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Pedagogical Perspective

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From humanities to STEAM: Gamified learning and the development of digital competencies in the classical high school[1]

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Abstract

Although classical high schools in Italy are traditionally associated with lecture-based instruction, the integration of gamification offers promising ways to enhance student engagement and motivation. This study addresses the challenge of incorporating digital and computational competencies into humanistic education by examining the implementation of gamified learning strategies at classical high school with STEAM curriculum in the South of Italy. The purpose of the study is to explore how tools such as escape rooms, educational robotics, and artificial intelligence can transform the perception of coding, specifically Python programming, as a relevant and accessible subject within a classical curriculum. A longitudinal mixed-methods case study design was adopted. The sample included 52 students and 3 teachers who voluntarily participated in a year-long innovation program. Data were collected through pre/post questionnaires, direct observation, performance assessments, and interviews. Quantitative data were analyzed using chi-square tests; qualitative data were examined via thematic analysis. Results revealed a significant increase in students' motivation, particularly in coding and robotics activities. Students reported enhanced engagement, improved collaboration, and reduced anxiety through AI-assisted coding. Teachers also perceived improved digital and pedagogical competencies, despite time constraints. Escape rooms emerged as particularly effective for promoting active learning, problem-solving, and interdisciplinary connections. These findings highlight the transformative potential of gamification in classical education settings. Practical implications include the need for professional development focused on integrating playful learning strategies. Future research should further explore scalable models to bridge the gap between humanities and digital education through sustained pedagogical innovation.

Keywords: Gamification, escape room, classics, Python, coding.

Introduction and background

The contemporary educational landscape is undergoing a profound transformation, intensified by the integration of digital technologies and innovative teaching methodologies within traditional

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learning environments. Several studies (Havzi et al., 2023; Inamorato dos Santos, 2023; Napal Fraile, 2018; Vodă et al., 2022) highlight the growing need to bridge the gap between humanities education and technological competencies. This calls for a redefinition of school curricula in which digital skills are not seen as supplementary, but rather as an essential component of a comprehensive cultural education. In this broader context of renewal, the experience of a classical high school stands out. For several years now, the school has embarked on a path of pedagogical innovation aimed at overcoming the traditional divide between classical education and technological skills. While preserving its strong humanistic identity, the school has gradually introduced elements such as computational thinking, coding, virtual reality, and educational robotics. This has transformed it into a dynamic experimental laboratory where traditional disciplines intersect with digital innovation, giving rise to hybrid and multidisciplinary learning paths.

This study stems from the desire to systematically analyze and evaluate the outcomes of this transformation, with particular focus on the use of gamification, AI-driven activities, and goal-based learning approaches—those grounded in the achievement of concrete objectives. In this sense, the project aims not only to introduce methodological innovation but also to propose a cultural shift capable of rekindling student motivation and fostering new forms of critical, creative, and collaborative thinking.

Gamification began to gain structured academic attention between 2011 and 2017, especially concerning the integration of game mechanics into non-gaming contexts such as education, business, and healthcare. One of the most cited definitions comes from Sebastian Deterding et al. (2011), who describe gamification as the use of game design elements in non-game contexts. Importantly, this does not necessarily imply the use of actual games, but rather the strategic inclusion of game-like elements—such as points, leaderboards, and challenges—to motivate specific behaviors.

Between 2017 and 2020, research increasingly focused on the psychological and behavioral effects of gamification. Drawing on the theory of intrinsic and extrinsic motivation, scholars such as Deci, Olafsen and Ryan (2017) explored how gamification influences user motivation. A key point of discussion was the tension between intrinsic motivation (deriving satisfaction from the activity itself) and extrinsic motivation (driven by external rewards such as badges or prizes). Some studies raised ethical concerns about potential manipulation and the long-term sustainability of externally driven incentives. For instance, Zichermann & Linder (2010) and Sailer at al. (2017) examined the risks associated with overreliance on reward systems, including dependency on extrinsic reinforcement.

Over the past five years, gamification has evolved into more integrated and sophisticated forms, emphasizing personalization, inclusivity, and technological integration: (i) Personalization and Artificial Intelligence: The incorporation of AI has enabled increasingly personalized gamified experiences, tailored to user preferences and behaviors. Learning platforms and digital well-being programs now leverage predictive models to dynamically adjust rewards and track progress in real time (Cudicio & Sangalli, 2024; Palma & Amatori, 2024). (ii) Social Gamification: Another emerging trend is the integration of gamification with social gaming. Numerous studies have examined how social games and group dynamics enhance user engagement. Features such as social leaderboards, peer challenges, and real-time interactions are becoming more common, often fostering active learning communities (Rodrigues et al., 2022; Yang et al., 2022). (iii) Ethics and Sustainability: As gamification becomes more prevalent in fields such as mental health, online education, and professional training, interest in ethically responsible practices has grown. Researchers are increasingly concerned with the potential for gamification to manipulate user behavior and stress the need for long-term, autonomy-supportive experiences (Deterding et al., 2011; Koivisto & Hamari, 2019). (iv) Gamification in Education: Studies have shown that when properly designed, gamification can significantly enhance student engagement, interest in subject matter, and achievement of learning outcomes. Research by Hamari et al. (2014) demonstrated that gamification boosts engagement, but also emphasized the importance of balancing intrinsic and extrinsic motivations (Surendeleg et al., 2020).

Ethical critiques and concerns about the influence of gamification on users' decisions and behavior have also become increasingly relevant in academic discourse (Gray & Suri, 2019; Mekler et al., 2017; Seaborn & Fels, 2015; Triantafyllou, 2025; Vasalou et al., 2011).

Looking ahead, gamification is expected to continue evolving, with a focus on creating more sustainable, ethical, and user-centered experiences, enhanced by emerging technologies such as augmented reality (AR) and virtual reality (VR) to provide deeper immersion (Rapp & He, 2021; Zhao & Li, 2022).

Despite the growing body of research on gamification in education, few studies have explored its integration within classical or humanities-oriented curricula. Furthermore, little is known about how AI-driven gamified activities affect both student engagement and teacher practices in secondary school settings rooted in traditional pedagogy.

Building on previous work, this research aims to expand the literature by investigating the application of gamification as a tool to enrich educational practices at classical high school, within the broader framework of integrating digital innovation into traditionally humanistic curricula.

In a previous study, Author and Author (2024) examined the curriculum of a traditional Italian classical high school and outlined the school's innovative path in integrating alternative educational approaches and digital competencies.

The initial experimentation during the 2023–2024 academic year revealed the potential of merging humanistic content with digital tools. Preliminary observations showed a marked increase in interest toward STEAM disciplines among classical-track students, along with notable improvements in problem-solving abilities, collaboration, and learner autonomy.

In the 2024–2025 school year, the school aimed to adopt gamification not merely as a motivational gimmick, but as an integrated pedagogical framework designed to support the acquisition of digital skills through educational escape rooms, robotics projects, and Python programming activities. The introduction of artificial intelligence further enhanced this model, enabling more personalized, adaptive, and inclusive learning experiences.

Primary objectives of the study: (i) For students: To enhance motivation, develop digital competencies, and foster the perception of technology as a meaningful component of classical education. (ii) For teachers: To improve their mastery of innovative methodologies and boost motivation to incorporate technology, thereby encouraging more active and interdisciplinary teaching practices.

Research questions - Students: (i) How do students perceive the improvement in their digital skills (particularly in Python programming) following the educational intervention? (ii) To what extent has the introduction of gamification and coding methodologies affected students' motivation and engagement in the learning process? (iii) Do students believe that integrating coding and educational robotics within a classical curriculum helps challenge the traditional notion of a technology-free education?

Research questions - Teachers: (i) To what extent do teachers feel they have improved their pedagogical skills after incorporating gamification and educational robotics (including tools such as escape rooms) into their lessons? (ii) How do teachers assess their ability to integrate educational technologies, such as Python coding, into classroom activities? (iii) To what degree do teachers feel more motivated to adopt innovative teaching methods, such as escape rooms and robotics, compared to traditional approaches? (iv) Do teachers perceive the gamification- and coding-based interventions as effective in improving student engagement and learning outcomes? How have these methodologies influenced their perception of teaching efficacy?

This study was designed to explore how the implementation of gamification—particularly through coding and educational robotics—can influence student motivation and the acquisition of digital competencies, while preserving the traditional ethos of the classical high school. Additionally, it examines how the use of both physical and virtual escape rooms can enhance the learning process by promoting problem-solving, collaboration, and critical thinking skills.

Method

Design

This is a longitudinal mixed-methods case study (Bryman, 2016) conducted over one academic year at a classical high school, combining qualitative and quantitative approaches to examine the impact of gamification, coding, and educational robotics on student engagement and learning outcomes.

Participants

Participants (N = 52 students and 3 teachers) were recruited through convenience sampling from first to fourth years (Table 1). The student cohort consisted of 52 students (46% female, 54% male), distributed across first- to fourth-year classes: 20% in first year, 30% in second year, 30% in third year, and 20% in fourth year. Ages ranged from 14 to 17. The sample was selected to represent a range of prior competencies, allowing for an assessment of the project's transversal effectiveness across different skill levels.

Table 1 Demographic characteristics of the participating classical high school students.

Variable	Category	f	%
Class Level	First	10	19,2
	Second	30	16,8
	Third	30	16,8
	Fourth	10	19,2
Gender	Female	24	46,2
	Male	28	53,8

Three teachers participated in the project, including instructors of Art and Classics (Latin and Greek). They collaborated to integrate game-based activities into their respective subjects. Teachers received targeted training on designing escape rooms and incorporating coding and robotics into the traditional classical high school curriculum. This training included both theoretical and practical modules on gamification, Python programming, and educational robotics platforms.

Procedure

The intervention was structured into three main phases (Table 2): (1) an introduction to computational thinking through block-based programming, (2) the use of Choregraphe for programming humanoid robots, and (3) a goal-oriented exploration of Python, where students developed interactive projects such as mini-games and robotic tasks. Throughout the program, artificial intelligence acted as a virtual tutor, offering personalized support and feedback.

The intervention was conducted weekly during regular class hours and extracurricular hours included both teacher training and structured student sessions. Teachers received initial training on gamification strategies, Python, and robotics integration. Students participated in hands-on activities such as coding challenges, escape rooms, and group robotics projects, all designed to merge humanistic content with digital skills. Digital and physical escape rooms served as key tools to foster problem-solving, collaboration, and creativity, with tasks thematically tied to classical subjects like literature, history, and philosophy.

Table 2 Implementation Timeline and Structure of the Educational Intervention.

Phase	Description	Key Activities
Preparatory Phase	Conducted at the beginning of the school year to plan activities and train teachers.	- Teacher training on gamification, Python, and educational robotics- Activity planning and instructional design
1. Initial Teacher Training	Teachers received targeted training to integrate gamified activities into their teaching practice.	- Introduction to computational thinking- Basics of escape room design- Fundamentals of Python programming
2. Gamified Activities and Coding Sessions	Weekly sessions throughout the school year focused on developing digital and transversal skills through hands-on learning.	- Escape Rooms (physical & virtual): Linked to classical subjects and programming puzzles- Coding sessions: Python (from basics to advanced tasks)- Educational robotics: Students programmed robots collaboratively using Python
3. Final Evaluation	Assessment of outcomes conducted at the end of the academic year.	- Performance tests (Python and robotics)- Questionnaires (students and teachers)- Observations of engagement and collaboration

Each phase concluded with reflection activities guided by teachers acting as facilitators. A final evaluation assessed both technical competencies and engagement through direct observation, performance assessments, and feedback surveys. The project demonstrated how a traditionally humanities-based environment can effectively integrate digital tools and active learning methodologies.

Measures

Instruments for evaluating the effectiveness of the intervention

A variety of quantitative and qualitative instruments were employed to assess the effectiveness of the gamification-based educational intervention, coding sessions, and robotics activities (Table 3).

Table 3 Instruments and Measures for Evaluating the Educational Intervention.

Measure Type	Instrument	Target	Focus / Description	Data Type
1. Direct Observation	Field Notes and Session Logs	Students	Observation of behavior during coding, robotics, and escape room sessions (e.g., participation, collaboration, problem-solving, interaction)	Qualitative
2. Evaluation Questionnaires	Structured Questionnaires (Likert + open-ended)	Students & Teachers	Students: motivation, interest, perceived usefulness of coding and roboticsTeachers: motivation, confidence, effectiveness of activities	Mixed (quant + qual)
3. Student Performance	Formative and Final Assessments	Students	Teachers evaluated problem-solving skills, programming correctness, and ability to complete robotics tasks using Python	Quantitative
4. Feedback Surveys	End-of-program Feedback Forms	Students & Teachers	Students: engagement, perceived impact of gamificationTeachers: ease of integration, impact on teaching, perceptions of student skill development	Qualitative
5. Competency Indicators	Observation and Teacher Evaluation	Students	a) Programming Skills: Application of loops, conditionals, functionsb) Problem-Solving Autonomy: Independence in challenge resolution	Quantitative
6. Teacher Motivation Indicators	Self-Assessment + Observer Notes	Teachers	a) Confidence in using Python/gamificationb) Adaptation of teaching methods observed during implementation	Mixed (quant + qual)

These tools were designed to evaluate several aspects, including student engagement, the acquisition of digital competencies, and teacher motivation to adopt innovative pedagogical approaches.

Data analysis

Data were collected at two key moments—before and after the intervention—through direct observation, structured questionnaires, practical performance assessments, and open-ended feedback forms. A mixed-methods approach was adopted to analyze the effectiveness of the gamification-based educational program, integrating both quantitative and qualitative techniques.

Quantitative data, processed using Microsoft Excel, were used to measure changes in students' digital competencies, particularly in final coding tests and robotics tasks. Qualitative data, including observations, open-ended responses, and teacher journals, were analyzed thematically to capture participants' experiences, attitudes toward gamification, and the challenges encountered.

This strategy enabled data triangulation, offering a holistic view of teaching and learning dynamics throughout the project.

Validity, reliability, and ethical considerations

To ensure the scientific rigour of the study, particular attention was given to validity, reliability, and ethical standards.

Validity was enhanced through a data triangulation strategy that combined multiple sources—questionnaires, direct observations, performance assessments, and teacher feedback. This cross-verification minimized systematic bias and improved consistency. The intervention was context-specific, designed to integrate seamlessly into the classical high school curriculum, ensuring relevance and authenticity.

Reliability was supported by the use of clearly structured and unambiguous instruments, reducing the risk of misinterpretation and enhancing consistency in data collection.

Ethical considerations included: (i) Informed consent: All participants provided written consent at the start of the academic year. (ii) Privacy and data protection: Data were anonymized, securely stored, and accessed only by authorized researchers. Participants were assured of confidentiality and that their responses would be used solely for research purposes. (iii) Risk minimization: All activities were designed to be safe, inclusive, and free from physical or psychological stress. Particular care was taken to ensure that gamified experiences (e.g., escape rooms) were engaging but not overwhelming.

Findings

These practices not only demonstrated a positive impact on student engagement, but also contributed to redefining the role of technology in the humanities—no longer perceived as a distant or technical domain, but as a cross-disciplinary language capable of dialoguing with history, philosophy, literature, and the arts.

The data collected throughout the school year revealed significant results, both quantitatively and qualitatively, confirming the effectiveness of the integrated approach implemented at Classical High School. The findings are presented in two main categories: student outcomes and teacher outcomes.

Student results

Engagement and motivation

The analysis of questionnaire responses highlighted notable improvements in students' motivation and perception across several areas following the intervention.

Students reported feeling significantly more motivated during coding activities, attributing this change to the hands-on, collaborative nature of the tasks and the satisfaction of seeing immediate results. Similarly, robotics activities were found to boost motivation considerably, suggesting that integrating technology into the curriculum can positively influence engagement.

Working with the Choregraphe software also led to a marked increase in motivation, even among students initially unfamiliar or uninterested in the platform. Gamification strategies proved especially effective, as students responded very positively to game-based elements that made learning more enjoyable and dynamic.

Beyond motivation, the intervention notably transformed students' perceptions of the usefulness of coding, with many coming to see it as a relevant and valuable skill—even in a classical high school setting focused on the humanities. Importantly, perceptions of robotics also improved, indicating growing recognition of its educational potential within non-STEM-focused contexts.

These findings suggest that well-designed, interactive digital activities can play a key role in enhancing both motivation and perceived value of technology among students who might not initially see its relevance. See Table 4 for a detailed summary of pre- and post-intervention results.

Table 4 Summary of pre- and post-intervention results for key variables.

Variable	Pre-Intervention (%)	Post-Intervention (%)	χ^2	p	ϕ	Effect Size
Motivation during coding activities	30	72	15.39	< .001	.553	Large
Motivation during robotics activities	26	69	17.06	< .001	.448	Moderate
Motivation during Choregraphe activities	6	39	14.29	< .001	.524	Large
Motivation during gamification activities	18	67	22.84	< .001	.663	Large
Usefulness of coding in classical high school	16	70	28.72	< .001	.743	Very large
Usefulness of robotics in classical high school	12	55	17.06	< .001	.573	Large

Note. Percentages are based on a total of $N = 52$ participants. Chi-square (χ^2) and *p*-values were calculated using the Chi-square test of independence. Effect size (ϕ) refers to the strength of association, with $\phi > .50$ interpreted as a large effect.

Digital and computational thinking skills

The analysis of students' digital and computational skills revealed significant progress in foundational programming abilities. Post-intervention results showed that a large majority of student groups reached meaningful levels of operational competence: approximately 90% successfully completed at least 2 of 3 assigned programming tasks, demonstrating a practical grasp of the key concepts covered during the project (Table 5).

Notably, 75% of participants were able to apply loops and conditional structures effectively in real-world contexts, such as robot control or game simulation. These findings indicate not only the acquisition of technical knowledge but also students' ability to transfer it into meaningful applications.

Of particular interest is the role of AI-assisted tools in debugging: approximately 20% of students used AI autonomously to identify errors in their scripts, request alternative solutions, or generate corrected code. This suggests the emergence of early forms of technical metacognition, as students became more aware of their limits and proactively sought solutions using technology ethically and constructively.

The overall success of the learning process can largely be attributed to the task-oriented approach adopted throughout the activities. The use of concrete, goal-driven challenges—such as "make the robot dance with a custom choreography"—proved especially effective in engaging students who were initially disinterested or intimidated by programming. Clear and tangible objectives enhanced intrinsic motivation and reduced the perceived gap between theoretical learning and practical application.

Cross-curricular and soft skills

Beyond digital competencies, the intervention also fostered growth in a range of transversal and soft skills relevant to both academic and professional contexts. Observations during the activities and post-intervention questionnaires revealed improvements in several key areas:

Collaboration: Group coding challenges fostered improved peer dynamics, encouraging students to work together more effectively and to manage tasks through more precise role distribution.

Creativity: Many students demonstrated initiative and originality by customizing environments, command sequences, and robot behaviors, often going beyond the basic requirements.

Autonomy: Students gradually developed the ability to manage their learning independently, especially when using AI tools responsibly as virtual tutors. They were able to leverage technological assistance without becoming overly dependent on it, maintaining ownership of the problem-solving process.

Direct student feedback offers a more personal and qualitative perspective on the experience. Selected responses include:

> "I enjoyed working in groups and solving challenges together." (14-year-old student)
> "I appreciated the hands-on learning compared to traditional lessons." (15-year-old student)
> "It was interesting to use creativity to solve problems." (16-year-old student)

Many participants identified digital escape rooms as among the most engaging and effective educational tools. The playful, goal-driven format encouraged active participation and reflection, fostering a learning-through-play environment. The integration of AI-assisted programming was also widely appreciated, as it helped reduce performance anxiety, promoted problem-solving autonomy, and made the introduction to Python less intimidating.

However, some students offered constructive criticism and suggestions for improvement. For example, a few noted that unequal participation within groups was a challenge and suggested simplifying tasks to support broader inclusion:

> “Some classmates did not participate much; maybe simplifying tasks could help involve everyone.” (16-year-old student)

Others proposed a more apparent distinction between the gamified components and the more traditional instructional segments, to improve focus and clarity:

> “It might help to separate the gamification part from the traditional lessons.” (17-year-old student)

Table 5 Summary of qualitative findings

No.	Category	Key Findings
1	Digital skills	90% of student groups completed ≥2 out of 3 activities
2	Computational thinking skills	75% mastered loops/conditions; 20% used AI for debugging
3	Collaboration	Effective group work during challenges
4	Creativity	Scenario and command customization
5	Autonomy	Responsible use of AI tools
6	Positive perception of coding	Coding perceived as accessible and useful
7	Reduced anxiety due to AI	AI helped reduce performance anxiety
8	Positive perception of escape rooms	Escape rooms seen as engaging and educational
9	Suggestions for improvement	Requests to simplify or separate activity phases

Note. This table summarizes key qualitative findings based on thematic analysis of student feedback, field diaries, and open responses.

The integrated table 6 demonstrates a strong convergence between quantitative and qualitative data, reinforcing the significant positive impact of the intervention on students' motivation, digital skills, and teachers' perceived competencies.

Table 6 Integration of quantitative and qualitative findings

Dimension	Quantitative Results	Qualitative Findings
Motivation to code	Increase from 30% to 72% (χ^2 = 15.39, p < .001, ϕ = .55)	Students appreciated practical, hands-on coding; felt more motivated working in groups and seeing immediate results.
Motivation to use robotics	Increase from 26% to 69% (χ^2 = 17.06, p < .001, ϕ = .45)	Robotics activities perceived as engaging and useful; students enjoyed challenges and group collaboration.
Use of AI for debugging	20% autonomously used AI tools during final phase	AI perceived as reducing performance anxiety and fostering autonomy in problem-solving.
Gamification motivation	Increase from 18% to 67% (χ^2 = 22.84, p < .001, ϕ = .66)	Escape rooms and gamified tasks seen as fun, engaging, and effective for learning "by doing."
Perception of coding utility	Increase from 16% to 70% (χ^2 = 28.72, p < .001, ϕ = .74)	Coding perceived as accessible and relevant even in a classical studies context; increased interest reported.
Teacher digital competence	Not statistically significant due to small N, but clear trend towards improvement	Teachers reported higher confidence in using Python and gamification; AI seen as helpful for personalizing learning.
Teacher perception of effectiveness	100% rated the intervention as effective in increasing student engagement	Teachers noticed increased enthusiasm and focus, especially in typically less motivated students.

Teacher results

Digital and pedagogical competence

Although only three teachers participated in the study, their responses offer meaningful insights into the perceived development of their digital and pedagogical competencies following the intervention. Due to the limited sample size, Fisher's exact test was employed for statistical analysis. While the shift in self-assessed competence from "low" to "high" was evident, the p-value of .100 indicates that the change is not statistically significant at the conventional 5% level—a limitation that likely stems from the small number of respondents.

Nonetheless, the qualitative data tells a richer and more compelling story. All participating teachers reported a tangible increase in confidence when integrating technology into their daily teaching. In particular, they felt more capable of:

- Designing and delivering innovative, student-centered learning activities;
- Using Python not just as a technical tool, but as a didactic medium adaptable to a variety of disciplines;
- Incorporating gamification strategies, such as escape rooms, to promote motivation and engagement.

The teachers also emphasized the positive role of artificial intelligence tools, which they described as helpful for personalizing learning, simplifying assessment tasks, and supporting students with real-time debugging suggestions.

Their comments reflect both pedagogical enthusiasm and critical reflection:

> "Greater classroom engagement, increased enthusiasm and interest—even from students

> who typically seem less motivated—and facilitated learning." (Art teacher)
> "Students showed improved focus, greater task commitment, and responded positively to stimulating learning environments. The main limitation: limited time, especially when the school curriculum must be completed." (Latin and Greek teacher)

Although time constraints and curricular pressures remain a concern, teachers expressed strong appreciation for the approach's transformative potential. The experience appears to have sparked pedagogical renewal, suggesting that even within rigid school structures, technology-enhanced methodologies can foster both teacher growth and student-centered learning.

Perceived effectiveness

All three participating teachers (100%) rated the intervention as either "very effective" or "quite effective" in promoting student engagement—particularly among those students who typically showed lower levels of participation. Several educators emphasized that the learning-by-doing approach not only captured students' interest but also aligned unexpectedly well with the pedagogical methods of classical language instruction, helping to make abstract computational concepts more tangible and relevant within a humanities-oriented curriculum.

Their reflections offer valuable qualitative insights into classroom dynamics and perceived learning outcomes:

> "I noticed greater engagement and growing enthusiasm—even among students who are usually less motivated. Learning seemed easier and more natural." (Math teacher)
> "Students were more focused, more committed, and responded positively to a stimulating and interactive learning environment. The main limitation remains time constraints." (Latin and Greek teacher)

The combined analysis of quantitative and qualitative data offers a robust and multidimensional understanding of the intervention's overall effectiveness. Statistically significant improvements were observed in students' motivation and in their perceptions of the usefulness of coding, robotics, and gamification—despite the classical academic setting. These quantitative findings are further contextualized and enriched by qualitative evidence, which sheds light on the pedagogical mechanisms and contextual conditions that may have facilitated such changes. In particular, student feedback and teacher observations underscore the importance of active learning, personalization through AI tools, and the emotional impact of working with engaging, goal-oriented tasks.

Discussion

The study confirms that an integrated educational approach combining gamification, coding, educational robotics, and artificial intelligence can be effective even in a traditionally humanistic environment, such as a classical high school. The hybrid and goal-oriented nature of the learning activities—where students used Python to solve real-world problems, supported by digital and collaborative tools—proved particularly potent (Cudicio & Sangalli, 2024). This aligns with theories of active learning and contextualized procedural instruction commonly endorsed in STEM education (Bau et al., 2017) .

Student testimonies emphasized the engaging, collaborative, and interactive features of the activities, which significantly enhanced motivation. Qualitative feedback noted that AI tools reduced anxiety, fostered autonomy, and made coding more accessible—reinforcing quantitative evidence of improved computational competence. This aligns with educational theories highlighting how gamified environments stimulate intrinsic motivation and reduce cognitive load (Krath et al., 2021; Hamari et al., 2014).

From the teachers' perspective, although statistical significance was limited by the small sample, qualitative data revealed meaningful growth in confidence and motivation to apply digital pedagogical tools and gamification strategies. Educators reported heightened student engagement and enthusiasm, validating the quantitative findings. This triangulation of methods underscores the value of combining numerical data with narrative insights to capture the broader educational impact of interventions based on coding, robotics, and gamification (Seaborn & Fels, 2015; Koivisto & Hamari, 2019).

Role of AI

One of the most innovative aspects of the intervention was the use of artificial intelligence as support for coding. Far from replacing the teacher, AI was perceived by students as an accessible and available assistant, capable of providing explanations, suggestions, alternatives, and real-time debugging (Palma & Amatori, 2024). This reduced the initial frustration often associated with the transition from block programming to textual syntax (Mekler et al., 2017). Moreover, AI fostered differentiated learning by adapting to individual needs and providing a sense of control and autonomy even to students with less technical backgrounds (Friedrich et al., 2024).

Value of goal-oriented learning

The goal-based approach, centered on "learning by doing," proved particularly effective in the classical high school context, where theoretical abstraction often predominates. In this case, the concreteness of activities (escape rooms, robot movements, simulations) helped to root computational logic concepts in everyday practice (Yang et al., 2022). This type of learning also stimulated an experimental mindset, encouraging trial and error and the search for alternative solutions, key traits of critical thinking (Rodrigues et al., 2022). This echoes findings from broader gamification studies, which show that challenge-based mechanics promote mastery, engagement, and intrinsic motivation.

Implications for classical high school teaching

The experience at classical high school suggests that innovative methodologies can not only coexist with the classical curriculum but can also enhance its formative nature, offering students tools to interpret the present with the same depth as they analyze the past (Friedrich et al., 2024). What is more, several students noted that using AI and robotics challenged their initial perception of classical education as detached from technology. This aligns with Hamari et al.'s (2014) findings that gamification can revitalize engagement without compromising educational identity. However, while gamification increases engagement, a careful balance between intrinsic and extrinsic motivation is necessary (Deci, Olafsen & Ryan, 2017; Surendeleg et al., 2020). In particular, student reflections emphasized the need for teachers to blend gamified activities with traditional lessons, ensuring clarity and inclusivity. Effective implementation demands ongoing teacher training rooted in personalized education, not simply technology adoption (Bray & McClaskey, 2018; Ferotti, 2011).

Conversely, the experience also offered teachers a professional growth opportunity and methodological reflection, leading them to reconsider their role not as content transmitters but as facilitators of meaningful experiences (Havzi et al., 2023; Napal Fraile et al., 2018).

This project has already demonstrated a meaningful impact on both student outcomes and teacher practices (European Commission, 2020). Students showed significant increases in motivation and engagement, mastering key digital and computational skills such as programming with Python, logical reasoning, and autonomous use of AI tools for debugging. Moreover, the intervention fostered transversal skills including collaboration, creativity, and autonomy, which are crucial for 21st-century learning. For teachers, the project encouraged a shift toward more innovative pedagogical approaches, increasing their confidence and motivation to integrate coding, gamification, and AI into their regular teaching (Teidla-Kunitsõn et al., 2023). These changes collectively suggest that the intervention not only improves immediate learning results but also promotes a sustainable evolution in teaching methodologies aligned with modern educational demands.

Limitations and future directions

While the results of this study are promising, some limitations must be acknowledged.

First, the small sample—limited to a single school—restricts the generalizability of the findings. Future research should involve broader and more diverse populations across multiple institutions to assess the scalability of the model.

Second, possible selection bias may have influenced the outcomes, as the participating school already showed a strong inclination toward innovation. A more randomized sampling approach would help ensure greater representativeness.

Third, the reliance on self-reported data introduces the risk of social desirability bias, particularly in questions related to motivation and engagement. Future studies could combine surveys with observational data or digital analytics to improve validity.

Finally, while the project highlights the potential of combining humanistic education with emerging technologies, its long-term success requires systemic support: teacher training, infrastructure, and inclusive policies. With these in place, similar initiatives could become sustainable models for an education system that is both rooted in tradition and responsive to contemporary challenges.

Conclusion

This study has demonstrated that the integration of gamification, programming, educational robotics, and artificial intelligence into a classical high school context is not only feasible, but pedagogically effective. The intervention generated meaningful improvements in both student motivation and the development of digital, computational, and transversal skills. These outcomes are particularly significant considering the traditionally theoretical and humanistic orientation of the classical curriculum.

A central strength of the approach lay in its progressive and goal-oriented structure, which enabled students, including those less confident with technology, to engage in coding activities in an inclusive and accessible way. The presence of AI tools as intelligent scaffolds further personalized the learning experience, offering real-time feedback, reducing anxiety, and fostering a sense of autonomy. This allowed learners to experience programming not as an abstract technical skill, but as a tool for creative expression and problem-solving—an attitude aligned with constructivist and learner-centered pedagogies.

A cornerstone of this success was the role of the teacher: when properly trained in educational technologies, teachers act as a bridge between the humanistic traditions of the past and the technological opportunities of the present, guiding students to make meaningful connections between disciplines and eras. Their ability to interpret classical heritage through the lens of contemporary tools is essential to ensuring that innovation does not distance but rather deepens cultural identity.

The findings of this pilot open several promising avenues for future exploration: (i) Replicability and adaptation of the model in other classical or humanities-focused schools; (ii) Development of sustainable, interdisciplinary modules that integrate computational thinking with core humanistic competencies; (iii) Strategic use of AI as a pedagogical facilitator, not merely a technical assistant, to support differentiated instruction and learner agency.

Beyond the quantitative gains in digital skills, the project produced a qualitative transformation in how both students and teachers perceive learning. Students reported higher motivation, reduced performance anxiety, and greater confidence in facing technological challenges. Teachers, in turn, reported an increased willingness to experiment with innovative, student-centered practices, as well as a deeper awareness of their evolving role as facilitators of learning, rather than mere transmitters of content.

In sum, the experience at classical high school stands as a virtuous case of dialogue between tradition and innovation. It shows that the apparent dichotomy between humanistic knowledge and technological competence is not a conflict, but a convergence—a fusion of skills and sensibilities necessary for educating the citizens of tomorrow. Mastering Homer’s language and Python syntax need not be viewed as mutually exclusive pursuits; rather, they are complementary dimensions of a well-rounded, critically literate, and future-ready learner.

Statement of researchers

Researchers contribution rate statement

The authors confirm their contribution to the paper: study conception and design: Author 1 and Author 2; data collection: Author 1 and Author 2; analysis and interpretation of results: Author 2 and Author 1; draft manuscript preparation: Author 2 and Author 1. All authors reviewed the results and approved the final version of the manuscript.

Conflict statement

All authors declare that they have no conflicts of interest.

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