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Appropriation of literacy technologies in the classroom: reflections from creative learning design workshops with primary school teachers

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Background: Approaches to teacher professional development, such as learning designs (LDs), can facilitate primary school teachers' appropriation of literacy technology in the classroom. LDs are detailed learning activities and interventions designed by teachers to plan their use of technology.
Methods: Using a creative design methodology to carry out a series of LD workshops with teachers, we aimed to understand how primary school teachers envision learning and teaching with two distinct technologies designed to support children's reading skills: a game and an e-reader. Employing systematic qualitative content analysis, we compared LDs developed by teachers for each technology.
Results: Our study shows that while principles of teacher instruction are consistently incorporated across the LDs, the design of each technology plays an important role in how

teachers plan their students' learning and focal reading skills. Further, teachers' perception of the technology is as important as the features of the design. Compared with the e-reader, the game is perceived as an individual practice activity with less opportunities to learn with peers. Finally, across both technologies, teachers envision supporting additional literacy skills, beyond those designed in the technology, highlighting the importance of explicitly facilitating LDs intended to foster within-subject learning.
Conclusions: These findings raise a new set of considerations on how to support teachers to design literacy learning and teaching activities with technology, and also offer a new methodological approach to facilitate LDs in future research and teacher training.

Keywords: instructional design, literacy technology, teacher professional development, learning design, design methods

Highlights

What is already known about this topic

- Professional development supports teachers to appropriate literacy technologies in the classroom.
- The learning design approach has been shown to facilitate professional development by placing teachers in the role of the designer.
- The learning design approach can support and complement existing pedagogical approaches in the classroom, as well as to foster socio-constructivist learning.

What this paper adds

- In the context of literacy, teachers rely on the learning aims of the technology and its pedagogical approach to determine how and what their students will learn.
- Teachers embed learning with peers when the technology aligns with existing social practice in the classroom.
- Teachers reappropriate literacy technology designed to support reading skills to extend into other literacy skills, such as writing and oral language.

Implications for theory, policy or practice

- The paper offers a learning design methodology to support teachers in creating activities that integrate literacy technologies in the classroom.
- The methodology includes strategies that support teachers to embed learning with peers alongside reflecting a broad coverage of literacy learning objectives.

Literacy teachers are increasingly using digital technologies in the classroom, and previous research has explored how this benefits children's learning. For example, spellchecker technology with audio and visual feedback can encourage children to self-correct (Downs et al., 2020), whereas learning game rewards can motivate children to set new learning goals (Vasalou et al., 2017). Despite these learning features, a meta-analysis of a prominent literacy game – GraphoGame – found no effect of this technology on young children's literacy learning except for children who were scaffolded by an adult from the outside

(McTigue et al., 2020). This work highlights the significant role that teachers play during their students' engagements with education technology. The focus of the present study was to better understand how teachers plan to use technology in the classroom to support literacy learning by taking a learning design (LD) approach. LDs are one way in which to facilitate the connection between pedagogy and technology by placing teachers in the role of designing their use of technology (Laurillard et al., 2018). The LD approach facilitates the process of teachers' creative application of technology, that is, their *appropriation*, to fit their contexts and goals. In producing LDs that can be reshared, teachers can also influence their peers and community of practice (Dix, 2007; Laurillard et al., 2018; Salovaara & Tamminen, 2009).

Fostering Appropriation Through Learning Design

Digital technology is often used by people in unexpected ways that does not always involve the use of the design features embedded in the technology as intended by the designer (Dix, 2007; Salovaara & Tamminen, 2009). Accordingly, a distinction can be made between 'technology as designed' and 'technology in use' (Carroll et al., 2001). Drawing on ethnographic research, Dourish (2003, p. 467) defines this *appropriation* as 'the way in which technologies are adopted, adapted and incorporated into working practice. This might involve customisation in the traditional sense (that is, the explicit reconfiguration of the technology in order to suit local needs), but it might also simply involve making use of the technology for purposes beyond those for which it was originally designed, or to serve new ends.' It has been argued that the design of the technology can promote appropriation, for example, by offering flexible routes of achieving a task and ways to modify the technology (Dix, 2007; Salovaara & Tamminen, 2009). Additionally, people's social and cultural practices also play an important role in how technology is interpreted, leading to different patterns of appropriation (Bruce et al., 2010; Salovaara & Tamminen, 2009). Therefore, design and context can equally shape how technology is appropriated.

In recognising that people can design their own uses of technology, Sengers and Gaver (2006) highlight the importance of explicitly supporting this discovery, an aim that is at the centre of the LD field. LDs are detailed learning activities and interventions that teachers create to plan their use of technology. Daziel et al. (2016) explain that LDs capture the core elements of practice that according to Agostinho et al. (2009) are effective when they offer (i) detailed and complete descriptions of tasks, (ii) the resources and supports needed to accomplish the activity, and (iii) implementation of context. To facilitate the pedagogical underpinnings of teachers' practice and scaffold their designs, Laurillard (2013) identified six types of learning corresponding to cognitive, constructivist and sociocultural theories of learning and teaching, which in later work the same research team embedded within their LD approach. LDs produce suggested lesson plans/templates that can be reused by other teachers (Laurillard et al., 2018), addressing the wider impetus to share the creative outcomes of appropriation (Dix, 2007; Salovaara & Tamminen, 2009).

Reflecting upon the pedagogical dimension of appropriation, some researchers have maintained that LDs are pedagogically agnostic leaving it to teachers to reflect upon their own pedagogical commitments in LDs (Daziel et al., 2016). In contrast, others have proposed that the process of creating LDs can be transformative. Recognising that education should not only focus on academic knowledge and skill, the production of LDs can

enable teachers to take a socio-constructivist lens designed to engender students' social interaction in support of their learning such as peer or collaborative learning (e.g., Mangaroska & Giannakos, 2018). However, less is known about the content of LDs generated by teachers through these processes, the appropriation patterns emerging and whether a socio-constructivist approach does indeed inform how teachers conceptualise their learning activities.

Highlighting the importance of exploring this question, past research shows the challenge teachers face to facilitate and maintain effective peer collaboration around technology despite their belief that it benefits children's learning (Davidsen & Vanderlinde, 2016). Teachers supporting younger students in particular must consider how to embed different forms of instruction to scaffold their students' social interactions (Krahenbuhl, 2016), a task that could pose challenges in the context of technology. Additionally, reflecting upon the influence of technology design, it is important to recognise that design for education can be underpinned by its own pedagogical principles, which in turn may have an impact on how teachers perceive the opportunities they offer for peer interaction. In line with this, past work shows that characteristics of the digital task – such as whether it is timed or open-ended – can shape the quality of children's interaction with each other (Falloon & Khoo, 2014; Fleck et al., 2021).

In this paper, we report on a set of LD workshops carried out with teams of primary school teachers. This activity was planned to support teachers to appropriate two digital technologies in class designed to foster primary school children's reading skills: the Navigo game and the Amigo e-reader. To promote reshareability of these LDs, they were embedded in a teacher manual shared with schools who used this technology over a period of 2.5 years. The content of the LDs generated by teachers in the workshops was examined to understand how teachers planned to appropriate Navigo and Amigo. Our overarching research question is: *how do teachers appropriate literacy technology intended for classroom teaching, and do literacy technologies engender different types of appropriation?* This is addressed through the following sub-questions comparing the two technologies: (1a) What type of literacy skills are targeted in the LDs? (1b) What is the approach to learning embedded in the LDs? In exploring how literacy technology *design* might shape teachers' LDs, we aimed to gain a better understanding of how different technologies can be used to support children's literacy skills, as well as to identify new patterns of appropriation that can be scaffolded explicitly in future LD workshops to foster digitally mediated literacy learning. To this end, aiming to inform future efforts to facilitate teachers' appropriation of technology in literacy teaching, we also draw methodological implications, identifying particular ways in which our approach supported teachers to design activities alongside opportunities for improvement.

Methodology

Context and Literacy Technologies

The research reported here was carried out in the context of a Horizon 2020 EU-funded project on literacy and personalised digital technology. The aim of the project was to *design* new personalised literacy technologies and to *embed* these technologies within the classroom teaching. The approach taken was to involve teachers as co-designers in design research activities throughout these phases.

As part of this research, the project team designed and developed two education technologies to support the development of reading skills: the Navigo game and the Amigo e-reader. Each technology was informed by reading development and games-based learning theories, input from teachers and students, and designed to support children aged 5–8 in primary school to learn how to read (Benton et al., 2021; Révész et al., 2021; Vasalou et al., 2021).

Navigo is situated in an Egyptian narrative (Figure 1). The player's goal is to find their grandma who has lost her way in the desert. Through accessing the game's main pyramid, the child encounters a range of instructional game activities. As the child successfully completes the activities, new rewards are unlocked in the form of avatar items that allow the child to customise their avatar. Additionally, new villagers are saved and thus unlocked leading up to the final reward, the grandma. The game contains around 900 short activities presented across 15 game types, covering decoding skills, word recognition and grammar. Each activity has a prescribed learning objective presented at the start in the form of instructions. In the majority of the activities, children have three rounds of questions to answer followed by formative verbal feedback in the event of an error.

Amigo contains 100 age-appropriate fiction/non-fiction texts (Figure 2). A number of instructional features support word decoding and vocabulary during text reading. Once a text is selected, children receive a 'prereading' activity that introduces a phonological or morphological feature presenting in the text. After engaging with the activity, and upon entering the text, a 'text-highlighting' feature can be switched on to highlight all occurrences of the feature. Additionally, there are word-level instructional supports including the ability to tap on a word and look up its dictionary definition, and construct a 'tricky word list' that contains the syllable breakdown, sentence context and phonetic representation of words chosen by children. Amigo also incorporates text to speech to read aloud a text.

In summary, both technologies were designed to foster accurate and fluent reading. Whereas the game activities included in Navigo additionally covered grammar, Amigo's dictionary was designed to also foster word comprehension.

Following the project's technology design phase, we focused on supporting teachers to embed the two technologies in their practice. In keeping with the collaborative approach taken and seeking to foster appropriation, we conducted a series of LD workshops for each technology. The workshops were designed to support teachers to create their own LDs for Navigo and Amigo. These LDs were subsequently integrated in a teacher manual[1] offered to 10 schools who participated in a 2.5-year technology pilot, reflecting our desire for the LDs to be reused across schools. Following the LD workshops, teachers received

Figure 1. Navigo game (left: mechanic practising word decoding; right: mechanic practising grammar).

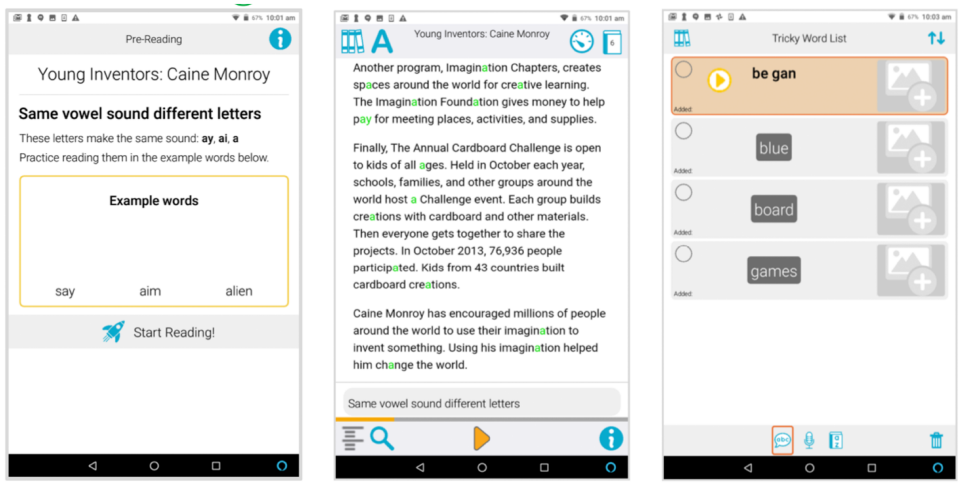


Figure 2. Amigo (left: prereading activity on vowel digraphs; middle: text highlighting vowel digraphs; right: tricky word list generated by a child).

professional development on the technology and its potential use in the classroom in part informed by the LDs embedded in the teacher manual. While using Amigo and Navigo, teachers were also encouraged to consult the manual and use/adapt the LDs it contained. The present work focuses on our methodological approach to LD followed by an analysis of teachers' LDs to understand their patterns of appropriation.

Participants

Ten primary school teachers and five teaching assistants from schools in London participated in a total of 5 LD workshops. All the teachers reported to be confident with digital technology. There was a mix between teachers who had been involved in the design of the Amigo e-reader and Navigo game previously, and new teachers whose schools had expressed interest in joining the project. All staff were responsible for delivering literacy lessons in Key Stages 1 (children aged 5–8) and 2 (children aged 8–11). LD workshops were conducted in groups of 3–5. Two researchers were present. The second author facilitated the session, and the other researcher recorded the LDs generated.

Learning Design Workshops

It has been proposed that LD methodologies can be 'creative' (Mangaroska & Giannakos, 2018). However, the approaches employed in past work to support teachers in crafting LDs have not been informed by literature on creativity, instead focusing on developing digital authoring LD tools for teachers (e.g., UCL's learning designer and Macquarie University's Learning Activity Management System). Design thinking is an approach to design digital technology, processes and outcomes (Razzouk & Shute, 2012). Design thinking has been adopted by researchers and practitioners in the fields of interaction design, business and education as a methodology that can stimulate creative problem-solving. While different models have been proposed to capture its process, they share a number of characteristics, two of which informed our methodology: (i) the facilitation of

divergent followed by *convergent* thinking and (ii) the involvement of collaborative teams. Design thinking provided a general framework and methods to devise hands-on creative LD workshops with teams of teachers. Our workshops contained a first phase dedicated to divergent thinking, and two further phases to support the teachers to converge and refine their LDs. The workshops were designed to be carried out in small collaborative teams of 3–5 with a separate 2-hour workshop for each technology. Overall, the five workshops carried out lasted 10 hours.

Phase 1: Introduction and Divergence (Materials: Cards, Tablets and Post-it Notes)

The inspiration cards creative method was used in Phase 1. Inspiration cards were devised by Halskov and Dalsgård (2006) to facilitate divergent thinking during design thinking. An inspiration card is a physical card presenting a space for a title, image and brief description of the card. There are two types of inspiration cards: domain cards and technology cards.

Domain cards describe the learning domain, context of digital technology use, user-group characteristics and so on. For our workshops, we designed three card types:

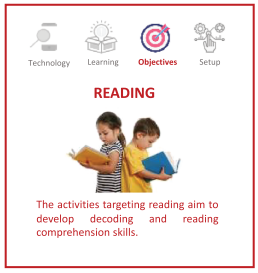
- *Learning objectives* cards captured three literacy areas, namely, reading, writing and oral production, which teachers can target during their literacy lessons together.
- *Set-up* cards described the time required to run a learning activity and the granularity of class configurations (i.e., individual, group and whole class).
- *Types of learning* cards reflected a variety of ways to learn informed by Laurillard's (2013) conversational framework (summarised in Table 1).

Technology cards reflect the functionality of technology and were designed to express the breadth of design features for Amigo and Navigo. Each distinct feature appeared on a single card. By combining two categories of cards to create new outputs, that is, *domain* cards and *technology* cards, it is possible to uncover generative design opportunities (Halskov & Dalsgård, 2006). Moreover, given our aim to develop actionable LDs, the cards ensured that teachers would create LDs that were closely coupled with technology functionalities. Figure 3 displays example domain and technology cards.

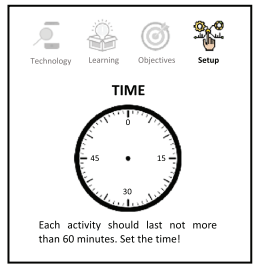
Table 1. Six types of learning (Laurillard, 2013).

Acquiring	Acquisition activities relate to instances where the students read, hear or watch content without action or articulation on their part.
Collaborating	Collaboration activities are those where students produce a shared output through interaction.
Discussing	Learning through discussion requires the learner to articulate their ideas and questions, and to challenge and respond to the ideas and questions from the teacher and/or from their peers.
Investigation	Investigation activities involve students in extracting and using information from texts, documents and resources analytically and critically.
Practising	Practice involves students putting theory into practice towards a goal, generating an action to achieve it and using the feedback to modulate their action or their conception.
Producing	Production involved the generation of an output such as an essay, design or performance, where students use their current conceptual or practical understanding.

DM: Learning objectives [3 cards] – Reading



DM: Set-up cards [4 cards] – Time



DM: Types of learning [6 cards] – Practice

TC: Reader cards [14 cards] – Tricky word list feature

TC: Games cards [18 cards] – Game mechanic difficulty feature

Figure 3. Example domain (DM) and technology cards (TC).

During the workshops, the facilitator organised the *domain* and *technology* cards divided by category and type. The facilitator explained card categories and types starting from the *learning objectives* card using an example card from the deck. It was first established that all the teachers understood the content and differences between cards. For the *technology* cards, in particular, researchers used a tablet to demonstrate the features of each technology, introducing one card at a time. The *domain* cards were presented in both Amigo and Navigo workshops. Given their distinct functionalities, the *technology* cards were different in each respective workshop. Following this introduction, the facilitator prompted the teachers to generate new LDs by combining cards. The only guidance offered to teachers was to use at least one card from each category and type. In line with divergent thinking, participants were asked to quickly create as many LDs as possible. Once an LD had been created, the teachers were asked to write two to three keywords on a Post-it note used to later 'recall' the aims of the LD during Phase 2. The aim was to create approximately 10 LDs in 40–50 min. During this phase, facilitators did not intervene actively in the process, and their role was to ensure the session proceeded smoothly, while answering questions.

Phase 2: Convergence (Materials: Post-it Notes)

The facilitator asked participants to rank the 10 LDs from Phase 1 using Post-it notes. If participants struggled, the facilitator prompted them with convergence criteria: which LD

supports the learning objective best? Which one is the most feasible to perform in class? Which one promotes a diversity of learning types? At the end of this phase, teachers were asked to articulate the criteria they used to rank their LDs.

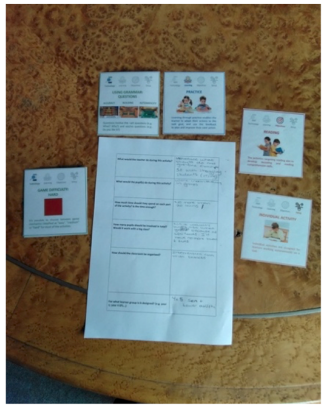
Phase 3: Refinement (Materials: Five Printed Templates of the Table)

Once the LDs had been ranked, the Top 5 were focused upon. Whereas the cards supported teachers to create a first draft of their LDs, the aim of this phase was to describe the specific details of what teacher and students would do during the activity. To achieve this, a paper template was provided prompting the teachers to answer the following questions:

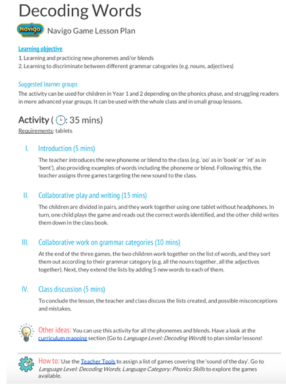
- What will the teacher do during this activity?
- What will the student(s) do during this activity?
- How much time should students spend on each part of the activity? Is the time enough?
- How many students will be involved in total? Would it work with a big class?

Given the goal to produce reusable LDs that would be reshared in a teacher manual, the template used in this final stage allowed the formalisation and representation of each LD created in the workshop within the teacher manual. Figure 4 presents example outputs from each phase. To exemplify a resultant LD, we describe the right-hand side of the figure: this LD is an activity that begins with pre-teaching a letter-sound correspondence followed by collaborative game practice with Navigo between pairs of children on the same language feature. Children have predesignated roles. While one child plays the learning task, the other child writes down the correct target responses on a piece of paper. Once the children have completed this decoding task, they group the words based on their grammar category and discuss their outputs with the teacher who corrects misconceptions. It is clear from this example that the teachers who created this LD extended the learning into different objectives while they defined a clear pedagogical role for themselves.

Phase 1 – Inspiration cards arranged



Phase 3 – LD refinement template completed



Teacher manual – example final LD for the Navigo game

Figure 4. Workshop outcomes (left: cards combined to form an LD in Phase 1; middle: template completed to refine LD in Phase 3; right: final LD included in the teacher manual).

Data Collection and Analysis

During the workshops, photographs of the LDs from Phase 1 were taken and the templates produced in Phase 3 were recorded. In total, 50 LDs were created in Phase 1 of which 23 (12 for Navigo and 11 for Amigo) were refined during Phases 2 and 3, thus forming the focus of our analysis. A qualitative content analysis (Bryman, 2016) was performed on the 23 LDs to address the two research questions (RQs).

RQ1a: Scarborough's (2001) Reading Rope was used as a framework to identify areas targeted in each LD, as it clearly maps out different skills that contribute to reading. Scarborough (2001) identified and refined two dimensions to reading in the 'Simple View of Reading' framework (Hoover & Gough, 1990): word recognition and language comprehension. Table 2 details the skills reflected in the LDs within the two dimensions. Note that 'language structure' is used to refer to the observed grammar activities.

RQ1b: Each LD was segmented into subtasks, that is, 'turns'. For example, one of the LDs started with pre-teaching (Turn 1) followed by game play with Navigo (Turn 2). The LDs produced for Amigo contained on average 5 turns (54 total turns across Amigo LDs), and for Navigo, there were 3.8 turns on average (46 total turns across Navigo LDs). Using Laurillard's (2013) six types of learning as presented in Table 1, we coded the learning type(s) associated with each turn. Following this fine-grained analysis, we classified each LD as 'learning with peers', 'individual learning' or 'mixed'. LDs coded as 'learning with peers' involved discussion or collaboration. LDs coded as 'individual learning' involved students practising, investigating or producing outputs on their own. 'Mixed' LDs were those incorporating individual and learning with peers. This analysis allowed us to determine the orientation of socio-constructivist learning within a given LD.

Consistent with qualitative content analysis, a collaborative coding approach was taken (Richards & Hemphill, 2018). Three of the authors collaboratively developed the analytic framework and refined it through application on a subset of LDs (three LDs for each app). Following the development of the analytic framework, one of the authors coded the

Table 2. Dimensions of reading and reading skills (Scarborough, 2001).

Word recognition: decoding
Word recognition: sight word recognition
Language comprehension: background knowledge
Language comprehension: vocabulary
Language comprehension: language structures
Language comprehension: verbal reasoning
Language comprehension: literacy knowledge

remaining data set, which was checked by another member of the team, and in a few cases, the application of the codes was revised.

Results

RQ1a: What Type of Literacy Skills are Targeted in the Learning Designs?

Within the Amigo LDs, teachers were most likely to focus on supporting *vocabulary*, followed by *word decoding*. Both of these skills were reflected in technology features available, namely, the word lookup dictionary function and the tricky word list that presented the syllable breakdown of a word alongside the sentence context it appeared in. In addition to LDs relying on Amigo features, many of the Amigo LDs reflected a broader focus on *language comprehension* (e.g., developing comprehension questions, tapping into background knowledge and verbal reasoning). Thus, teachers reappropriated Amigo to support new learning objectives that were not designed into the technology and instead chose to target a wider range of skills.

The LDs produced for Navigo targeted children's *language structures*, *decoding* and *sight word recognition*. This pattern of results mirrored the availability of games within Navigo. In contrast to Amigo, which was reappropriated to target new skills, the game was not extended into developing other areas of literacy skill.

Differences between the two technologies were also found in relation to the combination of skills taught. Whereas Navigo LDs focused on one skill, those created for Amigo targeted a wider range of skills. In 5 out of the 11 Amigo LDs, teachers mixed two, or more, literacy areas. An example LD for Amigo asked children to identify and highlight all words containing a target feature (*word decoding*) followed by an oral and written sentence construction task using these words (*language structures*). Figure 5 summarises these findings highlighting the differences between the two technologies.

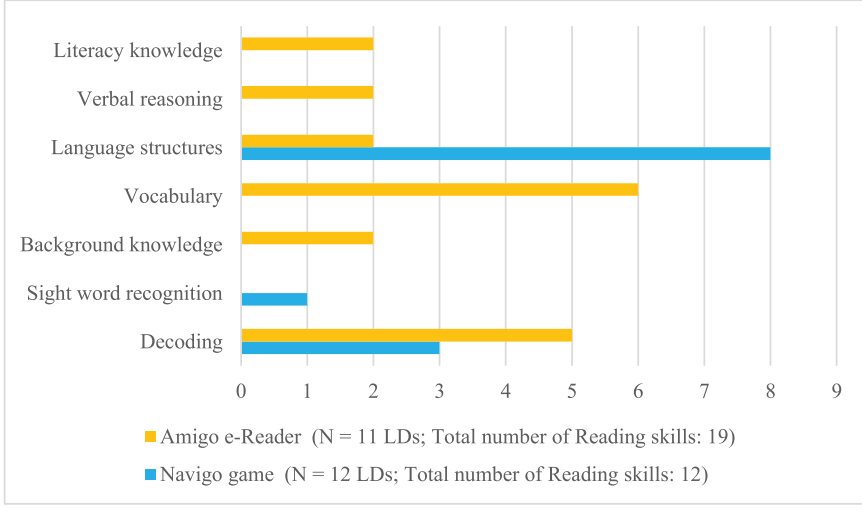


Figure 5. Frequency of skills embedded in the LDs for the two technologies (note: a single LD could target more than one reading skill).

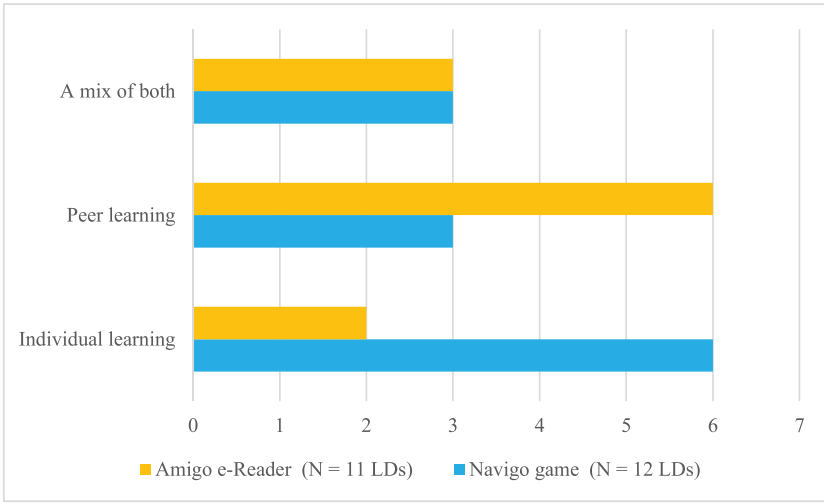


Figure 6. Number of LDs reflecting an individual or peer learning approach.

RQ1b: What is the Approach to Learning for Each Technology in the Learning Designs?

As Figure 6 indicates, teachers tended to favour individual learning in Navigo, while Amigo elicited more learning with peers. Across both technologies, teachers planned a smaller set of mixed lesson plans, where it was difficult to determine the balance between individual and learning with peers. For example, one LD involved the students responding individually to a task, before checking their individual answers within small groups, with a similar amount of time spent pulling out answers individually or comparing/discussing them in groups.

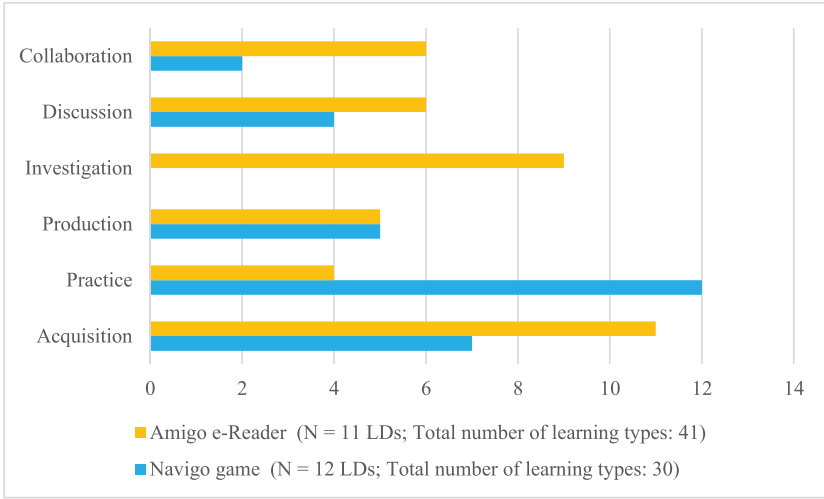


Figure 7. Types of learning designated in the LDs for each technology (note: one LD could contain more than one type of learning).

This pattern of findings was corroborated through the finer-grain account of the types of learning associated with each technology. Figure 7 shows that teachers approached Navigo as an opportunity for practice, and this was the most prevalent type of learning appearing in all Navigo LDs. Opportunities to learn with peers, such as collaboration and discussion, appeared in just half of the Navigo LDs. In terms of the approach taken to discussion and collaboration around Navigo, the LDs captured a variety of ideas. These ranged from students discussing the use of the language feature, producing joint outcomes postgame and feeding back to the class what they achieved in Navigo to reflect on possible misconceptions.

In contrast, 9 out of the 11 LDs created for Amigo incorporated discussion, collaboration or a combination of both. For example, children were envisioned discussing word lists generated from Amigo in groups to determine if they are similar, or collaboratively working through their word lists. Additionally, in contrast to the LDs produced for Navigo and their focus on practice, the Amigo LDs incorporated opportunities for investigation, such as searching for word meaning or highlighting sentences that contained a language construction. Also, as Figure 7 shows, compared with Navigo, the types of learning identified for Amigo were spread across more categories.

Despite their differences, there were also commonalities in the LDs for the two technologies. Acquisition took the form of external instruction delivered by the teacher to introduce the language concepts, with teachers additionally facilitating access to the text within Amigo, either by using text to speech or by reading the text aloud with a preference for the latter. Across both technologies, teachers incorporated equal elements of production asking students to generate written or verbal outputs based on their learning from Navigo or Amigo, or using current conceptual or practical understanding. Examples included acting out a verb, or creating new words/sentences that contain the targeted language feature.

On the whole, the analysis clearly shows that technology was not designed to be used by children independently. Within their LDs, teachers described teacher-led instruction and scaffolds, as well as peer interaction to support or extend the learning fostered in the technology.

Discussion

Technology Design Shaping Literacy Learning

Given the age of the children, it is not surprising that teachers incorporated elements of external instruction connected with *acquisition* as well as other instructional principles such as checking for misconceptions (Krahenbuhl, 2016). Furthermore, the design of each technology directed teachers to embed different types of learning within the LDs. Whereas the structured activities of the Navigo game tended to be perceived by the teachers as a way of *practising* reading, the Amigo e-reader was associated with *investigation* on word study. Laurillard (2013) shares the pedagogical importance of combining types of learning. Given our finding that technology design can encourage teachers to adapt different patterns of learning, future LD workshops seeking to foster technology use in literacy learning could combine technologies underpinned by different principles to produce a holistic and more diverse set of LDs for the literacy classroom.

The design of Navigo and Amigo also influenced the literacy skills teachers embedded within their LDs. *Word decoding* and *language structures* were consistently identified as

the focus for Navigo, aligning with the game's content. In contrast, within the Amigo LDs, we found that teachers addressed the full range of literacy skills. Furthermore, in almost half of Amigo's LDs, teachers embedded multiple skills, which were not seen in Navigo. The richer LDs created for Amigo were additionally evidenced by the comparatively higher number of turns. It is here where Amigo's design may have fostered this skill crossing. Like other e-readers, Amigo presented age-appropriate text encouraging teachers to extend their LDs into language comprehension skills. Amigo also offered word-level design features that supported word recognition. Importantly, the *technology* cards forming part of our methodology brought attention to specific technological features allowing teachers to map them with their knowledge of literacy. This highlights the importance of incorporating detailed technology representations during the production of LDs with teachers, extending previous LD methodologies that have tended to provide teachers with representations of the pedagogical aspect (e.g., Laurillard et al., 2018).

Appropriation of Literacy Technology Beyond its Original Design

Prior research has often focused on evaluating the effectiveness of digital interventions for literacy posing RQs that test learning outcomes fostered by the technology 'as designed' (Carroll et al., 2001). In contrast, our findings indicate that the use of literacy technologies may not be homogeneous with teachers planning to use the technology for new purposes and learning aims. Related to this, teachers tended to incorporate within their LDs a 'production' task following children's engagement with technology. While Amigo and Navigo were both designed to support reading, a production task was included by teachers to encourage transference of skills (i.e., to use the skills practised in the technology in other writing and speaking activities). The time investment required to expand the role of technology beyond its original design intention was most salient in the case of Amigo where teachers proposed to design custom materials, such as comprehension questions, to accompany texts. Following Laurillard et al. (2018) who highlight the importance of teachers sharing their LDs as a knowledge community, a pragmatic goal of these communities could be to additionally share learning material designed by teachers to be used alongside the technology.

The *domain* 'learning objective' cards embedded in our methodology may have partly encouraged teachers to extend their designs beyond reading and across other areas of the English curriculum. This methodological choice aligned with previous research showing that technology is often not adopted 'as designed', but rather appropriated and creatively shaped by its users to extend to new needs (Salovaara & Tamminen, 2009). In the context of technology designed for formal education, it can be challenging for designers to offer quality content for a subject area that is also comprehensive. As a consequence, many literacy apps include limited coverage of the curriculum. Our findings indicate that the *domain* cards included as part of our LD methodology can offer literacy teachers a method to extend their anticipated use of digital technology into within-subject learning.

Opportunities and Gaps for Socio-constructivist Learning with Literacy Technology

Teachers' LDs showed a sharp difference with respect to socio-constructivist learning: the use of Amigo was more often approached as an opportunity to learn with peers, whereas Navigo was perceived as an individual learning task. Within the United Kingdom, there

has been a drive to incorporate social interaction in the context of book reading, reflected in teaching approaches, such as reciprocal reading (O'Hare et al., 2019). Given Amigo's focus on digital texts, it is possible that teachers drew from these existing pedagogical methods to include more discussion and collaboration within the LDs. Thus, even though past research has shown there is a general lack of teacher knowledge in how to engender collaboration with technology (Davidsen & Vanderlinde, 2016), it is possible that prior teaching practices can encourage transference of socio-constructivist learning to the digital domain.

Our research further indicates a need to better support teachers in embedding student collaboration and discussion into LDs intended to facilitate the use of literacy games. When playing learning games, children engage in spontaneous social talk around games, which at times can offer emergent opportunities to learn with peers (Vasalou et al., 2017). However, effective collaborative discussion and coordination around game-based learning has also been shown to require adult scaffolding. This can involve supporting children to develop a collaborative attitude, the placement of a joint tablet to enable visibility, or the orchestration of children's verbal and physical action to maintain symmetricity (Fleck et al., 2021). Other work has identified the importance of criteria for grouping students to engender collaborative discussion (Gutierrez-Santos et al., 2016). To this end, teachers' Navigo LDs can be taken to indicate a lack of knowledge in how to support learning with peers around games. Facilitators of LD workshops could incorporate research underpinning collaborative game learning within their workshops, for example, through the inclusion of new domain cards designed to foster evidence-based patterns of collaboration. Given the lack of turns we identified in the Navigo LD as compared with Amigo, teachers could be additionally prompted to build more natural pauses between game play, embedding collaboration and student discussion in between.

Limitations

The paper examined the content of LDs generated by teachers to understand how they planned to appropriate Navigo and Amigo. Our analysis of teachers' choices led us to distil gaps/opportunities for designing future LDs in the domain of literacy. We also identified methodological recommendations to facilitate teachers' design process towards these new directions. However, teachers were not invited to explain the reasoning of the design choices they reflected within their LDs, or to provide their perspective on the analysis, which we acknowledge would have enriched and validated further the interpretative analysis.

Conclusion

This research aimed to support and understand teachers' appropriation of two literacy technologies in the classroom, a literacy game and an e-reader. Within their LDs, teachers planned to introduce learning aims and support students during their engagements with technologies, highlighting the important role of pedagogy for children in primary education. In support of previous research, the present findings highlight that both features of the technology design and established sociocultural practices can shape teachers'

appropriation and in turn students' learning. By identifying teachers' appropriation patterns, this study also offers a number of methodological recommendations on how to best facilitate LD workshops. Placing teachers in the role of the designer, the LD approach can contribute to the portfolio of professional development activities tailored to schools, informing the broader need for teaching programmes that prepare teachers in using technology in the classroom (UK Government for Science, 2020).

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Note

1. Teacher manual: https://ireadprojecteu.files.wordpress.com/2021/01/english-teacher-manual-jan-2020.pdf.

Data Availability Statement

Research data are not shared.

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