaluation (5 and 2%).

In the skill: 'Operations and calculation' (**Figure 5**), the post-test changes indicated a greater increase in the high (20%) and regular (25%) level of the mixed gamification group. Although the change in group B was noticeable, it was still smaller (10 and 18%). Statistical comparison showed significant differences in favor of group A ($F = 25.500$, $p < 0.05$). On the other hand, in the ability of 'sequencing and calculation', the scores of group A and B did not show significant differences ($F = 23.430$; $p < 0.05$). The decrease was greater in the regular (5%) and low (10%) levels, compared to the decrease in group B: 4 and 12%. Other significant changes were observed in the problem-solving component ($F = 15.130$; $p < 0.05$). Here the decrease in the low (20%) and fair (24%) level of this skill was greater in group A: 'problem solving by properties'.

Finally, in the skill: "problem solving by type of operation", the change was noticeable in all levels of the subjects of group A: high (+20%), regular (+18%), low (–12%), very low (–10%). Significant differences were also found ($F = 31.210$; $p < 0.05$). Although the gains were significant, it is important to note that the students in the control group decreased their underachievement, especially at the low level.

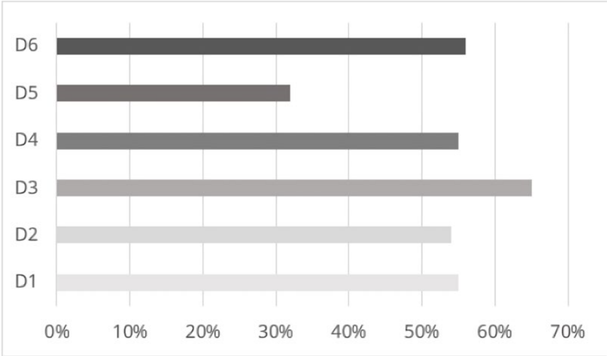

Figure 5. Growth proportion of performances in mathematics dimensions (post-test) (D1: Sequencing of quantities; D2: Geometry, deduction and displacement; D3: Operations and calculation; D4: Sequencing and calculation; D5: Problem solving by property; D6: Problem-solving by type of operation). (Source: Authors' research database)

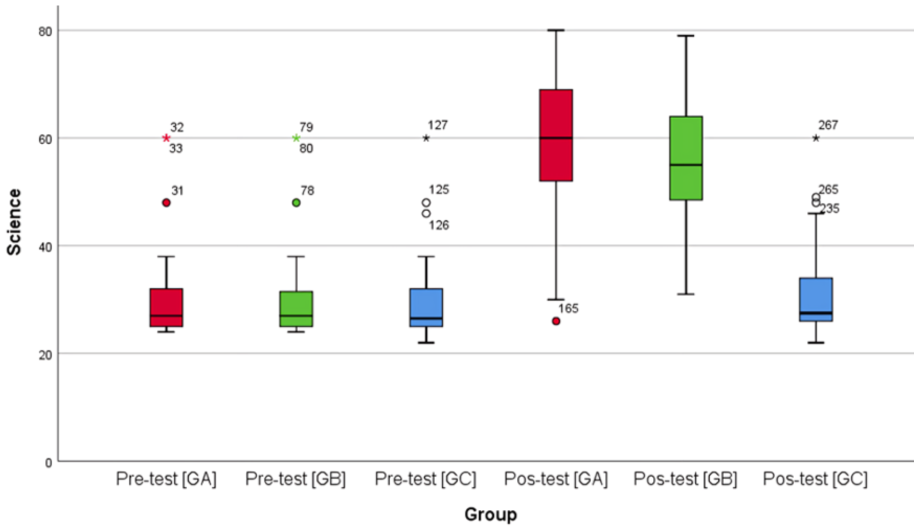

Figure 6. Comparison of scores in the science dimension (Source: Authors' research database)

Dimension: Sciences

Figure 6 presents values for the cognitive dimension on the non-significant pre-test comparisons in science ($F = 0.077$; $p > 0.05$). The mean difference obtained from the intergroup comparison was low level (I-J = 0.319), but not significant (sig. = 0.979). Given these results, it is necessary to admit that the data reported before applying the mixed gamification method with D-S-$F_{[IR]}$, explain the academic balance (**Figure 6**).

The post-test evaluation showed significant differences of the D-S-$F_{[IR]}$ strategy with mixed gamification ($F = 93.119$; $p < 0.05$). This allowed us to test the hypothesis assessing the effects of using mixed gamification with the pedagogical method of didactic interaction. However, an analysis of intergroup differences did not present relevant data to discriminate individualized effects (GA-GB = 2.872; $p > 0.05$), nor between the experimental groups with the highest score and the control group. (GA-GC = 28.172; $p > 0.05$). The analysis of interdependencies has revealed high-level values for group A as well as for group B and group C, with no evidence of differential effects (HSD = 30.91; $p > 0.05$).

Specific performances in science

The analysis of the indicators of the science dimension (**Figure 7**), showed a low level of differences between the scores of the 'observation' component between group A (18.87) and group B (18.68), as well as in the trait characterized as hypothesis development (1.09). On the other hand, the picture has been similar for the component: deduction and verification (1.59). It should be noted that the average scores derived from the pre-test evaluation did not present significant differences in the analyzed indicators.

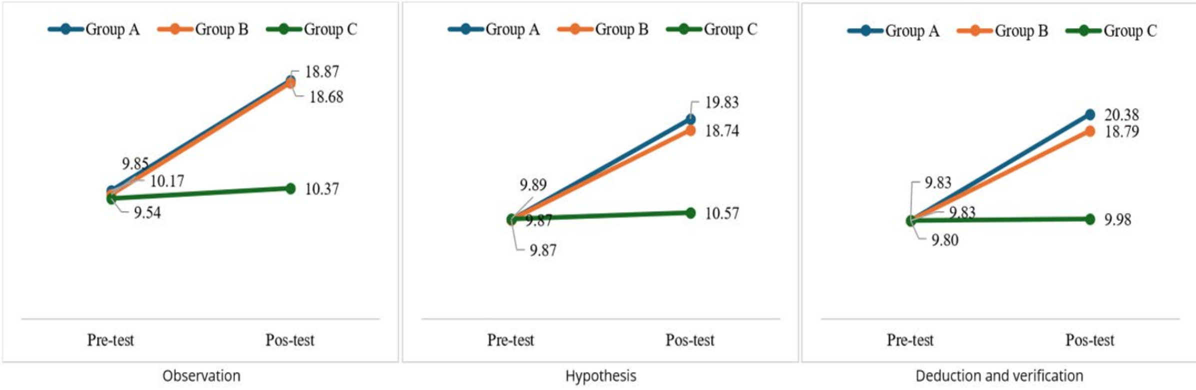

Figure 7. Comparison of science indicators (Source: Authors' research database)

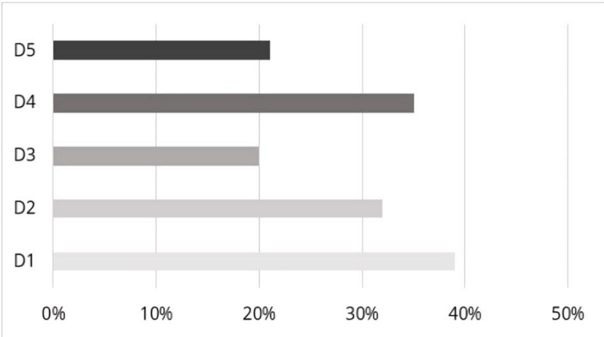

Figure 8. Growth proportion of performances in science dimension (post-test) (D1: Classification and identification; D2: Hypothesis; D3: Probability and formulation of solutions; D4: Simulated verification; D5: Verification in context). (Source: Authors' research database)

Among the science performances (**Figure 8**), we found non-significant improvements in 'classification and identification' (F = 33.210; p > 0.05). This took the form of a change from the low level of group A (–15%) to group B (–13.5%), and 23% in the very low level of group A. These differences support the lack of values in the discrimination of scores obtained in the area in general. On the other hand, a non-significant improvement was found in the 'hypothesis' skill (F = 30.110; p > 0.05), and the levels of group A were also higher: regular (+31%) and high levels (+15%). The post-test report of: 'Probability and solution approach' indicates a greater decrease in the low, very low and regular levels in group A (–15%; –18%; +21%), with no significant differences (F = 18.055; p > 0.05).

The 'simulated comparison' performance reports showed greater decreases in low, fair and high levels in group A (–12%; –15%; +21%), compared to the levels found in group B (–10%; –8%; +17%), with significant effects (F = 201.505; p < 0.05). In the skill: 'checking in context' no significant differences were found (F = 155.030; p > 0.05). However, the increase was relative to 20% of the participants in group A at a high level.

Dimension: Communication

The communication dimension has presented pre-test values without significant differences (F = 0,026; p > 0,05) (**Figure 9**). Thus, the compared differences have not been significant between group A and group B (I-J = 0.106; p > 0.05). Similarly, between the comparison of groups A and C (I-J = 0.309; p > 0.05).

The post-test assessment demonstrated intergroup differences over the control group (**Figure 7**), also supported by the data report (F = 85.770; p < 0.05). However, differentiating effects could not be inferred between group A and group B versus group C scores (I-J = 24.13; p < 0.05). No significant values can be deduced between the effects of methodology A and methodology B (I-J = 0.043; p > 0.05), nor in the Tukey discrimination values (HSD = 31.91; p > 0.05). This indicates that the effects of the D-S-F methodology (IR), with mixed gamification did not differ from the effects of group B, but did differ from the effects of group C.

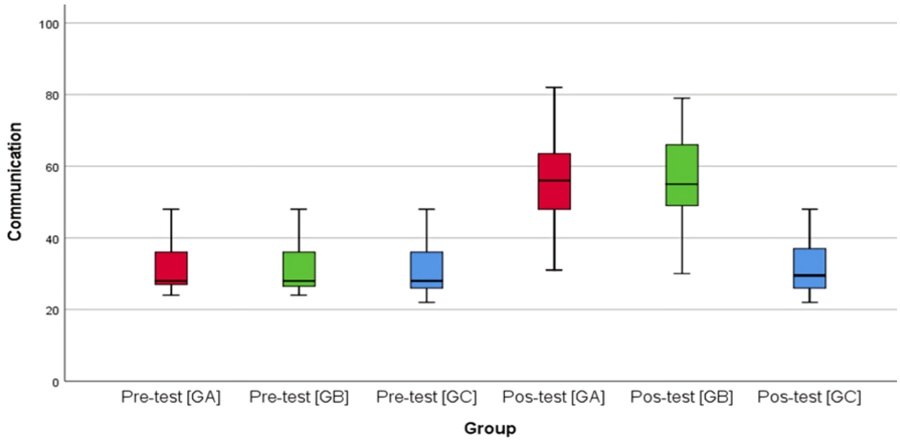

Figure 9. Comparison of scores in the communication dimension (Source: Authors' research database)

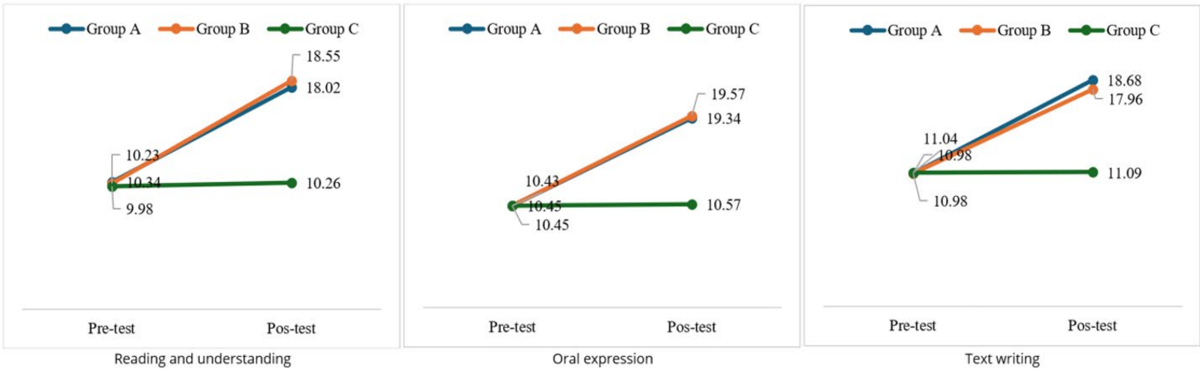

Figure 10. Comparison of communication indicators (Source: Authors' research database)

Specific performances in communication

The initial values in the communication dimension showed stability (**Figure 10**), with no significant differences. The same applies to the values of oral expression as well as to the values of writing skills.

The post-test evaluation has shown non-significant differences between groups A and B (0.53), whose scores exceeded those of group C. These were favorable for group B (**Figure 10**). On the other hand, in oral expression, favorable differences were received for group B (0.23). The comparison of the averages of the writing dimension of the text reported favorable differences for group A (0.72). The differences make it possible to declare non-significant progress in pedagogy of the type: D-S-F$_{[IR]}$.

The reading and comprehension component has found a significant increase between the scores of the performance: "comprehension of short texts" (**Figure 11**), being favorable for group A ($F = 1.231$; $p < 0.05$). However, this growth is due to the decrease in the very low (–8%) and low level (–18%). Group B levels showed an accumulation in the low level (–10%) and in the regular level (+24%). In relation to the changes in the performance: 'inferences and reflection', the low and very low levels (–9%; –8%) of group A as well as group B (–7%; –9%) decreased. In the performance: 'critical stance' the changes were significant in group A ($F = 12.131$; $p < 0.05$). In this case, the low (–25%) and very low (–15%) levels decreased. In group B, the reduction was greater in the low (–20%) and fair (–10%) levels.

Comparative scores on the performance: 'gestures and movement' showed non-significant differences ($F = 9.015$; $p > 0.05$). The most significant changes in group A were visualized at the regular level (–14%) towards the high level (+14%). In group B the changes were visualized at the low level (–10%). In that sense, the differences are not noticeable between groups (**Figure 11**), which was also evident in the performance: 'transmission of messages' of group A. The increase is visualized in the high level (+9%), with a smaller increase in the regular level (+15%), and a smaller decrease in the low level (–9%). There were no significant differences here ($F = 10.135$; $p > 0.05$). On the other hand, in the performance: 'sentence writing' the differences were significant for group A ($F = 13.500$ $p < 0.05$).

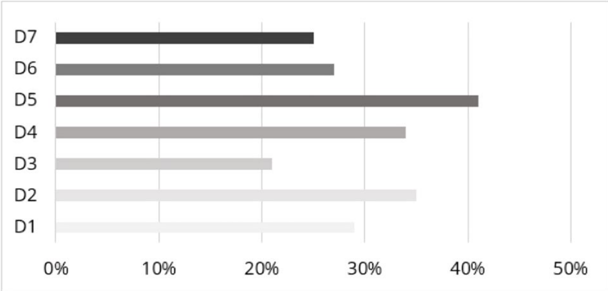

Figure 11. Growth proportion of performances in communication dimension (post-test) (D1: Understanding short texts; D2: Inferences and reflection; D3: Critical stance; D4: Gestures and movement; D5: Transmission of messages; D6: Writing sentences; D7: Coherence and cohesion). (Source: Authors' research database)

The decrease was greater in the very low level of group A (–15%) and low level (–15%). On the other hand, the level of greatest decrease in group B was the low type (–10%) and the regular type (–8%), although they were not significant for the general contrast. On the other hand, in the performance: "coherence and cohesion", the changes were not significant in the intergroup contrast ($F = 9.110$ $p > 0.05$). Regarding their progress, the decrease in group A was evident in the low and regular type level (–23%; –12%).

DISCUSSION

Effectiveness in Low School Cognitive Performance

The developed D-S-$F_{[IR]}$ type pedagogical method (dynamics, strategy, feedback, interactive reinforcement) generated more visual, attentional as well as participatory attraction in the students to obtain cooperative cognitive results. This indicated that the achievement of the amelioration of their underachievement due to the engaging playful competences. The feedback activities allowed the students in group A to reformulate their answers through questions, cross-examination, answers and reflections. As there was greater participation in the feedback activities, there was also motivation to continue participating. In principle this is due to the development of gamified activities with differentiated learning environments such as Kahoot, Mentimeter and the use of video games, which allowed diverse groups to participate without being limited to the use of a single environment. The mixed gamification carried out during more than six months of development has made it possible to achieve a better participatory experience by inclining the attitudes of the participants to compete according to their game preferences (Holguin-Alvarez et al., 2023; Villalustre-Martínez, 2024; Vu et al., 2024; Wang, 2020; Yuan & Zheng, 2024).

In addition to this, the development of verbal interactions for cognitive work has made it possible to improve cognitive performance with feedback systems based on the use of pedagogical discourse, direct questioning, and teacher support in gamifying the class (Amodia-Bidakowska et al., 2023; Formosa et al., 2022; Grabner-Hagen & Kingsley, 2023; Lupiáñez & Rico, 2015; Shooken et al., 2024; Smit et al., 2023; Wang, 2020). Therefore, it is accepted that mixed gamification includes the extrinsic motivational effects of learning as well as the energizing effects of cooperative activity. Similarities are found with other studies in which greater selective reception and attention to information by the learner is elicited in collaborative virtual games (Christensen et al., 2020; Dalsgaard et al., 2020). It is necessary to take relevance of extrinsic motivational effects generated by the use of virtual platforms such as attitudinal assessment, cognitive feedback, which after verbal interaction students directed their attention to specific games, e.g., Google Jamboard, Padlet, or Popplet; both to organize themselves and to monitor and feedback the experiences of others (where also autonomous motivation is involved), also strengthened their procedural learning in science or communication. This pedagogy has also been visualized in the advice and agreements generated among the members of each team to use video games such as Top Gear or Mario Bross, the obtaining of collective scores under agreements in mathematical tasks (Elisha Ding & Yu, 2024; Holguin-Alvarez et al., 2023; Villalustre-Martínez, 2024).

We cannot ignore the implication of didactic tools such as: Padlet, Popplet, Kahoot!, Mentimeter, Quizziz, and other similar tools that encourage the achievement of objectives unlike traditional games, here we can see the accompaniment with the use of platforms and video games in the interactivity phases of the learning sessions carried out, resulting in a dissipation of the cognitive recharge of learning. Some strategies such as the ones we used involved the use of Kahoot, Quizziz, and Mentimeter, were homologous to the use of other studies that report encouragement towards collective participation, and the lessening of fear before evaluation (Cadet, 2023; Santiago et al, 2024; Videnovik et al., 2024; Wirani et al., 2022), although differences in tool use benefited autonomy like Padlet, given its organizational weaknesses (Cassum & Fatima, 2024; Link & Sullivan, 2024; Ofianto et al., 2024). Other research reveals that the playful power of gamification focuses on sustained engagement when the teacher sticks to the aesthetic benefits of the platforms (Andriani et al. 2019; Infante-Villagrán et al., 2021; Scolari et al., 2018).

While it is true that the effects of the use of video game content in class may have offset other variables such as distraction and false motivation, the progress made by the schoolchildren in the group that enjoyed them (group B) is notable, the results showed that the effect of the use of this medium was greater than that of the pedagogical activities. It seems that the feedback dynamics were stronger in group A subjects, which corroborates that the use of playful tools should be cooperative rather than individualistic (Scolari et al., 2018). The intention to compete in groups supports the collaborative traits of the members, increasing their psychological well-being to help each other (Nicolaidou et al., 2022; Ros-Morente et al., 2018; Scolari et al., 2018).

Effectiveness in the Dimensions and Indicators of Cognitive Performance

Underachievement in mathematics was significantly reduced, with the contribution of mixed gamification (A) being more impressive than the use of virtual teaching tools (B). Specifically, the mixed gamification approach program significantly improved mathematics components such as logical reasoning, calculation and operations, and problem solving. In this case, variables that hindered logical reasoning were reduced, the ability to calculate and develop mathematical operations and additive problem solving were enhanced. Therefore, the effects of mixed gamification reduced underperformance, compared to the sole use of video games. This agrees with other studies that accept that the effects of gamification allow the opening of reasoning through the search for mathematical objectives to learn (Gokbulut, 2020; Kalogiannakis & Papadakis, 2017; Toda et al., 2019; Wang, 2020), dynamization of goals through group gamification (Aldemir et al., 2018; Chen et al., 2020), and the achievement of feedback to ensure knowledge (Byl & Topping, 2023; Kooloos et al., 2023; Smit et al., 2023). Usually, this type of behavior is neglected in classrooms that rely on trial and error, conditioning the effectiveness of learning under autonomous learning. The teaching phases with the D-S-F (IR) method were less distracting than those classes that implemented the use of game elements. It seems that this is still often a problem for gamified teaching (Di Giacomo et al., 2017; Holguin-Alvarez et al., 2020; Li et al., 2013; Loganathan et al., 2019; Nicolaidou et al., 2022; Toda et al., 2019). However, this study contributed to the recognition that the mixed elements of serious play and leisure play provoke more effective learning profiles if accompanied by both methodologies, beyond individualizing their effects.

In relation to the components of logical reasoning, calculation, operations, and problem solving, many students were able to develop sequences on numerical quantities, perform operations with numbers of different digits, and solve quantity, equality, and additive problems. The formation of formal operations and mastery in the conversion of quantities to their symbolic materialization has been verified in students who participated in competence games (group A), and who managed to rehearse interactions with their teachers when questioned (guiding and challenging questions) or when confronted with safety questions (feedback questions). The program adapted pedagogical training with gamification and solved mathematics learning with trained group purposes (Chen et al., 2020; Elisha Ding & Yu, 2024; Lopez & Tucker, 2017). Evidence shows that participation determines skill attainment and reduces computational disabilities when peer-to-peer competitions are conducted.

The decrease in performance in specific mathematical skills of students in group A (mixed gamification), in contrast to the effects generated in group B (unilateral gamification). The growth proportionality analysis of these performances showed an improvement in the ability to sequence quantities (+35%), geometric measurement and its deductive operations (+7%), as well as the ability to perform calculations with given quantities (25%). These low-level skills changed to regular and high levels, due to participation in experimental activities. Thus, students with more practice have educated others with lesser skills to respond more actively in cooperative development with video games and virtual platforms. This has been visualized in studies that found greater student apprehension when motivated to restore their motivation to learn mathematics (Hardof-Jaffe & Amzalang, 2024; Liu, 2025).

Low-level learners demonstrated that the game provided reciprocal feedback with immersive technologies. In this sense, pedagogical models of the type: video + behavioral game + neutral game (Dainer-Best & Rubin, 2024), have been successfully homologated in students with similar characteristics to students with difficulties in learning mathematics (Holguin-Alvarez et al., 2023). The behavioral and neutral game was conducted with playful feedback practices, which involved adapting the predictive model: motivation + conversation (Yuan & Zheng, 2024), to a practical model in the classroom using virtual game tools accompanied by teacher feedback.

In relation to the science dimension, the participating subjects in group A and group B managed to increase their cognitive performance compared to those in the control group (C). In this case, differences were found with respect to the observation component (diff. = 0.19; $p < 0.05$). Although these were significant, no discrimination indices were obtained. In relation to the hypothesis development component, there were no significant values (diff. = 1.09; $p > 0.05$), as well as in the deduction and testing component (diff. = 1.59; $p > 0.05$). The approach with gamification media based on the use of virtual platforms such as Mentimeter and Kahoot! allowed teachers to explore the prior knowledge of students, as we had initially proposed, the application of mixed gamification with verbal interactions allows subjects to explore and describe their prior knowledge in preliminary activities, this was achieved without limiting students only to use video games to reduce stress as in the predecessor study (Holguin-Alvarez et al., 2023), or as has already occurred in others that worked on emotional regulation and motivational levels with gamification (Pimmer et al., 2021; Ros-Morente et al., 2018; Scolari et al., 2018). Here we have overcome this limitation in order to establish a more didactic approach based on accompanying discourse to help learners acquire problem information and solve problems (Hagemann & Decius, 2024; Nebel et al., 2016; Shooken et al., 2024).

The increase in the indicators of this dimension allowed the students in the experimental groups (A and B) to develop observation, hypothesizing, deduction and verification skills. This has arisen because virtual platforms have been used as means of exploration (Hervás et al., 2018; Infante-Villagrán et al., 2021), video games have enabled collaborative learning (Amodia-Bidakowska et al., 2023; Kooloos et al., 2023). This highlights the development of schoolchildren's confidence in reasoning to learn science after feedback (Baydas & Cicek, 2019; Byl & Topping, 2023; Merrick & Fyfe, 2023). Therefore, the conversational interaction effects we adapted from Yuan and Zheng (2024) have been secured to achieve these capabilities.

The findings in the science dimension demonstrate the influence of gamification effects and feedback dynamics on the growth of low-level skills in classification (+10'%), hypothesis generation (+15%), probability search (+5%), simulated checks (+20%); and context checking (+20%). Although there was an increase in their scores and the change was significant in some cases without convincing differentiation effects. This scenario denoted some lack of expertise on the part of the students to cross-check information found on the web regarding the activities carried out, as this field involved constant research practice for observation and hypothesizing skills. In that sense, the program was limited to developing game activities to achieve autonomy in knowledge construction (Elisha Ding & Yu, 2024), the lack of activities to create games is evident. However, the progress noted in the skills to test students' experiential knowledge has benefited from the use of virtual technologies (Cadet, 2023; Santiago et al., 2024), which may result in the effects generated in them to obtain information in gaming and questioning activities.

In the communication variable, the participants of the three groups showed similar scores before starting the experiment and the efficiency of the D-S-$F_{[IR]}$ method was demonstrated, with technologies used in the intervention sample. These subjects have managed to develop potential skills to communicate better, to understand texts more efficiently, and to write texts with greater proficiency. To a certain extent, the use of guiding verbal interactions (guiding questions) has developed higher scores in groups A and B. These have served as a means to perfect more solid communicative competences from cooperative reading, achieving group conversations in the interaction with virtual platforms and in the competences with video games could also intervene in this achievement. Here we endorse the coincidences with the reports that reported games that develop basic cognitive skills for other areas (Barata et al., 2017; Contreras et al., 2019), and the development of the habit to communicate better has allowed to achieve this effectively.

The text writing dimension showed similar scores in the three groups with no differences between the experimental groups (A and B). This turned out to be more of a limitation than a result, since it is known that writing performance in this context has usually been low due to the effects of the pandemic on students who developed virtual education for two years. In this sense, it is important to develop further studies with direct gamification in writing in students with the characteristics of this research. It is also important to involve variables such as parental support and curriculum development (AlDahdouh, 2021; Delgado et al., 2021), since some evidence references that these have been one of the weaknesses in evaluations at the educational level (Delprato & Akyeampong, 2019), even before the appearance of the pandemic. Finally, the use of digital tools is necessary to assess writing by considering students as digital citizens.

The effects have been visualized in the skills of comprehension of short texts (+25%), inferences (+17) and critical stance (+40). Also in gestures, in the transmission of messages in oral expression (+10%); and in the writing of sentences (+30%), as well as in the coherence and cohesion of textual production (+35%), without obtaining significant discrimination indices. However, the comparison with group C (control) was verified in this specific analysis. Regarding this eventuality, students have shared written practices and close conversations about the topics developed in the feedback dynamics, creativity and collaborative narrative allowed them to better understand the written texts, as well as to express their ideas with order (Cattoni et al., 2024; Villalustre-Martínez, 2024; Warden et al., 2024).

In that sense, we have managed to increase the low performance in groups A and B, without subjecting their members to purist reading practices, plus with cooperative work they also determined the transcription of texts to narrate passages of the text in class without fear and fear of others due to the implementation of games adapted for exposition. The teacher's accompaniment in this exercise supports the idea that reflective methods, which include verbal expression and openness to dialogue, feed back into the expository facility (Nazari & Hu, 2024). In that sense, our program has allowed us to improve the sensory preparation of the expository subjects when exposing some oral text in class when developing practice activities in the development phases of the class, similar to what is recommended by research with musicalization resources (Sun, 2025). In the case of mixed gamification, we also included musical elements to dynamize the games.

The study has contributed to knowing the effectiveness of interactive strategies with conversational accompaniment adapted from automatic feedback methods (Yuan & Zheng, 2024), the use of applications that allow investigating scientific and video game knowledge as a method of orientation towards the game. participatory (Holguin-Alvarez et al., 2023). Here we managed to understand that feedback as a contribution to the dynamics and application of gamification strategies allows students to become more confident in learning about their own knowledge, so we believe that human interactions and cognitive feedback should not be limited to the sole use of technologies but should also coin the emotional processes of the teacher to interact with their students. For this reason, we implemented a follow-up model based on guiding, questioning and reassuring questions that accompany mixed gamification.

Among the specific limitations we found the difficulty of the program to engage in playful means of writing, many of the participants in the three groups conceived social networks as a usual means of communication despite their young age. While the pre-assessment of communication domains as part of the underachievement as well as the control of intervening variables were considered, the main obstacle was the constant practice. This would have helped to find out whether at low achievement levels, communication skills would only be limited to the assessment of oral skills or to the oral comprehension of texts. On the other hand, more instruments are needed to measure attentional processes in mathematics achievement in the face of cultural diversity.

In this sense, other lines of comprehensive psycho-pedagogical care can be used for other studies that seek to replicate this research, including comparative gamification methods and the control of their intervening effects on the central treatment. Finally, new research routes suggest using methodologies focused on a cognitive approach, including the cognitive domain variable of talented students. This could be considered in order to establish whether the effects of disruptive gamification can benefit this type of sample equally or better than subjects with problems learning science, communication, mathematics, or in other areas related to the social sciences.

CONCLUSIONS

The evidence allows us to conclude in the achievement of human and cognitive skills useful to students to communicate better, learn to use mathematics and participate in science learning cooperatively. The verification of the proposed hypothesis allowed us to verify that the use of mixed gamification methods allows reducing the low level of cognitive performance in schoolchildren, conditioning this intervention to the accompanying application of the development of dynamics, strategies and feedback with interactive reinforcement. Therefore, positive effects were achieved in the experimental groups that received a pedagogical methodology with mixed gamification in mathematics, science and communication. The particular evidence allowed us to verify better effects of the use of applications, virtual platforms and video games in the development of the characteristics for learning mathematics, without having sufficient evidence to determine if this approach compared to the sole accompaniment of video games allows us to differentiate the experimental effects on performance. cognitive science and communication.

The research carried out allows us to guide towards the work of gamifiers in the line of virtual didactics, considering the selective limitations of the sample under a probabilistic approach that allows including a greater number of subjects in a comparative experimentation. On the other hand, it is suggested to verify, from a qualitative approach, the didactic transpositions of teachers when using discursive methodologies and tropicalized gamification methods. This will allow subjects with differentiated characteristics to be selected to verify the didactic effectiveness of other verbal and gamified interactive methods.

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Ethics declaration: This study followed the ethical criteria set out in favor of the Declaration of Helsinki, being an experimental approach were reviewed and evaluated in full review status by the ethics committee of the university that directed the original research project entitled: 'Mixed gamification and teaching styles: A study of the effects on pedagogy and school learning' (evaluation report). The research project was evaluated by the National Ethics Committee of the Professional School of Primary Education, Universidad César Vallejo, Lima [PID-3261]. The evaluation was ruled favorable during phase B of the Research Support Fund-2024 [FDH-CE-ID 17070]. Parents provided consent for their children's participation through documented reporting to the authors. Minor participants provided informed consent. The documents are anonymous and are not available to the public sector. The study subjects requested to keep their identity and participation data confidential.

Declaration of interest: The authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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