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Research Paper

How to improve reading and writing skills in primary schools: A comparison between gamification and pen-and-paper training

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ABSTRACT

This research investigates the potential of gamified tools to enhance motivation as well reading and writing skills in pupils, from 8 to 11 years old. The study compares the impact of gamified applications to traditional pen-and-paper activities, utilizing standardized reading and writing tests. The training duration spans 12 h within the school setting, and the sample comprises 113 children with typical development, evenly distributed across two groups. The results indicate significant improvements in reading and writing speed and accuracy for each group, with a slightly higher effect observed in the experimental gamified training group, although this difference was not statistically significant. Although motivation did not directly mediate performance in either group, students in the experimental training groups expressed greater enthusiasm for the activities. These findings emphasize the importance of comprehensive training and pave the way for future investigations into the effects of gamified tools on other real-life skills and motivational aspects. Such studies would prove fundamental to understand the limitations and benefits of gamification, enabling its effective integration into school programs.

1. Introduction

One of the ways children learn and acquire new skills for their everyday life is through play (Huizinga, 2014), during which their experience is accompanied by pleasurable emotional sensation (Held & Špinka, 2011), bringing both immediate psychological benefits and long-term benefits in the form of acquired skills. For these reasons, in the last decades, the importance of analysing the use of games in learning processes has increased. Furthermore, the idea that games are characterised by valuable principles both for learning and making each activity fun and engaging, is well-established in several research fields, such as education. The use of games during teaching-learning processes could increase the attention of students and their involvement using an intrinsic desire for improvement (Murray et al., 2004). One possible approach to achieve greater engagement, keep motivation high, and offer students the opportunity to be active throughout the learning process is through games by using technological tools. An innovative solution within the educational context involves integrating traditional teaching methods with games and video games. Moreover, in accordance with the constructivist perspective of learning in which the learner actively processes information and constructs knowledge, game-based activities fundamentally alter the learner's experience by letting them explore and interact with the game world or context, in their own way and according to their mental model. The learner activity is the focus of the learning process, rather than the teacher's instruction (Dalgarno, 1996; Quinn & Neal, 2008; Obikwelu & Read, 2012). Extensive research has demonstrated the effectiveness of games as valuable tools for fostering active participation, concentration, motivation, and social interaction among students. These research fields (i.e., game design, education, etc.) gave birth to conceptual constructs such as *edutainment, game-based learning, games for purpose*, and *gamification* (Deterding, 2011). For the present research, the methodology of *gamification* is specifically considered as it has been incrementally studied and analyzed, especially in the educational context.

This paper is structured as follows. Firstly, we discuss the literature related to the use of gamification for learning, focusing on the key elements of game design and their relationship with motivational processes. Subsequently, we provide a detailed description of the study, including the methods, procedures, and materials used. Moving forward, we present our findings, which encompass the changes observed after training within each group, the distinctions between the different groups under consideration. Additionally, the study emphasises the

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crucial role of participants' motivation and perception of fun in the learning activities. Finally, we discuss the implications of our findings and conclude our work.

1.1. Gamification for learning

The term *gamification* appeared at the beginning of the twenty-first century after the work of an English programmer, Nick Pelling (2011). It concerns the use of game design elements in traditional educational contexts (Deterding et al., 2011), to enhance experience and involvement (Huotari & Hamari, 2012; Zicherman & Cunningham, 2011) by using technology tools. The features of a digital instrument for learning are essential to improve competencies by maintaining the motivation, attention, and engagement of the users high during the execution of the tasks, aligning students' attention to desired outcomes, and allowing the knowledge transfer in daily life (Pasqualotto, Parong, Green, & Bavelier, 2023).

The first crucial aspect is not only to generate initial interest in the learning topic but also to sustain the learner's motivation throughout the learning process (Cochrane & Green, 2021; Pasqualotto, Parong, Green, & Bavelier, 2023). One effective way to achieve this is by ensuring the adaptivity of the training difficulty, preferably through closed-looped algorithms (Mishra, Anguera, & Gazzaley, 2016). Adaptivity involves gradually increasing the difficulty level as the learner's ability improves. In other words, as the participant becomes more proficient at completing training tasks, the complexity of those tasks should also increase, thus keeping the participant constantly challenged at the edge of their abilities (Vygotsky, 1981). Providing feedback during the learning process is equally crucial (Sailer et al., 2017). In this regard, extensive evidence supports the notion that motivation plays a crucial role in shaping in-game experiences (Malone, 1981), and conversely, in-game experiences can influence players' motivation to continue playing. Within this context, the Self-Determination Theory (SDT) serves as a widely recognized theoretical framework for investigating motivation (Deci & Ryan, 1985, 2000; Rigby & Ryan, 2011; Ryan & Deci, 2000). SDT emphasises the satisfaction of intrinsic psychological needs, including *competence, autonomy, and relatedness*. Specifically, the need for autonomy involves a desire for responsibility and control over one's behavior. The need for competence relates to effectiveness and expressing one's abilities to achieve specific objectives. Finally, the need for relatedness pertains to connection, acceptance, and being part of a community. Positive results have been observed regarding the use *gamification* and the satisfaction of motivational needs, and such results depend on desired behaviors, the personality of the users, and the outcomes observed (Dalmina et al., 2019; Peng et al., 2012; Xi & Hamari, 2019; van Roy & Zaman, 2019).

Another crucial point is aligning learners' attention with desired learning outcomes (Pasqualotto, Parong, Green, & Bavelier, 2023). Some risks could distract the players from the learning objective, such as keeping children's attention directed towards interesting but irrelevant stimuli (Sundararajan & Adesope, 2020). To address this, correct design elements, such as visual and audio cues, should be employed to focus on essential learning features (Castro-Alonso et al., 2021). Additionally, effective games should have clear and well-defined goals that align with the desired learning results (Mayer, 2016). In the field of gamification, one possible solution to apply is using progress bars and performance graphs, in which the first one indicates the progression towards a defined goal, while the second one compares the scores to previously achieved points in order to obtain the outcomes (Sailer et al., 2013).

Finally, a significant consideration to do concerns skills transfer (Schmidt & Bjork, 1992). Indeed, the primary objective of most cognitive training paradigms is to maximize the extent of generalisation of learning. Typically, training tends to enhance performance on the specific practiced task, but this improvement does not necessarily extend to similar tasks (for a meta-analysis on near and far transfer in cognitive training, see Sala et al., 2019). Previous research has indicated that increasing both the overall training variability and the intermixing of training tasks can enhance the generality of learning (Deveau et al., 2015; Dunlosky et al., 2013). However, determining which patterns of improvement across tasks, designed to tap the same core construct, signify true changes in the construct remains a subject of considerable debate in the field (Au et al., 2015; Green, 2020; Melby-Lervåg et al., 2016).

1.2. Gamification and game design

The concept of *gamification* has recently evolved to focus on the experiential quality of playing and gameful experiences, rather than specific elements of game design (Gooch et al., 2016; Hamari, 2019; Seaborn & Fels, 2015; Xi & Hamari, 2019), such as scores, prizes, leaderboards, levels, progress bars, challenges, ratings, etc., which can affect specific motivational mechanisms (Spanellis et al., 2016; Vassileva, 2012). In a recent study by Xi and Hamari (2019), the authors examined the relationship between user interactions and various elements of *gamification*. They identified three main categories of gamified features aimed to increase player motivation. The immersion-related outlines (i.e. avatar, storytelling, customisation, etc.) aim to engage users in self-directed activities and promote autonomous thinking (Koivisto & Hamari, 2019; Peng et al., 2012; Stefanou, Perencevich, DiCintio, & Turner, 2010); the achievement-related features (i.e. points, badges, feedback, leaderboards, tasks, etc.) measure player behavior and encourage goal-oriented behaviors (Hamari, 2017; Hamari et al., 2018; Rigby & Ryan, 2011; Sailer et al., 2014); the social-related characteristics (i.e. groups, messages, social network, etc.) create a sense of relatedness and strengthen interpersonal relationships (Shiau et al., 2018). Xi and Hamari (2019) found that immersion-related features were associated with autonomy satisfaction, while achievement and social–related features were associated with all three psychological needs.

These findings suggest that game design should incorporate different gamified features to effectively motivate users. Specifically, in a study (Sailer et al., 2017), the impact of different game design elements on the satisfaction of basic psychological needs was examined. The results revealed that badges, rankings, and performance charts positively influenced the need for competence by providing feedback and increasing task significance (Peng et al., 2012; Rigby & Ryan, 2011). On the other hand, avatars, storytelling, and teammates influenced social experiences by fostering shared goals (Rigby & Ryan, 2011). However, perceived autonomy was not affected by any specific game design aspect, suggesting that it may depend on other decision-making processes (Peng et al., 2012). The authors emphasised the importance of players' awareness of these game design elements to achieve the desired results. Gamified features can serve as both extrinsic and intrinsic motivators, depending on the context and individual preferences (Deterding, 2011).

The literature indicates that the positive effects of *gamification* can be achieved through a comprehensive design process. While it is important to analyse the effects of different *gamification* elements, it is crucial to consider that these elements may have multiple motivational effects based on their situational meaning. However, the literature also reports negative or null results of using gamification to improve learning (Hyrynsalmi et al., 2017; Toda et al., 2017). These negative influences are related to limiting challenges resulting from poorly implemented gamified features, which hinder users from realizing their full potential. Additionally, there are harmful concerns, such as adverse effects on user behavior, including addiction-like behaviors related to gambling and excessive gaming (Hyrynsalmi et al., 2017). The first category concerns problems resulting from poorly implemented gamified features, restricting users from realizing their full potential. While the second one involves serious and ethical problems, such as gambling and game addictions.

Furthermore, some studies have found no significant differences

between innovative strategies like gamification and traditional methods due to the design of the gamified elements and their implications for individual motivation (Domínguez et al., 2013; Hanus & Fox, 2015; Katz et al., 2014). To address these challenges, involving users in the design process could be a potential solution (Menestrina et al., 2021). Therefore, adopting a multilevel approach to gamification design becomes necessary to understand and harness its potential impact, taking into account both the individual's needs and general motivational mechanisms.

1.3. Gamification in the educational context

Gamification has emerged as an innovative and effective strategy for enhancing student motivation and engagement, particularly in the context of literacy improvement (Deterding et al., 2011). By integrating game elements into educational programs, gamification offers students a dynamic and immersive learning experience. Numerous studies emphasize the efficacy of gamification in fostering the development of specific academic skills, such as reading and writing, while simultaneously nurturing essential soft skills like cooperation and social communication (Aldemir, Celik, & Kaplan, 2017; Gray et al., 2019; Hamari et al., 2014; Sailer et al., 2017; Xi & Hamari, 2019). The use of gamification was analyzed from primary to university grades (Hainey et al., 2016). In particular, this methodology has a positive and effective influence on involvement, motivation, learning results, satisfaction, and fun, both in children with typical development (Landers, 2014; Lee et al., 2013; Lister, 2015; Pasqualotto, Altarelli, et al., 2022) and with learning difficulties (Cuschieri et al., 2014; Dymora & Niemiec, 2019).

Studies focus on the impact of learning technology usage on a particular type of learner, specifically, primary school students, and the most popular outcomes regarding an improvement in mathematics, science, language, and social skills (Chauhan, 2017; Hainey et al., 2016). Some studies have concentrated on the influence of learning technology usage on a single aspect of learning, such as reading (Cheung & Slavin, 2012; Pasqualotto, Altarelli, et al., 2022), writing skills (Wollscheid et al., 2016) and mathematical skills (Li, & Ma, 2010). Some recent reviews highlight the positive effect of using gamification strategies in the educational context. A work analyzes 54 empirical studies that demonstrated the potential to enhance learning outcomes (Dehghanzadeh, Farrokhnia, Dehghanzadeh, Taghipour, & Noroozi, 2023). Another research describes the modalities in which gamified tools are implemented to increase efficacy in the educational context and to achieve various educational purposes, from mathematical to writing and reading skills (Zeybek & Saygı, 2023). Giving more detail, Cheung and Slavin (2012) highlight studies that demonstrated an improvement in reading skills in comparison to traditional methods. Moreover, another study reveals a larger impact of gamification methodology on comprehension and reading abilities in children, who attend primary school, concerning the traditional approach (Prados Sánchez et al., 2023). This modality is used in the school environment, in a telematic or a hybrid manner to acquire new knowledge (Vrcelj et al., 2023; Nieto-Escamez & Roldán--Tapia, 2021).

However, some studies did not find better learning outcomes by using gamified tools in comparison to traditional activities and more research is needed to support the effectiveness of gamification strategies in the educational context (Dichev & Dicheva, 2017; Oliveira et al., 2023). Although, an integration between innovative and classical interventions could provide better outcomes in order to maintain students' attention at a high level, as well as the motivation for the learning process, and expected better results (Cheung & Slavin, 2012; Ciolan, 2013; Zainuddin et al., 2020).

Although the empirical results thus far have generated a considerable amount of optimism regarding the implementation of gamified tools in educational settings, including gamified cognitive training (Green & Newcombe, 2020), a recurring theme throughout the extensive literature is that the journey toward utilizing them as effective learning tools has encountered challenges that were not initially anticipated.

1.4. Aims and hypotheses

The objective of the research was to assess the effectiveness, in terms of motivation, involvement, and improvement of reading and writing skills, of gamified digital applications compared to traditional activities through training of 12 h in 8–10 years old children with typical development in school contexts. The primary objectives of this study were to examine.

RQ1. - the impact of gamified applications on reading and writing performance;

RQ2. - the relative effectiveness of gamified applications compared to traditional pen-and-paper learning activities;

RQ3. - the motivational and engagement benefits of gamified applications in comparison to pen-and-paper exercises.

To address these inquiries, the study's design incorporates experimental, cross-sectional, and mixed methods. Our hypotheses are as follows: Gamified applications facilitate an enhancement of reading and writing skills in primary school children. The improvement in these abilities following training is more significant for the gamification group compared to the pen-and-paper group. Motivation and engagement mediate the acquisition of skills when utilizing gamified applications. These hypotheses form the basis of our research framework, guiding our investigation into the effectiveness of gamified training in enhancing writing and reading skills.

2. Methods

2.1. Selection and participants

The study involved 146 participants, aged 8–11 years (M = 9.16, SD = 0.92), who were attending the 3rd (8–9 years old), 4th (9–10 years old), and 5th (10–11 years old) grades of Primary School in the northern region of Italy. After presenting the project and parents and children accepting to participate, we obtain informed consent from caregivers. The sample consisted of 78 females and 68 males, distributed across 10 different classrooms. Random assignment was used to allocate the classrooms to either the gamification group (81 students) or the pen-and-paper group (65 students). However, during the subsequent analysis stage, individuals who did not have Italian as their native language and/or had undisclosed psychopathological or developmental disorders (unspecified for privacy reasons) were excluded from the study. This exclusion was necessary as these conditions could potentially influence performance in reading and writing tasks (N = 33). As a result, the final sample comprised 113 children, with 67 in the gamification group and 46 in the pen-and-paper group. No significant differences were found between different groups for demographic and cognitive characteristics, and literacy scores at T1. The descriptive statistics of the groups are reported in Table 1.

2.2. Procedure

This study adhered to the ethical standards set forth by the Italian Association of Psychology (AIP), the most recent version of the Declaration of Helsinki (World Medical Association, 2013), and the Ethics Committee of the University of Trento (Prot. 2019–015).

The experimental procedure (Fig. 1) was.

1. Initial assessment of performance (T1): the general intellectual ability was assessed using the subtest Matrix Reasoning (WISC-IV) and neuropsychological tests investigating reading and writing skills (DDE-2, MT-3, and BVSCO-2).

Table 1
Demographic and cognitive characteristics, the fluid intelligence quotient (Reasoning with matrix-RM, express in standard points), and writing and reading skills (Means, SD) of gamification and pen-and-paper groups before and after training.

	G1 group[a] (n = 32)			P1 group[b] (n = 18)			Test	p	G2 group[c] (n = 35)			P2 group[d] (n = 28)			Test	p
	M	SD	Min-Max	M	SD	Min-Max			M	SD	Min-Max	M	SD	Min-Max		
Sex (F-M)	17–15			10–8			0.02[e]	0.87	18–17			14–14			0.01[e]	0.91
Age (y)	9.12	0.75	8–11	8.94	0.72	8–10	0.87[f]	0.39	9.08	0.91	8–11	9.21	0.96	8–11	0.52[f]	0.60
IQ (RM)	12.62	4.16	1–16	13.05	3.65	3–18	0.38[f]	0.70	13.68	4.06	1–19	13.25	3.87	1–19	0.51[f]	0.61
***Word** (DDE-2)*																
Speed	−0.72	1.04	−2.87-1.58	−0.19	1.19	−2.52-2.43	1.47[f]	0.15	−0.20	1.06	−2.12-2.43	−0.20	0.78	−1.99-1.37	0.03[f]	0.97
Accuracy	−1.48	2.10	-7-1	−0.93	1.66	−4.67-1	1.05[f]	0.30	−0.56	1.26	-4-1	0.01	1.23	-4-1.25	2.10[f]	0.04*
***Non-word** (DDE-2)*																
Speed	−0.46	0.94	−2.14-2.15	−0.10	1.05	−1.96-2.07	1.15[f]	0.26	−0.17	0.91	−2.22-2.17	0.03	0.87	-2-2	0.93[f]	0.36
Accuracy	−1.20	1.40	−4.75-0.6	−0.63	1.32	−4.4-0.8	1.57[f]	0.12	−0.31	1.12	−4.25-1	0.07	0.98	−2.25-1.25	1.46[f]	0.14
***Text** (MT-3)*																
Speed	−0.80	1.07	−2.99-2.27	−0.38	1.15	−2.83-2.45	1.19[f]	0.24	−0.51	1.03	−2.4-1.7	−0.21	0.95	−2.22-1.69	1.24[f]	0.22
Accuracy	−1.94	2.12	-8-0.57	−1.59	1.94	−7.1-0.45	0.70[f]	0.50	−0.99	1.17	−4.75-0.73	−0.89	1.50	−6.49-0.92	0.32[f]	0.75
***Writing** (BVSCO-2)*																
Accuracy	−2.30	3.01	−13.08-1.03	−2.33	2.98	−9.54-1.32	0.04[f]	0.97	−1.84	2.48	−9.04-1.03	−1.30	3.19	−11.06-0.89	1.17[f]	0.25

[a] G1 = Gamification group, APP Orthography Training.
[b] P1 = Pen-and-paper group, Orthography Training.
[c] G2 = Gamification group, APP Developmental Dyslexia.
[d] P2 = Pen-and-paper group, Dyslexia and Sublexical Treatment.
[e] $\chi 2$-value.
[f] T-value.
[*] sig. $\alpha < 0.05$.

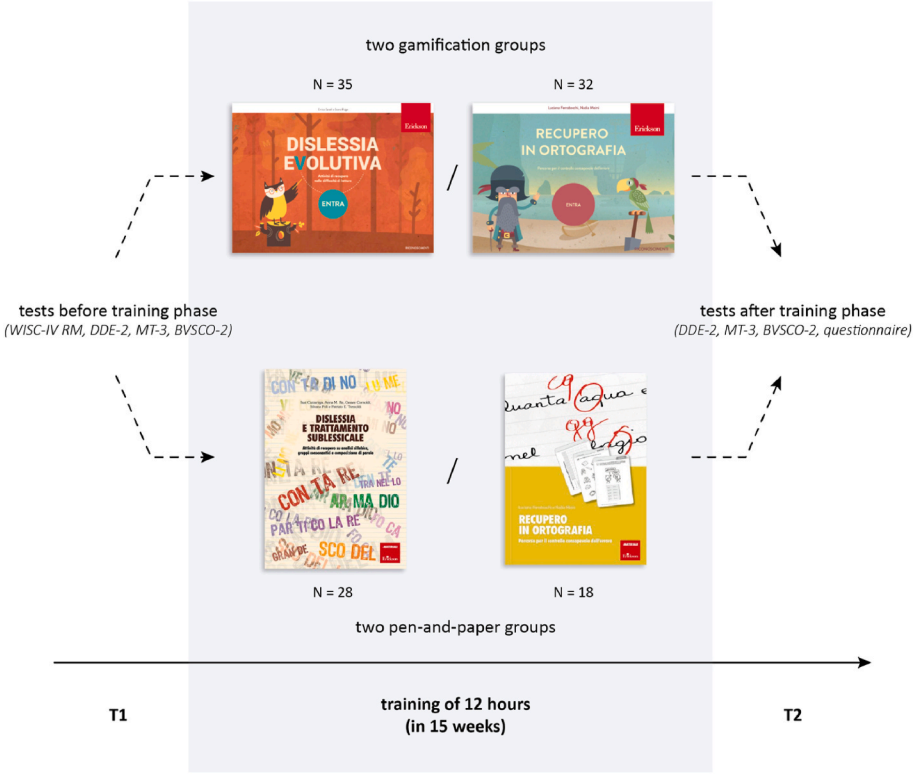

Fig. 1. The procedure of the study.

2. Training activities: for fifteen weeks, a collective and equal class treatment took place, with one 50 min meeting per week, for a total of 12 h;

- gamification groups used the Gamified applications Developmental Dyslexia (Savelli & Pulga, 2016) or Orthography Training (Ferraboschi & Meini, 2016);

- pen-and-paper groups were involved in pen-and-paper activities using Dyslexia and Sublexical Treatment (Cazzaniga et al., 2005) or Orthography Training (Ferraboschi & Meini, 2014).

3. Final assessment of performance (T2): neuropsychological tests investigating reading and writing skills (DDE-2, MT-3, and BVSCO-2) were performed and the Questionnaire about Gameful Experience and Intrinsic Need Satisfaction was submitted to assess children's motivation and general appreciation for the activities.

Regarding the training activities, for both the gamification and pen-and-paper groups, the sessions were conducted in the classroom during regular school hours, under the guidance of the reference teacher and with the presence of two researchers. The specific day of training was determined based on the class's weekly schedule, with the Italian lesson serving as the consistent time slot for each group. During these sessions, each student engaged in the activity individually, with the gamification groups using designated tablets provided by the researchers, while the pen-and-paper groups utilized traditional books, also supplied by the research team.

2.3. Materials

2.3.1. Neuropsychological tests to assess the pre- and post-training

2.3.1.1. Collectively assessment.

- *WISC-IV: Wechsler Intelligence Scale for Children-IV* (Orsini et al., 2012)

The clinical tool serves as an assessment of the cognitive capabilities of children ranging from 6.0 to 16.11 years of age. It is a standardized scale with satisfactory validity and reliability (Orsini et al., 2012). The instrument was standardized on an Italian population and translated (Orsini et al., 2012). The battery comprises ten primary and five additional subtests, crucial for deriving five composite scores. They provide standardized *z-scores* (M = 100; SD = 15) relative to the five indices that are: Verbal Comprehension, Visual Spatial, Working Memory, Processing Speed and the total IQ. For this study, only the Matrix Reasoning subtest was considered, included in the Visual Spatial Index, which provides an estimation of fluid intelligence. It refers to the capacity to think logically and solve problems in novel situations, regardless of prior knowledge. The task requires the child to see an incomplete matrix and selects the better response choosing between different visual options. It was administered collectively in class and the test provides standardized *z-scores* (M = 7; SD = 3).

- BVSCO-2: Battery to assess Writing and Orthography competence (Batteria per la valutazione della scrittura e della competenza ortografica-2, Tressoldi et al., 2013)

It is a comprehensive assessment tool that covers various aspects of the writing skills learning process, following the orthographic learning model which includes alphabetic, orthographic, and lexical phases. It is a clinical Italian instrument for the diagnosis of Developmental Dysorthopraphy and Dysgraphia, with satisfactory validity and reliability (Tressoldi et al., 2013). It evaluates graphism, orthographic competence, and the production of written text, providing estimates of the competence of children in Primary and Lower Secondary Schools. For the research, only the test focusing on orthographic competence was used, specifically the dictation of a specific text suited to each class level. It is administered by a researcher collectively in class, in which the adult reads a text, following the general speed of the group, and the children write in on a white paper. It provides information about the number of errors during the writing process and the typology (phonological, non-phonological, accents and double letters). The different indices provide standardized *z-scores* (M = 0; SD = 1).

2.3.1.2. Individual assessment.

- DDE-2: Battery to asses Developmental Dyslexia and Dysorthopraphy (Batteria per la valutazione della Dislessia e della Disortografia Evolutiva-2, Sartori et al., 2007)

This tool evaluates reading and writing skills and it is a golden standard Italian instrument for the diagnosis of Specific Learning Disorders, specifically Developmental Dyslexia and Dysorthography with high reliability and validity (Sartori et al., 2007). It is suitable for use from the 2nd grade (7-years-old) of Primary School up to the 3rd grade (14-years-old) of Lower Secondary Schools, enabling the measurement of individuals' performance. For this research, the selected tests included word list reading and non-word list reading, which allow for the calculation of speed indices (syllables per second) and accuracy indices (number of errors) in reading ability. It requires a child, individually, to read with a loud voice five short lists of words (112 in total) and three lists of non-words (48 in total). The different indices provide standardized *z-scores* (M = 0; SD = 1).

- *MT-3-Clinical Test (Prove MT-3-clinica,* Cornoldi & Carretti, 2016)

It assesses reading comprehension and decoding abilities in children at the Primary and Lower Secondary School levels. It is a clinical Italian instrument for the diagnosis of Developmental Dyslexia, with satisfactory validity and reliability (Cornoldi & Carretti, 2016). Specifically, for the aims of the research, only the decoding test was used. The task requires the child to read, individually, a text aloud, which allows the calculation of speed index (syllables per second) and accuracy index (number of errors). The text's variation is based on the grade level of the students. The different indices provide standardized *z-scores* (M = 0; SD = 1). The suitability of the texts for different school levels is determined by various factors such as text length, word length, word repetitions, and word frequency.

2.3.2. Instruments used during the training

The selection of gamified tools for training is motivated by the fact that, within the context of the Italian language, they represent relatively unique instruments specifically designed for enhancing writing and reading skills. Furthermore, these applications directly correspond, both structurally and in content, to the equivalent pen and paper exercises offered.

2.3.2.1. Gamified tools.

The applications were installed on mobile devices (tablets) that were different from each other for ergonomic characteristics and manufacturer (Apple: iPad, iPad mini; Samsung Tab S2; Huawei MediaPad T3).

- *Developmental Dyslexia (Dislessia Evolutiva,* Savelli & Pulga, 2016)

The application aims to improve specific aspects of the reading process in children from 6 years of age. It aligns with the Dual-Route Cascaded model of reading (Coltheart et al., 2001) and the developmental framework of reading (Frith, 1986). It allows for the development, automation, and integration of the reading process during a child's development. The App offers personalised paths by combining different tasks to accommodate individual difficulties and the various stages of reading acquisition.

The intervention program is designed with progressively increasing difficulty to foster a sense of achievement. It provides support and assistance features, such as prompts, suggestions, and progression indicators, to prevent frustration and stress that could lead users to abandon the activity. Additionally, audio-visual feedback acts as

reinforcements for performance and enhances the user's immersion.

- *Orthography Training (Recupero in Ortografia,* Ferraboschi & Meini, 2016)

The application focuses on recovering and improving orthographic correctness skills in primary and lower secondary school children. The design of the activities is based on Uta Frith's developmental framework of writing (1986), which emphasises the importance of the alphabetic phase in recognising the relationship between sound and graphemes. Tressoldi and Cornoldi (1991) proposed a classification of errors in the Italian language, including phonological errors (in which the relationship between phoneme and graphene is not respected), non-phonological errors (related to the orthographic representation of words), and errors in accents and double letters (concern the omission or addition of a double letter or accents). The application activities are designed to address these different types of errors and help children develop error awareness and control automatic writing processes.

2.3.2.2. Pen-and-paper activities. Two books were used, Dyslexia and Sublexical Treatment and Orthopraphy Training, and both offer comparable exercises to those found in the two applications.

- *Dyslexia and Sublexical Treatment (Dislessia e trattamento sublessicale,* Cazzaniga et al., 2005*)*

The training activities in the book draw inspiration from Frith's model (1986), particularly focusing on the transitional phase between the alphabetic and lexical phases of reading. The activities aim to reinforce reading strategies that enable the automatic recognition of syllables. The book presents a program comprising six distinct areas of work, each with its objective, and the activities are arranged in sheets that gradually increase in difficulty. Each unit is self-contained and can be combined in various ways to create personalised work plans tailored to address specific difficulties.

- *Orthography Training* (*Recupero in Ortografia,* Ferraboschi & Meini, 2014)

The exercises presented in the book draw inspiration from Frith's model (1986) of the developmental process of writing and encompass the three primary categories of errors: phonological, non-phonological, and errors related to accents and double letters. The book aims to enhance children's error awareness and assist them in acquiring strategies to effectively manage automatic writing processes.

2.3.3. "Gameful Experience and Intrinsic Need Satisfaction" questionnaire

The questionnaire (see Appendix A) used in this study consists of three sections, with the first two sections completed exclusively by children in the experimental groups, focusing on their experience with the gamified applications. The final section was completed by all participants. The first part of the questionnaire aimed to assess and measure the user experience with gamified applications, services, and systems, drawing upon a qualitative approach developed by Högberg et al. (2019). It identified seven dimensions of gaming experiences: accomplishment, challenge, competition, guided, immersion, playfulness, and social experience. The dimensions and corresponding items were presented in a random order, and participants rated their agreement on a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree". The second part of the questionnaire, inspired by recent research by Hassan and Hamari (2019) and Koivisto and Hamari (2019), aimed to explore the participants' motivation, a critical factor in driving and sustaining behavior. It examined elements related to motivation, including immersion (avatar, guiding character, narrative context, personalization), achievement (challenges, trophies, feedback, progression), social aspects (competition), and prompts. Participants indicated the frequency of their interactions with specific gamified elements on a 7-point Likert scale ranging from "never" to "every time," as well as the importance they attributed to these interactions, ranging from "not important" to "very important". The third part of the questionnaire focused on assessing the participants' needs for competence, autonomy, and relatedness. Using a 7-point Likert scale, participants indicated the extent to which statements regarding their experience with the apps or their performance in pen-and-paper activities were true for them. This section drew upon the work of McAuley et al. (1989) and Richer and Vallerand (1998). The choice of this questionnaire, created specifically for adults, was supported by the authors of the tools, who requested to test it, without any modification, on children population. Additionally, participants were asked to rate the overall level of fun they perceived during the training activities on a 7-point Likert scale, ranging from "not fun" to "highly fun".

3. Results

The analysis has been done by using the software R-Studio (R Core Team, 2021). The data were assessed for normal distribution and homogeneity using the Shapiro-Wilk and Levene's tests (Uttley, 2019). Repeated measures analysis of variance (ANOVA) was employed to examine longitudinal changes when assumptions were met. Conversely, when violations of assumptions were present, paired Wilcoxon signed rank tests with continuity correction were conducted. Significant results were further analyzed through post-hoc tests using the Tukey method. The data are available on Open Science Framework (OSF).

3.1. Reading and writing skills after training

The first research question (RQ1) focused on analysing the impact of training from the pre-test at T1 to the post-test at T2. To evaluate the training effect on reading and writing skills, Repeated Measures ANOVAs were performed, considering Time (T1, T2) and Measure (Word, Non-word, Text) as within-subject factors. Detailed results of these analyses are presented in Tables 2 and 3. In line with our hypotheses, there were significant improvements in reading and writing skills, both for gamification and pen-and-paper groups.

Reading speed. A significant Time effect was observed, as children made significant improvements in their speed of reading individual words, whether they were real words or not, as well as words presented within a context. Post-hoc analyses confirmed that gamification groups showed significant enhancements in their reading speed for words, non-words, and text, similarly, the children in pen-and-paper groups.

Reading accuracy. Similarly, in terms of reading accuracy, the Time factor showed a significant interaction across all measures. However, post-hoc analysis revealed that only children in gamification groups demonstrated significant improvements in nearly every index (words, non-words, and text). On the other hand, children in pen-and-paper groups did not show significant improvements.

Writing accuracy. A significant Time effect was observed, for all groups, in writing accuracy. Post-hoc analyses also demonstrated significant differences for both gamification and pen-and-paper groups.

3.2. Comparison between gamification and pen-and-paper groups

To analyse the training effect, between gamification and pen-and-paper groups (RQ2), on improvement index (Δ) of writing and reading abilities from pre-to post-training, a MANOVA was run, with Group (G1, G2, P1, P2) as between-subject factor.

Contrary to our hypotheses, the findings indicated that there was no significant difference in the improvement of reading and writing skills between the gamification and pen-and-paper groups. Univariate tests further confirmed that there were no significant differences between the paired groups (Table 4). In conclusion, both gamification and pen-and-

Table 2
Intraindividual training effects of gamification groups on reading and writing skills [Means (SD)].

	G1 group (n = 32)		*F value*[a]	*p*[b]	*ES*[c]	G2 group (n = 35)		*F value*[a]	*p*[b]	*ES*[c]
	T1	T2				T1	T2			
Word										
Speed	−0.72 (1.04)	0.08 (1.30)	64.27	<.001	0.68	−0.20 (1.06)	0.59 (1.10)	39.14	<.001	0.73
Accuracy	−1.48 (2.10)	−0.46 (1.23)	18.89	<.001	0.59	−0.56 (1.26)	0.02 (0.87)	15.23	<.001	0.53
Non-word										
Speed	−0.46 (0.94)	0.16 (1.15)	56.64	<.001	0.59	−0.17 (0.91)	0.44 (0.78)	15.23	<.001	0.72
Accuracy	−1.20 (1.40)	−0.45 (1.11)	29.72	<.001	0.59	−0.31 (1.12)	−0.10 (0.91)	15.23	<.001	0.20
Text										
Speed	−0.80 (1.07)	−0.06 (1.15)	98.02	<.001	0.67	−0.51 (1.03)	0.38 (1.16)	106.6	<.001	0.81
Accuracy	−1.94 (2.12)	−0.65 (1.33)	23.58	<.001	0.73	−0.99 (1.17)	−0.26 (0.82)	29.57	<.001	0.72
Writing										
Accuracy	−1.94 (2.12)	−1.00 (1.79)	32.61	<.001	0.48	−1.84 (2.48)	−0.20 (1.28)	44.09	<.001	0.83

[a] Time (T1-T2) x Group interaction (G1 = Gamification group, Application Orthography Training; G2 = Gamification group, Application Developmental Dyslexia).
[b] Test significance *p < .05, **p < .01, ***p < .001.
[c] Effect sizes of interaction Time: Group expressed as Cohen's d (0.01 very small, 0.20 small, 0.50 medium, 0.80 large).

Table 3
Intraindividual training effects of pen-and-paper groups on reading and writing skills [Means (SD)].

	P1 group (n = 18)		*F value*[a]	*p*[b]	*ES*[c]	P2 group (n = 28)		*F value*[a]	*p*[b]	*ES*[c]
	T1	T2				T1	T2			
Word										
Speed	−0.19 (1.19)	0.42 (1.27)	38.86	<.001	0.49	−0.20 (0.78)	0.62 (0.85)	56.31	<.001	1.00
Accuracy	−0.93 (1.66)	−0.35 (1.48)	5.36	.033	0.37	0.01 (1.23)	0.12 (0.81)	0.59	.448	0.10
Non-word										
Speed	−0.10 (1.05)	0.32 (1.22)	11.82	.003	0.37	0.03 (0.87)	0.67 (0.98)	47.67	<.001	0.69
Accuracy	−0.63 (1.32)	0.39 (1.22)	1.47	.242	0.80	0.07 (0.98)	0.32 (0.89)	9.08	.005	0.27
Text										
Speed	−0.38 (1.15)	0.02 (1.12)	7.19	.015	0.35	−0.21 (0.95)	0.43 (0.94)	33.08	<.001	0.68
Accuracy	−1.59 (1.94)	−1.08 (1.75)	2.49	.133	0.28	−0.89 (1.50)	−0.32 (1.11)	18.35	<.001	0.43
Writing										
Accuracy	−2.33 (2.98)	−1.10 (1.89)	23.97	<.001	0.49	−1.30 (3.19)	−0.18 (1.04)	24.33	<.001	0.47

[a] Time (T1-T2) x Group interaction (P1 = Pen-and-paper group, Orthography Training; P2 = Pen-and-paper group, Dyslexia and Sublexical Treatment).
[b] Test significance *p < .05, **p < .01, ***p < .001.
[c] Effect sizes of interaction Time: Group expressed as Cohen's d (0.01 very small, 0.20 small, 0.50 medium, 0.80 large).

Table 4
Interindividual training effects of gamification and pen-and-paper groups on improvement in reading and writing skills.

		G1 - P1		G2 - P2	
		F value[a]	p[b]	F value[a]	p[b]
Word	Speed	0.83	0.36	0.01	0.90
	Accuracy	0.08	0.78	0.25	0.62
Non-word	Speed	0.20	0.66	1.10	0.30
	Accuracy	0.03	0.87	3.43	0.07
Text	Speed	0.06	0.81	0.04	0.84
	Accuracy	0.96	0.33	0.06	0.81
Writing	Accuracy	0.04	0.85	0.004	0.95

[a] Time (Δ) x Group interaction (G1 = Gamification group, Application Orthography Training; P1 = Pen-and-paper group, Orthography Training; G2 = Gamification group, Application Developmental Dyslexia; P2 = Pen-and-paper group, Dyslexia and Sublexical Treatment).
[b] Test significance *p < .05, **p < .01, ***p < .001.

paper training determined an improvement in the reading and writing skills, without a superior efficacy of the two typologies.

3.3. Fun and motivation effects on performances

The analysis of the feedback questionnaire revealed that the training received positive reception, as a majority of the children expressed high levels of approval for both gamified activities (M = 5.98, SD = 1.51) and traditional activities (M = 6.32, SD = 1.15) on a Likert scale ranging from 1 to 7, where 7 indicated the highest level of enjoyment (Fig. 2). An

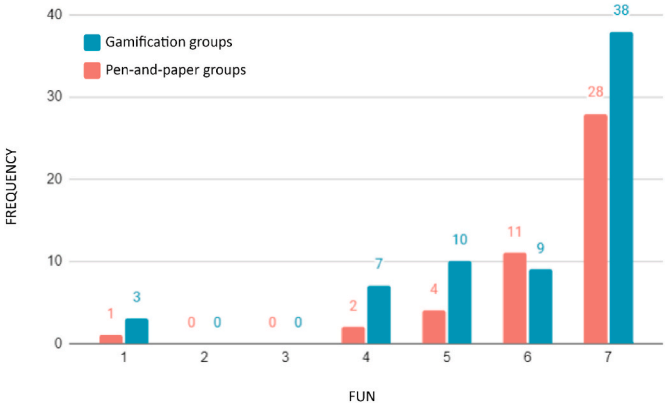

Fig. 2. Participant's perception of fun for both gamification and pen-and-paper conditions [Likert scale: 1 indicates "little", 7 indicates "a lot"].

Independent Samples *t*-test was conducted to compare the level of satisfaction between males and females in both conditions, but no statistically significant differences were observed (p = .249).

To address the research question regarding the impact of fun experienced during the training activities on improvements in reading and writing skills (RQ3), a multiple regression analysis was performed. Contrary to our hypotheses, the analysis did not reveal any significant effects, indicating that the level of enjoyment did not have a significant impact on performance improvements.

To assess the potential mediating effect of intrinsic psychological

needs on performance improvements resulting from different training approaches (RQ3), a causal mediation analysis was conducted. This analysis aimed to explore the role of intrinsic psychological needs as a potential mechanism through which the training approaches influenced performance outcomes.

The third part of the questionnaire, although based on validated instruments (McAuley et al., 1989; Richer & Vallerand, 1998), was created and directly used in the study without a previous validation process in the Italian context. It is composed of three subscales: the *competence* subscale ($\alpha = 0.72$), the *autonomy* subscale ($\alpha = 0.56$), and the *relatedness* subscale ($\alpha = 0.83$; Cronbach's α: $0.9 \leq \alpha$ excellent, $0.8 \leq \alpha < 0.9$ good, $0.7 \leq \alpha < 0.8$ acceptable, $0.6 \leq \alpha < 0.7$ questionable, $0.5 \leq \alpha < 0.6$ poor, $\alpha < 0.5$ unacceptable). No significant difference was observed between the gamification and pen-and-paper groups in terms of the children's reported satisfaction of psychological needs. Using a bootstrap confidence interval of 95% the findings, contrary to our hypotheses, indicated that there was no mediation in the model, meaning that the performance improvements were not influenced by psychological needs satisfaction (Fig. 3 and Table 5).

4. Discussion

With the hereby presented study we aimed to address the following questions. The first concerns the impact of gamified applications on reading and writing skills. The second question is related to comparing the effect of gamified tools to traditional pen-and-paper activities. The third research question concerns the influence of motivational and engagement processes on the different types of training. The last is related to the analyses of the effect of different gameful experiences on improvements in reading and writing abilities.

Firstly, as expected, noticeable learning enhancements were observed after 12 h of training, as a result of the specific focus of the applications and textbook used for reading and writing skills development. This improvement was evident in children, aged 8 to 10, that used gamified and traditional pen-and-paper activities. After training, all groups showed significant improvements in learning performances, in line with the literature (Landers, 2014; Lee & Hammer, 2011; Lister, 2015). Specifically, both reading speed and accuracy improved for words, non-words, and texts, indicating that the different training approaches effectively enhanced children's reading and writing skills. The same findings are present in literature (Cheung & Slavin, 2012; Pasqualotto, Altarelli, et al., 2022). The results suggested that the two reading strategies, namely the lexical and sublexical approaches, worked together effectively (Coltheart et al., 2001). There was a greater emphasis on the lexical approach, where the word's meaning is first retrieved before accessing its pronunciation. This led to an increase in reading speed, particularly when encountering frequently occurring regular and irregular words. The exercises focusing on individual word units contributed to a faster conversion process, thus positively impacting reading speed. However, there was a less frequent significant improvement in reading accuracy. This could be attributed to the increased reading speed, which raised the likelihood of errors and reduced reliance on the sublexical reading strategy when encountering new or less common words.

Moreover, significant improvements in writing skills were observed between pre- and post-training performances, like the study of Wollscheid et al. (2016). A collaboration was observed between the phonological and lexical approaches to writing. The phonological approach involves the use of traditional phoneme-graphene conversion rules to write infrequent regular words, while the lexical approach allows direct access to a mental store of whole word forms for writing irregular words (Tressoldi & Vio, 2012). This finding aligns with the developmental framework of writing (Frith, 1986), which suggests a transition from the alphabetic to the orthographic stage in 3rd grade (8–9 years old). In the orthographic stage, the speed of writing is no longer affected by word length or graphene complexity but is influenced by the nature and frequency of the whole word. For the 4th (9–10 years old) and 5th (10–11 years old) grades, there is a further transition to the lexical stage, where the orthographic form of a word is retrieved from a specific mental lexicon, leading to faster writing and reduced loss of information during dictation tasks.

Although there were no statistically significant differences in post-training performances between groups that used gamified applications and groups that engaged in pen-and-paper activities. However, it is worth noting that the experimental conditions showed greater improvements, which aligns with the initial expectations. These results are

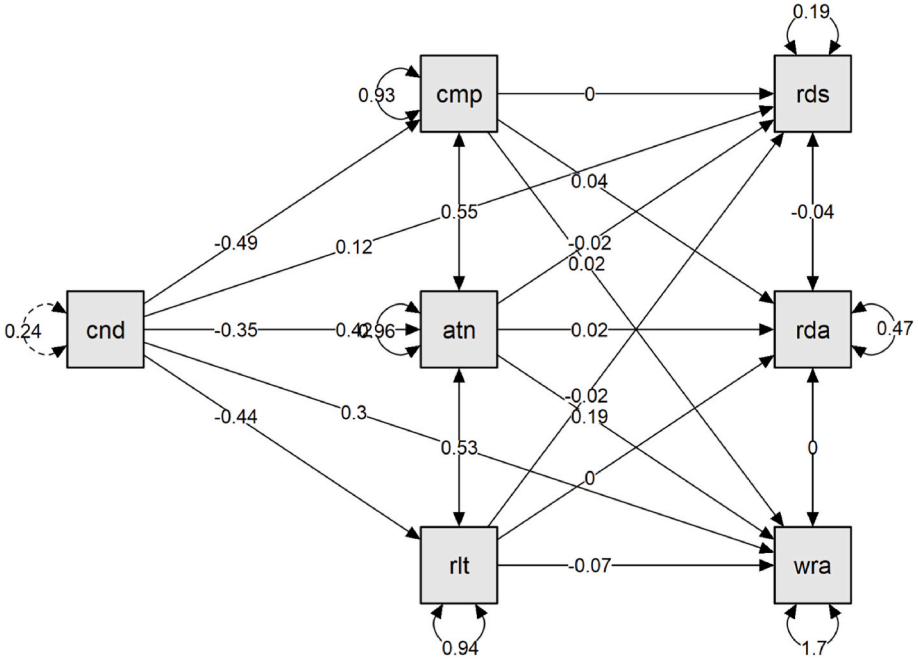

Fig. 3. Path plot of causal mediation analysis model. X is the training condition ('cnd'), Y is performance improvements in term of Total Reading Speed ('rds'), Total Reading Accuracy ('rda'), and Total Writing Accuracy ('wra'), and M are the mediating variables of Competence ('cmp'), Autonomy ('ant'), and Relatedness ('rlt').

Table 5
Direct, Indirect, and Total effects of the causal mediation analysis model.

Direct effects								
			estimate	std. error	*z-value*	*p*	95% Confidence Interval	
							lower	upper
Condition	→	Reading Speed	0.117	0.087	1.345	0.179	−0.052	0.288
Condition	→	Reading Accuracy	0.416	0.137	3.044	0.002	0.155	0.653
Condition	→	Writing Accuracy	0.303	0.258	1.174	0.240	−0.131	0.777

Indirect effects										
					estimate	std. error	*z-value*	*p*	**95% Confidence Interval**	
									lower	upper
Condition	→	Competence	→	Reading Speed	<.001	0.028	−0.036	0.972	−0.075	0.058
Condition	→	Autonomy	→	Reading Speed	0.008	0.020	0.424	0.671	−0.026	0.071
Condition	→	Relatedness	→	Reading Speed	0.007	0.025	0.275	0.783	−0.051	0.075
Condition	→	Competence	→	Reading Accuracy	−0.021	0.044	−0.471	0.638	−0.126	0.062
Condition	→	Autonomy	→	Reading Accuracy	−0.007	0.030	−0.236	0.814	−0.111	0.037
Condition	→	Relatedness	→	Reading Accuracy	<.001	0.038	−0.026	0.979	−0.090	0.072
Condition	→	Competence	→	Writing Accuracy	−0.010	0.082	−0.126	0.899	−0.236	0.207
Condition	→	Autonomy	→	Writing Accuracy	−0.065	0.067	−0.977	0.328	−0.243	0.007
Condition	→	Relatedness	→	Writing Accuracy	0.031	0.073	0.427	0.669	−0.178	0.399

Total effects							
			estimate	std. error	*z-value*	*p*	**95% Confidence Interval**	
							lower	upper
Condition	→	Reading Speed	0.131	0.084	1.555	0.120	−0.028	0.305
Condition	→	Reading Accuracy	0.387	0.132	2.924	0.003	0.127	0.616
Condition	→	Writing Accuracy	0.259	0.252	1.030	0.303	−0.204	0.757

consistent with previous studies (Domínguez et al., 2013; Hanus & Fox, 2015; Katz et al., 2014; Toda et al., 2017) that also found no statistically significant difference in effectiveness between gamified training and traditional training methods. This suggests that both treatments are effective. Therefore, it can be concluded that the two methodologies (Caponetto et al., 2014), which are evidence-based and valid strategies, can be used in conjunction to enhance the learning process, like suggested by Cheung and Slavin in a previous research (2012).

Moreover, we analyse the influence of motivation during the learning process. It plays a crucial role in this, as it drives individuals to initiate and sustain actions toward achieving goals. Intrinsic motivation, derived from internal and autonomous regulation, promotes interest, motivation, psychological well-being, and performance improvement, according to SDT (Deci & Ryan, 1985). *Gamification*, operating between introjected and identified regulation dimensions, encourages individuals to desire improvement through an extrinsic reward system, indirectly enhancing intrinsic motivation (Legault, 2017; Ryan & Deci, 2000). It provides an enjoyable, stimulating, and constructive experience that satisfies the psychological needs of *competence, autonomy, and relatedness* (Deci & Ryan, 2000). Based on these needs, individuals try to realise their potential and continuously learn and develop skills (Ryan & Deci, 2002).

While studies have shown how *gamification* can enhance the satisfaction of these needs during the learning process (Kapp, 2012), there are also contradictory or insignificant findings, such as in the present research neither the enjoyment derived from the activities nor the satisfaction of Intrinsic Needs had a significant positive or mediating impact on performance after the training period in any of the subject groups. The design elements of a game can satisfy competence and relatedness but may not fully address autonomy (Sailer et al., 2017). Additionally, *gamification* affordances can act as both extrinsic and intrinsic motivators depending on the context and individual factors (Deterding, 2011). Proper design is crucial for desired effects, and attention should be given to the psychological needs, personality, and motivations of users (Dalmina et al., 2019; Gee, 2003; Karanam et al., 2014). Motivational experiences vary between individuals and have different effects based on user types and situational and contextual elements (Huotari & Hamari, 2012; Seaborn & Fels, 2015; van Roy & Zaman, 2019). Nevertheless, it's worth noting that the questionnaire was initially designed for an adult population, and children encountered challenges during its completion. The decision to employ the questionnaire in its original form was a direct request from the tool's authors, who aimed to assess its applicability to a diverse demographic, including children in primary schools. It appears that these tools may prove effective for an older sample, yet for younger participants, it may be crucial to introduce certain modifications and simplifications to the items to enhance comprehension of the questions. Although there was no significant mediating effect, it is important to note, particularly at a qualitative level, the satisfaction reported by the children who participated in the different training activities. In fact, in the enjoyment questionnaire of the proposed activities, there was a greater appreciation for the use of gamified software in improving reading and writing skills compared to traditional pen-and-paper activities (Lee et al., 2013). The increased fun and engagement perceived by children during learning activities could be considered by teachers when designing initiatives and exercises in the classrooms. Pupils perceived these activities as games, evoking positive emotions. Play is a well-established modality through which children acquire new skills (Huizinga, 2014). Therefore, integrating gamification into the traditional classroom activities could enhance children's competencies and skills during school time.

4.1. Limitations and future research

The primary limitation concerns the concluding questionnaire, where children often encountered difficulties in understanding the questions and sought frequent clarifications. This aspect potentially compromised the response of individuals, leading to inaccurate answers at times. To address this limitation, future analyses could consider the age, or the specific school year attended by the children. It would be valuable to explore differences in the level of appreciation of the activities across different classes and conduct correlations between gender and age concerning the participants' final performance. Additionally, the questionnaire was administered only after the training phase, whereas it could have been beneficial to have it at the beginning as well.

This would have allowed for the observation of potential differences or significant changes before and after the training activities, enabling the examination of whether the type of training had a mediating effect on changes in intrinsic motivation. Another limitation is related to the implementation of different training programs at school. Although the exercises provided were suitable for the participants' age and abilities, resulting in positive outcomes in terms of performance and engagement, they were not tailored to the specific needs of the school groups. Instead, they were the same for all participants. As a result, some students found the activities appropriate for their skills, while others found them either too easy or too challenging, leading to feelings of frustration and anxiety. It is worth noting that even with the most well-received gamified activities, some children perceived the training as repetitive exercises. Therefore, there is a potential for improvement in the design of the applications used or the exploration of different software. These aspects could have influenced the motivation of the students, their proactivity, and ultimately their performance after the training. To overcome this limitation, it could be useful to consider the age or the class attended by the children in the final analyses. Specifically, it could be interesting to analyse the differences in the level of appreciation of the activities between different classes and conduct some correlation between gender and age on the final performance. Another limitation regards the study design. In this project, it was not foreseen that pen-and-paper groups would carry out the gamified experience at the end of the training, allowing them to try more fun and engaging activities than the traditional ones. In future research, it would be useful to give the possibility to the different groups to try all the conditions, both gamified and pen and paper exercises in order to have for each child all benefits that this project could take.

4.2. Conclusions

The present research aimed to assess the effectiveness of using gamified digital software, compared to traditional pen-and-paper activities, in improving motivation, involvement, and reading and writing skills. The intervention activities were carried out using a tablet or traditional books in school settings. Gamified applications demonstrate a level of effectiveness in improving student performance that is comparable to traditional pen-and-paper exercises. However, during gamified activities, pupils reported a higher level of satisfaction and engagement compared to the traditional training. This implies that both methodologies are valid and can complement each other in supporting educational outcomes. The innovative form of digital teaching, means gamified activities, holds significant educational benefits for both students and teachers. For instance, students would receive immediate feedback, have clear objectives in their tasks, and learn from their mistakes without fear of judgment. This combination of teaching methods can enhance students' proactivity, motivation, and engagement in the learning process, whereas for teachers gamified applications can serve as an integrative tool. They can help achieve general learning objectives for the entire class while addressing individual students' specific needs through targeted exercises, using an individualization and personalization approach. Finally, gamified applications also offer a valuable tool for remote teaching, especially in the current context.

CRediT authorship contribution statement

Angela Cattoni: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Francesca Anderle:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Paola Venuti:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Angela Pasqualotto:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

I share the link to my data on OSF. Link: https://osf.io/yp8x4/?view_only=f52762479cda4211865267b8550f876f.

Appendix A. Questionnaire about Gameful Experience and Intrinsic Need Satisfaction

Construct	Item	Scale (Likert 7)	Developmental Dyslexia	Orthography Training	Pen-and-pencil activities
	How much fun did you have playing [APP]?	little/a lot	x	x	x
	Please indicate how much you agree with the following statements, regarding your feelings while using [APP]. Overall, [APP] …	disagree/agree			
Accomplishment	Makes me feel that I need to complete things	disagree/agree	x	x	
Accomplishment	Pushes me to strive for accomplishments	disagree/agree	x	x	
Accomplishment	Inspires me to maintain my standards of performance	disagree/agree	x	x	
Accomplishment	Makes me feel that success comes through accomplishments	disagree/agree	x	x	
Accomplishment	Makes me strive to take myself to the next level	disagree/agree	x	x	
Accomplishment	Motivates me to progress and get better	disagree/agree	x	x	
Accomplishment	Makes me feel like I have clear goals	disagree/agree	x	x	
Accomplishment	Gives me the feeling that I need to reach goals	disagree/agree	x	x	
Challenge	Makes me push my limits	disagree/agree	x	x	
Challenge	Drives me in a good way to the brink of wanting to give up	disagree/agree	x	x	
Challenge	Pressures me in a positive way by its high demands	disagree/agree	x	x	
Challenge	Challenges me	disagree/agree	x	x	
Challenge	Calls for a lot of effort in order for me to be successful	disagree/agree	x	x	
Challenge	Motivates me to do things that feel highly demanding	disagree/agree	x	x	
Challenge	Makes me feel like I continuously need to improve in order to do well	disagree/agree	x	x	
Challenge	Makes me work at a level close to what I am capable of	disagree/agree	x	x	
Competition	Feels like participating in a competition	disagree/agree	x	x	
Competition	Inspires me to compete	disagree/agree	x	x	
Competition	Involves me by its competitive aspects	disagree/agree	x	x	
Competition	Makes me want to be in first place	disagree/agree	x	x	
Competition	Makes victory feel important	disagree/agree	x	x	

(*continued on next page*)

(*continued*)

Construct	Item	Scale (Likert 7)	Developmental Dyslexia	Orthography Training	Pen-and-pencil activities
Competition	Feels like being in a race	disagree/agree	x	x	
Competition	Makes me feel that I need to win to succeed	disagree/agree	x	x	
Guided	Makes me feel guided	disagree/agree	x	x	
Guided	Gives me a sense of being directed	disagree/agree	x	x	
Guided	Makes me feel like someone is keeping me on track	disagree/agree	x	x	
Guided	Gives me the feeling that I have an instructor	disagree/agree	x	x	
Guided	Gives me the sense I am getting help to be structured	disagree/agree	x	x	
Guided	Gives me a sense of knowing what I need to do to do better	disagree/agree	x	x	
Guided	Gives me useful feedback so I can adapt	disagree/agree	x	x	
Immersion	Gives me the feeling that time passes quickly	disagree/agree	x	x	
Immersion	Grabs all of my attention	disagree/agree	x	x	
Immersion	Gives me a sense of being separated from the real world	disagree/agree	x	x	
Immersion	Makes me lose myself in what I am doing	disagree/agree	x	x	
Immersion	Makes my actions seem to come automatically	disagree/agree	x	x	
Immersion	Causes me to stop noticing when I get tired	disagree/agree	x	x	
Immersion	Causes me to forget about my everyday concerns	disagree/agree	x	x	
Immersion	Makes me ignore everything around me	disagree/agree	x	x	
Immersion	Gets me fully emotionally involved	disagree/agree	x	x	
Playfulness	Gives me an overall playful experience	disagree/agree	x	x	
Playfulness	Leaves room for me to be spontaneous	disagree/agree	x	x	
Playfulness	Taps into my imagination	disagree/agree	x	x	
Playfulness	Makes me feel that I can be creative	disagree/agree	x	x	
Playfulness	Gives me the feeling that I explore things	disagree/agree	x	x	
Playfulness	Feels like a mystery to reveal	disagree/agree	x	x	
Playfulness	Gives me a feeling that I want to know what comes next	disagree/agree	x	x	
Playfulness	Makes me feel like I discover new things	disagree/agree	x	x	
Playfulness	Appeals to my curiosity	disagree/agree	x	x	
Social experience	Gives me the feeling that I'm not on my own	disagree/agree	x	x	
Social experience	Gives me a sense of social support	disagree/agree	x	x	
Social experience	Makes me feel like I am socially involved	disagree/agree	x	x	
Social experience	Gives me a feeling of being connected to others	disagree/agree	x	x	
Social experience	Feels like a social experience	disagree/agree	x	x	
Social experience	Gives me a sense of having someone to Share my endeavors with	disagree/agree	x	x	
Social experience	Influences me through its social aspects	disagree/agree	x	x	
Social experience	Gives me a sense of being noticed for what I have achieved	disagree/agree	x	x	
	Please estimate the average frequency/importance of interacting with the following dimensions of [APP].				
Immersion	The frequency of interacting with character guide	never/every time	x	x	
Immersion	The importance of the character guide	unimportant/important	x	x	
Immersion	The frequency of interacting with customisation of avatar	never/every time		x	
Immersion	The importance of the customisation of avatar	unimportant/important		x	
Immersion	The frequency of interacting with customisation of character guide	never/every time	x		
Immersion	The importance of the customisation of character guide	unimportant/important	x		
Immersion	The frequency of interacting with narrative	never/every time		x	
Immersion	The importance of narrative	unimportant/important		x	
Progression	The frequency of interacting with trophies	never/every time		x	
Progression	The importance of trophies	unimportant/important		x	
Progression	The frequency of interacting with the customisation of increasingly difficult tasks	never/every time	x		
Progression	The importance of the customisation of increasingly difficult tasks	unimportant/important	x		
Progression	The frequency of interacting with performance statistics	never/every time	x	x	
Progression	The importance of performance statistics	unimportant/important	x	x	
Progression	The frequency of interacting with progress indicators	never/every time	x	x	
Progression	The importance of progress indicators	unimportant/important	x	x	
Progression	The frequency of interacting with visual/audio guide feedback	never/every time	x	x	
Progression	The importance of visual/audio guide feedback	unimportant/important	x	x	
Progression	The frequency of interacting with retry option	never/every time	x	x	

(*continued on next page*)

(*continued*)

Construct	Item	Scale (Likert 7)	Developmental Dyslexia	Orthography Training	Pen-and-pencil activities
Progression	The importance of retry option	unimportant/ important	x	x	
Social	The frequency of interacting with competition	never/every time	x	x	
Social	The importance of competition	unimportant/ important	x	x	
Prompts	The frequency of interacting with character guide to receive help	never/every time		x	
Prompts	The importance of character guide to receive help	unimportant/ important		x	
Prompts	The frequency of interacting with lifebelt to receive help	never/every time	x		
Prompts	The importance of the lifebelt to receive help	unimportant/ important	x		
	For each of the following statements regarding the use of [APP], please indicate how true it is for you.				
Competence	I think I am pretty good at [APP] activities	untrue/true	x	x	x
Competence	I am satisfied with my performance at [APP] tasks	untrue/true	x	x	x
Competence	After working at [APP] activities for a while, I felt pretty competent	untrue/true	x	x	x
Autonomy	I believe I had some choice about doing [APP] activities	untrue/true	x	x	x
Autonomy	I felt like I had to do [APP] activities (R)	untrue/true	x	x	x
Autonomy	I did [APP] activities because I wanted to	untrue/true	x	x	x
Relatedness	When I used [APP], I felt supported by my classmates	untrue/true	x	x	x
Relatedness	When I used [APP], I felt understood by my classmates	untrue/true	x	x	x
Relatedness	When I used [APP], I felt valued by my classmates	untrue/true	x	x	x

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