

ORIGINAL ARTICLE

Digital storytelling: An educational approach for enhancing dyslexic children's writing skills, critical and cultural learning

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Abstract

This paper reports an exploratory pilot study- which is part of a larger study- examining the impact of an innovative approach to enhancing the writing skills of primary school students with dyslexia, digital storytelling (DST), linked to critical and cultural learning. The study adopted a single-subject design with a pre-experimental approach (A-B) to explore connections between the use of digital storytelling, and children's writing skills, as well as cultural and critical dimensions of learning. A socio-cultural framework, drawing on Green's 3D model, and the Not-So Simple View of Writing, informed the methodology adopted. A dual perspective aligning with the socio-cultural theory was adopted, delving into both product and process of digital storytelling. The results revealed significant improvements in writing skills, cultural and critical behaviours, pre and post intervention, with large effect sizes, suggesting this may be a promising classroom approach to improve literacy and learning in children with dyslexia.

KEYWORDS

critical learning, cultural behaviours, digital literacies, digital storytelling, dyslexia, writing skills

Key Points

- This is the first research to date examining the operational, cultural, and critical dimension of Green's 3D model in primary school students with dyslexia.
- Using keyboarding features of the DST platform decreased spelling and semantic errors.
- The study showed positive shifts in dyslexic students' attitudes towards writing, enhanced executive functions, while also fostering critical and cultural behaviours.
- Educators can promote inclusive and culturally responsive pedagogy for students with dyslexia by incorporating DST into writing activities.

INTRODUCTION

Dyslexia and writing difficulties

Dyslexia, a complex specific learning difficulty, has spurred ongoing debates regarding its definition and

underlying neurological origins. The prevailing theories of dyslexia, including the magnocellular (Galaburda & Livingstone, 1993; Stein & Talcott, 1999) and phonological models (Snowling, 2008; Vellutino et al., 2004) are often criticised for their reductionist one-dimensional approach (Ramus et al., 2003). By focusing solely on either

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visual processing deficits (magnocellular theory) or phonological processing difficulties (phonological theory), these models overlook the multifaceted nature of dyslexia. Frith's three-level framework (Frith, 1997, 2002), on the other hand, provides a holistic approach, considering biological, cognitive, and behavioural factors. At the biological level, genetic origins (Fisher & DeFries, 2002; Fisher & Francks, 2006) and neurobiological factors have been considered important (Shastry, 2007). Cognitively, deficits associated with dyslexia may include issues related to working memory, phonological awareness, and slow processing (Morton & Frith, 1995). However, environmental factors, including teaching methods and cultural attitudes, have been found to significantly impact dyslexic students' writing and reading skills (Berninger et al., 2002). Frith's model serves as a foundational framework, which contemporary research continues to build on. For instance, contemporary neuroimaging studies continue to highlight the role of phonological processing deficits in dyslexia (Vandermosten et al., 2020), while also incorporating insights into the genetic underpinnings and neurobiological markers associated with the disorder (Pinel et al., 2021). The acknowledgement of the role of resilience and protective factors in the development of dyslexia (Catts & Petscher, 2022) further enriches Frith's model by acknowledging differences in cognitive profiles and adaptive strategies.

Recently, a new definition has emerged according to which dyslexia is a set of processing difficulties that affect the acquisition of reading and spelling, with literacy attainment being weak in relation to many attainments (Holden et al., 2024). The developmental trajectory of dyslexia depends on genetic and environmental influences, with difficulties existing on a continuum and commonly co-occurring with other developmental difficulties (Carroll et al., 2024). This definition aligns with Frith's perspective in terms of approaching dyslexia as a multifaceted deficit.

The Not-So-Simple View of Writing (NSVW) approach provides a useful framework for understanding the impact of dyslexia on the writing skills of students (Berninger & Winn, 2006). The NSVW builds upon the Simple View of Writing (SVW) emphasising the role of working memory in transcription, executive function, and text generation. Here, the text generation's central role underscores the importance of not only possessing transcription skills (spelling, handwriting/keyboard) but also self-regulation skills operated by executive functions (i.e. goal setting, planning, monitoring, revising, evaluating). Difficulties in transcription skills restrict working memory, as seen in students with dyslexia who may rely heavily on working memory for spelling, limiting resources for higher-order tasks. Similarly, difficulties in executive functions or working memory can affect transcription skills as writers struggle to recall and accurately record their thoughts (Ahmed et al., 2022; Berninger et al., 2002). Within the NSVW framework, children with dyslexia have trouble with spelling, handwriting

and executive function behaviours, which results in low overall writing quality. Moreover, high-quality writing depends on good transcription skills, working memory and executive functions—all of which can be hard for children with dyslexia (Hebert et al., 2018).

Importance of digital storytelling (DST) in literacies

Storytelling is essential for literacies since it enhances cognitive and socio-cultural development, allowing students to personalise their learning and construct their own meaning (Smeda, 2014; Lisenbee & Ford, 2018). This approach is beneficial for dyslexic students since it leverages their strengths in creativity, making literacies more engaging.

Digital literacies and digital storytelling

Writing is key for digital literacies. Digital storytelling defined as the process of generating a digital story on a digital storytelling platform where the storyteller uses their own voice to convey their story on an educational topic, plays an essential role in this context (Armstrong, 2003; Lambert, 2010). This story is both written and enriched with multimedia components to enhance the storytelling experience. As a cognitive and socio-cultural construct, literacies play a fundamental role in empowering individuals with the cognitive tools required to comprehend, analyse, and critically engage with diverse textual and symbolic forms, enabling them to be active participants in knowledgeable societies (Goodfellow, 2011). In line with the broader sociocultural perspective adopted by new literacies scholars (Goodfellow, 2011; Kress, 2010; Lankshear & Knobel, 2008) there is a need to consider the multimodal nature of literacies in the context of digital storytelling; Green's 3D model can be useful in this context (Colvert, 2015; Green & Beavis, 2012). This model consists of three overlapping and interrelated dimensions: operational, cultural, and critical. The operational dimension focuses on language and technological competencies, enabling effective communication and collaboration in digital contexts. The cultural dimension considers literacies as expressions of meaning within cultural contexts, fostering decision-making based on cultural understandings. The critical dimension encourages reflective processes, questioning digital texts, and power dynamics. Cultural factors influence operational skills, as cultural norms and practices shape students' interactions with digital environments. Moreover, cultural perspectives play a key role in critical analysis and evaluation, prompting students to challenge assumptions and consider diverse viewpoints. Critical thinking skills enable informed decisions regarding multimodal writing.

For instance, recognising that modes are elements of texts, we argue that choosing and integrating these

modes 'operates' to construct the final representation of the text. At the same time, this multimodal perspective highlights the cultural dimension, where students' personal and social contexts shape their communication, reflecting cultural understanding (cultural dimension). This approach invites a critical analysis of how meaning is constructed and communicated (critical dimension) with verbal writing being one mode among many.

Digital literacies and dyslexia

By focusing on the social cultural dimensions of literacies, Green's model challenges the notion that dyslexia is solely a cognitive deficit, instead highlighting the role of societal attitudes and educational practices in mitigating the challenges of dyslexia. By applying Green's model to interventions for dyslexic students, it becomes clear that strategies should not only address cognitive skills but also consider the social supports and cultural adaptations that can support this population. This could involve creating more inclusive learning environments by using assistive technology, promoting understanding of diverse literacy practices, and fostering a culture that values different ways of learning.

Literature review

Within the operational dimension of Green's 3D model, previous studies suggest that digital storytelling holds promise in enhancing writing skills, particularly for struggling writers (Foley, 2013; Miller, 2010; Robin, 2016). Sylvester and Greenidge (2009) found that the digital storytelling multimedia elements encouraged struggling writers to write coherently by revising their scripts, while avoiding gaps and omissions. Verigakis et al. (2010) presented a framework for the design of an interactive, user-centred storytelling system fostering the development of literacy skills (narrative comprehension and recall) in dyslexic children. However, the exact methodologies employed in these studies remain somewhat unclear, and no research to date has provided a comparative analysis with pre and post-test and/or control groups.

The cultural dimension of digital storytelling (Green's 3D model) has been linked to enhanced cultural competence (Grant & Bolin, 2016). Mega Fariziah Nur Humairoh (2022) found out that DST promotes undergraduate students' expression of cultural identities, verbally and visually, maximising multimodal literacy. Through DST, students activate their background experiences to critically illustrate intersecting cultural ideas, enhancing cultural awareness. Niemi et al. (2014) concluded that primary school students integrated their previous cultural experience and knowledge into the digital stories produced.

DST is also key for critical thinking skills. Niemi et al. (2014) found that DST fosters critical thinking by

encouraging students to reflect critically on their choices, such as considering the selection of online information needed for their story. Niemi et al. (2014) and Karakoyun and Kuzu (2016) found that digital storytelling encourages students to provide and evaluate peer feedback critically. Similarly, Hwang et al. (2023) conducted a quasi-experiment demonstrating that integrating peer assessment into digital storytelling activities enabled students to reflect deeply on their work and critique their videos using assessment rubrics and peer feedback. Yang & Wu, 2012 found that students were challenged with thinking critically about effective combinations of content and multimedia elements while considering the audience's perspective. This process of reflection and justification is an enactment of Green's critical dimension, moving beyond mere revision to foster critical skills.

Despite the available evidence on the positive role that DST can play in learning and development, the specificity of the impact of DST on the cultural and critical dimensions of literacies for students with dyslexia in primary school settings remains unexplored. The current research is the first to date to address these identified gaps by examining the writing skills of students with dyslexia in primary school, as framed by the NSVW, following a pre-experimental design (A-B) and looking to examine all three dimensions of Green's 3D model in this population. The aim is to investigate how digital storytelling could enhance the writing skills of primary students with dyslexia (operational dimension), also considering the critical and cultural dimensions of Green's 3D socio-cultural theoretical framework. To achieve this aim, the following research questions (RQs) were formulated:

RQ1: How might digital storytelling influence the writing skills of primary school students with dyslexia, including spelling when using the keyboard, semantic difficulties, and executive functions?

RQ2: How might digital storytelling influence the perceptions of students with dyslexia about themselves as writers?

RQ3: To what extent does digital storytelling provide opportunities for students with dyslexia to bring their own perspectives into the multimodal writing process according to the cultural dimension of Green's 3D model?

RQ4: To what extent does digital storytelling enhance the ability of children with dyslexia to engage in critical analysis and reflection on their writing, consistent with the critical dimension of Green's 3D model?

METHODS

Research design

A mixed methods approach was adopted to address the RQs (Creswell & Plano Clark, 2011; Plano Clark, 2017). A convergent parallel design was used, since both qualitative and quantitative strands were

TABLE 1 Participants' details.

Participants' ID	Gender	Age (years)	Year	Diagnosis
P1	Male	10	5th	Specific learning difficulties–dyslexia
P2	Male	9	4th	Specific learning difficulties–dyslexia
P3	Female	10	5th	Specific learning difficulties–dyslexia

implemented simultaneously. They were then independently analysed, and integrated at the interpretation phase. Within this mixed methods approach, a single-subject design was adopted, which has been widely employed in special and inclusive education (Maggin et al., 2011) particularly for investigating dyslexia (Lim & Oei, 2015; Wery & Diliberto, 2017). This was an A-B pre-experimental design, in which A stands for baseline assessment and B for intervention. Digital storytelling was the independent variable (intervention adopted), while writing skills, executive functions, cultural and critical behaviours of children with dyslexia were the dependent variables. Additionally, to evaluate the interactions among peers, between peers and teachers, and between children and the digital environment, semi-structured interviews with the students and document analysis of the final multimodal texts produced were conducted. Lastly, observation rubrics capturing both quantitative and qualitative data related to executive functions, cultural and critical behaviours were used during the pre-experiment; single-subject designs are concerned with both products and process (Rogers & Graham, 2008). Therefore, this convergent approach to mixed method research, including pre-experimental data of both qualitative and quantitative nature, alongside interviews and document analysis was seen as a robust method to examine all aspects of the experience of digital storytelling by dyslexic children.

Sampling

A non-probability purposive sampling technique was adopted in this study, conducted in a small provincial town in Southern Greece. This sampling technique enabled the selection of participants with a specific profile operating on the principle that researchers 'can get the best information through focusing on a relatively small number of instances deliberately selected on the basis of their known attributes' (Denscombe, 2014, p 41). Three students participated in the study, meeting the inclusion criteria, defined as: (a) pupils of primary school age from 9 to 12 years old, studying in the same, mainstream school, where the first researcher works as a teacher, (b) with diagnoses of dyslexia or a specific learning difficulty in the areas of phonological processing or decoding based on psycho-cognitive assessments conducted by an independent and recognised evaluator /institution, and (c) no other overlapping diagnoses (i.e. hearing impairment/

deafness). Their diagnosis of dyslexia had been obtained prior to this research and was documented in school records, accessible to teachers and researchers following parental permission. Recruitment followed convenience sampling, with the first author approaching parents and children meeting the inclusion criteria within her professional network. Table 1 summarises participants' demographic details.

Measures and tools

A range of tools were used, enabling the collection of both quantitative and qualitative data. These included assessment and observation rubrics tailored to enable systematic observations within the pre-experiment, self-assessment writing checklists and semi-structured interviews. Additionally, the final multimodal products were also assessed.

To address *RQ1*, two assessment rubrics were developed, providing a categorisation of spelling errors based on Protopapas et al. (2013), Mouzaki et al. (2010) and Xanthi (2017). The first rubric consists of errors related to misspelt words categorised as follows:

- Phonological errors, defined as spellings that affected the pronunciation of the word, altering its phonological identity.
- Grammatical errors concerned alternative, phonologically equivalent spellings of inflectional suffixes.
- Orthographic errors concerned alternative, phonologically equivalent spellings of word stems, including roots and any derivational morphemes preceding the obligatory inflectional suffix.
- Stress errors concerned the stress diacritic, which obligatorily marks the vowel of the stressed syllable in every Greek word with two or more syllables.
- Capital/lowercase letters concerned the use of lowercase instead of capital letters at the beginning of a sentence or a name as well as the use of capital letters between lowercase letters in a word.

Errors were further classified into specific subcategories (Appendix 1). The second rubric includes punctuation errors, including primary (period, comma, exclamation, question mark) and secondary (hyphen, colon, etc.) punctuation marks. These rubrics allowed documenting the number of words and errors at both baseline (A) and intervention (B). An additional

assessment rubric was developed to categorise semantic errors based on Protopapas et al. (2013), as follows: number of additions, omissions, substitutions and repetitions of words and missing inter-word space.

Addressing *RQ1*, *RQ3* and *RQ4*, observation rubrics were to identify specific behaviours occurring in the school classroom, in detail (Stake, 2010). These were completed as soon as possible following the end of each intervention session and informed by the video recordings. The observation rubrics addressed the following areas:

Executive functioning (EF) strategies

Two observation rubrics were developed, one for the baseline assessment (A) mapping EF strategies used in the writing phases, and one for the DST intervention (B). This was informed by the theoretical framework of the NSVW and included assessment of the following: goal setting, planning, self-monitoring, revising/finalising, self-efficacy, self-evaluation and self-selection of modes (Berninger et al., 2002; Graham & Harris, 2009; Zimmerman & Riesemberg, 1997). Building on Sarikaya and Yilar will's work (Sarikaya & Yilar, 2021), a 4-point grading scale (Beginning, Developing, Accomplished, Exemplary) and space for field notes were also incorporated, for noting behaviours, qualitatively.

Cultural behaviours (RQ3) and Critical behaviours (RQ4)

Two observation rubrics were created for cultural and critical behaviours, aligning with writing and digital storytelling processes. The rubrics covered the assessment of cultural or critical behaviours, a grading scale (1. Beginning, 2. Developing, 3. Accomplished, 4. Exemplary) with descriptors to support rating, and space for field notes. Colvert's ludic authorship model (Colvert, 2015) and Marsh et al.'s research on children's engagement with makerspaces (Marsh et al., 2018) informed the list of behaviours, aligning with Green's 3D model. The behaviours were adjusted to match students' activities in phases A and B. Descriptors for each grading level were informed by the literature. To ensure alignment with Green's 3D model, the behaviours identified from Colvert and Marsh et al. were cross-referenced with Green's definitions. The activities and behaviours were structured across four phases: Pre-Writing, Writing, Post-writing, Sharing–baseline assessment–

Pre-production, Production, Post-production, and Distribution –intervention-. In pre –writing and pre-production, tasks such as determining the aim of writing and choosing topics and modes of communication assessed students' understanding of social and cultural contexts and their ability to make meaningful, culturally relevant decisions. For instance, selecting a topic

that aligns with their background and creating dramatic questions based on personal experiences reflected their cultural engagement, while critically reflecting on chosen resources highlighted their critical thinking. During the Writing and Production phase, tasks like creating the plot and combining diverse modes required students to draw on personal and cultural experiences, personalising their stories, and critically evaluating their creative decisions to ensure alignment with their writing goals. In Post-Writing/Post-production and Sharing/Distribution, the rubrics continued to assess the intertwined cultural and critical dimensions. Post writing/Post-production tasks, such as providing peer feedback and redesigning work based on comments, encouraged students to reflect on their cultural stance and critically analyse feedback, ensuring culturally informed and thoughtfully revised stories. Similarly, Sharing/Distribution tasks, including selecting dissemination methods, required students to choose means that resonated with their cultural preferences while critically reflecting on the effectiveness of their choices within their social context.

Self- assessment writing checklists

Students with dyslexia benefit from checklists, enhancing self-awareness and promoting independent writing (Zumbrunn & Bruning, 2013). The study developed two self-evaluation checklists aligned with the Greek Language Curriculum's objectives (IEP, 2021) and modified for student needs, as the study was conducted in a Greek state primary school. Phase A goals included spelling, punctuation, sentence coherence, and paragraph development, while Phase B focused on comparability of media, spelling, punctuation, and sentence coherence.

To complement the quantitative and qualitative data gathered through the rubrics described above, semi-structured interviews were conducted with the students, to enable a more in-depth understanding of their experience (Adeoye-Olatunde & Olenik, 2021; Smith, 2018). Interviews were conducted with students as a group before and after the intervention. Each of the interviews lasted approximately 15–20 min and was audio recorded. Recorded interviews were transcribed verbatim. Group interviews present a valuable approach to data collection, resembling one-to-one interviews while leveraging the dynamic of social interaction among participants (Denscombe, 2014). The interview questions focused on executive functioning behaviours, perceptions of students about themselves as writers, and their cultural and critical behaviours. Interviews for children with dyslexia were adapted, by using child-friendly language, fostering a supportive atmosphere for participation, and employing open-ended questions to stimulate conversation. As a teacher, my role facilitated this adaptation by understanding of individual learning needs, while being patient giving them ample

time to express themselves. To address RQ3, the final multimodal paper texts, produced in the baseline assessment, alongside final digital multimodal texts, developed in the intervention, were analysed via socio-semiotic analysis (Kress, 2010). Each participant produced two final texts, one in phase A and one in phase B, enabling the examination of personal social-cultural meaning.

The digital storytelling platform used was Storyjumper (<https://www.storyjumper.com/>). StoryJumper is a versatile software that supports various storytelling genres (i.e. narrative writing, reflective journal, dialogue text- and integrates various modes such as text, images, and sound). Drawing on indicative studies using Storyjumper, in Damavandi et al.'s (2018) study, primary English as Foreign Language (EFL) learners showed positive attitudes, appreciating its child-friendly design. The platform's word processing features facilitated grammar and spelling revisions and ready-made images aided idea generation. Similarly, Karakuş et al. (2020) reported enhanced engagement and creativity in primary second-grade students using Storyjumper, attributing it to engaging layout, and multimedia elements.

Procedure

The study was conducted over 5 weeks, and six school hours per week (2 school hours every Tuesday, Wednesday and Friday). It was carried out both in the computer classroom and the integration classroom during school hours. In the Greek education context, students with Special Educational Needs/Disabilities (SEN/Ds) can be placed in either a mainstream classroom for students who can cope with the demands of a regular classroom, alongside typically developing peers, and taught by the main classroom teacher, or in an 'integration' classroom, which is a specialist classroom for students who have a diagnosis for learning difficulties or other SEN/Ds.

In phase (A) students followed the traditional writing steps for composing a story, namely pre-writing, writing, post writing, and sharing, to enable the assessment of baseline skills. In phase (B), participants created their multimodal stories, using the digital storytelling platform and following the four phases of the digital storytelling process, namely (a) pre-production (b) production (c) post-production, and (d) distribution. In both phases, the first author assumed the role of facilitator, actively articulating the various stages of the writing process to the students.

Table 2 presents the activities along with the measures that took place in phase A and phase B. It should be mentioned that consent from both the students and their parents had already been obtained. Measurements in Phase A were administered over a period of 2 weeks for six school hours per week (12h in total), while phase B measurements were administered over a period of 3 weeks (16h in total). Both phases were held during the normal school day.

Data analysis

Using data collected through the assessment rubrics developed and described above, the total number of phonological errors as a fraction of the total words used was calculated (for each child) by adding the subcategories (P1+P2+P3+P4+P5) / (total number of words) %. Grammatical (G1-G3), orthographical (O1-O4), stress errors (S1-S5), errors in capital/ lowercase letters (CL-CL3) were similarly calculated as fractions of total words. In the second rubric, punctuation errors were categorised into primary (PP1-PP3) and secondary (SP1-SP3) errors, and then expressed as fractions of total words using equivalent formulas. No additions were calculated in the third rubric since it already included the total number of word additions, omissions, substitutions, repetitions and missing inter-word spaces. The percentage of errors was calculated by dividing the number of errors by the total number of words each child used. Group-level descriptive statistics of the above measurements was provided at two timepoints: draft 1 (initial writing-baseline) and draft 2 (writing after intervention). The median was preferred over the mean due to the small sample size and its resilience to outliers (Denscombe, 2014; Robson & McCartan, 2016). For effect size, Cohen's D was calculated based on the difference between phase A and phase B. Cohen's D values of about 0.2 represent a small effect size, values about 0.5 represent a moderate effect size and values 0.8 or greater represent a large effect size (Cohen, 1988).

Participant behaviours during the activities were observed and rated using the four-level descriptors developed and described above. The intervention using Storyjumper introduced new ways of working, thinking, and behaving. Students critically combine semiotic resources to convey their message effectively and respond to the dramatic question-central point of DST-(critical dimension), while considering their background and the socio-cultural context (cultural dimension). Additionally, students had to self-monitor by checking the compatibility of the selected modes (executive function and critical dimension). This multimodal approach aligns with Kress's (2010) concept of affordances, as the software provided new possibilities for expression that were not available in the pen-and-paper task used in the baseline.

Two raters, the first author and a second, independent classroom teacher, assigned scores based on observation and video recordings. Total scores were calculated for each participant, and A-B phases. Interrater agreement was assessed using Cohen's weighted Kappa statistics, a robust measure considering the possibility of chance agreement (Fleiss et al., 1969). The weighted statistic was preferred due to the ordinal nature of the outcomes in the domains: executive functioning, cultural, and critical behaviours. Cohen's weighted Kappa was calculated for each domain separately and combined as an overall measure using STATA version 17 BE. The scale of Kappa value interpretation is the

TABLE 2 Description of the activities and measures in phases A and B.

Weeks	Days	Phases of writing/digital writing process	Type of activities	Duration	Description	Measures
Baseline assessment (phase A)						
1st week	Tuesday	Pre-writing phase	Collaborative activity	2 h—90min	Ice-breaker questions were asked that included statements and questions such as: 'We are going to do some writing activities on paper and in computers. Do you like writing?' Following the warm-up questions, students were informed about the activities via the information sheets and discussion with the first researcher. Consent forms were completed	
	Wednesday		Individual activity	2 h—90min	Students chose their topic between two suggested, the sea and land pollution, proposed in the Greek Language Curriculum (IEP, 2021). The purpose and audience were then identified	Observation rubrics for executive functioning, cultural and critical behaviours
	Friday		Collaborative and individual activity	2 h—90min	The students engaged in a brainstorming session, sharing their existing knowledge on the topic while the first author documented their ideas on the board. Prompted by the first author, they identified areas they wished to explore further about sea pollution. Given the unavailability of the school library due to construction, the team collectively decided to conduct online research to delve into the causes of sea pollution	Observation rubrics for executive functioning, cultural and critical behaviours
2nd week	Tuesday	Writing phase	Individual activity	2 h—90min	Students were given storymap templates and started working on them by writing on a problem, its causes, consequences and proposed solutions for the problem	Observation rubrics for executive functioning, cultural and critical behaviours
	Tuesday	Writing phase	Individual activity	2 h—90min	Students created the first draft of their story on paper	Observation rubrics for executive functioning, cultural and critical behaviours
	Wednesday	Post writing phase	Individual and collaborative activity	2 h—90min	Students revised their initial drafts using a self-assessment checklist provided by the first author. After completing the self-assessment, students engaged in discussions with their peers and the first author to receive feedback. Comments focused on spelling, punctuation, sentence structure for coherence, and communicating their messages via diverse modes and means	Assessment rubrics for spelling and semantic errors
	Friday	Post writing phase and sharing	Individual activity	2 h—90min	Having finalised their texts, two students chose to enhance theirs with sketches, while one preferred not to. Following completion, they collaborated on finding modes and means for sharing their stories, considering their audience. They proposed printing copies for distribution among family members and teachers	Observation rubrics for executive functioning, cultural and critical behaviours

(Continues)

TABLE 2 (Continued)

Weeks	Days	Phases of writing/digital writing process	Type of activities	Duration	Description	Measures
1st week		Intervention- (phase B)				
	Tuesday	Preproduction phase	Collaborative activity	2 h—90min	Introduction to Storyjumper via tutorial videos and platform navigation. Exemplar digital stories created in this platform were presented	Observation rubrics for executive functioning, cultural and critical behaviours
	Wednesday		Collaborative activity	2 h—90min	Having selected their topic in the first week of the baseline assessment, students identified the aim and the audience of writing. Following this, they used online resources such as Google and YouTube on a tablet to gather follow-up information regarding the topic	Observation rubrics for executive functioning, cultural and critical behaviours Assessment rubrics for spelling and semantic errors
2nd week	Friday	Production phase	Individual activity	2 h—90min	Students organised their story plot in the digital storyboard. They started typing the script in the boxes of the digital storyboard, while they added images and figures. Each student followed a different authoring digital practice based on their own writing style	Observation rubrics for executive functioning, cultural and critical behaviours Assessment rubrics for spelling and semantic errors
	Tuesday		Individual activity	2 h—90min	Students completed the above activities	Observation rubrics for executive functioning, cultural and critical behaviours Assessment rubrics for spelling and semantic errors
	Wednesday	Postproduction phase	Individual activity	2 h—90min	Students corrected spelling, punctuation and semantic errors using a self-assessment checklist and the word-processor- as facilitator	Observation rubrics for executive functioning, cultural and critical behaviours Assessment rubrics for spelling and semantic errors
3rd week	Friday		Individual activity	2 h—90min	Students attempted to enhance their stories by incorporating sounds. Having added sound effects, they checked the compatibility of the diverse selected modes of communication. It should be mentioned that due to a malfunctioning voice recorder, they were unable to personalise their stories with their own voices	Observation rubrics for executive functioning, cultural and critical behaviours
	Tuesday		Collaborative activity	2 h—90min	Students reviewed and responded to feedback on each other's digital texts, adjusting selections of media, and refining combinations of sound effects and images based on the comments received	Observation rubrics for executive functioning, cultural and critical behaviours
	Wednesday	Dissemination phase	Collaborative activity	2 h—90min	Students discussed and found ways of their stories dissemination. They suggested sharing them via sending the link to their audience	Observation rubrics for executive functioning, cultural and critical behaviours Socio-semiotic analysis of texts

Note: Before week 1-phase A, a group interview was conducted, and after the completion of the intervention (week 4), the remaining group interviews with students were carried out. The text analysis began in week 3 and 4 in phase A and B respectively and continued for several weeks. All observation rubrics were informed by video-recordings. Assessment rubrics for spelling and semantic errors were informed by, and after the completion of the intervention, based on the students' texts.

following (Landis & Koch, 1977): <0: No agreement, 0–0.20: Slight agreement, 0.21–0.40: Fair agreement, 0.41–0.60: Moderate agreement, 0.61–0.80: Substantial agreement, 0.81–1.0: Perfect agreement.

Interview transcripts were analysed using Reflexive Thematic Analysis (RTA), a method for identifying, analysing, and reporting patterns (themes) within data, while involving continuously questioning the assumptions made during interpretation and coding of the data (Braun & Clarke, 2019). The following six stages were adhered to when conducting the analyses: familiarisation with the data, generation of initial codes, searching for themes, reviewing the themes, defining and naming themes and producing the report (Braun & Clarke, 2019).

The final multimodal and digital texts produced in both phase A and phase B were analysed through social-semiotic analysis based on Kress's design approach (Kress, 2010). Multimodal text design, viewed through a social-semiotic lens (Kress, 2010), involves designers employing diverse signs/modes (text, images, gestures, music) for intended meanings. Drawing on their socio-cultural experiences, students construct interpretations of the chosen resources. Meaning-making encompasses transformation (reorganisation within a mode) and transduction (reshaping resources across modes) processes (Kress, 2000, 2003, 2010). Following the above two processes, participants' multimodal texts were analysed, to gain a deeper understanding of their semiotic choices and how they reflect on their own cultural background.

RESULTS

The purpose of this study was to examine how digital storytelling can enhance the writing skills of primary students with dyslexia, framed by Green's 3D socio-cultural framework. Specifically, the research looked at: (1) how digital storytelling might influence the writing skills of primary school students with dyslexia, including spelling when using the keyboard, semantic difficulties, and executive functions; (2) How digital storytelling might influence the perceptions of students with dyslexia about themselves as writers; (3) The extent to which digital storytelling provides opportunities for students with dyslexia to bring their own perspectives into the multimodal writing; and (4) the extent to which digital storytelling influences the critical writing behaviours of children with dyslexia.

QUESTION 1: How might digital storytelling influence the writing skills of primary school students with dyslexia, including spelling when using the keyboard, semantic difficulties, and executive functions?

Table 3 presents percentages of spelling errors for each pupil, separately, in each time point along with the

TABLE 3 Percentages of spelling errors at two time-points (Draft 1—baseline assessment, Draft 2—intervention) and median improvement for three participants.

Time	Id	Written_ words	Phonological_ total_	Grammatical_ total_	Orthographic_ total_	Stress_ total_	Capital_ lowercase_ letters_	Total_ primary_ punctuation_ errors_	Total_ secondary_ punctuation_ errors_
			P%	P%	P%	P%	P%	P%	P%
Draft 1	P1	93	2.15	2.13	0.00	0.00	0.00	0.00	1.30
Draft 2	P1	118	0.00	9.09	4.88	1.75	9.68	7.45	0.00
Draft 1	P2	49	14.29	11.54	3.57	7.79	7.32	5.26	13.98
Draft 2	P2	28	0.00	1.08	1.06	0.00	4.08	3.85	7.14
Draft 1	P3	77	10.39	8.54	3.51	8.60	6.38	5.08	0.00
Draft 2	P3	57	0.00	12.24	9.61	3.57	7.79	4.87	1.75
Median improvement for three participants									
Draft 1	P1	—	2.63	4.21	2.23	1.21	0.24	2.22	0.02
	P2								
	P3								
Draft 2	P1	—	6.45	7.33	9.67	20.80	1.08	3.52	1.30
	P2								
	P3								

Abbreviation: P, percentage.

median improvement in spelling performance for the entire group. Each draft includes various measurements related to spelling errors such as phonological errors, grammatical errors, orthographic errors, stress errors, capitalisation and lowercase errors, primary and secondary punctuation errors.

Initially, in Draft 1, participants exhibited spelling errors across different categories, albeit at varying percentages. However, in Draft 2, following intervention, there was a significant decrease in most types of errors across all participants. Hence, although the extent of improvement varied among the students, a consistent trend of continued progress was observed across all error categories post-intervention.

Considering the spelling performance for the participants as a group, a notable improvement post-intervention compared to baseline assessment was observed. Specifically, the highest improvements were observed in stress errors, followed by orthographical, grammatical, and phonological errors, with punctuation and capitalisation errors showing the least improvement.

Further analysis utilising the observation rubric revealed a consistent progression in spelling behaviour EFB3.1d (Check and correct the spelling of the words and the punctuation) with participants demonstrating a shift from lower to higher levels of accomplishment.

As far as semantic errors are concerned, their percentages are presented for each child separately at two time points in the Table 4 along with the median improvement.

Initially, in Draft 1, the most common errors were additions, omissions and substitutions, with percentages around 1%. Notably, in Draft 2, after intervention, there was an increase in the number of substitutions and

repetitions for P1. Conversely, P2 showed a decrease in errors overall, suggesting successful intervention. P3 exhibited fluctuations in error types across drafts, with a decrease in additions and repetition, but an increase in substitutions in Draft 2.

While semantic errors showed no significant improvement overall, compared to baseline assessment, the intervention improved the categories of semantic difficulties to a notable degree. No significant improvement was observed in substitution errors, since a median of 0% improvement at the total substitution errors after baseline assessment as well as intervention was identified. The highest improvement is noticed in the number of omissions and repetitions, followed by improvements in errors in the missing inter-word space and the number of additions.

Examining the specific behaviour outlined in the observation rubric, it was found that P1 and P2 displayed an increased tendency to check and correct sentence structure (EFB3.1a), whereas P3's performance remained almost steady.

Effect size for the majority of the spelling and semantic errors was consistently high indicating a substantial impact of the intervention on phonological, grammatical, and orthographic errors (>0.8 for each). The only exception was the number of omissions where Cohen's D was 0.280.

Exploring the influence of constructing multimodal stories on executive functions, findings indicate an improvement in 8/14 observed behaviours during intervention, with three participants moving from lower levels of accomplishment to higher ones across all phases (Table 5). A substantial agreement between raters (weighted Kappa 0.767) was observed. Indicatively P1 displayed improvements in behaviours, such as selecting modes for convening the message (2.2a) and checking and correcting the structure of the sentences they have written (3.1a). P2

TABLE 4 Percentages of semantic errors at two time-points (Draft 1 – baseline assessment, Draft 2- intervention) and median improvement for three participants.

Time	Id	Written words	Number_of _Additions_ P%	Number_of_ Omissions_ P%	Number _of_ Substitutions_ P%	Number _of_ Repetitions_ P%	Missing_ interword_ space_ P%
Draft1	P1	93	1.08	1.06	0.85	0.00	0.00
Draft2	P1	118	1.06	0.00	48.98	46.15	3.57
Draft1	P2	49	1.30	1.22	0.00	0.00	0.00
Draft2	P2	28	4.88	0.00	0.00	0.00	0.00
Draft1	P3	77	4.08	3.85	0.00	2.60	2.44
Draft2	P3	57	1.92	0.00	7.79	2.44	5.26
Median improvement for three participants							
Draft1	P1	-	0.00	0.16	0.00	0.16	0.00
	P2						
	P3						
Draft2	P1	-	0.23	2.60	0.00	0.60	1.30
	P2						
	P3						

Abbreviation: P, percentage.

TABLE 5 Common improved executive functioning behaviours and rating of behaviours observed only in the intervention.

Phases of DST process	Executive functioning strategies	Behaviours	Baseline assessment	Intervention	Indicative statements
1.Pre-production	1.2Planning	a. Plan/continue to plan according to the purpose	Raters 1 & 2 P1, P2, P3 Developing level	Raters 1 & 2 P1, P2, P3 Accomplished level	P3 determined the purpose [thinking aloud]: 'We write about the sea... about the sea pollution' (self-correction) [...]. 'We could write more about why the sea has been polluted and what we can do'.
		d. Organise the structure of the plot in the story maps	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	
2. Production	2.1Self-efficacy	a. Create the first draft	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	
	2.2 Self- selecting modes	a. Select modes/ semiotic resources of conveying the message	P1, P2 Developing Level P3 Accomplished level	P1, P2, P3 Exemplary level	
3. Post-production	3.1 Self-monitoring	a. Check and correct the structure of the sentences they have written to be appropriate	P1 Beginning P2/P3 Developing level	P1, P2, P3 Accomplished level	P3 'The sea has been polluted The sea has been polluted by the rubbish... The sea has been polluted because we throw rubbish in the sea'.
		d. Check and correct the spelling of the words and the punctuation.	P1 & P3 Developing level P2 Beginning level	P1, P2, P3 Accomplished level	
	3.2 Self-evaluating	a. Identify areas of improvement	P1, P2, P3 Developing level	P1, P2 Accomplished level P3 Exemplary level	
	3.3 Revising/ finalising	a. Make changes based on self- assessment rubric	P1, P2, P3 Developing level	P1, P2, P3 Exemplary level	
Behaviours observed only in the intervention					
1.Pre-production	1.2 Planning	c. Make research on the topic of writing; determine the digital sources to research.	-	P1, P2, P3 Exemplary level	P3: 'We should write in the search box "causes for the sea" (in Google)'. P1: 'No, we should write causes of the sea pollution [...]. This text is too long, let's find a video instead [...]. This is a video by students like us. It will be easy [...]. It will be easier to watch instead of reading [...]'.
3. Post-production	3.1 Self-monitoring	e. Check the compatibility of the selected modes	-	P1, P2, P3 Exemplary level	

Note: In the baseline assessment, the behaviour 'conducting research on the topic of writing in the school library' corresponding to intervention 1.2c, was not observed due to the school library being under construction.

exhibited progress, notably in spelling and punctuation (3.1d), transitioning from struggling to proficient levels, and in making changes based on self-assessment rubric (3.3a). P3 showcased marked improvements, particularly in creating the first draft (2.1a) and identifying areas of improvements (3.2a), progressing from developing to accomplished and exemplary levels, respectively. Regarding the behaviours exclusively observed during the intervention, all participants received high rating from both raters.

The qualitative analysis of interview data suggests that EF strategies have been perceived by students to have improved. Themes (TM) and Subthemes (STM) presented in [Appendix 2](#).

Students expressed appreciation for the organisational benefits offered by storyboards (STM 1.2.3), P1: 'I feel better in organizing my thoughts [...] You can change its size easily and you can put whatever you want; for example images, pictures, sounds', facilitating idea generation. P3: 'I could see what I have written in the previous box and continue writing, continue writing my ideas'. (STM 1.2.1, 1.2.2). Additionally, the user-friendly design of the platform enabled them to plan without facing any considerable difficulties. P2: 'I could look at the previous ideas just by clicking. I find easily whatever I want for example images'. (STM 1.2.4) They also reported that the word processor features notably eased the identification and correction of spelling and semantic errors, P1: 'The platform could show you your mistakes and then you could change the way of their writing [...]. We could understand which words have been written correctly and which not'. (STM 1.4.1, 1.4.2) alleviating traditional challenges associated with handwriting. P3: 'I faced difficulties in understanding my letters on the paper, but not on the computer'. (STM 1.4.3) Participants also reported feeling more independent during the digital story creation process P1: 'I feel more independent writing on the computer'. (TM4).

The aforementioned findings complement the high ratings of participants in behaviours 1.2a, 1.2d, 2.1a, 3.1a and 3.1d in the observation rubric ([Table 5](#)).

QUESTION 2: HOW MIGHT DIGITAL STORYTELLING INFLUENCE THE PERCEPTIONS OF STUDENTS WITH DYSLEXIA ABOUT THEMSELVES AS WRITERS?

The Themes (TM) and Subthemes (STM) identified are presented in [Appendix 2](#).

Prior to the intervention, students expressed neutral to negative feelings about traditional paper-based writing (STM 2.1.1, 2.1.2). They highlighted challenges such as difficulties in writing and idea generation (STM 2.3.1, 2.3.2, 2.3.3, 2.3.4). P2 'It is boring [...]. The pencil breaks and then it is difficult to write [...]. I do not know how to write almost all the words'. The above statements were

followed by neutral feelings that students have about themselves as writers (STM 2.2.1). P3 'Sometimes, I am a good writer, some others I am not. I do not know why'.

However, following the intervention, there was a noticeable change in participants' perceptions ([Appendix 3](#)). They exhibited positive attitudes towards writing and themselves as writers (STM 2.1.3, 2.2.2) emphasising their newfound ability to incorporate multimedia elements, such as images and sounds into their stories. P3 'I think that I am better at it now. I can read my text, I can understand my letters'. This shift was accompanied by feelings of productivity during the digital storytelling process. P2: 'I added images and sounds. I am better at putting all these together and say what I want and not just writing [...] I was productive'.

Crucially, participants reported feeling more capable of overcoming their spelling difficulties (STM 2.3.5) when utilising the word processor features of the platform, leading to increased motivation. The multimodal nature of digital storytelling (STM 2.4.1), combined with the relevance of the topics to their interests (STM 2.4.2) contributed to a sense of engagement during the writing process (STM 2.4.3) P3: '[...] Before, I was feeling bored, while on the computer not. I was focus. I liked the topic'.

QUESTION 3: TO WHAT EXTENT DOES DIGITAL STORYTELLING PROVIDE OPPORTUNITIES TO STUDENTS WITH DYSLEXIA TO BRING THEIR OWN PERSPECTIVES INTO THE MULTIMODAL WRITING PROCESS ACCORDING TO THE CULTURAL DIMENSION OF GREEN'S 3D MODEL?

All participants showed improvement in 7/ 12 v behaviours according to both raters with substantial agreement between them (weighted Kappa 0.796) ([Table 6](#)) and significant increases in scores from baseline assessment to intervention. For instance, participants demonstrated a transition from developing to exemplary levels in behaviours like providing comments based on personal stance (3.1a) and understanding effective means of dissemination within social and cultural contexts (4.1b). Additionally, there was evidence of enhanced proficiency in choosing modes that suit personal preferences (1.4a) and shaping production experiences based on feelings and thoughts (2.1a). Notably, behaviours observed exclusively in the intervention, were highly rated for P1 and lower for P2 and P3.

During the analysis of interview data Themes (TM) related to participants' cultural experiences with the DST were identified. These themes are presented in [Appendix 2](#).

TABLE 6 Common improved cultural behaviours and rating of behaviours observed only in the intervention.

Phases of DST process	Tasks	Behaviours	Baseline assessment	Intervention	Indicative statements
1. Pre-production	1.4 Select modes/semiotic resources of communication such as text, images, music, sounds	a. Choose modes that are making meaning to them	Raters 1 & 2 P1, P2 Developing level P2 Beginning level	Raters 1 & 2 P1, P2, P3 Exemplary level	P3: 'I will put also a butterfly, because I like butterflies'. P2: 'I have put the rubbish to show clearly to other students that the sea has been polluted by the rubbish. Now, I will write that the sea has been polluted by them. I want them to understand what I want to say'.
		b. Choose modes that are making meaning to their intended audience	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	
2. Production	2.1 Create plot	a. Draw on their own experiences in the creation of the script, bringing their own understandings to it	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	P1: 'Here, I have added a touching music, because we have thrown toxic waste and the fish has died'. P1 commented on P3's story during the intervention 'The solution is to clean our seas. So, to my understanding you should put this in the next box' [...] As far as I know, only if the ship is destroyed, the oil will pollute the sea'.
		2.2. Combine diverse modes to make meaning	P1, P2, P3 Beginning level	P3 Accomplished level Rater 1 P1 & P2 Accomplished level	
3. Post-production	3.1 Proceed to peer comments and assessment	a. Provide comments based on their stance, on their background	P1, P2, P3 Developing level	P1, P2, P3 Exemplary level	
		3.2 Take into mind their peers' and teacher's review	P1, P2, P3 Beginning level	P1, P2, P3 Developing level	
4. Distribution	4.1 Select means of dissemination	a. Redesign in response to feedback	P1, P2, P3 Beginning level	P1, P2, P3 Developing level	
		b. Understand most effective means of disseminating within the social and cultural context	P1, P2, P3 Developing level	P1, P2, P3 Exemplary level	
Behaviours observed only in the intervention					
1. Pre-production	1.5 Find out the dramatic question	a. Create a question that has meaning to them based on their experiences	-	Rater 1 P1 Accomplished level	Rater 2 P1 Developing level
		b. Create a question having in mind their audience	-	Rater 1 & 2 P2 & P3 Beginning level P1 Exemplary level, P2 & P3 Beginning level	

All participants expressed that the chosen topics resonated with their backgrounds (TM 3.1), allowing them to express their feelings more effectively compared to traditional paper-based writing (TM 3.2). While two participants preferred expressing feelings exclusively through digital storytelling, one found both mediums suitable for expression. The above findings align with the high ratings of participants 1 and 2 in behaviour 2.2a included in the observation rubric.

Participants highlighted the advantages of the DST platform in providing multiple modes of expression, which facilitated their preference for it over paper-based writing (TM 3.3). P2: 'On the part where the fish died I added a sad music to accompany the image and the text. It is nice to express your feeling using so many ways'. Additionally, they recognised the platform's potential in making stories accessible to students with disabilities and those from diverse cultural backgrounds, considering audience comprehension and cultural context (TM 3.4). P1: '[...] some people cannot read so we could help them by recording the story'. P3: 'If a student is from Albania and he cannot read well, he can understand better our stories. He can see the images and hear the sounds'. Participants' comments reflected their previous experiences, informing their approach to digital writing (TM 3.5, 3.6). P1: 'On paper it was difficult to understand his letters. On the platform I understood them and I knew that he was right when he wrote that the ships pollute the sea. I had seen ships to do this at Ammoudara'.

The aforementioned findings justify the high ratings of participants in behaviours 1.4a, 1.4b, 4.1a, 3.1a, and 3.2a included in the observation rubric (Table 6).

The socio-semiotic analysis of the data provided deeper insights into the transformation of students' writing practices from the baseline assessment to the intervention. In baseline assessment, students relied predominantly on written text, with limited use of visual elements. However, during the intervention, a notable shift towards a multimodal approach was observed, incorporating visuals, audio, and text to convey messages (Appendix 4). For example, students used colour, images, and sound effects to express emotions and highlight social issues like sea pollution. This transition reflects a more expressive and inclusive means of expression, enabling students to engage with diverse semiotic resources aligned with their cultural backgrounds and contexts. For example, P3 utilised colour, style, and sound effects to emphasise the seriousness of sea pollution, while P2 combined images and sounds to convey the severity of the issue and evoke emotions. Students actively engaged in transforming and transducing modes of representation to enhance communicative effectiveness, demonstrating agency and creativity within the multimodal writing process facilitated by the DST platform. For instance, P1 reorganised text into dialogue, incorporated figures, and added sounds to complement images and align with emotional content.

QUESTION 4: TO WHAT EXTENT DOES DIGITAL STORYTELLING ENHANCE THE ABILITY OF CHILDREN WITH DYSLEXIA TO ENGAGE IN CRITICAL ANALYSIS AND REFLECTION ON THEIR WRITING, CONSISTENT WITH THE CRITICAL DIMENSION OF GREEN'S 3D MODEL?

Both raters observed improvements in 6/11 critical writing behaviours (Table 7) with a moderate inter-rater agreement level (weighted Kappa 0.527). Additionally, the scores demonstrated a significant improvement from baseline assessment to intervention. For instance, students demonstrated improvement in critical thinking behaviours, such as justifying their choices (1.4a), evaluating information (3.1a), and providing comments on arguments (3.1b), moving from lower to higher level of accomplishment. Notably, behaviour observed exclusively in the intervention showed high levels of accomplishment.

Interview data analysis revealed students' perceptions of critical thinking in writing. The theme (TM) and Subthemes (STM) are presented in Appendix 2. Participants expressed confusion regarding critical thinking on paper, citing challenges such as letter formation, spelling, and punctuation. P3 'I had to think about the stress, the full stops and the letters'. However, during the intervention phase, students found it easier to articulate instances of critical thinking, particularly in relation to multimedia composition. Critical thinking behaviours were evidenced during the transformation and transduction phases of DST, where students demonstrated adeptness in modifying and combining different modes of communication to convey their messages effectively (STM 4.1.1, 4.1.2). P1: 'I thought cleverly when I should put together images, text and sounds to say what I want'. P3: 'I could also change the letters, their colour and made them bold when I wanted to say something important'. This was exemplified by statements indicating consideration for audience comprehension and use of multimedia elements to enhance message clarity (STM 4.1.3). P2: 'I could present my ideas by putting together sounds and images so the others understand my words'.

These findings complement the high scores of participants in behaviours 1.4a, 2.2a, and 4.1a in the observation rubric (Table 7).

DISCUSSION

This study investigated the impact of digital storytelling on the writing skills of primary students with dyslexia through Green's 3D socio-cultural framework. It examined how digital storytelling affects spelling, semantics,

TABLE 7 Common improved critical behaviours and rating of behaviours observed only in the intervention.

Phases of DST process	Tasks	Behaviours	Baseline assessment	Intervention	Indicative statements
1. Pre-production	1.4 Select modes/semiotic resources of communication, such as images, music, sounds	a. Reflect critically on their choices: Why did I choose these modes?	Raters 1 & 2 P1, P2, P3 Developing level	Raters 1 & 2 P1, P2, P3 Exemplary level	
		a. Reflect critically on their choices: Why did I combine these modes?	P1, P2 Beginning level P3 Developing level	P1, P2, P3 Exemplary level	
2. Production	2.2 Combine diverse modes/semiotic resources to make meaning	a. Evaluate the information provided by others in their team	P1, P2, P3 Accomplished level	P1, P2, P3 Exemplary level	P2 discussed with P3: 'What changes did you say I should make?' P3: 'Put the plastic bags in front of the boat so they can be seen'. P2: 'I got it!'
		b. Justify their comments and recommendations to their peers' story	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	P1 commented on P3's story 'You should enlarge this box. It is too small for your text and images [...] You should add who said these words. It's not obvious'. P2: 'I want to change this image. I have to add the sea. I write about the sea. I do not know how to write it in English to look for it. O, I got it! I will use Google translator'.
3. Post-production	3.1 Proceed to peer comments and assessment	a. Reflect critically on the changes: Why did I go through changes in these parts?	P1, Developing level P2, P3 Beginning level	P1, P2, P3 Accomplished level	
		a. Reflect critically on their choices: Why did I choose these means?	P1, P2, P3 Developing level	P1, P2, P3 Accomplished level	
4. Distribution	4.1 Choose means to distribute their digital stories.				
Behaviours observed only in the intervention					
1. Pre-production	1.5 Find out the dramatic question	a. Reflect critically why did I choose this question? How I will answer it?	-	Raters 1 & 2 P1 Exemplary level P3 Beginning level Rater 1 P2 Developing level	Accomplished level

and executive functions, and the students' self-perception as writers. Furthermore, it explored the opportunities for students to incorporate their perspectives into multimodal writing and how digital storytelling influences critical thinking in writing.

Beginning with spelling performance, some variability persisted across participants and error types, indicating that spelling performance is in accordance with their level of phonological development (Beers et al., 2018; Diamanti et al., 2014; Protopapas, 2010). This implies that participants with dyslexia with more advanced phonological development made fewer spelling errors than those with less advanced phonological development. Considering the three participants as a group, notably, the errors in stress category showed the higher improvement followed by improvement in orthographic, grammatical and phonological errors. Greek is often classified as a transparent language with relatively consistent stress patterns, aided by the presence of diacritic marks indicating the correct position of lexical stress in every word (Douklias et al., 2009). This consistent stress pattern, where every word of two or more syllables carries stress on a single syllable, could potentially assist students with dyslexia in identifying stress patterns more easily (Protopapas et al., 2013; Protopapas, 2010), particularly when provided with options, as they can rely on predictable pronunciation rules.

Utilising the word processor features of the platform, a significant decrease in most types of errors across all participants was observed, suggesting the effectiveness of the intervention in improving spelling accuracy. Students could approach a reasonable approximation for the words they wanted to spell and identified the correct spelling for the word when options are provided (Hebert et al., 2018). As soon as the misspelled words were highlighted, they right-clicked on the word and options popped up. Additionally, detecting spelling errors was easier since the text was more legible compared to that in the baseline assessment. This aligns with the hypothesis proposed by Beers et al. (2018, p. 4) assuming that when students with dyslexia use keyboarding '[...] the text produced is consistently legible, and this may help with detecting spelling errors'.

Producing more eligible sentences enabled students to revise them, identifying potential semantic errors. This finding aligns with previous studies (Beers et al., 2018; Morphy & Graham, 2012) indicating that keyboarding can enhance the writing process for students with learning difficulties by providing a supportive environment for planning and revision. Similarly, Graham and Perin (2007) suggested that students with dyslexia exhibit higher writing quality when typing. We can assume that based on 'the not so simple view of writing' the use of keyboarding (transcription) free memory space allowing students to focus on higher order writing skills. When transcription skills are sufficient, more working memory space and resources are available for executive functions

such as goal setting, planning, self-monitoring, and revising, allowing writers to generate text more similar to that of skilled peer writers (Berninger et al., 2002).

The analysis of executive functions indicated a significant improvement, with participants demonstrating enhanced focus on writing purpose, and idea generation. The use of storyboards proved beneficial in organising thoughts and facilitating planning. These results align with the theoretical framework emphasising the importance of freeing up cognitive resources for higher-order writing skills (Berninger et al., 2002). Participants reported increased independence, and reduced handwriting difficulties, reflecting positively on their engagement during the intervention.

By integrating visual and auditory modes, students had alternative pathways for expression, compensating for difficulties in verbal writing. This multimodal approach fosters engagement and builds confidence, since students are may less likely to experience failure. By providing communicative friendly support, we can mitigate the writing challenges faced by these students, aligning with Frith's statement that 'cultural tools give us power to mitigate the symptoms of neuro-cognitive deficits' (Frith, 2002, p.64). By facilitating a more holistic approach to text production, we can argue that the interplay of these modes supports dyslexic children in achieving more effective communication.

Regarding students' perceptions of themselves as writers the intervention elicited a transformative shift from negative and neutral to positive attitudes. Specifically, in baseline assessment, students expressed neutral to negative feelings towards traditional paper-based writing, mentioning difficulties in writing. However, following the intervention, participants exhibited positive perceptions of themselves as writers, aligning with the findings of Foley's study (Foley, 2013) in primary school student population, including struggling writers. Participants in the current study reported feeling more engaged and productive when utilising DST multimedia elements to convey their ideas, as opposed to solely relying on writing. This shift in attitude was accompanied by a sense of overcoming writing difficulties and a motivation to participate in the writing process. This attitudinal transformation underscores the potential of incorporating DST in enhancing dyslexic students' engagement and efficacy in writing tasks.

When it comes to cultural behaviours, the DST platform provided a more diverse range of modes for expression of meanings and feelings, enabling students to better express their previous experiences and reflect on their cultural background. The exploration of cultural behaviours reveals promising outcomes, with the intervention fostering opportunities for students to express their cultural backgrounds more authentically considering both the cultural context and the diverse audience. This aligns with findings by Fariziah Nur Humairoh (2022), emphasising the importance of incorporating

culturally responsive elements in DST interventions in typically developing populations to promote diversity.

Considering the critical dimension of DST, the intervention increased also the opportunities for students to demonstrate critical behaviours. Improvements in critical behaviours were evident, with participants showing enhanced critical thinking during the transformation and transduction phases for conveying messages effectively. Moreover, they had to think critically regarding evaluating and providing feedback, a finding that resonates with the research conducted by Niemi et al. (2014), Karakoyun & Kuzu (2016), as well as Hwang et al. (2023) in typically developing primary school populations. This underscores the potential of the DST, in nurturing critical thinking abilities among students with dyslexia.

These findings have practical implications for educators and practitioners working with students with dyslexia. The findings of this exploratory study, suggest that incorporating DST into writing activities can serve as a valuable approach for addressing spelling difficulties and enhancing executive functions, making writing tasks accessible to students with dyslexia, and that further research in this area should be considered. By providing a supportive digital environment with word processor features, educators can scaffold students' writing skills and promote independent learning.

Furthermore, educators can recognise the cultural diversity of students with dyslexia and leverage DST as a means of fostering inclusive and culturally responsive pedagogy. By allowing students to draw upon their own backgrounds and experiences in multimodal writing, educators can create more engaging and relevant learning experiences that resonate with students' interests.

Moreover, educators can boost critical writing behaviours of students with dyslexia within the context of DST. These behaviours go beyond simply composing sentences; they involve higher-order thinking skills that enable students to analyse, evaluate, and synthesise information effectively taking into account the context.

While the study yields valuable insights, it is essential to acknowledge its limitations, such as the small sample size and inability to generalise the findings. Nevertheless, the design adopted provides insight as to possible courses of action for children in similar position, which should be further explored in future research of experimental nature. Additionally social and cultural factors, (i.e. socioeconomic status, educational background) may have influenced the improvements observed. The main phase of this research, which is currently in progress, will incorporate a longer study period with a larger sample size, also considering social-cultural influences.

CONCLUSION

This exploratory study investigated the impact of digital storytelling (DST) on the writing skills of primary

students with dyslexia within Green's 3D socio-cultural model. It uncovered DST's potential as an inclusive and culturally responsive pedagogical approach. The DST intervention effectively addressed spelling difficulties by providing supportive features like word processors, which aided phonological development and promoted independent learning. Additionally, integrating keyboarding facilitated the writing process, allowing students to focus on higher-order skills while enhancing planning and revision. Moreover, DST intervention positively influenced executive functions, improving audience awareness, idea generation, and organisational skills. This not only enhanced writing abilities but also fostered student independence and engagement. Participants reported a transformative shift in their self-perception as writers, with DST fostering positive attitudes towards writing and increased motivation to participate in tasks. DST also provided opportunities for authentic expression of cultural backgrounds, promoting diversity and inclusivity. Furthermore, DST nurtured critical thinking abilities, enabling effective message conveyance and information evaluation within multimodal writing contexts. Educators and practitioners are encouraged to integrate DST into writing instruction for students with dyslexia, creating inclusive learning environments tailored to diverse needs.

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No funding was received for the purpose of the present study.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon reasonable request to the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

Ethical approval was obtained.

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REFERENCES

- Adeoye-Olatunde, O.A. & Olenik, N.L. (2021) Research and scholarly methods: semi-structured interviews. *JAACP: Journal of the American College of Clinical Pharmacy*, 4(10), 1358–1367.
- Ahmed, Y., Kent, S., Cirino, P.T. & Keller-Margulis, M. (2022) The not-so-simple view of writing in struggling readers/writers.

- Reading & Writing Quarterly*, 38(3), 272–296. Available from: <https://doi.org/10.1080/10573569.2021.1948374>
- Armstrong, S. (2003) The power of storytelling in education. In: Armstrong, S. (Ed.) *Snapshots! educational insights from the Thornburg center*. Lake Barrington, IL: The Thornburg Center, pp. 11–20.
- Beers, S.F., Mickail, T., Abbott, R. & Berninger, V. (2018) Effects of transcription ability and transcription mode on translation: evidence from written compositions, language bursts and pauses when students in grades 4 to 9, with and without persisting dyslexia or dysgraphia, compose by pen or by keyboard. *Journal of Writing Research*, 9(1), 1–25.
- Berninger, V.W., Abbott, R.D., Abbott, S.P., Graham, S. & Richards, T. (2002) Writing and reading: connections between language by hand and language by eye. *Journal of Learning Disabilities*, 35(1), 39–56.
- Berninger, V. & Winn, W. (2006) Implications of advancements in brain research and technology for writing development, writing instruction, and educational evolution. In: MacArthur, C., Graham, S. & Fitzgerald, J. (Eds.) *Handbook of writing research*. New York, NY: Guilford Press, pp. 96–114.
- Braun, V. & Clarke, V. (2019) Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597.
- Carroll, J., Holden, C., Kirby, P., Snowling, M.J. & Thompson, P.A. (2024) Forthcoming. Contemporary concepts of dyslexia: A Delphi study. Available from: <https://osf.io/preprints/osf/tb8mp>
- Catts, H.W. & Petscher, Y. (2022) A cumulative risk and resilience model of dyslexia. *Journal of Learning Disabilities*, 55(3), 171–184.
- Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*, 2nd edition. Hillsdale, NJ: Erlbaum.
- Colvert, A. (2015) Ludic authorship: reframing literacies through peer-to-peer alternate reality game design in the primary classroom/ Angela Colvert. Thesis: (PhD), University College London, 2015. London, United Kingdom.
- Creswell, J.W. & Plano Clark, V.L. (2011) *Designing and conducting mixed methods research*, 2nd edition. London: Sage.
- Damavandi, Z.M., Hassaskhah, J. & Zafarghandi, A.M. (2018) The effects of computer assisted mediating prompts on EFL Learners' writing ability. *International Journal of Education and Literacy Studies*, 6(1), 64–71.
- Denscombe, M. (2014) *The good research guide: for small-scale social research projects*, 5th edition. Berkshire: McGraw-Hill/Open University Press.
- Diamanti, V., Goulandris, N., Stuart, M. & Campbell, R. (2014) Spelling of derivational and inflectional suffixes by Greek-speaking children with and without dyslexia. *Reading and Writing*, 27, 337–358. Available from: <https://doi.org/10.1007/s1145-013-9447-2>
- Douklias, S.D., Masterson, J. & Hanley, J.R. (2009) Surface and phonological developmental dyslexia in Greek. *Cognitive Neuropsychology*, 26(8), 705–723.
- Fisher, S.E. & DeFries, J.C. (2002) Developmental dyslexia: genetic dissection of a complex cognitive trait. *Nature Reviews Neuroscience*, 3(10), 767–780.
- Fisher, S.E. & Francks, C. (2006) Genes, cognition and dyslexia: learning to read the genome. *Trends in Cognitive Sciences*, 10(6), 250–257.
- Fleiss, J.L., Cohen, J. & Everitt, B.S. (1969) Large sample standard errors of kappa and weighted kappa. *Psychological Bulletin*, 72(5), 323–327.
- Foley, L.M. (2013) *Digital storytelling in primary-grade classrooms*. Arizona: Arizona State University.
- Frith, U. (2002) Resolving the paradoxes of dyslexia. In: Reid, G. & Wearmouth, J. (Eds.) *Dyslexia and literacy: Theory and practice*. John Wiley & Sons. England, pp. 69–83.
- Frith, U. (2002) Resolving the paradoxes of dyslexia. *Dyslexia and Literacy. Theory and Practice*, 69–83.
- Galaburda, A. & Livingstone, M. (1993) Evidence for a magnocellular defect in developmental dyslexia. *Annals of the New York Academy of Sciences*, 682(1), 70–82.
- Goodfellow, R. (2011) Literacy, literacies, and the digital in higher education. *Teaching in Higher Education*, 16(1), 131–144. Available from: <https://doi.org/10.1080/13562517.2011.544125>
- Graham, S. & Perin, D. (2007) A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology*, 99(3), 445.
- Grant, N.S. & Bolin, B.L. (2016) Digital storytelling: a method for engaging students and increasing cultural competency. *Journal of Effective Teaching*, 16(3), 44–61.
- Green, W. & Beavis, C. (2012) *Literacy in 3D: an integrated perspective in theory and practice*. Camberwell, Victoria: ACER Press.
- Harris, K.R. & Graham, S. (2009) Self-regulated strategy development in writing: Premises, evolution, and the future. *British Journal of Educational Psychology*, 2(6), 113–135.
- Hebert, M., Kearns, D.M., Hayes, J.B., Bazis, P. & Cooper, S. (2018) Why children with dyslexia struggle with writing and how to help them. *Language, Speech, and Hearing Services in Schools*, 49(4), 843–863.
- Holden, C., Kirby, P., Snowling, M.J., Carroll, J. & Thompson, P.A. (2024) Forthcoming. Towards a consensus for dyslexia practice: Findings of a Delphi study on assessment and identification. Available from: <https://osf.io/preprints/edarxiv/g7m8n>
- Hwang, G.J., Zou, D. & Wu, Y.X. (2023) Learning by storytelling and critiquing: a peer assessment-enhanced digital storytelling approach to promoting young students' information literacy, self-efficacy, and critical thinking awareness. *Educational Technology Research and Development*, 71, 1079–1103. Available from: <https://doi.org/10.1007/s11423-022-10184-y>
- IEP. (2021) *Greek national language curriculum*. Athens: Greek Ministry of Education, Religious Affairs, and Sports.
- Karakoyun, F. & Kuzu, A. (2016) The investigation of Preservice teachers' and primary school students' views about online digital storytelling. *European Journal of Contemporary Education*, 15(1), 51–64.
- Karakuş, M., Turhan Türkkan, B. & Arslan Namlı, N. (2020) Investigation of the effect of digital storytelling on cultural awareness and creative thinking. *Eğitim ve Bilim*, 45(203), 309–326. Available from: <https://doi.org/10.15390/EB.2020.8576>
- Kress, G. (2000) Multimodality: challenges to thinking about language. *TESOL Quarterly*, 34(2), 337–340.
- Kress, G. (2010) *Multimodality: a social semiotic approach to contemporary communication*. New York: Routledge.
- Kress, G.R. (2003) *Literacy in the new media age*. London & New York: Routledge.
- Lambert, J. (2010) *Digital storytelling cookbook*. Berkeley: Digital Diner Press.
- Landis, J.R. & Koch, G.G. (1977) An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics*, 363–374.
- Lankshear, C. & Knobel, N. (Eds.). (2008) *Digital literacies: concepts, policies and practices*. New York, NY; Berlin, Germany; Oxford, UK: Peter Lang.
- Lim, L. & Oei, A.C. (2015) Reading and spelling gains following one year of Orton-Gillingham intervention in Singaporean students with dyslexia. *British Journal of Special Education*, 42(4), 374–389.
- Lisenbee, P.S. & Ford, C.M. (2018) Engaging students in traditional and digital storytelling to make connections between pedagogy and children's experiences. *Early Childhood Education Journal*, 46(1), 129–139. Available from: <https://doi.org/10.1007/s10643-017-0846-x>
- Maggin, D.M., O'Keeffe, B.V. & Johnson, A.H. (2011) A quantitative synthesis of methodology in the meta-analysis of single-subject research for students with disabilities: 1985–2009. *Exceptionality*, 19(2), 109–135.

- Marsh, J., Arnseth, H.C. & Kumpulainen, K. (2018) Maker literacies and maker citizenship in the MakeKEY (makerspaces in the early years) project. *Multimodal Technologies and Interact*, 2(3), 50. Available from: <https://doi.org/10.3390/mti2030050>
- Mega Fariziah Nur Humairoh. (2022) Building undergraduate students' cultural identity through digital storytelling. *Communication Teacher*, 37(3), 235–245. Available from: <https://doi.org/10.1080/17404622.2022.2127820>
- Miller, L.C. (2010) *Make me a story: teaching writing through digital storytelling*. Portland, ME: Stenhouse Publishers.
- Morphy, P. & Graham, S. (2012) Word processing programs and weaker writers/readers: a meta-analysis of research findings. *Reading and Writing*, 25(3), 641–678.
- Morton, J. & Frith, U. (1995) Causal modeling: A structural approach to developmental psychopathology.
- Mouzaki, A., Protopapas, A., Sideris, G. & Simos, P. (2010) A trial for the spelling assessment. In: Mouzaki, A. & Protopapas, A. (Eds.) *Spelling: learning and disorders*. Athens: Gutenberg, pp. 326–338.
- Niemi, H., Harju, V., Vivitsou, M., Viitanen, K., Multisilta, J. & Kuokkanen, A. (2014) Digital storytelling for 21st-century skills in virtual learning environments. *Creative Education*, 5(9), 657–671. Available from: <https://doi.org/10.4236/ce.2014.59078>
- Pinel, P., Fauchereau, F., Moreno, A., Barbot, A., Lathrop, M., Zelenika, D. et al. (2021) Genetic variants of FOXP2 and KIAA0319/TTRAP/THEM2 locus are associated with altered brain activation in distinct language-related regions. *Brain Structure and Function*, 226(4), 1175–1192.
- Plano Clark, V.L. (2017) Mixed methods research. *The Journal of Positive Psychology*, 12(3), 305–306.
- Protopapas, A. (2010) *Spelling: learning and disorders*. Athens: Gutenberg, pp. 67–104.
- Protopapas, A., Fakou, A., Drakopoulou, S., Skaloubakas, C. & Mouzaki, A. (2013) What do spelling errors tell us? Classification and analysis of errors made by Greek schoolchildren with and without dyslexia. *Reading and Writing*, 26, 615–646.
- Ramus, F., Rosen, S., Dakin, S.C., Day, B.L., Castellote, J.M., White, S. et al. (2003) Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain*, 126(4), 841–865.
- Robin, B.R. (2016) The power of digital storytelling to support teaching and learning. *Digital Education Review*, 30, 17–29.
- Robson, C. & McCartan, K. (2016) *Real world research: a resource for users of social research methods in applied settings*, 4th edition. Chichester: Wiley.
- Rogers, L.A. & Graham, S. (2008) A meta-analysis of single-subject design writing intervention research. *Journal of Educational Psychology*, 100(4), 879–906.
- Sarikaya, İ. & Yılar, Ö. (2021) Exploring self-regulation skills in the context of peer assisted writing: primary school Students' sample. *Reading and Writing Quarterly*, 37, 552–573. Available from: <https://doi.org/10.1080/10573569.2020.1867677>
- Shastri, B.S. (2007) Developmental dyslexia: an update. *Journal of Human Genetics*, 52(2), 104–109.
- Smeda, N., Dakich, E. & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: a comprehensive study. *Smart Learning Environments*, 1, 1–21.
- Smith, J.A. (2018) Semi-structured interviewing in qualitative research: advances and challenges. *Journal of Qualitative Psychology*, 5(1), 53–63.
- Snowling, M.J. (2008) Specific disorders and broader phenotypes: the case of dyslexia. *The Quarterly Journal of Experimental Psychology*, 61(1), 142–156. Available from: <https://doi.org/10.1080/17470210701508830>
- Stake, R.E. (2010) *Qualitative research: studying how things work*. New York, NY: The Guilford Press.
- Stein, J. & Talcott, J. (1999) Impaired neuronal timing in developmental dyslexia—the magnocellular hypothesis. *Dyslexia*, 5(2), 59–77.
- Sylvester, R. & Greenidge, W.L. (2009) Digital storytelling: Extending the potential for struggling writers. *The Reading Teacher*, 63(4), 284–295.
- Vandermosten, M., Boets, B., Wouters, J. & Ghesquière, P. (2020) A qualitative and quantitative review of diffusion tensor imaging studies in reading and dyslexia. *Neuroscience & Biobehavioral Reviews*, 108, 48–69.
- Vellutino, F.R., Fletcher, J.M., Snowling, M.J. & Scanlon, D.M. (2004) Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, 45(1), 2–40.
- Verigakis, N., Stavarakis, M. & Darzentas, J. (2010) Educational interactive storytelling for narrative comprehension and recall in dyslexic children: Employing a mythic narrative structure. In Proceedings of the First International Workshop on Interactive Storytelling for Children, IDC 2010 (pp. 9–12). Barcelona, Spain.
- Wery, J.J. & Diliberto, J.A. (2017) The effect of a specialized dyslexia font, OpenDyslexic, on reading rate and accuracy. *Annals of Dyslexia*, 67, 114–127.
- Xanthi, S.V. (2017) Qualitative analysis of 4th–6th grade students' errors in dictation and free writing spelling tasks. *Research in Education*, 6(1), 1–17. Available from: <https://doi.org/10.12681/hjre.10619>
- Yang, Y.T.C. & Wu, W.C.I. (2012) Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: a year-long experimental study. *Computers & Education*, 59(2), 339–352.
- Zimmerman, B. & Riesemberg, R. (1997) Becoming a self-regulated writer: a social cognitive perspective. *Contemporary Educational Psychology*, 22, 73–101.
- Zumbrunn, S. & Bruning, R. (2013) Improving the writing and knowledge of emergent writers: the effects of self-regulated strategy development. *Reading and Writing*, 26, 91–110.

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APPENDIX 1

RUBRIC FOR SPELLING ERRORS

Written words	Correct spelling	Phonological										Grammatical				
		Substitution		Addition		Omission		Inversion		Other	Inflectional suffixes			Non-inflected suffixes		Art.
		S	Ph	S	Ph	S	Ph	S	Ph		N	A	V			
Phonological S=syllable Ph=phoneme Grammatical N=noun A=adjective V=verb Art.=articles Orthographic Th. R.=thematic rule										Exc. Th. R.=exception of thematic rule E.V.V.=Etymological visual vowel E. V. C.=Etymological visual consonant Stress Om.=omission Misp.=misplacement Sup.=Superfluous Sec.om.=Secondary stress omissions Mon. W.=Monosyllabic Word						

APPENDIX 2

THEMES AND SUBTHEMES FOR EACH RESEARCH QUESTION

Research Questions (RQ)	Themes (TM)	Subthemes (STM)
1	1. Setting goals	1.1.1 Determination of the writing purpose 1.1.2 Identification of the main idea 1.1.3 Determination of the audience
	2. Planning	1.2.1 Plan/continue to plan according to the aim 1.2.2 Ease of idea generation 1.2.3 Organise the structure of the plot in the digital storyboard 1.2.4 Overcome handwriting difficulties 1.2.5 Child-friendly design
	3. Self-efficacy	—
	4. Self-Monitoring	1.4.1 Check the spelling of the words and the punctuation via keyboarding 1.4.2 Check and correct the structure of the sentences they have written to be appropriate 1.4.3 Overcome handwriting difficulties
	5. Revising	—
2	1. Feelings about writing	2.1.1 Negative feelings for writing 2.1.2 Neutral feelings for writing 2.1.3 Positive feelings about writing
	2. Perceptions about themselves as writers	2.2.1 Neutral perceptions about themselves as writers 2.2.2 Positive perceptions about themselves as writers
	3. Writing difficulties	2.3.1 Handwriting difficulties 2.3.2. Spelling difficulties 2.3.3 Semantic difficulties 2.3.4 Poor idea development 2.3.5 Overcome spelling difficulties
	4. Motivation	2.4.1 Multimodal ways of conveying a message 2.4.2 Topic based on their preferences 2.4.3 Engagement
	5. Moderate familiarity	—

Orthographic		Stress			Capital/lowercase letters			Other notes	
Th. R.	Exc. Th. R.	E.V.V	E.V.C.	Other	Om.	Misp.	Sup.	Sec.om.	Mon.W

APPENDIX 2 (Continued)

Research Questions (RQ)	Themes (TM)	Subthemes (STM)
3	1. Topics close to their interests 2. Expression of feelings 3. Preference for DST writing process 4. Social and cultural context 5. Provide feedback based on their background 6. Make changes based on their peers' comments	— — — — — —
4	1. Convey the messages critically via diverse modes	4.1.1 Transduction – Combinations of multiple modes 4.1.2 Transformation – Changes within the mode 4.1.3. Comprehensible messages

APPENDIX 3

SAMPLE OF INTERVIEW TRANSCRIPTION

Researcher: I would like to let me know how you felt when you were writing on the DST platform. [0:10:01, 23/03/2023]

P2: Perfect! [0:10:07, 23/03/2023] positive feelings about writing

P1: Well! [0:10:08, 23/03/2023] positive feelings about writing

Researcher: Why do you feel perfect, [name of the student]? [0:10:12, 23/03/2023]

P2: Eee, because I did not write with the hand anymore. [0:10:13, 23/03/2023] not get tired by handwriting

Researcher: Mmm, you don't like writing with the hand, do you? Why my dear? I would like to know about your feelings, if you are ok to share them with us. [0:10:20 23/03/2023]

P2: Sure, I feel boring writing with the hand and also my hand gets tired [0:10:22, 23/03/2023]

Researcher: Ok, I understand. You, [name of the student], how did you feel? [0:10:25, 23/03/2023]

P3: I felt well! It is better writing on the platform because my hand doesn't hurt and I felt confident. [0:10:28 – 23/03/2023] positive feelings about writing not get tired by handwriting confident

P1: Ei, why did you steal my idea? [0:10:40 23/03/2023]

Researcher: You said, my dear, that you felt well when you were writing on the digital storytelling platform why did you feel like that? [0:10:43, 23/03/2023]

P1: Eee because my hand did not hurt and you feel well [0:10:55, 23/03/2023] not get tired by handwriting positive feelings about writing

Researcher: So, everyone has mentioned that it is tiring... [0:10:57, 23/03/2023]

P1: When writing with hand [0:10:58 – 54, 23/03/2023]

Researcher: Ok I got it! I remember that when I asked [name of student] what difficulties did he face when writing he said he faced difficulties in understanding his letters [0:11:08, 23/03/2023]

- P2:** Yes, miss, because I make terrible letters [0:11:55, 23/03/2023]
- Researcher:** Ok, my dear. So, guys. Did you face any others difficulties when writing on paper? Let's remember. [0: 12:06, 23/03/2023]
- P1:** A word [0: 12:20, 23/03/2023]
- Researcher:** Could you please explain? [0: 12:21, 23/03/2023]
- P1:** Let's say, for example, the word /είναι/ you don't know if it is writing with /ει/ or /ι/[0: 12:22, 23/03/2023]
- Researcher:** Ok, You [name of student], did you face difficulties when writing your story on paper ? [0:12:40, 23/03/2023]
- P3:** Emm, the hand. Also, I agree with what [name of student] said before. A lot of times you do not know how to write a word. [0:12:45, 23/03/2023]
- Researcher:** Axam, great. Let me ask you something else. Do you believe that the activity we did by using the DST platform, namely writing the story on the DST platform, assist you to overcome these difficulties? [0:12:59, 23/03/2023]
- P2:** Yes! Before, I was feeling boring, while on the computer not. I was focused. [0:13:12, 23/3/2023]. positive feelings about writing, engaged in the process
- Researcher:** By saying “before” you mean when writing on paper? [0:13:14, 23/3/2023].
- P2:** Yes, miss. [0:13:15, 23/3/2023].
- Researcher:** Great. What did you like the most and lead you being so focused? [0:13:17, 23/3/2023].
- P2:** Mmm, I like that we could add images, sounds to our story. Not just writing [0: 13:23, 23/3/2023] diverse modes of expression
- Researcher:** Axam. Thank you ! You, [name of the student], Does it help you to overcome the difficulties that you face before ? [0: 13:42, 23/3/2023]
- P1:** Yes, because it has some words that I did not know how to write and now I know. It was easier to correct. Now, I remember how to write them [0: 13:53, 23/3/2023] correct spelling errors] ease to recall the spelling of a word
- Researcher:** Mmm, interesting. You mean that is easier to write them again in the future?
- P1:** Yes, I think that I remember them. [0: 14:01, 23/3/2023] ease to recall the spelling of a word
- P3:** The same goes for me. When you write a word once, it is difficult to remember. But we correct a lot of times one word and that help us to remember it. [0: 14:07, 23/3/2023] ease to recall the spelling of a word
- Researcher:** Great! Let me ask you something else. [name of student] I will start with you. I remember that you said that you feel boring when writing a story. Now, does the creation of the digital story change the way you feel about writing? [0: 14:15, 23/3/2023]
- P2:** Yes. [0: 14:26, 23/3/2023]
- Researcher:** Axam. Could you please explain to us a little more? [0: 14:30, 23/3/2023]
- P2:** I do not feel boring. It was entertaining. [0: 14:43, 23/3/2023] positive feelings about writing
- Researcher:** Ok, great! You, guys, had said that you feel so-so when writing a story and the way you feel it depends on the topic. Please, correct me, if I have misunderstood. [0: 14:46, 23/3/2023]
- P1:** Yes, you are right. [0: 14:53, 23/3/2023]
- Researcher:** Now, that we have written on the DST platform does your feeling about writing change? [0: 15:02, 23/3/2023]
- P2:** Yes, because the topic liked us [0: 15:04, 23/3/2023] interesting topic
- P1:** Yes, I have chosen this topic about the sea because I like it. I had ideas to write about. If I do not like the topic, ideas do not come to my mind easily. The platform helped me to write my ideas easier. [0: 15:07, 23/3/2023] interesting topic write easily
- Researcher:** Ooo. Could you please explain us what do you mean by saying this? [0: 16: 00, 23/3/2023]
- P1:** Yes, because you keyboard, you do not write the whole story with your hand. [0: 16:02, 23/3/2023] not get tired by handwriting
- Researcher:** Ok, I got it. [0: 16:03, 23/3/2023]
- P2:** The hand does not hurt. [0: 16:05, 23/3/2023] not get tired by handwriting
- Researcher:** Ok, let me ask you something else now. When do you believe that you write a better story? On paper or on the DST platform? And why? [0: 16:15, 23/3/2023]
- P2:** On the platform; because it shows you your mistakes. For example, the /μολώνω/ I may have written it with /ο/ and it needs /ω/. [0: 16:20, 23/3/2023] identify and correct the spelling errors
- Researcher:** What else did you like? [0: 16:30, 23/3/2023]
- P2:** The images, the cute figures. I could say what I want not just by writing. I was productive. [0: 16:32, 23/3/2023] diverse modes of expression productive
- Researcher:** And how that it helps your text to be better? [0: 16:37, 23/3/2023]
- P2:** Because, for example, I had put an image with a ship and I showed that the toxic waste pollute the sea. Then I write about it. [0: 16:42, 23/3/2023] diverse modes of expression ResearcherO, great opinion. I got it! You [name of the student]? [0:17:04, 23/3/2023]
- P1:** Because, as I said before, my hand did not get tired and also we could put a lot of things. So you can describe what you write. [0:17:10, 23/3/2023] diverse modes of expression not get tired by handwriting
- Researcher:** Ooo, great! You [name of student]? [0: 17:27, 23/3/2023]
- P3:** On the computer because we correct our mistakes and the stress and our text is more comprehensible. Our letters are comprehensible. [0:17: 31, 23/3/2023] correct spelling and stress errors

Researcher: Ok, let me ask you something else. If I ask you which skills do you think you developed the most during writing on the DST platform? Can you understand what I mean by saying skills? [0:17:38, 23/3/2023]

P1: Yes, where it facilitated us the most. [0:17:43, 23/3/2023]

Researcher: So, let me know. [0:17:46, 23/3/2023]

P1: You know, the letters are ready in the keyboard. [0:18:01, 23/3/2023]

Researcher: Just a moment because I am a little bit confused. Let me paraphrase the question. In which areas did it help you to become better? [0:18:05, 23/3/2023].

P1: On the spelling. Some words I did not know or remember how to write them and on the full stops commas etc [0:18:19, 23/3/2023]. Correct spelling and punctuation errors

Researcher: Ok! Let me ask something else. In order to organize better your text which facilitates you the most? [0:18: 33, 23/3/2023].

P3: I don't know for sure. [0:18: 58, 23/3/2023].

Researcher: Ok, no worries. You [name of student]? [0:19:01, 23/3/2023].

P2: I managed to correct my mistakes, not to do, to do less spelling errors [0:19:10, 23/3/2023]. Correct spelling errors

Researcher: You [name of student] ? [0:19:15, 23/3/2023].

P3: To [redacted] and to put nice pictures in my text [0:19:26, 23/3/2023]. [redacted] diverse modes of expression

Researcher: Perfect! One more question, guys. How would you assess yourself regarding your own writing compared to the past? [0:19:30, 23/3/2023].

P3: I think that I am better at it now. [redacted] I [redacted]. Also, [redacted] able to read my story, without asking me all the time

what I have written here and here. [0:19:34, 23/3/2023]. Positive feelings about themselves as writers [redacted] of the text

Researcher: I am really happy to hear that. What about you, [name of student]? [0: 19:50, 23/3/2023]

P1: As I have already said, I felt more independent when I was writing on the platform. I could think by myself without asking your help all the time. [0: 20:00, 23/3/2023]. independent

P2: Yes, I could add images and sounds, and I think that I am better at putting all these together and say what I want and not just writing. [0: 20:38, 23/3/2023]. diverse modes of expression

Researcher: O great! I am very happy to hear such opinions. Now, as we are moving to the end of this interview is there anything else that you would like to add? [0:20:55, 23/3/2023].

P1: No [0:21:32, 23/3/2023].

P3: No [0:21:33, 23/3/2023].

P2: No [0:21:34, 23/3/2023].

Researcher: Thank you, guys, for your time! Let's go out for our break! [0:21:36, 23/3/2023].

APPENDIX 4

PARTICIPANT'S DIGITAL STORIES

The following links include participants' digital stories:

P1 <https://www.storyjumper.com/book/read/151496201/64a45d88235c6>

P2 <https://www.storyjumper.com/book/read/151496221/64a152c0b07d0>

P3 <https://www.storyjumper.com/book/read/151496231/64a45cfc9653b>