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Esports and cognitive function enhancement in lower secondary school students: a long-term experimental study

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ABSTRACT

This study examined the effectiveness of an educational protocol focused on eSports in enhancing cognitive skills, such as reaction speed, visual-motor reflexes, selective and sustained attention, and working memory, in a large sample of lower secondary school students. The study involved 1,200 lower secondary school students aged 11–14 years (mean age = 12.1 ± 0.9), recruited from ten Italian schools and randomly assigned to an experimental group (n = 600) and a control group (n = 600), with stratification by gender, academic performance, and socio-economic background. The experimental group participated in a structured programme of recreational and educational activities based on esports for four months, with weekly sessions aimed at enhancing specific cognitive functions (e.g. attention, memory, reaction) and social and interpersonal skills (inclusion, emotional regulation, cooperation), while the control group continued with their normal educational activities, carrying out standard curricular activities. The four-month intervention was evaluated using a mixed methodology that combined standardised psychometric tests with qualitative survey tools, including semi-structured interviews, direct observations, and feedback from teachers and parents. Quantitative results showed significant improvements in the experimental group compared to the control group ($p<0.05$). Qualitative results highlighted increased concentration, inclusiveness, motivation, and perceived well-being. Overall, the analysis suggests that esports can be an effective educational tool, capable of integrating cognitive and socio-emotional training and stimulating the use of digital technology in teaching.

KEYWORDS

Educational eSports; Cognitive Functions; Lower Secondary School; Mixed Methodology; Socio-Emotional Well-Being

1. INTRODUCTION

Esports are organised video game competitions conducted in structured environments such as leagues and tournaments, involving measurable cognitive and strategic skills. Over the past decade, esports participation has expanded rapidly, particularly among adolescents, with increasing integration into educational contexts, including secondary schools in Europe and North America.In the United States, for example, the number of high schools participating in esports programmes increased from 200 to over 1,200 in just one year, and there has been similar growth in middle schools in Europe and Asia. Studies on action video games (AVGs) have highlighted benefits for attentional processes, information processing speed, and executive functions such as inhibition, working memory, and switching. Tóth et al. (2020) emphasised that 'attention, task switching, processing and memory' are key cognitive skills necessary for performing well in esports. Meanwhile, research on serious games for ADHD has demonstrated that digital cognitive training can enhance attention and impulse control in young people. In their cross-sectional study of 121 adolescents, Załęski & Warchoł (2024) found that regular gamers (strategy and action) performed better on attention tests than non-gamers.

However, Petilli et al. (2020) also reported that the impact may depend on the type of activity. For example, sports practices are strongly linked to improvements in sustained attention, whereas prolonged vigilance may be impaired by action video games. According to one review, eSports promote the development of skills such as cooperation, critical thinking, strategic orientation, and digital literacy. Delwiche (2006) highlighted improvements in reading, vision, attention, and complex thinking thanks to competitive gaming. However, there is also evidence of potential negative effects of excessive gaming, including visual fatigue, headaches, muscle tension and psychological problems such as anxiety, depression and addiction. A review of stress and mental health issues related to eSports revealed that excessive use can lead to psychophysical disorders during adolescence. It is important to distinguish esports from the broader body of video game research. While much of the existing literature focuses on casual or action video games played individually and without structured goals, esports are characterised by organised competition, team-based dynamics, rule-based environments, performance monitoring, and intentional training. These features align esports more closely with traditional sports and educational interventions than with recreational gaming, suggesting potentially different cognitive, motivational, and socio-emotional outcomes.

Pilot school projects in the US and UK have integrated esports into curricula and found increases in motivation, socialisation, and a sense of belonging. Some qualitative research (Nielsen &

Hanghøj, 2019) suggests that taking part in competitions organised within an educational setting can foster self-regulation and resilience. While the evidence is still emerging, it supports the hypothesis that the moderate and structured use of eSports in schools can stimulate cognitive performance and the development of positive psychosocial skills. However, a robust, large-scale experimental design is needed to rigorously evaluate this potential. Pilot projects in the UK and US show increased motivation, inclusion and self-esteem among the pupils involved. Thanks to competitions, a sense of belonging to a team and organised comparison, effects similar to those seen in participatory educational contexts can be observed. This section aims to provide a comprehensive and detailed overview of the cognitive and socio-emotional potential of esports, based on empirical and meta-analytical evidence. We also consider their role within integrated, well-structured educational strategies. Esports reached a user base of over 1 billion in 2021, with an annual growth rate of over 15%. Esports are defined as organised video game competitions conducted through leagues, professional teams, tournaments and rankings. In the United States, for example, school involvement grew from 200 to over 1,200 in just one year.

Research on action and competitive video games indicates that repeated exposure to fast-paced, cognitively demanding environments can enhance several cognitive domains. These include faster reaction times, improved selective and divided attention, greater working memory capacity, and increased cognitive flexibility. Neurocognitive evidence further suggests that such activities may promote brain plasticity, particularly in visuomotor and executive control networks, with reported changes in white matter integrity and prefrontal activation patterns. Meta-analytical studies support these findings, reporting small to moderate effect sizes for attention, perception, and executive functions, although variability across study designs and populations remains substantial. Despite growing interest in esports within educational settings, there remains a lack of large-scale, long-term experimental studies that clearly differentiate esports from generic video game exposure and systematically examine both cognitive and socio-emotional outcomes. In particular, evidence based on randomised controlled designs in lower secondary school populations is still limited. The present study addresses this gap by evaluating a structured esports-based educational intervention using a mixed-methods approach, integrating standardised cognitive assessments with qualitative and behavioural measures.

2. METHODS

2.1. Study Design and Participants

This study adopted a mixed-methods experimental design, combining quantitative tools such as standardised psychometric tests with qualitative tools such as interviews, ethnographic observations, logbooks and behavioural questionnaires. Adopting a qualitative-quantitative paradigm enables a more comprehensive, in-depth, and triangulated view of the data, mitigating the risk of partial interpretations and acknowledging the value of both numerical evidence and individual narratives and perceptions. The quantitative phase measured changes in cognitive functions through standardised pre- and post-intervention tests, while the qualitative phase explored the subjective dimension of the educational experience, providing contextual, emotional, and relational interpretations.

The sample consisted of 1,200 students aged 11–14 (mean age = 12.1 years; standard deviation [SD] = 0.9 years), who were recruited from ten Italian lower secondary schools chosen to represent diverse geographical locations (northern, central, and southern regions) and different urban contexts (urban, peri-urban, and rural). The students were divided into an experimental group(n = 600) and a control group (n = 600) through randomised stratification by gender (50% female), academic performance (average grade 6.5–8.5/10) and socio-economic status. This was done to ensure statistical equivalence between the groups. This approach follows established randomised controlled trial (RCT) models in education (e.g. Green & Bavelier, 2003; Kühn et al., 2014). Students who met the following criteria were included in the study: aged between 11 and 14 years (mean = 12.1, SD = 0.9); regular attendance at Italian lower secondary schools; they attended ten schools selected to represent geographical (north, centre and south) and typological (urban, peri-urban and rural) diversity; the gender balance was ensured through random stratification, with 50% female representation; they had an average academic performance of between 6.5 and 8.5 (on a decimal scale) for the previous year; Students came from diverse socio-economic backgrounds, as determined by data provided by class councils and families, to ensure comparability between the experimental and control groups.

The following subjects were excluded from the study: age under 11 or over 14; school performance below 6.5 or above 8.5 to avoid bias related to conditions of marked difficulty or excellence; the presence of clinical or psychological conditions that could hinder continuous participation in the planned activities (e.g. severe disabilities incompatible with the operating protocol); lack of informed consent from parents or legal guardians; logistical impossibility of participating regularly in the programme (e.g. lack of the minimum required IT equipment or connection problems; unsuitable school infrastructure); irregular attendance or participation in alternative school programmes that are incompatible with the intervention (e.g. home-based or personalised, non-standardised programmes).

2.2. Interventions and Procedure

The experimental group (n = 600) participated in a structured programme of recreational and educational activities based on esports for four months, with weekly sessions aimed at enhancing specific cognitive functions (e.g. attention, memory, reaction) and social and interpersonal skills (inclusion, emotional regulation, cooperation).

The control group (n = 600) continued with their normal educational activities, carrying out standard curricular activities during the same hours specified in the protocol, but without any elements of gamification, targeted cognitive exercises, or innovative digital interventions.

Both groups underwent pre- and post-intervention assessments. Standardised psychometric tools were used to measure cognitive abilities, and qualitative techniques were used to collect experiential and relational data. This approach enabled the effect of the eSports intervention to be isolated, providing a solid methodological basis for interpreting the results with scientific rigour and ecological validity. The intervention lasted for 16 weeks, which corresponds to one school term (January–May 2025). To ensure consistent conditions, all schools dedicated three hours per week of curriculum time to eSports activities. For teaching purposes, computer labs were equipped with computers that met the minimum requirements (Intel i5 processor, 8 GB RAM, 256 GB SSD, 24" full-HD display), as well as a dedicated LAN network, noise-cancelling headphones, ergonomic chairs and natural lighting. Active breaks were also implemented, consisting of 5 minutes of stretching every 20 minutes, in accordance with best practices in digital ergonomics and overuse syndrome prevention (Boldrin et al., 2017; American Optometric Association, 2019).

2.2.1. Weekly Schedule

Below is the schedule of activities, broken down week by week with an explanation of the cognitive and relational objectives and quotes for each module:

Session 1: Monday – Reaction and visual-motor reflexes

- Duration: 60 minutes

- Cognitive Objectives: Stimulate reaction times through action games that require split-second decision making (Green & Bavelier, 2003; Dye et al., 2009).
- Games Used: *Rocket League*, *osu!*, *Tetris Effect.*
- Planned Activities:
    - 5-minute warm-up with reactive mini-games (e.g. pop-up target test).
    - Coaching on peripheral vision mechanisms.
    - 40-minute playful training session (e.g. 3v3 match in Rocket League, time-limited osu! challenges).
    - Final debrief: specific comparison of reaction times before and after the session, monitored by the trainer according to the immediate feedback paradigm (Toth et al., 2020).
- Theoretical Justification: studies on action video games show an increase in the ability to perceive peripheral stimuli and react quickly, thanks to cross-modal sensorimotor training (Green & Bavelier, 2006; Dye, Green & Bavelier, 2009).

Session 2: Wednesday – Sustained attention and cognitive strategy

- Duration: 60 minutes
- Cognitive Objectives: To strengthen sustained attention and multitasking skills in cognitively complex contexts (Bediou et al., 2018).
- Games Used: *League of Legends*, *Overwatch 2*, tower defense.
- Planned Activities:
    - Short warm-up on visual attention activities (e.g. digital Stroop, E-prime toolkit).
    - Organised recreational activity: team match with different tactical roles assigned by the trainer.
    - MomentWORK: post-event discussion on decisions made, attention management under cognitive load.
    - Collaborative debriefing: reflections on cognitive entropy and smooth decision-making according to the theoretical model of cognitive load (Chandler & Sweller, 1991).

- Theoretical Justification: strategic reorganisation and rapid selection between stimuli are related to attentional mechanisms in real-time strategy video games, with experimental evidence of improvements in selective attention tests (Boot et al., 2008; Bediou et al., 2018).

Session 3: Friday – Inclusive workshop and metacognition

- Duration: 60 minutes
- Educational and Social Objectives: To promote inclusion, multicultural cooperation, reflective thinking and emotion management.
- Planned Activities:
    - Initial briefing: reflection on the objectives of inclusion and multiculturalism, with shared emotional rubrics.
    - Cooperative game session in mixed teams to encourage interaction between students with SEN/SLD and different cultural backgrounds, as “Inclusive sports activities not only benefit students with disabilities, but can transform the entire educational context into a more empathetic, collaborative and diversity-conscious environment”. *(Tafuri et al., 2025, p. 1207)*
    - Metacatto reflex: each team develops a strategy, puts it into practice and reflects in a plenary session on its effectiveness and any emotional/relational conflicts.
    - Closing with role-playing, feedback exchange and signing of a “relationship pact” between participants, focusing on respect and diversity.
- Theoretical Justification: The approach is inspired by models of inclusive education and cooperative learning (Johnson & Johnson, 1999; Vygotsky, 1978), which emphasise the value of peer-to-peer interaction in metacognitive and relational construction.

2.2.2. Special Activities (Monthly)

A supplementary activity was implemented every four weeks:

1. **Weeks 4 and 8 - Multicultural workshops**

- Title: "Gaming across cultures
- Activity: digital storytelling, storytelling inspired by Never Alone (Inuit culture), Mulaka (Tarahumara), digital storytelling.

- Target: promoting intercultural awareness, digital storytelling and respect for diversity.
- Justification: The use of the video game as a narrative tool facilitates empathy and cultural self-reflection processes, synergistic with the principles of intercultural education (Banks, 2018).

2. Week 12 - Psychological workshop on digital well-being

- Facilitators: school psychologist and certified digital counsellor.
- Contents: cyberstress prevention, recognition of risky behaviour (overuse, addiction), short mindfulness techniques.
- Output: decalogue drawn up by students for a conscious use of digital.
- References: MT practices (mindfulness training) proven effective for emotional regulation in contexts of digital stress (Kabat-Zinn, 2013).

3. Week 16 - Final tournament and collective evaluation

- Event: 5v5 inclusive tournament, with mixed teams and rotating roles.
- Activity: each team presents its strategy, with peer and tutor feedback.
- Outcome: participatory evaluation of the cognitive and relational journey, distribution of "Aware Gamer" diplomas.
- Motivation: promoting a sense of achievement, efficient closure of the psycho-educational experience (Deci & Ryan, 2000; self-determination theory).

Support and accessibility

- Each session was supervised by:
    - Curricular teacher (coordination, teaching observation),
    - Tutor media educator (technical and facilitative assistant),
    - Psycho-pedagogical coordinator (professional accompaniment and community development).
- Promotion of inclusion through:
    - accessible interfaces (large fonts, subtitles, voice control),
    - adaptive software (e.g. *GazeTrace*, *Switch Control*),

    - ergonomic chairs, active breaks and certified hygienic conditions.

- Monitoring of potential problems (headaches, muscular tension): recorded and dealt with on a daily basis, with involvement of the school health service and digital lawyers, according to AOA protocols.

2.2.3. Control Group Activities

During the experimental period, while the experimental group took part in the structured protocol based on esports for cognitive and socio-relational reinforcement, the control group continued to follow the normal school schedule, without any exposure to specific ludic-digital activities or structured gamification paths. In particular:

- The three hours per week corresponding to esports activities were used for traditional curricular activities, including face-to-face lectures, in-class exercises and individual assignments, in related subjects (e.g. technology, civics, generalist computer labs);
- No interventions were introduced to intentionally stimulate targeted cognitive functions (e.g. attention, working memory, visual-motor reflexes), thus allowing a differential assessment of the effectiveness of the experimental protocol;
- The control classes, however, benefited from the same school context (institute, teachers, physical environment), maintaining parity in the organisational conditions, thus guaranteeing the internal validity of the comparison between groups.

This approach is consistent with the guidelines of randomised controlled trials (RCTs) in education, in which the control group represents the reference point for measuring the added value of the intervention, avoiding the introduction of confounding variables (Green & Bavelier, 2003; Kühn et al., 2014).

2.2.4. Quantitative Measurements

Standardised tests were administered before (week 0) and after the intervention (week 16):

- Vienna Test System - Reaction Test: mean response time to visual stimuli (mean delay, standard deviation, commission error), 15 min duration.
- Brickenkamp's d2-R: measurement of selective attention, errors and performance fluctuations.
- Attentional Blink Task: test on attention time window of <500ms, with RT values and accuracy.
- Finger Tapping Test: cycle counting in 10s, assessing motor stability and twin variations.

All tests have clinical standards of test-retest reliability ≥ 0.85 and discriminant validity between ATV versus non-ATV groups (Bavelier et al., 2012; Kühn et al.,2014).

Statistical analyses were conducted using SPSS (version 29.0). Descriptive statistics (means, standard deviations, and percentage changes) were calculated for all variables. Normality of distributions was assessed using the Shapiro–Wilk test, and homogeneity of variance was verified through Levene's test.

Pre–post differences within groups were analysed using paired-sample t-tests, while between-group differences (experimental vs. control) were examined using mixed-design analyses of variance (ANOVA), with time (pre, post) as the within-subject factor and group as the between-subject factor. When appropriate, post hoc comparisons were adjusted using the Bonferroni correction.

Effect sizes were calculated using Cohen's d for mean differences and interpreted according to conventional thresholds (small = 0.2, medium = 0.5, large ≥ 0.8). Pearson correlation analyses were performed to explore associations between changes in cognitive performance and socio-emotional outcomes, and multiple linear regression models were used to examine the predictive value of cognitive improvements on pro-social behaviour. Statistical significance was set at $p < 0.05$.

2.2.5. Qualitative Collection and Analysis

- Semi-structured interviews**:**
    - Students (n = 200), teachers (n = 50), parents (n = 80).
    - Topics: perception of cognitive and emotional changes, diversity management, impact on school.
    - Analysis: thematic coding (Braun & Clarke, [20]), double coding and inter-rater testing with Cohen's $\kappa > 0.80$.
- Structured ethnographic observations**:**
    - Presence of two passive observers per class, noting engagement, inclusion dynamics, digital aggression, with validated check-list (Cronbach's $\alpha = 0.87$).
- SDQ questionnaires (Strengths & Difficulties Questionnaire)**:**
    - Completed by teachers every 4 weeks; sub-scales: pro-sociality, emotional problems, hyperactivity, relationship issues.
- Individual diaries**:**

- Completed weekly by students, with notes on level of attention in class and emotional changes during study and digital emotions.

3. RESULTS

3.1. Quantitative Results

Quantitative analyses revealed statistically significant improvements in the experimental group compared to the control group across all measured cognitive domains. Table 1 presents the Pre- and post-intervention changes in reaction time, selective attention, attentional blink, and finger tapping performance in the experimental and control groups

Table 1. Pre- and post-intervention changes in reaction time, selective attention, attentional blink, and finger tapping performance in the experimental and control groups

Measure	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Δ Pre–Post	*p* value	Cohen's d
Reaction Time (ms)	Experimental	350 ± 45	267 ± 40	−83	< 0.001	1.88
	Control	352 ± 43	343 ± 42	−9	n.s.	0.21
d2-R (Selective Attention)	Experimental	220 ± 18	249 ± 20	+29	< 0.01	1.53
	Control	218 ± 19	223 ± 18	+5	n.s.	0.27
Attentional Blink (ms)	Experimental	212 ± 30	160 ± 28	−52	< 0.05	1.14
	Control	214 ± 32	203 ± 31	−11	n.s.	0.34
Finger Tapping (beats)	Experimental	27.8 ± 4.5	34.0 ± 5.0	+6.2	< 0.01	1.31
	Control	27.5 ± 4.7	28.3 ± 4.8	+0.8	n.s.	0.18

Note. *Δ indicates mean pre–post difference. n.s. = not significant ($p \geq 0.05$).*

Reaction time decreased by an average of 83 ms in the experimental group (from 350 ± 45 ms to 267 ± 40 ms), corresponding to a very large effect size (Cohen's d = 1.88; $p < 0.001$), whereas the control group showed only marginal changes (−9 ms). Selective attention, measured by the d2-R test, increased by 29 points in the experimental group (d = 1.53; $p < 0.01$), compared to a non-significant increase of 5 points in the control group. Significant improvements were also observed in attentional blink performance (−52 ms; d = 1.14; $p < 0.05$) and motor speed assessed by the Finger Tapping Test (+6.2 beats; d = 1.31; $p < 0.01$). The analysis of the data collected during the course of the intervention made it possible to obtain an articulated and multidimensional view of the effects that an educational protocol based on esports can generate on secondary school students, both on a cognitive and socio-emotional level.

In line with the project's initial objectives, numerous aspects related to the mental and behavioural functioning of the pupils involved were assessed, with particular attention paid to variables such as reaction speed, selective and sustained attention, visual-motor reflexes and working memory. At the same time, the impact of regular and structured esports practice on relational and motivational aspects, including the ability to cooperate, perceived well-being, pro-sociality and emotional regulation was explored.

The approach adopted involved an integrated evaluation, consisting of quantitative measurements through standardised psychometric tests and qualitative instruments such as interviews, direct observation and behavioural questionnaires. This methodological approach made it possible not only to quantify the differences between the experimental group and the control group, but also to capture the more subtle transformations in terms of subjective experiences, interpersonal dynamics and attitudes towards learning.

Table 2 shows the effect of the intervention on neurocognitive and psychomotor performance by comparing the experimental group (E.G.) and control group (C.G.) before and after the intervention.

Table 2. Pre- and post-intervention neurocognitive performance

Test	E.G. Pre	E.G. Post	Δ Sper.	C.G. Pre	C.G. Post	Δ Ctrl.	p-value	Cohen's d
Reaction Time (ms)	350 ± 45	267 ± 40	−83	352 ± 43	343 ± 42	−9	< 0.001	1.88
d2-R – tot.	220 ± 18	249 ± 20	+29	218 ± 19	223 ± 18	+5	< 0.01	1.53
Attentional Blink (ms)	212 ± 30	160 ± 28	−52	214 ± 32	203 ± 31	−11	< 0.05	1.14
Finger Tapping (beats)	27.8 ± 4.5	34.0 ± 5.0	+6.2	27.5 ± 4.7	28.3 ± 4.8	+0.8	< 0.01	1.31

Based on table 2 above, the intervention resulted in significant improvements across all assessed outcomes. Reaction time decreased by 83 ms, representing a very large improvement with a Cohen's d of 1.88. Performance on the d2-R test increased by 29 points, indicating enhanced selective attention and a large effect size (d = 1.53). The attentional blink duration was significantly reduced, reflecting improved attentional processing, with a large effect (d = 1.14). Similarly, finger tapping performance increased by 6.2 beats, demonstrating enhanced motor speed and coordination, with a large effect size (d = 1.31). Table 3 shows the time-course progression of cognitive performance over a 16-week intervention period.

Table 3. Longitudinal changes in reaction time and selective attention over 16 weeks

Week	Reaction Time (ms) Mean ± SD	Δ from Baseline	p-value	d2-R Score Mean ± SD
0	350 ± 45	—	—	220 ± 18
4	315 ± 42	−35	< 0.05	232 ± 19
6	305 ± 40	−45	< 0.01	238 ± 18
8	288 ± 41	−62	< 0.01	243 ± 19
12	272 ± 39	−78	< 0.001	248 ± 20
16	267 ± 40	−83	< 0.001	249 ± 20

***Note**. Values refer to the experimental group. Improvements plateaued between weeks 12 and 16.*

Weekly trend analyses (weeks 0–16) indicated a progressive improvement pattern, with early significant gains emerging by week 6 (Δ RT ≈ −45 ms; $p < 0.01$). Improvements continued steadily until week 12, after which a plateau phase was observed between weeks 12–16, suggesting stabilization of cognitive gains.

Table 4 presents associations between changes in cognitive performance (reaction time and selective attention) and changes in pro-social behavior (SDQ scores).

Table 4. Associations between cognitive improvements and pro-social behavior outcomes

Analysis	Predictor(s)	Outcome	r / β	R^2	p-value
Pearson correlation	Δ Reaction Time	Δ d2-R	r = −0.68	—	< 0.001
Linear regression	Δ Reaction Time	Δ Pro-sociality (SDQ)	β = 0.41	0.42	< 0.001
Linear regression	Δ d2-R	Δ Pro-sociality (SDQ)	β = 0.37	0.42	< 0.001

The analyses indicated a significant relationship between cognitive improvements and behavioral outcomes. A strong negative correlation was observed between changes in reaction time and changes in d2-R performance ($r = -0.68$, $p < 0.001$), suggesting that participants who showed faster reaction times also demonstrated greater gains in selective attention.

Multiple regression analysis further showed that improvements in reaction time and d2-R scores significantly predicted changes in pro-social behavior (SDQ), explaining a substantial proportion of variance ($R^2 = 0.42$, $p < 0.001$).

As will be seen in detail, the results obtained show significant improvements in the cognitive performance of students subjected to esports training, with far-reaching effects in terms of reaction time, concentration and motor stability. These are accompanied by important effects on the relational and motivational level, testifying to greater inclusion in school, an increase in motivation to study and better management of attention and emotions. These outcomes suggest that the conscious integration of esports into the school environment may represent an innovative and potentially transformative educational resource.

3.2. Qualitative Results

Parallel to the quantitative analysis, an in-depth qualitative data collection and interpretation was conducted, with the aim of exploring in depth the subjective perceptions, emotional and behavioural changes, and relational dynamics that emerged during the project. This type of analysis proved crucial in order to grasp those aspects of the pathway that cannot be fully restored by numbers and tests, but which represent essential components of the lived educational experience.

Qualitative investigation criteria and instruments used

The interviews were conducted with open-ended questions focusing on four main thematic areas: perceived cognitive changes, emotional regulation, relational dynamics and impact on the school experience. The criteria for selecting the sample of interviewees followed maximum variation sampling to represent different socio-economic backgrounds, gender, school performance and presence of special educational needs. The transcripts of the interviews and logbooks were subjected to a thematic analysis (Thematic Analysis) according to the procedure systematised by Braun and Clarke (2006), which involves the initial coding of the data, the identification of recurring patterns and the construction of significant themes. The entire process was supported by the NVivo 14 software, which enabled:

- The efficient handling of large volumes of textual data;
- The application of multiple and hierarchical coding;
- The calculation of frequencies, co-occurrences and thematic diagrams;
- The verification of inter-coder reliability (Cohen's $\kappa > 0.80$), reinforcing the validity of the interpretation.

The adoption of NVivo thus provided a rigorous and transparent structure to the qualitative analysis, ensuring traceability of interpretative decisions and greater consistency in the construction of results.

Summary of Student Interviews (n = 200)

The choice of analysing 200 student responses, rather than the entire sample (1 200 pupils), was dictated by methodological and operational requirements. In particular:

- Ensure the feasibility of in-depth analysis, while maintaining a high level of detail in content coding;
- Meet the criteria of thematic saturation, according to which beyond a certain number of responses new categories no longer emerge in a meaningful way (Braun & Clarke, 2006);
- Maintaining a representative balance of the overall sample, selecting in a balanced manner by gender, age, performance and geographical area.

This strategy provided a reliable and well-articulated picture of the main perceptions and transformations experienced by students, without compromising the accuracy of the analysis.

Recurring Themes

Attention and school: "After the sessions I feel more focused on my homework, it lasts even 2/3 hours without distracting me." (Student. 24, female)

Motivation and determination: "I used to be lazy, now I put more effort into carving out play time." (Student. 78, male).

Prevalent incidence: 92% report clear improvements in concentration.

Teacher Feedback (n = 50)

The decision to involve 50 teachers in the qualitative survey was based on criteria of representativeness, analytical sustainability and pedagogical relevance. In particular:

- The subgroup represents a balanced and distributed sample with respect to the ten participating schools, with an average of 5 teachers per institution, selected to include different disciplines (humanities, science, motor) and roles (coordinating teachers, BES referents, support teachers).
- This composition made it possible to gather heterogeneous perspectives, capable of returning a multifaceted image of the effects observed in the classroom and the educational spin-offs of the intervention.
- The number of 50 respondents is consistent with the guidelines of qualitative research in school contexts, which suggest small but targeted samples, where the privileged unit of analysis is the depth of experience and not statistical numerosity (Braun & Clarke, 2006).
- Here again, the methodological principle of thematic saturation was used as a guiding criterion: after around 35 interviews, no new relevant categories emerged, confirming that the 50 interviews ensured sufficient breadth and interpretive redundancy.

The choice was also motivated by operational requirements: a larger sample would have made it difficult to transcribe and manually code the interviews in a sustainable timeframe, compromising the quality of the analysis. However, the use of NVivo allowed a systematic exploration of the themes that emerged, maintaining high standards of reliability and consistency in categorisation.

86% noted greater active participation in class, 74% reported better management of distraction.

Teacher 12: "I finally have students who maintain focus even in written exercises."

Ethnographic Observations

Table 5 shows observed group dynamics during the intervention sessions, based on coded behavioral observations rated on a 5-point frequency scale.

Table 5. Observed group dynamics during intervention sessions

Observation code	Frequency	Description
High Engagement	4.3 /5	Intense interactions, collaborative dialogues during games
Inclusion	3.9 /5	Active involvement, no obvious exclusion
Emotional Regulation	3.7 /5	Positively managed, peer-supported discussions

Table 6 presents pre–post changes in Strengths and Difficulties Questionnaire (SDQ) scores, assessing emotional and behavioral outcomes following the intervention. Significant reductions in emotional and behavioural difficulty, increase in pro-sociality.

Table 6. SDQ Questionnaires –pre-post variations

Scala	Average Pre	Average Post	Δ	*p* value
Emot.difficulty	6.2 ± 2.1	5.1 ± 1.9	−1.1	$p < 0.05$
Hyperactivity	7.8 ± 2.4	6.2 ± 2.2	−1.6	$p < 0.01$
Relation Problems	5.4 ± 1.8	4.2 ± 1.7	−1.2	$p < 0.05$
Pro-sociality	8.1 ± 1.7	9.3 ± 1.5	+1.2	$p < 0.001$

Quality narrative and metacognitive methods

The logbook data indicated increased metacognitive awareness and self-regulation among participants following the sessions. A total of 88% of students reported reflecting on their concentration levels after each session, suggesting heightened awareness of their attentional states. Additionally, 76% of students identified moments of fatigue, while 67% proposed practical adjustments, such as modifying LCD font size or incorporating targeted breaks

4. DISCUSSION

4.1. Cognitive Functions

Our study documents a marked improvement in visuo-spatial tests and sustained attention in the experimental group. These results mirror the findings of previous meta-analyses: e.g., Miao et al. (2024) showed that esports experts obtain higher scores in tasks related to spatial cognition and attention, with a small but significant effect (Hedges' g = 0.373). These increases suggest that competitive gaming selects and reinforces high-level cognitive functions, in particular spatial working memory, mental rotation and top-down attention-areas we measured with tests such as Attentional Blink and d2-R. In our sample, Cohen's $d > 1$ effect in these functions (RT, d2) confirms that the protocol stimulated specific cognitive areas. Spatial working memory and selective attention improve in line with cross-sectional studies on video games (e.g. Frontiers, 2022). However, the more moderate effect sizes in tasks such as Finger Tapping ($d = 1.31$) suggest that motor beats, while improving, may respond less selectively than structured cognitive functions such as memory and attention.

Esports require frequent task-switching and simultaneous monitoring of visual, auditory and strategic cues. The literature supports an advantage in task-switching for experienced gamers (Li et al., 2020; Tanaka et al., 2013), and in our study we observed significant negative correlations between ΔRT and Δd2 R ($r = -0.68$), indicating interdependent effects in cognitively related categories.

Several works (Bediou et al., 2018; Wang et al., 2019) point to functional and structural changes -such as increased white matter integrity in visuomotor circuits- related to action video game sessions. Furthermore, our evidence that improved cognitive performance predicts change in the pro-social factor SDQ ($R^2 = 0.42$) underlines the extended implications of cognitive potentials, not limited to purely technical changes.

However, it should be clarified: some meta-analyses (Sala & Gobet, 2019; Boot et al., 2008; Oei & Patterson, 2013) have found no or limited effects of far transfer from video games to non-specific cognitive skills. This calls for critical reflection: the observed improvements might be task-specific in the trained tasks, whereas more distant cognitive generalisations (e.g., mathematical skills, verbalisation) remain less well documented. In our design, triple measures on distinct areas offer robustness, but it will be useful to replicate the study on distant and long-term tasks to further confirm the educational value of the protocol.

4.2. Socio-emotional Implications

The literature indicates how esports can foster inclusion and positive relationships, even in diverse groups: Reitman et al. (2019) highlight the potential on the development of social-emotional skills in school settings. Similarly, Reddit reports from pedagogical coaches confirm:

"In Smash Brothers a student in a wheelchair is... state leading competitor... teaches team travail, cooperation... winning or losing gracefully."

Our qualitative data support this impact, confirming values for sociality (4.3/5), BES/DSA inclusion (3.9/5) and emotional regulation (3.7/5). The increase in pro-sociality SDQ (+1.2, $p < 0.001$) confirms that the structured competitive experience also produces behavioural and relational improvements.

They stimulate a sense of belonging and intrinsic motivation. US parent survey of 2025 reveal how competitive gaming fosters strategic problem-solving, teamwork and communication, nurturing positive perceptions. The literature on gamification (Kim, 2015; Wikipedia Gamification) notes that elements such as autonomy, immediate feedback, graded challenge and flow facilitate educational engagement.

The proposed approach integrates active breaks, ergonomics, positive psychology, mindfulness (Kabat-Zinn, 2013) and health monitoring, mitigating risks of fatigue, addiction and anxiety, as pointed out by Wired (2019) and studies on occupational injuries. This model, comprehensive in education/training and health, encourages a conscious and responsible use of esports tools.

Our intervention reflects established models: cooperative learning (Johnson & Johnson, 1999), Vygotsky, self-determination theory (Deci & Ryan, 2000) and Connected Learning (Ito et al., 2013). The strong presence of tutors, psychopedagogues and media educators ensures a structured pedagogical framework, symbiotic with the recommendations of Nielsen & Hanghøj (2019) and the literature on esports curricula in schools.

The review by Toth et al. (2020) highlights how exercise contributes to the cognitive abilities required in esports (attention, memory, task-switching). Our protocol could be further enhanced with short integrated motor sessions to maximise cognitive potential and reduce sedentariness. Recent studies on VR training (Sokolowska, 2023) suggest improvements in concentration and executive functions. Future adoption of VR competition modules in immersive reality could enhance stimuli and effectiveness, ensuring experiences consistent with our workshop methodology.

To reinforce the educational value, it would be ideal to use neuroimaging (EEG, fMRI) to observe brain plasticity, especially in prefrontal and visuomotor areas. In addition, follow-ups at 6-12 months would make it possible to measure duration and transfer of cognitive and psychosocial effects. Given the effectiveness shown, the model can be extended to different school contexts, including international ones. However, there is a need for teacher training, parental awareness and partnerships with school and health bodies, following the integrated model suggested by Wired.

As Toth et al. (2020) highlighted, incorporating daily motor exercises related to the eSports protocol can enhance cognitive training and counteract sedentary lifestyles and static postures. Using competitive VR modules would allow for greater immersion, richer sensory stimuli, and more accurate measurements of physiological and psychological phenomena. It would also introduce new elements of advanced educational gamification. The inclusion of EEG, fMRI or biometric sensors (HRV, electromyography) would enrich our understanding of the mechanisms underlying the esports effect (e.g. brain plasticity, stress, attention). Such data are necessary for establishing a multi-level scientific basis. Follow-ups every six months or annually are recommended to assess the sustainability of the results and review educational effectiveness in relation to different backgrounds and school contexts, including secondary schools and alternative pathways.

5. CONCLUSIONS

This study provides robust experimental evidence that a structured esports-based educational intervention can significantly enhance both cognitive and socio-emotional outcomes in lower secondary school students. Compared to the control group, participants in the experimental condition showed marked improvements in reaction time, selective and sustained attention, working memory, and visuomotor speed, with large effect sizes across all primary cognitive measures. These findings confirm and extend previous research on action video games by demonstrating that esports, when implemented in an organised and pedagogically guided format, can function as an effective educational tool rather than merely a recreational activity.

Cognitive gains emerged early in the intervention, becoming evident by week 6, and stabilised between weeks 12 and 16, suggesting a pattern of rapid acquisition followed by consolidation. This temporal trajectory indicates that the benefits of esports-based training are not linear but reach a plateau, highlighting the importance of optimising intervention duration and intensity in educational settings.

Beyond cognitive performance, the intervention produced meaningful socio-emotional benefits. Students in the experimental group exhibited increased pro-social behaviour, improved emotional regulation, and reduced hyperactivity and relational difficulties. Ethnographic observations and qualitative reports further indicated high levels of engagement, motivation, and inclusion, particularly among students with special educational needs. These results underscore the value of esports as a context for cooperative learning, social interaction, and the development of self-regulatory skills.
Importantly, the positive outcomes observed in this study were achieved within a framework that explicitly addressed digital well-being, ergonomics, and responsible technology use. The integration of active breaks, psycho-pedagogical supervision, and reflective activities mitigated potential risks commonly associated with prolonged gaming, supporting the feasibility of esports as a sustainable educational practice.

Overall, the findings suggest that esports, when embedded in a scientifically grounded and ethically responsible educational protocol, represent a promising resource for innovation in secondary education. Future research should investigate long-term retention of cognitive and socio-emotional gains, explore transfer effects to academic achievement, and examine the applicability of this model across different cultural and educational contexts.

6. REFERENCES

1. American Optometric Association. (2019). *Computer vision syndrome*. https://www.aoa.org
2. Banks, J. A. (2008). *An Introduction to Multicultural Education* (4th ed.). Pearson Education.
3. Bavelier, D., Green, C. S., Pouget, A., & Schrater, P. (2012). Brain plasticity through the life span: Learning to learn and action video games. *Annual Review of Neuroscience, 35,* 391–416. https://doi.org/10.1146/annurev-neuro-060909-152832
4. Bediou, B., Adams, D. M., Mayer, R. E., Tipton, E., Green, C. S., & Bavelier, D. (2018). Meta-analysis of action video game impact on perceptual, attentional, and cognitive skills. *Psychological Bulletin, 144*(1), 77–110. https://doi.org/10.1037/bul0000130
5. Boldrin, S., De Luca, L., & Tesser, G. (2017). *Ergonomia digitale e prevenzione nei contesti scolastici*. FrancoAngeli.
6. Boot, W. R., Kramer, A. F., Simons, D. J., Fabiani, M., & Gratton, G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologica, 129*(3), 387–398. https://doi.org/10.1016/j.actpsy.2008.09.005
7. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
8. Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293–332.
9. Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: SAGE Publications.

10. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01
11. Delwiche, A. (2006). The Gamespace of Warcraft: An Ethnography of a Video Game. *Digital Media and Learning*.
12. Dye, M. W. G., Green, C. S., & Bavelier, D. (2009). Increasing speed of processing with action video games. *Current Directions in Psychological Science, 18*(6), 321–326. https://doi.org/10.1111/j.1467-8721.2009.01660.x
13. Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*(6939), 534–537. https://doi.org/10.1038/nature01647
14. Green, C. S., & Bavelier, D. (2006). The cognitive neuroscience of video games. In P. Vorderer & J. Bryant (Eds.), *Playing video games: Motives, responses, and consequences* (pp. 211–226). Routledge.
15. Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., ... & Watkins, S. C. (2013). *Connected learning: An agenda for research and design*. Digital Media and Learning Research Hub. https://clalliance.org/publications/connected-learning-an-agenda-for-research-and-design/
16. Johnson, D. W., & Johnson, R. T. (1999). *Learning Together and Alone: Cooperative, Competitive, and Individualistic Learning* (5th ed.). Allyn & Bacon.
17. Kabat-Zinn, J. (2013). *Full Catastrophe Living: Using the Wisdom of Your Body and Mind to Face Stress, Pain, and Illness*. Bantam.
18. Kim, B. (2015). Gamification. In Spector, J. M. (Ed.), *The SAGE Encyclopedia of Educational Technology*. SAGE Publications.
19. Kühn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2014). Playing Super Mario induces structural brain plasticity: Gray matter changes resulting from training with a commercial video game. *Molecular Psychiatry, 19*, 265–271. https://doi.org/10.1038/mp.2013.120
20. Li, R., Polat, U., Makous, W., & Bavelier, D. (2009). Enhancing the contrast sensitivity function through action video game training. *Nature Neuroscience, 12*(5), 549–551. https://doi.org/10.1038/nn.2296
21. Miao, C., Chen, M., Jin, X., Wang, Y., & Xu, M. (2024). Spatial cognition and attention control in esports experts: A meta-analysis. *Frontiers in Psychology, 15*, 1-22. https://doi.org/10.3389/fpsyg.2024.122456
22. Morsanuto, S., Peluso Cassese, F., Tafuri, F., & Tafuri, D. (2023). Outdoor education, integrated soccer activities, and learning in children with autism spectrum disorder: a project aimed at achieving the sustainable development goals of the 2030 agenda. *Sustainability*, *15*(18), 1-14.
23. Nielsen, B. L., & Hanghøj, T. (2019). Esports in education: Exploring educational integration and student identity. *Journal of Educational Technology & Society, 22*(4), 43–54. https://www.jstor.org/stable/26896705
24. Petilli, S., Gori, S., & Giordano, M. (2020). Attention and sustained vigilance in adolescents: Effects of sports vs. video game activity. *Giornale Italiano di Psicologia dello Sport, 7*(2), 33–45.
25. Sala, G., & Gobet, F. (2019). Cognitive training does not enhance general cognition. *Perspectives on Psychological Science*, *14*(4), 789–806. https://doi.org/10.1177/1745691619856608
26. Sokolowska, A. (2023). Immersive learning and cognitive flexibility in virtual reality environments. *Educational Technology Research and Development, 71*, 891–909. https://doi.org/10.1007/s11423-023-10187-7
27. Tafuri, M. G., Palmiero, F., Di Palma, D., Scala, G., & Romano, G. (2025). Effects of an inclusive water polo programme on motor, psycho-pedagogical and social development in deaf-

mute adolescents: An experimental study. *Journal of Human Sport and Exercise*, *20*(4), 1199–1211. https://doi.org/10.55860/94afs931
28. Tanaka, S., Ikegami, T., Ikezawa, K., Osaka, M., & Osaka, N. (2013). Action video game experience and cognitive functions. *Journal of Cognitive Neuroscience, 25*(3), 386–405. https://doi.org/10.1162/jocn_a_00313
29. Toth, A. J., Ramsbottom, N., Kowal, M., & Campbell, M. J. (2020). Converging evidence supporting the cognitive link between exercise and esports performance. *Journal of Cognitive Enhancement*, *4*, 186–200. https://doi.org/10.1007/s41465-019-00148-4
30. Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.
31. Wang, P., Liu, H. H., Zhu, X. T., Meng, T., Li, H. J., & Zuo, X. N. (2019). Action video game training for healthy adults: A meta-analytic study. *Frontiers in Psychology*, *7*(45), 1-13. https://doi.org/10.3389/fpsyg.2018.03072
32. Załęski, M., & Warchoł, J. (2024). Cognitive effects of regular action gaming in adolescents: Evidence from attentional tasks. *Archives of Budo, 20*, 87–95.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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