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Enhancing spelling competence for English as a foreign language young learners through digital escape rooms

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This study examines the efficacy of using a digital gamed platform in acquiring phoneme-grapheme correspondences of closed syllables with short vowels. Fifty-five fourth-grade English as a Foreign Language (EFL) learners navigated through five digital escape rooms where they learned, practiced, and produced target graphemes. Mixed methods analyses found that spelling competence in the intervention group as opposed to the control group improved in the post-test and continued to improve significantly in the delayed post-test. Following analysis of the participant interviews four themes emerged. Autonomous learning and self-monitoring were the dominant themes followed by engagement and motivation, self-confidence and self-esteem, and peer learning and social interaction in decreasing order of prevalence. Combining learning with play while participants navigated within the digital learning environment proved to be an effective method of teaching young EFL learners to spell. The results of this intervention contribute to recent research in the post-COVID-19 era and mirror OECD goals for the 21st century which have highlighted the need for effective digital platforms that promote independent learning while maximizing student engagement.

KEYWORDS

EFL (English as a foreign language), digital gamed learning, spelling, class intervention, early literacy

1 Introduction

Spelling is central to literacy acquisition since it cements written language in memory, thus unburdening cognitive resources that are freed to focus on the message (Grünke and Skirde, 2022; Kahn-Horwitz, 2020). When young English Foreign Language (EFL) learners begin their literacy journey, learning to spell adds an essential layer to word knowledge (Nation, 2002). Word knowledge has a positive impact on reading and writing (Laufer and Ravenhorst-Kalovski, 2010) and is an essential foundation for developing readers (Kim, 2017). Acquiring spelling competence, an integral component of word knowledge, is more complex than learning to read since it involves retrieving accurate word renditions from memory (Ehri, 2000; Mather and Jaffe, 2021). Spelling is important for literacy acquisition since learning about the alphabetic system and the orthographic form of words contributes to word pronunciation and meaning in memory and assists with word retrieval (Ehri, 2014; Perfetti and Hart, 2002). Emergent readers benefit from explicit teaching on their path

toward literacy (Galuschka et al., 2020; O'Leary and Ehri, 2020), especially for EFL learners who do not have a strong English background (Kahn-Horwitz, 2020).

For young English learners, spelling involves making phoneme-grapheme and grapheme-phoneme connections and learning about graphotactic patterns of the written script (Treiman, 2018). Spelling in a first language (L1) environment occurs after young learners have had many years of oral exposure to the language. Consequently, these L1 learners benefit from their familiarity with the language, supporting their literacy journey (Singh et al., 2021). EFL spelling acquisition does not provide this familiar language context and thus creates challenges. These challenges include EFL learners contending with matching phonemes to graphemes and graphemes to phonemes that are unfamiliar to them in a foreign script (Sammour-Shehadeh et al., 2022).

Treiman and Kessler (2022) demonstrated that statistical learning of orthographic and graphotactic patterns of English in an L1 environment is insufficient for young learners to acquire spelling. Instead, young learners need explicit teaching of these rules and patterns to boost their acquisition. A systematic approach to phonics instruction produces superior outcomes compared to non-systematic instruction (Castles et al., 2018; Ehri et al., 2001; Ricketts et al., 2011; Torgerson et al., 2006). Learning to encode and decode complex English orthography is crucial, especially for individuals who find it challenging (Weiser and Mathes, 2011). Explicit learning of orthographic patterns could be considered particularly imperative in an EFL setting where students have less exposure to the language's phonology and the written script. Positive correlations between explicit teaching and learning of orthographic patterns have been documented for both strong and less proficient individuals in an EFL, L1-Hebrew setting (Kahn-Horwitz, 2020).

The English language has a deep orthography, making learning to spell one of the more challenging aspects of becoming literate in this tongue (Katz and Frost, 1992; Moats, 2014; Pacton and Fayol, 2004). The regularity in the closed syllable words, usually the first words taught in a beginner phonics program, needs to be exploited (Fowler and Shankweiler, 2004). This regularity could speed up processes in memory, thus leading to automaticity, increasing the speed of spelling, and reading, and ultimately enhancing reading comprehension (Graham and Santangelo, 2014).

In an L1-Hebrew environment, young students reading English must contend with the variety of differences in English compared to their native language. For L1-Hebrew learners, English is a novel script; it is read from left to right, which is the opposite direction to the way Hebrew is read, and there are novel phonemes in English that pose significant challenges to young individuals (Kahn-Horwitz et al., 2011). Learning about the literacy components of a word, such as orthographic conventions and morphemes that comprise words, may assist learners in understanding, pronouncing, reading, and spelling words, which are the building blocks of the language (Vaisman and Kahn-Horwitz, 2020). In addition, EFL teachers who instruct students at all levels acknowledge the importance of teaching spelling and are eager to learn more to assist their learners in becoming literate (Saban and Kahn-Horwitz, 2022).

Thus, spelling activities need to be part of regular EFL classroom practice. Mastering a foreign language involves both cognitive and emotional processes. Academic success has long been

explained by a person's intelligence or cognition, while affective aspects of learning have relatively recently been co-opted into what accounts for academic success (Greenberg et al., 2017; Taheri et al., 2019). Positive or negative emotions are inseparable from the way an EFL student may choose to engage or avoid the learning process (Garrett and Young, 2009). Both cognitive and emotional factors play a crucial role in how an individual acquires proficiency in a second language (Melani et al., 2020; Swain, 2013).

Pishghadam et al. (2016) have categorized the emotions linked with each aspect of learning in an EFL context. Of all the skills, listening was the one that stood out for its associations with negative emotions. This could be explained by the fact that listening demands EFL learners to handle various complex challenges concurrently (Kim, 2017). Learners must identify new sounds while simultaneously trying to make meaning out of them. In addition, the absence of a visual stimulus in listening tasks makes this deciphering process challenging. Listening to a video clip could alleviate some of this frustration for EFL learners since the learner can focus on the facial expressions, lip-read, and gain contextual clues rather than just having to make meaning from the sounds (Woottipong, 2014). This could assist young learners in their literacy journey, whereby listening is part of making phoneme-grapheme connections. The teacher's role in alleviating stress in the EFL classroom is also central to ensuring positive learning outcomes. Code-switching, or more recently the concept of translanguaging that incorporates the learners' integration of their full language repertoire in the foreign language learning context including the use of learners' L1 in an EFL environment, has been cited as an effective way to create an emotionally supportive environment for acquiring EFL (Canagarajah, 2011; Suganda et al., 2021).

Motivating learners is challenging, especially in a foreign language setting and this can be enhanced when the basic needs of learners defined by self-determination theory are met (Al-Hoorie et al., 2022; Ryan et al., 2021). Self-determination theory defines the need for autonomy, competence, and relatedness as central for effective learning to take place (Oga-Baldwin, 2015; Ryan and Deci, 2017). Students are autonomous when the learning environment offers choices and opportunities for self-monitoring while developing intrapersonal and interpersonal skills (Adams and Richie, 2017; Charles et al., 2011). This concurs with the Organization for Economic Co-operation and Development [OECD] (2019) that advocates for student agency in the 21st century. Student agency involves learners taking responsibility for their educational journey in learning environments conducive to independent study. Independent learning environments facilitate self-regulation practices that allow students to plan, monitor, and reflect on their learning journey (Panadero and Alonso-Tapia, 2014). Autonomous learning fosters a favorable cycle of learning driven by intrinsic motivation, instilling a desire within the student to expand their knowledge further (McEown and Oga-Baldwin, 2019).

The feeling of competence is another crucial element in self-determination theory. Success-oriented tasks that reinforce confidence and self-efficacy contribute to a positive learning experience, leading to successful outcomes (Ryan and Deci, 2017). Learners should activate their cognitive processes of self-monitoring, strategizing, and managing that are a part of self-regulation to successfully acquire a foreign language

(Dewaele and MacIntyre, 2014; Murphy, 2014; Oxford, 2014). Liu et al. (2022) concur with this claim, pointing out that how a task is presented and engages the learner is crucial to motivation.

Relatedness, which is the third component of self-determination theory, occurs when learners feel they are doing something that their peers are also doing. Taheri et al. (2019) found that interpersonal relationships were a factor that contributed to language learning. Méndez López and Peña Aguilar (2013) stress that the social context of a learner influences motivation. Motivation occurs because learners want to prove to themselves and significant others in their social context that they are competent (Neys et al., 2014; Sailer et al., 2017).

Games have often been cited as enhancing motivation and engagement by creating interest and dynamism in learning (Charles et al., 2011). Gamed learning incorporates elements of play, which is an integral part of how young learners grow and develop social and cognitive skills, ultimately leading to academic success (Denham and Brown, 2010; Grünke and Barwasser, 2019; Karakoç et al., 2020). By encouraging learners to compete with themselves or with others, games create a need not only for learners to perform well but also to continue trying to improve their previous achievements. This intra-personal dialogue which monitors the learners' progress aligns with self-regulated learning practices while simultaneously fostering autonomy and satisfying the need for relatedness as stipulated by self-determination theory (Nall, 2020; McEown and Oga-Baldwin, 2019). An added advantage to playing games in the language classroom is to reduce stress. Richard-Amato (1996) suggests that the fun element in gaming can reduce this stress factor.

Today, most young individuals are called digital natives since they feel at home in a digital environment with easy access to the Internet via their tablets, cellular phones, or personal computers (Koivisto and Hamari, 2014). Digital natives tend to have shorter attention spans, finding learning from videos and interactive games particularly effective (Denmir and Sonmaz, 2021). Digital games are a particularly engaging form of play for digital natives and can be used for meaningful learning that impacts language acquisition (Göksün and Gürsoy, 2019). The interactivity inherent in digital games meets learners in their playground, harmonizing with their natural ways of interaction and engagement (Ilter, 2009). When learners play digital games, they often get immediate feedback on their performance and can modify their learning accordingly thus allowing for a feeling of competence in keeping with one of the three central elements of self-determination theory (Adams and Richie, 2017; Sucaromana, 2012).

Digital escape rooms include multiple digital games within a comprehensive learning environment that allow for self-regulation practice since they bequeath autonomy to learners by allowing them to plan their journey, monitor their progress, and reflect on their process (Cohen et al., 2022; Panadero and Alonso-Tapia, 2014). In addition, digital escape rooms create a multi-modality learning environment thus enhancing motivation and engagement while freeing up cognitive overload (Mayer and Moreno, 2003; Sweller et al., 2019). Digital escape rooms for learning purposes teach information in small accumulative chunks making the new knowledge more palatable and easier to cognitively digest (Clark and Mayer, 2023). A further advantage of using digital escape rooms for learning is that they incorporate the need to strategize which is part of the self-regulation role in the learning process

(Tobias et al., 2014). Participants that engage with all the elements within the digital escape room uncover codes that ultimately allow them to “free” themselves.

Lämsä et al. (2018) point out that more research needs to be conducted regarding the design of the kinds of games used in education. Digital gamed learning is a contemporary field of research with emerging insights calling for deeper investigation into maximizing the design of digital learning environments to optimize learning (Oga-Baldwin, 2015). An insight that emerged from the COVID-19 era is the crucial need for teacher support in adjusting teaching to the digital environment (Dotan et al., 2021). What is apparent from the literature is that gamed learning, especially in a digital format, is appealing to contemporary learners (Neys et al., 2014; Qian and Clark, 2016; Sailer et al., 2017). In sum, digital gamed learning simultaneously enhances motivation and engagement, aligning itself with the theory of self-determination, while fostering self-regulated practice (Chiu, 2022).

1.1 The current study

Many fourth graders in Israel's EFL programs are usually only in their second or third year of exposure to English, having learned basic phoneme-grapheme correspondences without being able to read or spell accurately. Most spelling is studied from the designated textbook with additional practice using traditional paper and pencil activities. These young learners are expected to tackle reading short texts. Many face difficulties with this transition due to inadequate practice in basic grapheme-phoneme and phoneme-grapheme correspondences, particularly vowel sounds (Kahn-Horwitz and Goldstein, 2023; Russak and Kahn-Horwitz, 2015). Fourth-grade students' phoneme-grapheme and grapheme-phoneme correspondence knowledge is still far from automatic. To this end, digital escape rooms were designed to reinforce and cement this knowledge playfully and engagingly.

This study evaluated the medium of digital escape rooms to assist fourth-grade EFL learners in focusing and mastering basic grapheme-phoneme correspondence knowledge. The research questions were:

1. To what extent will the EFL fourth-grade students improve their spelling following their use of digital escape rooms designed to teach English grapheme-phoneme and phoneme-grapheme correspondence?
2. How did the EFL fourth-grade students reflect on their experience learning grapheme-phoneme and phoneme-grapheme correspondences within the digital escape rooms?

2 Methods

2.1 Research design

This study is a complementarity mixed methods (QUAN → QUAL) (Riazi and Candlin, 2014) and quasi-experimental research. The quantitative aspect of this research measured English phoneme-grapheme correspondence knowledge and spelling

accuracy at three stages: pre-, post-, and delayed-post intervention conducted on an intervention and control group. The intervention and control groups both received English spelling instruction. The control group received this instruction through their regular textbook while the intervention group received five sessions of intervention through playing in the digital escape rooms. The digital escape rooms were designed as an online interactive learning environment to teach phoneme-grapheme correspondences. The escape rooms used videos, digital books and interactive games, which the participants interacted with to reveal the code and escape the room.

The qualitative aspect investigated young learners' perceptions of their experience while playing and learning in the escape rooms. A delayed post-test was conducted a month after the completion of the intervention to investigate to what extent the participants retained their knowledge. Following the delayed-post quantitative test, the participants in the control group engaged in the escape rooms. This possibility addressed ethical requirements regarding the benefits of this intervention.

2.2 Participants

The participants in this study were two classes of fourth-grade students with a mean age of 9 years and four months from a school in the north of Israel. They were all native Hebrew speakers and had begun to learn EFL in the third grade, twice a week for 45 min each lesson. The selection of the experimental and control groups was done randomly.

The intervention class had 30 students, and the control class had 29 students. Two of the students in the intervention class were found to be outliers. This student information tallied with the report from the homeroom teacher of two students with learning disabilities who could not read in their L1. In the control group, one student had a cochlear implant for deafness, and another student in the control group did not do the pre-test. These four students were thus excluded from the results. A total of 55 fourth graders participated in the research, with 28 in the intervention group and 27 in the control. The subsequent inferential analysis included 90% of the observations from the intervention group and 93% from the control group.

2.3 Measures

2.3.1 Quantitative measures

Single-word spelling dictation. 25 pre-, 23 post-, and 25 delayed-post-intervention experimental word spelling tests were created using the following steps:

1. The pre and post-test vocabulary items were chosen to include only the target phoneme-grapheme correspondences that would be revised in the escape rooms (see Table 1). Particular attention was given to balancing the number of target phoneme-grapheme correspondences so that there was an almost equal number of the targeted graphemes in each test. It should be noted that the /z/ phoneme of the < s > grapheme and the /nk/ phonemes were not counted, as EFL students at

the fourth-grade level were not expected to detect these two phonemes.

2. The choice of vocabulary items for the pre-test was not limited, but all post- and delayed post-test words had to be words that were not taught and practiced in the escape rooms. This decision was necessary since the aim was to test whether participants could apply their knowledge of phoneme-grapheme correspondence that they had accumulated following their experience in the five escape rooms.

Vocabulary for the dictation in all three tests was put through a vocabulary profiler to check for their categorization according to the CEFR standards. The specific tool used for this analysis can be found at <https://www.englishprofile.org/wordlists/evp>, and the words were profiled using the American English profile. Most of the words for the pre-test come from the A1 band in the CEFR (see Table 2).

1. There were limited choices for the voiced and unvoiced /th/ phonemes. Each of the three tests included examples of both the voiced and unvoiced /th/ phonemes. In the pre-test, there were two voiced /th/ phonemes ("this" and "that") and one unvoiced /th/ phoneme ("bath"). For the post-test, participants encountered two unvoiced /th/ phonemes ('thank', 'thin') and one voiced /th/ phoneme ('then'). In the delayed-post-test, there were two unvoiced /th/ ("path" and "think") and one voiced /th/ ("than").
 - a. Pre-intervention spelling words included: bad, bath, bed, best, can, cap, cat, hand, hat, hen, hid, his, hit, kid, kip, past, pet, pin, pink, sad, scat, skin, spend, test, that, this.
 - b. Post-intervention spelling words included act, ask, bend, bent, bet, bid, cab, den, did, hint, hip, hits, kit, pen, pest, sat, scab, send, skit, span, thank, then, thin.
 - c. Delayed-post intervention spelling words included: bib, bit, cast, dab, ad, desk, end, had, has, het, kin, net, nib, path, scan, sink, skip, snip, step, tact, tan, test, than, think, tip.

Neither pre- nor post-intervention spelling dictation words were presented in alphabetical order. Each vocabulary item was read aloud twice and a third time if the students asked. This repeated reading served as a control for memory limitations. The participants wrote the words down. Spellings of ad and add were both accepted as correct for this vocabulary item.

2.3.2 Qualitative measures

After the intervention was completed each of the participants was interviewed. The interview sessions took an average of twenty minutes per participant. Interview questions investigated the participants' feelings of self-efficacy about their experience of learning in an escape room environment. Table 3 lists the questions that the participants were asked.

2.4 Procedure

Students in the intervention and control groups studied English twice a week for a session of seventy-five minutes each. Three

TABLE 1 Grapheme frequency in pre-, post- and delayed-post tests.

Target graphemes	i	t	p	n	s	a	d	h	e	th	b	k	c	Total number of words
Pre	8	10	5	6	7	9	7	6	6	3	4	3	4	25
Post	8	9	4	9	8	7	6	3	8	3	6	3	3	26
Delayed-post	9	11	5	6	8	9	6	3	6	3	5	3	3	25

TABLE 2 Vocabulary items in pre-, post- and delayed-post tests.

	A1	A2	B1	B2	C1	C2	Unlisted
Pre	bad, bath bed, best can, cat hand, hat his, past pet, sad that, this	cap hit kid pink spend	hid skin tent				hen kip scat
Total no.	14	5	3				3
Post	did pen sat send then	ask hip hits thank thin	act cab bet kit	bend bent hint	bid	span	den pest scab skit
Total no.	5	5	4	3	1	1	4
Delayed- Post	dad, desk end, had test, than think	bit, net path sink	has step tip	cast skip tan	scan	tact	bib, dab het, nib snip, kin
Total no.	7	4	3	3	1	1	6

out of the five intervention sessions replaced the regular English classes. Two of the five intervention sessions were conducted during another lesson period due to logistical constraints. Playing in the escape rooms and learning to spell took the same proportion of time allocated to spelling acquisition in the control group using traditional methods. The intervention and control groups studied EFL using the same curriculum with the same EFL teacher.

As part of the Chief Scientist’s ethics research requirements, the parents of participating students signed a consent form. In addition, there was a face-to-face meeting with the head of pedagogy of the school and the parents. Both parents and students were notified that they could choose to refrain from participating in the research at any point during the process.

Each participant was given a code to ensure anonymity. The three spelling tests involved dictating each word twice, and the students were encouraged to look at the researcher’s mouth while pronouncing the word. Looking at the researcher’s mouth provided an addition to the acoustic input and was intended to assist with making the phoneme-grapheme connections. Students sometimes asked for an additional repetition of a word that was given. It was assumed that in line with the English curriculum, this would not be the first time that participants were exposed to the material such that the target phoneme-grapheme correspondences practiced in the escape rooms were a revision of what had been previously taught.

The intervention included five digital escape rooms (see the screenshot of digital escape room journey 1 in [Supplementary Appendix A](#)). Before the intervention, the first researcher piloted the escape rooms on two fourth-grade students from another school. This pilot provided feedback and resulted in an additional round of modifications of the elements in the escape rooms.

The participants familiarized themselves with the elements that they would encounter in the intervention by learning and playing in an introductory escape room before beginning the intervention. The introductory escape room contained all the elements of the intervention escape rooms. These elements included an explanatory video, slides of the video, practice games, and code games that mimicked the games the participants would encounter in the intervention escape rooms. This pre-training and familiarization of key elements of the digital learning environment was crucial for the learners and in keeping with Clark and Mayer’s principles of multimedia learning (2023).

The participants began their escape journey in a corridor where five animated characters stood waiting to receive a balloon as a reward. To enter each of the escape rooms, the participant clicked on a door in this corridor with the animated characters and this would lead the participant into the virtual escape room environment. Each of the intervention escape rooms took place in a different virtual environment, beginning in a child’s bedroom then in a water cave afterwards in the forest, in an underwater coral reef,

TABLE 3 Interview questions about the learning experience in the digital escape rooms.

1.	Describe your overall experience in the escape room.
2.	Describe your experience of learning English in the escape room.
3.	How does your experience learning English in an escape room compare to learning English in a regular classroom?
4.	When you think back to your experience in all five escape rooms, did your experience in the escape rooms change over time now that you have completed all five?
5.	What part of the escape rooms did you enjoy the most?
6.	What part of the escape rooms did you enjoy the least?
7.	Which games were the most effective in helping you learn?
8.	Which games or activities were the least effective in helping you learn?
9.	If you could, what would you add or remove from the escape room?
10.	How did you use the videos and slides to help you learn? Did you find yourself going back to the videos and slides if you wanted to clarify something?
11.	Do you feel that the escape rooms helped you become an independent learner, and if so, why?
12.	Did you do the escape rooms alone or with friends?
13.	What other aspects of English would you like to study in an escape room?
14.	What other school subjects would you like to study in an escape room?
15.	If you were allowed to play in these escape rooms in your free time, how often and why would you choose to?
16.	Do the escape rooms you played in English remind you of your computer games?








and finally in space. Each escape room consisted of a path with digitally interactive icons that the participants clicked on.

The participants followed a path with arrows directing them on their way. The structure of the escape rooms was consistent and included interactive icons for the teaching, practicing, and testing phases (see Table 4). The participants could navigate their way around the escape rooms as they chose and could move back and forth between the various phases at their will.

The first set of interactive icons in the escape room was dedicated to teaching the target phoneme-grapheme connections. The participant clicked on an interactive video icon and watched a video explaining the grapheme-phoneme correspondences. When the participants clicked on the next “i” (information) interactive icon they could watch Google slides with the same material that appeared in the video. The participants could progress at their own pace by clicking on the arrows in the slides.

The second set of icons was dedicated to practicing the learned material (see Supplementary Appendix B for the list of words the students encountered in the escape rooms intervention). The students practiced the phoneme-grapheme connections in games that did not yield codes and which they could play as often as they chose. The first practice icon activated a game with interactive cards that had the words with the target graphemes and their translations. The participants clicked on the card, listened to the word, and chose the correct option out of a choice of three

TABLE 4 Key to interactive icons appearing in each escape room.

Interactive icons per phase		Description
Teaching		The participant clicks the interactive video icon and watches a video of the teacher explaining the new material.
		The participant clicks the interactive information icon and can page through the slides of the video at their own pace.
Practicing		The participant clicks the interactive spanner icon and accesses an array of digital games designed to facilitate the practice and reinforcement of newly acquired material with built-in feedback.
		The participant clicks the interactive headphones icon and listens to a story that incorporates the grapheme-phoneme elements taught in the video.
		The participant clicks the interactive book icon and can read the story at their own pace.
Testing		The participant clicks the interactive gamer icon and accesses the game which ultimately leads to a code to exit the room.
		The participant clicks the lock icon enters the code to escape the room and goes to the corridor where the animated figure gets its balloon as a reward for completing the escape room challenge.

possibilities. The second practice game was a matching game, requiring participants to pair a word with its translation, revealing a picture beneath upon completion. This picture changed each time the game was replayed. The third practice button had a conglomerate of five games, which included matching the word to its correct pronunciation with each correct choice, filling up a sweet container, a Tic Tac Toe game, a crossword game, a memory game, and a matching game.

The second part of the practice phase was listening and reading stories that were based on the same phoneme-grapheme correspondences that were taught. The students clicked on the interactive headphones icon that led to a video of a story from English Club (Levitt, 2007). When they clicked on the interactive book icon the same story appeared in the form of Google slides and the participants could read the story and progress at their own pace by clicking on the arrows in the Google slides.

The third set of interactive icons was the code games. When clicked, the participants could play the games that yielded a code when completed. Each game revealed part of the code the participants needed to collect to “free” themselves from the escape room. A code sheet assisted the young learners in writing down the codes as they solved the games and in monitoring their own progress.

The final interactive gaming icon looked like a black game controller. Participants clicked on this black game controller icon and reached a Google Form requiring that they provide feedback. This feedback focused on metacognitive aspects of the learning experience. This was achieved by asking students to reflect on their experience of the different components in the escape rooms by choosing an emoji that reflected their overall feeling after completing the escape room. In addition, they answered questions that required rating their perceptions of their experience of the different components of the escape room. The form contained practice dictations based on the learned materials from the room. The Google Form also included the code that the participants had to choose. Once the correct code was chosen, it was converted into a four-digit code, which the participants used when they clicked the last interactive lock icon, where they were asked to type in the number code and “free” themselves from the escape room. Participants “freed” themselves from the room and back to the original corridor where each time one of the animated characters received a balloon as a reward for all their efforts. After completing all five escape rooms each of the five animated characters had received a different colored balloon. This was aimed at giving the participants a sense of achievement.

The intervention escape rooms were designed to optimize a seamless experience whereby the young learners did not require external assistance. In addition, the escape rooms used multiple digital tools to ensure a rich and comprehensive learning experience.

2.5 Data analysis

To answer Research Question 1, the main outcome variable, which was the Levenshtein distance score (see details in the results section below) was described using means, medians, and standard deviations. Repeated measures analysis of variance (RM-ANOVA) was applied to test the effect of the study stage (within-subject independent variable, pre-, post-, and delayed-post), group (between-subject independent variable, intervention, or control), and the interaction between them on the Levenshtein distance score (dependent variable). Normal distribution was tested using the Kolmogorov-Smirnov (K-S) test. Homoscedasticity was tested using Levene’s test, and sphericity was tested using Mauchly’s test. Bonferroni correction for multiple testing was applied for the simple effects analysis. The analyses were performed using R and SPSS software. The significance level of $p \leq 0.05$ was considered statistically significant.

3 Results

The quantitative results answered the first research question examining whether the spelling acquisition of the participants improved as a result of “playing” in the digital escape rooms that were designed to teach basic grapheme-phoneme and phoneme-grapheme correspondences. The outcome variable that reflected the students’ spelling ability was the Levenshtein distance score (Treiman et al., 2019). This score is based on the number of edits required to reach the proper spelling of the target word. For

example, if the target word was ‘cat’ and the participant spelled ‘cat,’ then the Levenshtein distance score was 0 (no edits required); if the participant spelled ‘kat,’ then the Levenshtein distance score was 1 (one edit required to correct ‘kat’ to ‘cat’); if the participant spelled ‘kad,’ then the Levenshtein distance score was 2 (two edits required to correct ‘kad’ to ‘cat’) and so forth. The number of edits was summed across all target words for each participant in each study stage. However, since each stage had a slightly different number of target words (pre-test: 25, post-test: 23, delayed-post-test: 25), the Levenshtein distance score for each participant was standardized by dividing their summed score by the number of words in the stage. Thus, the spelling ability measure was expressed as a fraction, and the direction of it is that *the higher the Levenshtein distance score, the worse the spelling and vice versa*. The Levenshtein distance score was calculated using the R software ‘stringdist’ package.

Table 5 and Figure 1 present descriptive statistics and the results of the inferential analysis yielded from the RM-ANOVA. As seen, the main effects for group and study stage were insignificant. However, the interaction effect between stage and group was significant, indicating a dis-ordinal interaction, i.e., while the intervention group almost linearly improved, the control group performed worse between pre- and post-stages and slightly improved between post- and delayed-post-stages. The simple effects analysis revealed a significant difference within the intervention group between pre- and post- ($p = 0.02$) and pre- and delayed-post ($p = 0.001$); the difference between post- and delayed-post- was insignificant ($p = 0.46$). Within the control group, all the equivalent differences were insignificant ($p > 0.05$ for all). Prior to the inferential analysis, normal distribution, equality of variance (homoscedasticity) and sphericity were tested. The analyses revealed that the Levenshtein distance score was normally distributed (K-S test: pre- $p = 0.11$, post- $p = 0.09$, delayed-post- $p = 0.11$) and homoscedastic across the groups (Levene’s test: pre- $p = 0.95$, post- $p = 0.58$, delayed-post- $p = 0.60$). The assumption of sphericity was also met (Mauchly’s Test: $p = 0.64$).

The second research question complemented the results of the first research question by providing an understanding of the participants’ perceptions of their experience in the digital escape rooms and whether this type of learning environment fostered a feeling of self-efficacy (Calfee and Sperling, 2010). Evaluation of what the participants felt about the experience of learning in the digital escape rooms was conducted by extracting themes from participant interviews. Four central categories, which included two themes in each category, resulted from coding the interviews of all the participants. These themes were derived after identifying, coding, and analyzing the interviews to look for repeated patterns (Braun and Clarke, 2006).

The data from the interviews were analyzed in three stages. During the first stage, participants’ responses were divided into meaning units, whereby each meaning unit expressed one idea. The second stage of analysis involved identifying common patterns so that similar meaning units could be grouped under common categories of meaning. The third stage involved re-examining the categories and defining the four final themes, each of which included two categories that belonged in a similar semantic field. Four themes emerged from this process: engagement and motivation, autonomous learning and self-monitoring, peer learning and social interaction, and self-confidence and self-esteem. The total number of meaningful responses in each

TABLE 5 Analysis of the effect of group and study stage on the Levenshtein distance score.

	Intervention			Control		
	Pre	Post	Delayed post	Pre	Post	Delayed post
Mean	0.99	0.85	0.76	0.85	0.97	0.93
SD	0.37	0.39	0.24	0.34	0.35	0.36
SE	0.07	0.07	0.06	0.07	0.07	0.06
Median	0.84	0.83	0.78	0.84	1.09	0.88
Min.-Max.	0.48–2.12	0.22–1.78	0.20–1.24	0.12–1.44	0.22–1.48	0.24–1.92
Group effect	$F_{(2,106)} = 1.81, p = 0.17$					
Study stage effect	$F_{(1,53)} = 0.38, p = 0.54$					
Group x Stage effect	$F_{(2,106)} = 8.62, p < 0.001$					

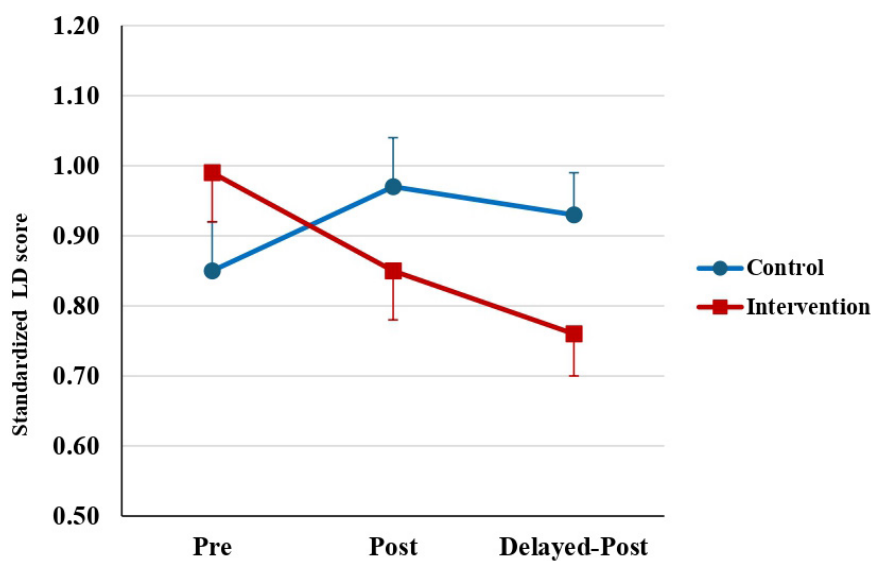


FIGURE 1 Standardized LD score within each group over the three study stage. Error bars represent the standard error (SE) of the mean.

theme was calculated, and a percentage of the total number of meaningful responses gauged from the interviews was given. This calculation gave insights into the relative dominance of one theme over another.

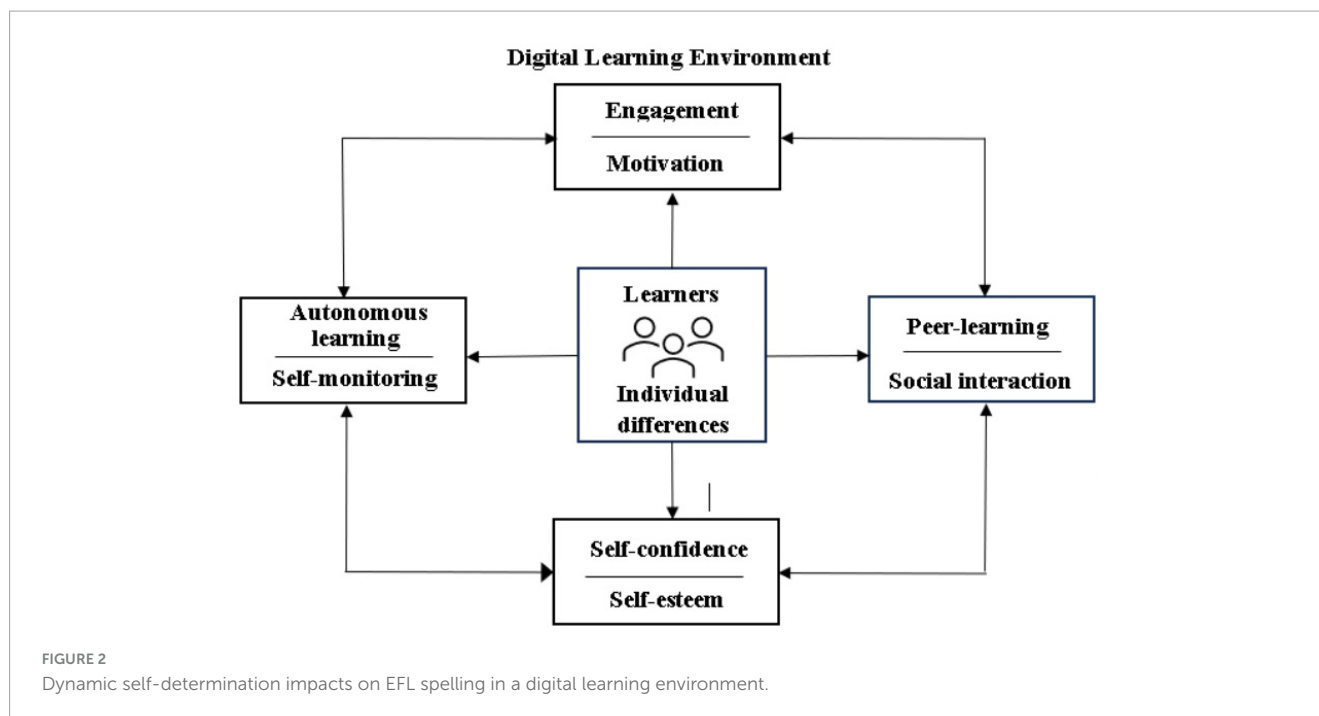
Autonomous learning and self-monitoring received 44% of the meaningful responses and contributed the greatest weight. Engagement and motivation were second, with 32% of the total relevant feedback. Twenty percent of the participants' meaningful responses related to the theme of self-confidence and self-esteem, while only 4% related to peer learning and social interaction. Figure 2 illustrates the metacognitive impacts on learning in the digital escape rooms. The students, with their individual differences, interacted in the digital escape rooms to a greater or lesser extent, demonstrating the four themes—autonomous learning and self-monitoring, engagement and motivation, self-confidence and self-esteem, and peer learning and social interaction, depending on each child's needs in real time.

The themes of autonomous learning and self-monitoring were reflected in the dominant responses. These responses reflected studying independently without a teacher and students managing their time. The young learners enjoyed controlling their own pace

and felt that this feature of the escape room digital environment contributed to a more in-depth type of learning experience.

Even though I follow the teacher in class, it is limiting because you have to go according to her pace. If you have a choice, learning at your own pace is preferable. For instance, you can read the slides for as long as you want and as often as you like.

Another participant claimed, "I listened to the story several times because that way I recorded the story in my mind." They frequently reflected on the fact that they enjoyed being able to choose when and where to begin their learning in the escape rooms, as well as having the opportunity to go back to watch the videos if they felt they had missed out on something in their learning process or if they wanted to revise something so that it would become clearer for themselves. "Sometimes I started with the games and then went back to the video so that I could learn what I needed to play the games." They remarked on how it differed from learning in the regular classroom, which is more teacher-centered, and that the independent approach they experienced in the escape rooms



was more convenient and efficient. “It’s not like in class when you don’t always get an answer because you have to wait for the teacher. I watched the videos a couple of times. It is more convenient.” The absence of a physical teacher alleviated the pressure that some learners described when the teacher is physically present, “It’s much more fun than learning with a teacher because with a teacher you feel she is testing you.” The learners also reported that they enjoyed the privacy of learning on their own and that it was a more peaceful learning environment than in the noisy classroom, “It’s nice being on your own and putting on the earphones and nobody is next to you to disturb you.” Having the independence to decide on what and how to learn was something that the young learners appreciated, “I skipped the video, and I began with the practice games.” or “I played the games enough times until I got the answers right.”

Engagement and motivation were the following dominant themes. They included the young learners expressing their enjoyment about learning and playing simultaneously, “It is easiest to learn when you are having fun.” This enjoyment was reinforced by their willingness to continue playing the games after school hours, “I would play the escape rooms in my spare time a thousand times.” “I wanted to continue learning with the escape rooms when they ended.” Learning in the escape rooms was a different experience from learning in the regular classroom. It also seemed to engage and motivate the young learners, “In the class, I also learn, but in the escape rooms, you have lots of games and choices.” The learners expressed their enthusiasm for learning in this digital environment. They suggested learning other subjects in escape rooms: “I would like to learn other subjects in the escape rooms.” The reward system inherent in gamification in learning engaged and motivated the learner: “I looked forward to getting the balloons.” Students found the competitive element of games appealing, relishing the challenge of hunting for the codes. “It was important to escape. That way you knew you had

completed your own challenge.” “The codes made it competitive.” “There was lots of competition and I like competition. It was me against the computer.” Another engaging and motivating aspect was the variety of games available in the digital escape rooms, which enabled the young learners to have choices in their learning process. “There were lots of activities to choose from.” Finally, the young learners reported that the different settings of each escape room enhanced their learning. “It’s like being in different worlds, it’s amazing.” “I felt like I traveled all over the world.” “It was an adventure.”

The students reflected on their sense of achievement when they overcame difficulties, giving them a feeling of self-confidence and self-esteem. “When we learn and succeed, it makes us happy, and we want to learn more.” A built-in feature of the digital games was decision-making, allowing the learners to review their decisions and return when they made a mistake. They repeated and improved their learning by reverting to previous game stages: “I learn more in the escape rooms than in class because you can repeat the game even if you make a mistake. You have a feeling of success, and it helps you remember the sounds and the letters.” “You can’t be disqualified so you learn and have a feeling of success.” In addition, digital games gave feedback encouraging the learners to develop strategies boosting self-confidence and self-esteem. “I like playing against the computer in the tic tac toe game because I liked trying to beat it each time.” The game variation took away from the laboriousness of repeated practice, which benefited the young learners in mastering the material and fostering their self-confidence and self-esteem. “As I answered more and more correct answers, I could see more and more of the picture of the elephant behind the words. It is my favorite animal. I loved that game.” And another response, “I loved the game of filling up the candy because when there is a snack it helps me concentrate. It was as if I was getting more and more candy every time I answered correctly.”

The theme of peer learning and social interaction accounts for a small proportion of responses relating to this theme. Even though it was expected that the young learners would learn and play in the escape rooms independently, they nevertheless found opportunities to interact with their peers. “I waited for my friends to catch up so that we could start a new game together.” Their responses attest that they benefited from interacting with their peers, “We helped each other solve the games.” or another, “I read one line of the story and my friend read another. I enjoyed reading more that way.” The young learners reflected how working together deepened their understanding, “I did the escape rooms on my own, and if I did not understand something, I asked my friends.” Social interaction between the young learners seems to have taken place when collaboration enhanced both the play and learning elements in the escape rooms,

I liked being on my own and being with my friends. We did the escape room at the same time. We helped each other solve the games. I listened to the video and story on my own and played the tic tac toe game, but all the rest was with my friends.

4 Discussion

Referring to the initial research questions regarding the improvement of EFL fourth-grade students' spelling through the utilization of digital escape rooms designed to teach English grapheme-phoneme and phoneme-grapheme correspondence, the following findings become evident: The quantitative results indicated that following the use of digital escape rooms the fourth-grade EFL students became better spellers. The intervention group students' EFL spelling significant improvement following the intervention attests to the digital escape rooms impacting learning, which was retained over time. In contrast, the spelling of the fourth-grade students in the control group who did not use the digital escape rooms worsened at the post-test stage and then slightly improved in the delayed post-test stage. The control group's relatively poor spelling performance could be explained by the inadequacy of imparting spelling instruction in the regular classroom setup using traditional textbook and paper and pencil methods, concurring with conclusions about how best digital natives learn (Denmir and Sonmaz, 2021; Koivisto and Hamari, 2014).

The multiple opportunities for revision of the phoneme-grapheme and grapheme-phoneme connections in the digital escape rooms could explain the successful outcomes of the intervention. Repeated graphotactic patterns and phonological input in keeping with the theory of statistical learning using the digital gamed learning in the escape rooms helped to cement the EFL young learners' spelling in memory and assisted in making spelling automatic (Ehri, 2014; Perfetti and Hart, 2002; Treiman and Kessler, 2022). Automaticity in the spelling process, which enables concentration on the message, is critical in the path toward literacy (Grünke and Skirde, 2022). This is especially true in an EFL setting where exposure to the language is limited, learners need to contend with novel phonemes, and the script is also foreign (Kahn-Horwitz et al., 2011; Kahn-Horwitz, 2020; Sammour-Shehadeh

et al., 2022). Repeated exposure to the explicit teaching of the phoneme-grapheme and grapheme-phoneme connections, word meanings, and the constant interaction with the words in the digital games facilitated word knowledge, which is the building blocks of learning to read English (Kim, 2017; Laufer and Ravenhorst-Kalovski, 2010; Nation, 2002; Seidenberg, 2017). Since English has a deep orthography which makes learning to read and spell complex, especially in an EFL setting, numerous exposures through hearing, reading, and interacting with the phonemes, graphemes, and words are essential (Katz and Frost, 1992; Moats, 2014; Pacton and Fayol, 2004; Vaisman and Kahn-Horwitz, 2020).

Inadequate teacher knowledge and materials could be another possible reason for EFL students not acquiring adequate English spelling instruction. EFL teachers are overwhelmed by the enormity of teaching EFL spelling and often lack knowledge (Saban and Kahn-Horwitz, 2022). In addition, the official textbooks used for teaching literacy in the EFL Israeli context do not place adequate focus on these grapheme-phoneme and phoneme-grapheme relationships (Fuchs et al., 2023). Teachers cannot be expected to impart adequate instruction to their students without the appropriate knowledge and guidance (Dotan et al., 2021). Consequently, a ready-made platform such as the escape rooms specializing in the explicit teaching of English spelling could assist teachers in optimizing their young learners' spelling acquisition.

The qualitative results indicate that the medium of digital escape rooms in teaching EFL students to acquire better spelling improved students' self-efficacy, as expressed in the four major themes that emerged from interviewing the participants. The dominant theme of autonomous learning and self-monitoring is not surprising since a critical feature of learning in the escape rooms was allowing the young learners relative freedom to choose where to be and how to pace their learning (Adams and Richie, 2017; Bai and Wang, 2021; Sucaromana, 2012) in keeping with self-determination theory (Al-Hoorie et al., 2022; Ryan et al., 2021). In addition, this independence seemed to be a significant contributing factor to the successful outcome of their learning. The participants expressed satisfaction at being able to make choices about their learning. The learners enjoyed being able to progress at their own pace, which does not usually occur in the regular classroom environment in which the teacher rather than the learner determines the pace of the lesson (Dewaele and MacIntyre, 2014; Liu et al., 2022; Murphy, 2014; Oxford, 2014). The process of being able to strategize, monitor and reflect on the learning in the escape rooms constitutes self-regulation while simultaneously addressing the needs for self-determination (Panadero and Alonso-Tapia, 2014).

It also appears that the absence of a teacher in the escape rooms alleviated stress in the learning process. The young learners did not need the teacher for word meanings and could independently refer to the digital flashcards with L1 translations (Suganda et al., 2021). The participants described the positive feelings associated with making mistakes in keeping with the competence factor in self-determination theory (McEown and Oga-Baldwin, 2019). The young learners enjoyed getting the feedback, which they used to correct themselves without being disqualified. Moreover, they did not feel criticized for making mistakes; therefore, there were no negative feelings associated with making errors. The participants felt that making mistakes was often an opportunity to learn more and be part of the practicing and learning process using digital

games. These feelings of autonomy and competence in the digital escape rooms mirror the positive effects of a learning environment which facilitates self-determination (Al-Hoorie et al., 2022; Ryan et al., 2021).

The extent of the young learners' engagement and motivation can be attributed to the learning enhancers inherent in the gamification of the escape rooms (Charles et al., 2011; Göksün and Gürsoy, 2019). The novel scenario in each escape room gave the young learners a feeling that they were immersed in a new adventure each time. The digital games juxtaposed learning and playing, while those that involved discovering the codes added a challenge (Denham and Brown, 2010; Garner, 2009; Grünke and Barwasser, 2019; Karakoç et al., 2020). In addition, the dual modalities of the audio-visual elements of the explanation videos and the digital games appealed to individual differences (Clark and Mayer, 2023). The dual modalities of audio-visual elements were also factors contributing to cementing the material into long-term memory, as illustrated by the finding that the learners retained what they learned even a month after completing the intervention (Pishghadam et al., 2016; Woottipong, 2014). The combination of fun and study seems to have sparked the young learners' interest and curiosity. The feeling of playfulness enhanced their learning and contributed to their willingness to practice and progress (Grünke and Barwasser, 2019). This concurs with the young learners being keen to continue playing in the escape rooms in their spare time.

The young learners' feelings of self-efficacy and self-confidence derived from the sense of achievement and success that they experienced while playing the games (Denham and Brown, 2010; Dewaele and MacIntyre, 2014; Karakoç et al., 2020; Liu et al., 2022; Murphy, 2014; Oga-Baldwin, 2015; Oxford, 2014). The games in the escape rooms were deliberately designed so that even when the learners made errors, they could correct their mistakes by replaying the games that reinforced the phoneme-grapheme and grapheme-phoneme connections. The automatic feedback and the built-in success outcomes of the digital games also taught the young learners to strategize so that they could win the games, find the codes, and ultimately escape. Strategizing demands decision-making and requires higher-level thinking skills, stimulating the learners (Charles et al., 2011; Nall, 2020; Tobias et al., 2014).

The theme of peer learning and social interaction was another positive outcome of this study since the digital escape rooms were designed for individual learners using earphones and PCs. This outcome confirms that learners enjoy and benefit from the input and interaction with other learners (Ghabanchi and Rastegar, 2014; Melani et al., 2020; Méndez López and Peña Aguilar, 2013; Pishghadam et al., 2016). The young learners felt they were detectives seeking the codes and collaborating to achieve their goals highlighting the relatedness component of self-determination theory that participants feel in the digital escape room learning experience (Al-Hoorie et al., 2022). By working together, the young learners assisted each other in understanding the literacy content taught in the escape rooms and how to strategize while playing the games (Taheri et al., 2019).

5 Limitations, conclusions and future research implications

This study is limited because it was conducted with two fourth-grade classes on a population from a high socio-economic background. In addition, this type of intervention requires schools to provide computers with a steady Internet connection that allows for smooth participation in the digital learning environment. Investigating this digital learning method to spell on different population groups and at different stages of EFL literacy development would be interesting.

The quantitative aspect of this mixed-method complementarity study (Riazi and Candlin, 2014) strongly supported structured and explicit instruction of grapheme-phoneme and phoneme-grapheme correspondences in closed syllables at a pace determined by each learner. The qualitative aspect highlighted a positive experience impacting the learners' cognitive processes as a consequence of their self-determination needs being met (McEown, and Oga-Baldwin, 2019).

The post-COVID-19 era in education has highlighted the need for effective digital learning environments that can reach a broader range of diverse learners as an additional resource for learning (Dotan et al., 2021; Oga-Baldwin, 2015; Tobias et al., 2014). Exposure to digital gamed learning, which operates by a challenge reward paradigm on platforms that do not necessarily teach anything specific, is a part of young learners' lives (Ilter, 2009; Koivisto and Hamari, 2014). The positive outcomes of this small-scale study suggest that we should leverage this tendency amongst our learners and incorporate digital gamed learning in our pedagogy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Chief Scientist Office, Ministry of Education, Israel. Permission granted on 31st July, 2022, file number 12505. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

MS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review and editing. MG: Supervision, Writing – review and editing. JK-H: Supervision, Writing – review and editing, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1434336/full#supplementary-material>

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