Integrated intelligent LEARNing environment for Reading and Writing

D7.3 – Evaluation of the ILearnRW system

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Abstract	This report describes the results of the iLearnRW project evaluation. It describes the data collected and presents an analysis of both the qualitative and quantitative data. It assesses the research questions as outlined in deliverable 7.1 and suggests answers based on the data..
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Project information

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1. Introduction

1.1. Overview of Research Questions

The research questions the evaluation was designed to answer were outlined in deliverable 7.1. This section briefly summarises the key questions.

Q1: Is the software usable and functional?

This question seeks to answer concerns such as:

- Is the software easy to use?
- Are the game instructions clear?
- Is the feedback given in the games helpful?

These were addressed by collecting both qualitative and quantitative data throughout the evaluation process.

Q2: Does the software require teacher guidance?

This question involves the ability of the software for independent use without any teacher guidance. It will be addressed by administering the software to a small sub-group of children, who will be given the opportunity to use the software at home, while parents will be instructed to only encourage the software use without giving any instructions. The non-guided group of children will be screened and assessed using exactly the same language materials (Screening/Re-assessment Tool) and on the same time frame as the guided group so as to enable comparison across groups.

Q3: Is the software effective in improving users' reading/writing skills?

This question involves the educational outcomes of the software use. It will be addressed by evaluating the users' difficulties in the language structures included in the user profile as these are manifested in both reading and writing.

Q4: How is the software best used in real educational settings?

This question is concerned with several subquestions.

1. What are the best teaching strategies used in conjunction with the software?
2. To what extent do the theoretical approaches incorporated into the iLearnRW software (i.e. multisensory, bottom-up learning, promoting metacognition, overlearning) fit in with existing teaching practices within the UK for children with literacy difficulties and how does this differ between different school contexts?
3. What additional resources are required in order to successfully support the integration of the iLearnRW software within schools and as part of existing teaching strategies?

Q5: Does the software promote confidence and independence in children?

This question was added during the evaluation process based on the observational evidence from the evaluation process.

1.2. Differences from plans

The deliverable 7.1 outlined specific sources of data for each of the research questions. However, in practice we felt it was necessary to use all data from all sources to provide an element of an answer to each question. Some sources of data provided a richer picture than expected whereas other source of data proved to be too preliminary to provide definitive answers.

1.3. Differences between Greece and UK

As outlined in previous deliverables, the differences between the evaluations in the UK and in Greece were due to different educational environments. This also resulted in both generating slightly different data sets. While both evaluations have the same logs and used the same model for screening, the Greek evaluation generated more data from more school environments and interacted with a wider variety of teachers. The Greek evaluators have also had more opportunities to observe classes. The UK evaluation, on the other hand, used fewer teachers and worked with children without integrating into their normal interventions (which do not exist in the UK). It was therefore not necessary to poll the teachers. Unlike with Greece, all of the UK children had a period of independent use and it was therefore felt necessary to interview all children about their experiences. This turned out to generate rich qualitative data that complement the analysis of the quantitative data contained in the logs.

2. Analysis of game logs and screenings (quantitative data)

2.1. Analysis of game play data (logs)

This section presents an analysis of game play data based on the logs collected in the process of evaluation.

The evaluation recorded X hours of game play in English and X hours of game play in Greek. However, confronting the logs with samples of actual usage (for instance during guided sessions when the user was known to have used the system) as well as user self-reporting (see section Session length and frequency under 3.1.4 below) reveals that not all game play was logged. This means that we can only partially rely on the logs for giving us a complete picture of what happened. They nevertheless provide a valuable quantitative picture of data use.

2.1.1. Data integrity issues

During analysis, it was discovered that the log data is most likely incomplete. We had reports from UK students who claimed to use the app regularly who only had a few log ins. We also noticed that some logs that should have happened during guided sessions in schools in both countries were not recorded or only reported as incomplete.

We identified the following types of issues with the logs:

- No login recorded
- Only login recorded but no game play
- Incomplete session recorded

It is impossible to reconstruct all of this data and these possible gaps in the data make it impossible to draw firm conclusions about statistical relationships between outcomes and game play. They do however, provide a valuable quantitative information about how the game was used that complements what the students themselves reported.

2.1.2. Game use UK

Recorded sessions and logins

The system recorded an average of 29 logins into the game per student for UK students with a maximum of 178 and a minimum of 1. See Table 1. This means that on average each student logged in at least once per week. However, this result raised further doubts about the integrity of the data. Three students were recorded as only having logged in once. While these were all students who did not use the game a lot (one having dropped out early on), they all attended guided school sessions during which they were observed to use the game.

	N	Minimum	Maximum	Mean	Std. Deviation
Students	55	1,00	178,00	29,3636	32,20844

Table 1 Number of logins per student (UK)

The total number of sessions played was 1,482 with an average session length of 2.3 minutes. The longest session recorded being 45 minutes.

Table 2 shows that over half of the students using the system at least once week and 15% more than twice a week.

Total number of logins	Number of students		
>5	6	11%	**45% under 20**
>=5	10	18%	
>=10	9	16%	
>=20	22	40%	**55% over 20**
>=50	6	11%	
>=100	2	4%	

Table 2 Game logins by category of frequency (UK)

Games Played

The three games that children in the UK played the most were:

- Post Office
- Serenade Hero
- Monkey Hotel

Together they represented almost 60% of total game play. This could explain why Post Office and Serenade Hero were identified as the most useful games for learning and Monkey Hotel as the second most fun game (see Table 38 and Table 39). However, the fact that Train Dispatcher, Junkyard and Knocking Maze were also popular among students while not receiving as much game play suggests that student choices of popularity were not based solely on availability.

	Total number of times played	Percent
Post Office	357	22,1
Serenade Hero	325	20,1
Monkey Hotel	243	15,0
Square	169	10,5
Junkyard	123	7,6
Knocking Maze	118	7,3
Field	91	5,6
Bridge Builder	73	4,5
Train Dispatcher	71	4,4
Total	**1570**	**97,2**

Table 3 Usage patterns by game (UK)

Table 4 shows that students were able to achieve success rates between 70 and 80% with words presented in the games. The only outlier is Train Dispatcher with 59%. This is not unexpected because the game involves actual spelling of words rather than just identification of whole words or their parts. However, it could also be due to a bug present for the first half of the evaluation that made it impossible for students to move on without getting a correct word, this may have resulted in a larger number of incorrect attempts.

N**ote**: Brief descriptions of games are provided in Appendix 6: Brief descriptions of games.

	Total Number of Words Played	Number of Unique Words Played	Mean Success Rate (%)	Total number of Applications
Field	327,33	244,00	,83	234,33
Bridge Builder	158,00	114,00	,80	196,00
Square	327,33	201,67	,78	209,00
Serenade Hero	271,67	163,60	,77	224,20
Monkey Hotel	253,29	161,43	,76	195,14
Knocking Maze	265,00	173,29	,76	180,29
Junkyard	463,25	310,00	,74	315,00
Post Office	147,58	84,25	,72	104,25
Train Dispatcher	178,33	143,33	,59	119,33

Table 4 Use of individual games by students in the UK (values mean per student)

	N	Minimum	Maximum	Mean	Std. Deviation
Total Number of Words Played	1613	6,00	1253,00	522,9839	381,20404
Number of Unique Words Played	1613	5,00	861,00	329,6882	241,65078
Mean Success Rate		,35%	1,00%	,7871%	,07014%

Table 5 Words played (UK)

The children were exposed most to problems from the categories containing difficulties related to consonants and blends (see Table 6). Blends and letter patterns are the largest categories but Consonants than vowels and suffixes. This suggests that the automated lesson planner did not take into the account the size of the category but rather suitability of that category to the most frequently played games. This was likely combined with students making choices from these categories when they were selecting what to play next.

	Percentage	Number of difficulties in category
Consonants	21,4	49
Blends and Letter	20,5	131

Patterns		
Vowels	12,8	71
Prefixes	11,7	42
Suffixes	11,3	92
Syllables	5,6	13
Confusing letters	5,4	15

Table 6 Profile categories UK students were exposed to

There was a statistically significant relationship between the amount of game play a student was exposed to and their success within the game. See Table 7. However, it is not clear in which direction the causal link is established. It is equally possible that students who play more are more successful because they get better as that students who are successful are likely to play more.

	Mean Success Rate	Total Duration	Total Number of Words Played	Number of Unique Words Played	Total number of Applications
Pearson Correlation	1	,320*	,312*	,340*	,327*
Sig. (2-tailed)		,019	,023	,013	,017
N	53	53	53	53	53

Table 7 Relationship of mean success rate to game play (UK)

This relationship holds constant across all measures of game play be they total numbers of words played or total time played. We also saw that students could succeed equally well across all games. Meaning that each game was a useful instrument of learning.

	Mean Success Rate	Total Duration	Total Number of Words Played	Number of Unique Words Played	Total number of Applications
Pearson Correlation	1	,410**	,404**	,444**	,439**
Sig. (2-tailed)		,000	,000	,000	,000
N	324	324	324	324	324

Table 8 Relationship between games and success (UK)

2.1.3. Game use Greece

Recorded sessions and logins

As it is observed in Table 9, the mean of 77 of participating students logged in the system on a total mean of 14,18 days (table 2) during the six months of the evaluation applied.

	N	Minimum	Maximum	Mean	Std. Deviation

Students	78	2,00	518,00	77,9744	81,04416

Table 9 Number of logins per student (Greece)

	N	Minimum	Maximum	Mean	Std. Deviation
Days played	78	1,00	47,00	14,18	10,92

Table 10 Number of days played per student (Greece)

Table 11 shows that 74% of the students using the system at least once week and 15% more than twice a week.

Total number of logins	Number of students		
<5	3	4%	**26% under 20**
>=5	8	10%	
>=10	9	12%	
>=20	13	17%	**74% over 20**
>=50	24	31%	
>=100	21	27%	

Table 11 Game logins by category of frequency (Greece)

Games Played

As the Table 12 shows, Square was the game most played by the students (38,5%); followed by Post Office and Monkey Hotel at 16,2% and 12,0% respectively. The rest of the activities are recorded in a percentage under of 10%.

These findings indicate the tendency of the students to select those games that enable them to feel that they play rather than to struggle to learn. This could be confirmed by the low degree of difficulty and complexity of the language content of these games. In addition, we could appreciate the above preference with regard to the possible and accurate correspondence between the profiles as they were initialized through the first screening test and the respective game the language material of which was fulfilling that profile characteristics.

	Total number of times played	Percent
Square	2213	36,4
Post Office	930	15,3
Monkey Hotel	730	12,0
Serenade Hero	551	9,1
Field	430	7,1

Knocking Maze	420	6,9
Bridge Builder	219	3,6
Junkyard	143	2,4
Train Dispatcher	110	1,8
Total	**5746**	

Table 12 Usage patterns by game (Greece)

Table 13 shows that a mean of 1615,5 words and a mean of 895,8 unique words presented in the games have been played by the students; a number which could be expected to be in correlation with the success rate. However, no statistical significance was recorded, indicating that the students' progress was independent of the account of the words. An indication that highlights the necessity to be very careful with the material that is applied in the intervention methods of learning difficulties. The most important is the quality of the used language material and not the quantity.

	N	Minimum	Maximum	Mean	Std. Deviation
Total Number of Words Played	6082	8,00	4232,00	1615,5062	1149,84204
Number of Unique Words Played	6082	1,00	3375,00	895,8019	909,24798
Mean Success Rate	6082	,64	1,00	,8459	,07613

Table 13 Words played (Greece)

The above findings are coming to be confirmed by the correlations estimated in the following table (Table 14):

		Mean Success Rate	Total Duration	Total Number of Words Played	Number of Unique Words Played	Total number of Applications
Mean Success Rate	Pearson Correlation	1	,010	,092	,037	,067
	Sig. (2-tailed)		,930	,422	,744	,556
	N	78	78	78	78	78

Table 14 Correlations between success rate and number of words played (Greece)

These correlations enable us to appreciate the stability of the progress as well the type of difficulties of the students.

In an additional attempt to test the potential and the kind of the possible correlation between the type of the task and the success rate in separate games, we found that the last one was not be affected by any other variables.

The only small divergence is recorded in the game of Post Office, which could be translated as a result of a strange combination between the low difficulty of the words and the high complexity of the game:

the students were getting more familiarized with the words as they were struggling a lot in their attempts to gain a high score (because of the complexity of the game).

The profile entries are regarded one of the main components of the language content of the software, as they include the most type of learning difficulties that the participated students face. The following table (Table 15) shows that the largest and the most common categories of difficulties were the syllable division (24.5%), the sound similarity between vowels (14,2%) and consonants (10,9%) and the suffixing (15,0%). According to the Greek research these types of difficulties constitute the profile the Greek students with learning disabilities.

Profile category	Percentage	Number of difficulties in category
0	1489	24,5
1	577	9,5
2	445	7,3
3	863	14,2
4	793	13,0
5	281	4,6
6	259	4,3
7	383	6,3
8	205	3,4

Table 15 Profile categories Greek students were exposed to

2.2. Screening

At the start of the project, each student received a short screening test designed to both initialize the user profile and to establish an ability benchmark. All students who still participated in the project at the end of the period were screened again and their results were compared.

The questionnaire was divided into five tasks in three sections testing different cognitive skills:

- Reading (decoding)
- Writing (spelling, encoding)
- Metacognition (identifying syllables, suffixes and prefixes)

2.2.1. Analysis of UK results

We saw positive improvements across all skills which is consonant with the self-reported improvements by students (see below). Each of the five tasks was analysed separately but the differences on all the tasks did not reach statistical significance in the screening. See Table 16.

The two tasks for which statistical significance was not reached were 1) the syllable division task and 2) writing. This was likely for different reasons.

1) It was suggested that the syllable division task be excluded even before the analysis was conducted because of issues with administration.

There are two issues with the syllable division task. 1. It required that students have sufficient metacognitive knowledge of syllables, 2. Syllable boundaries are not always unambiguous in English and are particularly difficult with orthography. While it was possible to overcome issue 1 with a simple explanation given to students prior to taking the test, issue 2 can only be remedied through consistent long-term instruction. The syllabification explanation was only offered during the first screening which resulted in higher variation in results on the final screening.

2) The writing task (dictation) was not administered during the initial screening at one school due to scheduling issues. This meant that the tested population was much lower.

						t	df	Sig. (2-tailed)
	Mean improvement	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Reading	-,08855	,33617	,04533	-,17943	,00233	-1,953	54	,056
Syllabification	-,02218	,30788	,04151	-,10541	,06105	-,534	54	,595
Writing	-,08333	,38685	,05969	-,20388	,03722	-1,396	41	,170
Suffix split	-,09509	,38448	,05184	-,19903	,00885	-1,834	54	,072
Split prefix	-,08436	,32001	,04315	-,17087	,00215	-1,955	54	,056

Table 16 Improvements from initial to final screening (UK)

2.2.2. Analysis of Greek results

Trying to interpret the results as recorded in Table 17, we saw that a high statistical significance is recorded in all the tasks between the initial and the final screening tests. Significance which highlights positive improvements across all tasks from initial to final. This supports the claim that the games (their language content and their construction) contributed to the improvement of the learning approach of the students and the lowering of their learning difficulties.

						t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Reading	**-,21000**	,45302	,05129	-,31214	-,10786	-4,094	77	**,000**
Split syllables	**-,20872**	,34390	,03894	-,28625	-,13118	-5,360	77	**,000**
Circle 1	**-,19077**	,48390	,05479	-,29987	-,08167	-3,482	77	**,001**
Circle 2	**-,17321**	,34020	,03852	-,24991	-,09650	-4,496	77	**,000**
Fill	**-,17987**	,46162	,05227	-,28395	-,07579	-3,441	77	**,001**

Table 17 Improvements from initial to final screening (Greece)

2.2.3. Comparison of Greek and UK screening results

When comparing the results of the two evaluations, it is readily apparent that the Greek students saw significantly higher (and more reliable) improvements. This is most likely explained by the fact that they took part in more game play and were exposed to more words. They were also always supported by a teacher and the use of the tablet was incorporated into a programme of remedial instruction.

The English students were expected to use the tablets more on their own and while many did do that (see analysis of interviews below), many did not both for technical reasons and because of a lack of interest. This resulted in a very varied cohort with some seeing large improvements and others small ones or even making no progress at all.

3. Analysis of Qualitative Data: Interviews, Questionnaires and Observations

3.1. Interviews with UK students

3.1.1. Background

To collect additional data, we interviewed all students who participated in the evaluation on the day they returned their tablets.

We had previously conducted interviews with all students both in group and individual settings to collect feedback on the games but the data gathered at those points served primarily to provide feedback to evaluators on the progress of the evaluation as well as feedback to developers on issues with the games. The previous interviews were also used to motivate students to engage with the evaluation, answer questions and suggest learning activities to them. Results of these interviews are described below.

The purpose of the final interviews was to provide the evaluation with qualitative data about all aspects of the student experience with the iLearnRW system and to complement the quantitative data collected. This was felt particularly necessary in the UK where students spent more time with the tablets independently thus limiting the amount of observational data for the evaluators.

3.1.2. Procedure

The final interviews were conducted by the evaluation staff using a semi-structured format. The format followed four broad questions with additional prompts (see appendices). The interviewer took notes on the form.

The interviews took place on the last day of the evaluation when the children returned their tablets. In two schools, due to scheduling restrictions, they were combined with the final screening while in one school, these two interviews took place on different days. The interview took between 5 and 15 minutes depending on the responsiveness of the student and the amount of feedback they had.

3.1.3. Data collected

In total, we interviewed 48 students. 5 students dropped out and 3 students were not present on the day of the final interviews. 31 interviewees were male, 16 female and 1 questionnaire was anonymous without gender marked.

The questionnaires responses were coded and the results tallied. The semi-structured format of the interview meant that not all children received exactly the same prompts and therefore the total tallies are not meant to represent a true picture of proportions of attitudes in the cohort. However, they do provide strong indications of the range of experiences and attitudes of the participants.

The responses provided data about the student patterns of independent use of the software as well as self-assessment of their progress along various axes. We also solicited their feedback about the usability of the games described in a separate section.

3.1.4. Student description of iLearnRW software use

Location of use

During their independent use, students used the software in a variety of contexts and locations. The vast majority of those who provided location (38) use the software at home (36). However, 10 also used it when visiting others ranging from relatives to friends. 2 students used it exclusively during visits due to lack of internet at home. Other place of use included transport (3) and school (3). See Table 18.

Home	36
Visits	10
School	3
In car	2
Cafe	1
Park	1
Tube	1
Total answered	**38**

Table 18 Locations of use of iLearnRW system

Time of use

Most students did not specify a time of play but those who did indicated a large range of options from morning, evening, when coming back to school, after lunch and weekends. 3 students admitted to not playing the game at all and 10 students only claimed to use it a little. 2 students did not have reliable internet at home during the period of independent use and 3 students experienced technical problems that limited their use of the tablet.

Session length and frequency

Some students also provided specific estimates of how often and for how long they used the Words Matter Game and Words Matter Reader. The results are summarised in the tables below.

1-2 sessions per week	7
2-5 sessions per week	3
6+ sessions per week	9
Total answered	**19**

Table 19 Weekly number of game sessions self-reported by students

Less than 10 minutes per session	3
More than 10 minutes per session	8
Median reported session length	25
Total answered	**11**

Table 20 Length of game sessions in minutes self-reported by students

1-2 sessions per week	7
2-5 sessions per week	3
6+ sessions per week	9
10+ sessions per week	2
Total answered	14

Table 21 Weekly number of reader sessions self-reported by students

Less than 10 minutes per session	3
More than 10 minutes per session	4
Median reader session length	15
Total answered	11

Table 22 Length of reader sessions in minutes self-reported by students

Patterns of use of Words Matter Games

The game system provided two complementary ways of launching individual activities. One was from the game world where players can encounter individual characters who will send them on 'missions' and the other was from the Ghostbook which indicates progress as well as gives a picture of overall skill.

Of the 26 students who provided an answer about their approach to the navigation of the game, the majority (14) simply launched activities by tapping individual characters in the game world while 6 used the Ghostbook. Only 6 used both approaches – which was intended pattern that was explained to them during guided use. See Table 23. No student reported the use of the history or suggested games tabs which were also introduced during guided sessions but not consistently emphasized. This indicates that the game needed more explicit guidance internally. It also confirms our observational impressions that many of the students did not engage fully with the whole range of game features – focusing rather on the immediate reward of play and result. It is impossible to determine whether this was due to the prototype nature of the product or the reluctance of players to engage more deeply with games. However, given the way we saw children engage with games during the design stage, it is more likely to be the former.

Launch games from game world	14
Launch games from Ghostbook	6
Launch games from both	6
Total answered	26

Table 23 Ways of navigating the game

Patterns of use of Words Matter Reader

A total of 41 children responded about their use of the Words Matter Reader. Of those, 17 mentioned frequency of use. 12 used it sometimes or a lot while 5 used it a little or not at all. See Table 24.

Not used reader at all	3
Not used reader much	2
Used reader sometimes	8
Used reader a lot	4
Total answered	**17**

Table 24 Frequency of reader use

10 students specified the time of use. 3 used the reader before going to be and one even when tidying their room suggesting that the benefit of text-to-speech (TTS) is comparable to that of audiobooks.

At night	2
Before going to bed	3
When bored	2
When free from other responsibilities	2
When tidying room	1
Total answered	**10**

Table 25 Times of reader use

During guided sessions, evaluators observed very high adoption and positive reception of the Text-to-Speech (TTS) feature of the reader. This was made highly prominent in the interface and led to many students being able to access text with a speed and ease that many of them had been unused to. During sessions, the students were given a chance to play with the voice settings, changing both the speed and pitch.

We were therefore curious to see how many would continue to use Text-to-Speech in their independent use of the reader. Of the 24 students who commented on TTS in their answers, the majority said they used TTS at least to a point. Only 5 said they read without speech assistance but of those, 1 admitted to using it sometimes in a separate answer. Interestingly, we found a diversity of approaches to the use of TTS. Despite playing with speech settings having been a very popular activity in guided sessions, only 2 students mentioned adjusting the voice settings. 6 students alternated between speech-assisted and pure-sight reading of whom one specified that they liked to read first and listen second and another that they listened first and then read. 5 students specified that they used TTS to have unknown or difficult words read out to them. For 3 of those, that was the only use of TTS. One student noted that she "liked reader more than games because of audio that reads out the words or the whole story."

Used TTS	18
No TTS	5
TTS for unknown words	5
Some reading most TTS	4
Changed voice settings	2

Read then TTS	1
TTS then read	1
Total answered	**24**

Table 26 Use of text-to-speech (TTS) by students using the reader

While some students reported using the reader as part of their leisure activity (2 when bored, 2 when free, 3 before going to bed), others students thought of explicitly as a learning tool.

5 students reported reading the text first on their own with the assistance of TTS and then to somebody else – most often a parent but in one case a sibling.

While several students reported size of text as a benefit in answers to other questions, only 3 students reported changing the colour settings.

The Words Matter Reader was bundled with a collection of 70 short readings provided by Dyslexia Action. These consisted of 50 short factual texts and were complemented with selected short stories from Aesop's Fables adapted from Project Gutenberg. These stories were very popular with students during in-class sessions but several of the more voracious reader users soon reported that they ran out of materials to read. In the largest school with 25 participating students, we polled the students as to the books they would like to read. In a group, they generated a list of 25 popular children's readings and young adult novels that they would like to read. We used Load2Learn to 5 out of those books available to them before the start of independent use. These were supplemented by 3 books from project Gutenberg. Of the 20, students who had those books installed on their tablet, 7 reported having read at least 1.

3.1.5. Student assessment of impact

Of particular value, is student perception of their improvement which corresponds nicely to the results obtained through screening. From the beginning, students were reporting positive reactions during guided sessions, and observations of student interactions was indicative of beneficial effects. See Table 27 and Table 28 for details.

Spelling	21
Writing easier	13
Reading more fluent	13
Reading easier	10
Can figure out words easier	7
Reads more	8
Understanding words	7
Split words into syllables	5
Can read harder words	4
Learn new words	3
Prefixes	3
Suffixes	3
Composition	2
Reading less boring	2
Writes more	2

Better memory	1
Sounding out words	1
Total answered	**42**

Table 27 Detailed coding of iLearnRW impact as perceived by students

The single effect most frequently mentioned by students was an improvement in spelling. Spelling was mentioned by half of the 42 students who commented on improvement. This is confirmed by the results of the screening tests where we saw an average of 13% improvement. 21 students out of 35 who took both dictation tests saw at least some improvement and 11 saw an improvement of 20% or more.

We also saw improvements in other aspects of writing with 13 students commenting that they find writing easier, 2 students claiming that they write more and 2 students noticing improvements in composition.

Improvements in reading were mentioned across a number of categories with 13 students noting an increase in reading fluency, 10 in ease of reading and 7 increased ability to read individual words. 8 students commented that they read more and 2 students even mentioned that they now find reading "less boring".

There was a great variety of comments having to do with the students familiarity with words with 33 comments on some aspect or another of learning to do with individual words. Most commonly, this had to do with word structure. 6 students explicitly mentioned being able to identify morphemes (prefixes or suffixes) as a benefit and 5 students commented on learning to split words into syllables as a learning. 7 students simply commented on their ability to "figure out hard words" which mostly referred to their ability to segment them. 1 student explicitly mentioned sounding out words. This can be seen as contributing to higher ease of word use and therefore a reduction of stress when reading.

7 students mentioned understanding new words as one of the types of improvements. It is not clear whether this always meant semantics or just a better grasp of the word but at least in some cases, the learning clearly involved meaning. This is surprising given that nowhere in the iLearnRW is the meaning of words explained (even in the reader, the info pop-up some students used to help them with difficult words, only included information about the word structure and not meaning). However, this indicates that students were exposed to unfamiliar words through the games or the reader and proceeded to discover their meaning outside of the game. This speaks to the motivating factor of this approach outside the game itself.

In summary, improvements in both writing and reading were mentioned about equally. This confirms our assumption that although, there was only one activity involved in the game that involved the actual process of writing, the increase in familiarity with word structure alone would have a beneficial impact on writing.

The games also fulfilled the stated aim of increasing the students' familiarity with the structure of words and their ability to segment words while reading and writing. This was commented on explicitly by 19 students.

An unanticipated benefit of the iLearnRW system was the impact on vocabulary. 14 students saw some benefit here, either by learning how to spell new difficult words or learning the meanings of words. All of the above leading to increased confidence as readers (see below).

Writing	36

Reading	35
Word structure	19
Vocabulary increase	14
Better memory	1

Table 28 Summary of iLearnRW impact as perceived by students

The results in this question were reinforced by student comments on why they thought they learned the most from a particular game. Here the majority of the responses has to do with individual words and their structure (12) with a sizable portion mentioning spelling (4). Only two mentioned the actual game mechanics or the process of play with 1 commenting that they had to "think a lot" and 1 appreciated the fact that while timing was important, the games were "not too fast".

How to spell words	4
Identify sounds in words	4
Suffix use	3
Learned new words	2
Help sounding out words	1
Had to think a lot	1
Prefixes	1
Pronouncing words	1
Timed but not too fast	1
Total answered	**15**

Table 29 Responses to why a particular game was good for learning

14 students also commented on the impact using the system had on their results at school. 10 directly commented on improvements in level, grade or test results. 5 commented on improvements in other aspects of school work such as increase speed, ability to do more difficult work, less distraction and more engagement in class. One student commented that it helps him when he remembers something from the game in class. Two students responded that they did not think there were any school improvements.

Spelling test results improved	4
Improved level	2
SATs easier	1
Improved grades	1
Improved literacy results	1
Small improvement	1
Finish work quicker	2
Can do more difficult work	1
Less distracted - can focus more on reading	1
Puts hand up now	1
Remembers things from the game	1

None	2
Total answered	**14**

Table 30 Student self-reporting of tablet use impact (items related to school results outlined)

Four students commented on having others remark on their improvement (which they attributed to use the iLearnRW system). 2 of those specified that this was a teacher and 1 a parent.

Students also had the chance to comment on the change in their attitudes. Of the 24 who were directly prompted whether their confidence increased, only one responded negatively. This is also reflected in the 14 responses to the general question of feeling rather than specific prompts. 9 students mentioned improvements in confidence (6 in general, 2 about reading in front of people, 1 about reading on tablets). 7 mentioned feeling better with 4 simply noting increased happiness with individuals giving specific reasons outlined in Table 31.

More confident	6
Feeling happier	4
Less nervous when reading out in class	1
Excited using tablet	1
Felt really bad before	1
Less frustrated	1
More confident reading in front of people	1
More confident reading on a tablet	1
Much better	1
Total answered	**14**

Table 31 Student responses about feelings and attitudes

3.1.6. Students' availability and use of technology

We took the opportunity during the final interview to poll students as to the availability of technology and their use of it. This provided valuable information about the future of using interventions using mobile technologies such as tablets and smartphones. This survey showed as that over 65% (31) of the 47 students (aged 9 to 11) who answered had access to a tablet at home. Of those, 12 also had access to a smartphone. Making a total of those who had access to at least one mobile platform 40 (or 85%) of the respondents. While this was hardly a representative sample, given that students were not selected for the evaluation based on their availability of or skills with technology, we can be optimistic about this as an indication of widespread availability of the underlying technology. It is also notable, that fewer of the respondents had access to traditional computer at home than one of the modern mobile technologies.

Access to a smartphone	9
Access to a tablet	19
Access to both a tablet and smartphone	12
Access to either a tablet or a smartphone	40

Access to a laptop	27
Total answered	**47**

Table 32 Access to technology by type

Also of interest is the predominance of Android-based devices (54%) as opposed to devices based on Apple's iOS (38%). We can further see a slight preference for smaller tablets of screen-size of 7-8 inches(71%) over large ones with screens of 9-10 inches. This difference is particularly pronounced on the Android side with only 3 large tablets out of 18, while the iPads are evenly distributed between the iPad Mini and a 10-inch tablet. Details of the responses are outlined in the tables below.

iPad Mini	6
iPad 10in	6
Android 7in	11
Android 8in	1
Android 9in	1
Android 10in	2
Kindle Fire	3
Blackberry	1
Total	**31**

Table 33 Tablet ownership by operating system and size

iPhone	8
Android	10
Windows Phone	2
Other	1
Total	**21**

Table 34 Smartphone ownership by operating system

iOS	20
Android	28
Windows Phone	2
Other	2
Total	52

Table 35 Mobile technology ownership by operating system

Several students asked about installing the iLearnRW software on their own tablet and 1 student in fact preferred to use his own tablet instead of the one provided. All students were given instructions on how to install the iLearnRW apps on their own Android tablet (see Appendices in deliverable 7.2). 2 reported having done so.

Thirteen students made comments about their current use of their tablet or smartphones with the results detailed in Table 36. The responses were too diverse and unfocused to draw any generalisations but not surprisingly, games were among those mentioned by a significant number (4). However, even more students (8) mentioned some form of access to text from reading (6) to listening (2).

Games	4
Reading	4
Learning apps	2
Reads online	2
Audiobooks	1
Comics	1
Listen to text	1
Many things	1
Not use	1
Times tables	1
Total answered	**13**

Table 36 Student use of home mobile technology

Some students also talked about things they learned about the use of tablets. They mentioned learning both the fact that this technology can be used for learning and reading as well as acquiring basic skills such as installing apps or even using the tablet or playing games. This reflects the evaluators' experiences during guided sessions where many, particularly younger, students lacked basic skills or understanding of technology (such as connecting to WiFi). While this presented no real obstacles to the evaluation itself and much of the necessary remediation took place through peer learning within minutes, it does underscore the fact that not all children are equally at home with new technologies.

Learned that you can read on a tablet	4
Learned that games can help with learning	3
Learned to use a tablet	3
Books are easier on a tablet	1
Download things	1
Installing apps	1
Learned how to play games	1
Reading on a tablet helps me with difficult words and is more fun	1
Starting to read more books now	1
Total answered	**13**

Table 37 Student learning about use of tablets

3.1.7. UK student feedback on games

N**ote**: Brief descriptions of games are provided in Appendix 6: Brief descriptions of games.

Ranking of games by usefulness and popularity

As a final question, students were asked about their perception of individual games. This was elicited through two questions:

1. Which game did you learn from the most?

2. Which game did you think was the most fun to play?

The results are summarized in the tables below. The tables contain answers from students who identified at least one game in one of the categories.

Post Office	7
Serenade hero	6
Junkyard	6
Monkey hotel	6
Train dispatcher	4
Square	3
Knocking maze	2
Bridge builder	2
Reader	2
Field	1
Not sure	2
Total answered	**37**

Table 38 Games ordered according to which game the students learned from the most

Knocking maze	14
Monkey hotel	9
Square	5
Serenade hero	3
Post Office	2
Junkyard	2
Train dispatcher	2
Bridge builder	2
Reader	1
Field	0
Not sure	1
Total answered	**39**

Table 39 Games ordered according to which game the students enjoyed the most

This survey revealed some very interesting facts about the student perceptions of the games. While there were definite favourites when it came to the game the students enjoyed, the games students thought they had learned from the most were much more varied. This indicates that students genuinely engaged with the learning aspect of the experience and could distinguish between the educational (serious) and game (fun) component of the game. Only a handful of students listed the same game in each category.

It is revealing that the Reader was given as a favourite in each category. 2 students thought they had learned from it the most and 1 student thought it the most "fun".

It is also revealing that the top most useful game for learning was listed as the Post Office (a game only identified as 'enjoyable' by 2 students). This was the game that was identified as most challenging during observations because it engaged multiple skills at once: memory, phonological awareness and speed of word recognition. This was closely followed by other games that sometimes presented a challenge to the students.

What the top games have in common is that they 1) helped the students make connections between sound and spelling (Post Office, Serenade Hero, Monkey Hotel, Train Dispatcher) and/or 2) exposed the students to the structure of the word (Junkyard, Serenade Hero, Train Dispatcher).

This is consonant with what the students identified as their learning (see Table 28 Summary of iLearnRW impact as perceived by students and Table 29 Responses to why a particular game was good for learning). It also underscores that the general approach taken by the iLearnRW game was the correct one.

The tally of the games identified as most enjoyable is also consonant with the observations during the guided portion of the evaluation. The clear favourite was Knocking Maze which had the most complicated game play of all the games. Students really liked that fact that they had to overcome challenges external to the learning aim by having to elude monkeys stealing packages to be delivered. This made it seem much more like a game and students definitely enjoyed playing it. By the same token, despite this game having great potential as a learning instrument, it was not see by many as the one to learn from the most. This is partly due to the fact that it only practices one aspect of phonics (number of syllables and sounds in a word) and partly to the relative infrequency of actual phonic tasks within the game as a proportion of the time spent playing.

It has this in common with the third favourite, Square, which includes a straightforward puzzle element and has a relatively light phonic load.

Monkey Hotel, the second favourite, had gameplay reminiscent of Whack-a-mole and its popularity was no surprise.

The only surprise was the relative low score for enjoyment of Junkyard, which also contains an element of game play external to the phonic task (Tetris) and scored the same as Monkey Hotel on usefulness for learning. Observations in class show that children enjoyed playing it but it clearly was not as popular as the other two with non-phonic elements of game play. This could be partly because unlike the others, the non-phonic part of game play (ordering parts of words) is not integral to achieving the main task most of the time. Specifically, students were able to complete their turn at the game before failing at the Tetris part could interfere with success.

Relative popularity of games like Train Dispatcher and Bridge Builder show the importance of engaging the learner-player across a wide range of activities to meet the diversity of individual preference when it comes to game interaction as well as cognitive engagement with the words.

It should also be noted that the popularity of the individual games could also be affected by how often they were presented to the individual student.

Feedback on games

11 students also offered specific feedback on the games as a whole. While most items of feedback were only received once in this case, they reflect feedback students gave observers during guided sessions. The feedback fell into several broader categories.

Customisability and guidance

- **More options on avatars:** Avatars were clearly high on students' minds. Even though the avatar could barely be seen during most of game play, most students spent a lot of time customising their avatar. During a casual conversation during guided sessions, one student even mentioned how nice it would be if he could customise his avatar's socks.
- **Better instructions:** One student commented that instructions should be played out with TTS. This echoes experiences from guided sessions. Despite the games being relatively easy, many students struggled to use them without explanation. Despite efforts to simplify them, the built in instructions were too difficult for many students to read as well as follow the sequence.

Interaction / Social

Throughout the guided period, many students informally mentioned how much they would like to play with others as they are used from many other games such as Minecraft. The features suggested during the final interviews included:

- Leader board
- Missions with friends online
- Chat

Game design

Several students, who were also gamers, considered the games to be too easy. The need for a challenging game play is confirmed by the popularity of the Knocking Maze, the game with the most challenging and game-like game play. One student in particular pointed to it as being "hard".

Some students were also concerned that the language they were getting for practice was too easy for them. This was not a very wide spread concern but it is clear that the suggestion engine needs further refinement.

One student suggested that adding maths activity would also be useful. The fact that some students see tablets as a useful instrument for remedial maths instruction is confirmed by several other students who planned to install (or have already installed) maths apps on their devices.

Game functionality

Many comments concerned the specific bugs in implementation either in the game as a whole or specific games. Some were concerned with general issues such as:

- Bugs that caused the game to crash or freeze.
- Connection (logging in) problems with unclear causes; even a small disruption in internet connectivity could cause problems for the game.
- Not enough variety offered by the automated lesson planner; some students complained of "always being sent to the same game".

Game story

One of the design features intended to motivate the students to return to playing the game, was the background story. This placed the player in a game world loosely modelled on the Mexican day of the dead. The key motivating plot point in the story is that the student assumes the role of a helper, helping to process words from the memories of the living into Word Matter that powers the game world. The story is introduced through an encounter with the ghost of a neighbour who used to do the job.

The story itself was interesting enough to the children when introduced (the game included an audio recording) but the story was fairly complicated and when asked concept checking questions as a group, the children struggled to pin point the key elements of the story, such as why Word Matter is important. In one school, due to a software bug, the story was read by one of the researchers instead.

When queried informally at several points during the evaluation, children could not recall many details about the story. During the final evaluation, only one student was able to recall the fact that it was necessary to process word matter to keep the world running.

However, it may be premature to conclude that a background story has no motivating power. It certainly did not make any impact on the participants in this evaluation who were just as content to experience the world as it was (with all its quirks) and provide their own background understanding. During the guided part of the evaluation, they found the fact that they could collect photos much more motivating.

This is likely to be due to the implementation. The story is never referenced again in the game in a way that matters. Each character has a background story intended to give reason for the game play but reading the story is not required to succeed in the game. There are no references to the game world running out of power in order to motivate students to return. A simple “power counter” in the game world with occasional reminders could have made the story more relevant. If this had been combined with fading out of parts of the game world or the characters, more children may have played the game more regularly during a period of independent study. Some elements of loss due to inactivity were implemented in the Ghostbook but the correlation between lack of play and the loss of credit was not made explicit and students were given no reminders.

3.1.8. Notes on student feedback and attitudes

In general, the final interviews went smoothly and provided valuable feedback. However, there were several students who exhibited a largely negative attitude and did not provide much of a response. Several students simply said that they didn’t think the games were very good and one disaffected student noted explicitly that he did not like the games because “they were about reading and reading was boring”. That same pupil had complained earlier during guided sessions that he was “missing PE” (physical education session) which was “the only thing I like at school”. Another student gave as the reason for not using the system much as “being busy with his dirt bikes” and another said that she was busy because “she played outside”. She also noted that her father did not let her play games on the computer. Other students alluded to difficult home situations as reasons for using the system less.

This suggests that despite the overall approach taken with iLearnRW (and the system tested in particular) have a lot of potential, it would be unwise to assume that the system can change a pupil’s attitudes on its own. Particularly when the use of the system is disconnected from what is happening at school or within the user’s peer group.

3.2. Questionnaires administered to Greek teachers

To collect additional data, a small-scale questionnaire was administered to 10 teachers who participated in the project. We received completed questionnaires from all the teachers. The questionnaire was given to the teachers after the students had completed all sessions. It consisted of 20 items covering their observations (see Appendix 4: Teacher feedback questionnaire in Greece (English translation) for details). The following is a summary of their responses grouped into three main sections:

1. Children's use of system
2. Perceived impact of the software on children (results, attitudes, etc.)
3. Use cases

3.2.1. Children's use of system

Regarding the use of system, the teachers commented that although in general terms the software was functional and many activities were quite entertaining, students faced several difficulties related mainly to instructions. The instructions in many activities were vague and the students did not know what to do in order to proceed with the given activity and how they could progress through different levels.

In addition, the navigation through the various games was problematic as it required much time in order to shift from one game to another.

Moreover, the graphics of the games were not always clear and they did not square with children's age and interests. For example, the 'Ghostbook' presents the characters used by a player with good classification combining image and explanation, giving at each character a special feature. However, the characters could have been more nicely designed.

The feedback of the game was not always supportive of children's efforts. The results of each activity were not accompanied by audio instructions, hence hindering the children's understanding of their mistakes. There was a lack of a clear and explicit guidelines on a positive feedback of wrong answers.

3.2.2. Perceived impact of the software on children (results, attitudes, etc.)

The impact of the software on children was in many cases dissimilar mainly due to the short duration of the intervention as students with severe learning difficulties could not deal with all the games. Furthermore, there was a great number of different levels and rounds thus making the progress through them a boring and sometimes exhausting task. Also, according to teachers' comments, the occurrence of several malfunctions of the system ('bugs', crashing down, etc.) did not help the children maintain a continuous flow in playing the game.

3.2.3. Use cases

As teachers commented in the questionnaires, this software could not be integrated in the educational system through the curriculum in its current version. Several modifications should be implemented if it is to adjust to the curriculum.

However, it was evident that children with a range of learning difficulties could be assisted by using this software.

3.3. Observations by iLearnRW evaluators

Although the original plan was for the teachers to work with students in classes independent, a variety of circumstances including a greater than anticipated need for support resulted in an evaluator being present in the majority of sessions. This was particularly important in the UK context where more students participated in a session at once and frequent software changes required an additional person to be present in most sessions.

This had the benefit of providing the evaluators with additional observational data.

3.3.1. Common observations by Greek and UK evaluators

Given that the evaluations were led by experts in education and class instruction, the focus of the observations was largely of a pedagogic nature. These observations were discussed during a joint session following the last consortium meeting in July. Observers in both countries agreed on the following:

The key point of agreement among the evaluators was that the games have great potential. They are clearly attractive to the students. It is obvious, from even a brief observation of a student playing one of the games, that this approach is powerful in replicating the best in multisensory classroom practice with additional components of enjoyment and motivation for the children. However, the evaluators also agreed that the actual implementation of the prototype makes it difficult for the system to live up to its full potential. While the overall impression the game gives is very strong and positive, there are too many details that let it down from simple bugs, unfinished features to a lack of implementation of important pedagogic principles. The game as a whole as well as the individual mini games far exceed the requirements of a prototype and (as the feedback from the children) can serve as a creditable first version of an app. However, the system as is cannot yet be seen as a finished stand-alone intervention that can be run by teachers without specialist support.

The two key issues are the lesson planner / progress tracking and in-game pedagogic and user support given to students.

The design of the Ghostbook and the game world do not make it obvious to the students what they have done and what else remains to do. There is also no clear explication of next steps other than suggestions of future games which are made without any explanation as to why. Students struggling with literacy often need additional structure and clear context for their activities. This was a concern we addressed in the initial specification and it was reflected in the way the game is designed. However, due to the complexity of the issue, implementation compromises were required and in practice, neither the students nor the teachers were sufficiently clear about the progress.

Students would have also benefited from a clearer linkage between the games and learning. This was expressed in the Ghostbook and at the start of each game, but without a teacher to explain what was meant by it, it was impossible for the student to make sense of this.

The games did not provide enough feedback on learning to the student. The prototype implemented this by displaying a list of successful and unsuccessful words as well as results of game play. However, students mostly ignored this screen and there was no way to see aggregate results or return to the results. There was also no description of the next step based on the results. The only other feedback was the largely unpredictable award of a photo. This was based on a change in the user

profile but the implementation did not emphasize this. To access an overview of the photos required 2-3 taps in the Ghostbook and children did not make use of this even after repeated instruction.

The games did not contain enough sign posting for the student to feel a sense of purpose. If they were bored of a game, they were not given enough reason to return. Several features to remedy this were discussed during the planning phases but their implementation exceeded the parameters of the prototype. Due to this, students required repeated support in how to play the game and often felt without purpose. Students who may suffer with working memory and sequencing issues were often given relatively complex compound instructions and in most cases, it was necessary to explain a game to them (sometimes repeatedly). This was not a shortcoming of the prototype (help was seen as a lower priority) but before the system can be used independently as a whole, it needs to pay attention to this aspect.

The evaluators also agreed that more learning strategies would make a useful addition to the game.

3.3.2. Additional observations by Greek evaluators

In many cases, technical issues led to the expression of reactions and behaviours such as disappointment, boredom and reluctance to run the games, in students as well in teachers.

Observations suggest that generally students found the use of tablets motivating and many would prefer to use them as the main means of instruction. They see them as an opportunity for engaging in pleasant and interesting learning experiences, without the necessity of being constantly presented with their own difficulties and the very strict learning and teaching rules.

In Greece, the asymmetry of familiarity and comfort-level with technology between students and teachers was pronounced (unlike in the UK where the teacher had been selected in part because of their willingness to use technology). Many Greek teachers were therefore at a disadvantage. However, this proved to be a motivating factor for some children who enjoyed explaining the technology to the teachers.

3.3.3. Additional observations by UK evaluators

Although, the iLearnRW system as a whole is not quite ready to use, it was seen as a highly desirable complementary system. One Dyslexia Action teacher who helped with initial evaluations asked to keep several tablets to use in her classes. She used the Words Matter Game and Reader regularly with her students in one school as an end of class reward. She commented that students enjoyed playing the games and using the reader when given as a treat in the last 10-15 minutes of the lesson. Dyslexia Action is planning to continue using the system in this manner with several teachers.

The UK evaluation has also revealed considerable differences in the ability of children to use technology. This seemed particularly prominent with younger children who struggled with even basic concepts such as connecting to WiFi.

Since relatively few children in the UK have an official diagnosis (statement) of dyslexia, not all participating children identified as dyslexic. Several were puzzled by the identification of the evaluators as belonging to Dyslexia Action saying things like “But I’m not dyslexic.”, “Does it matter that I’m dyslexic.” or “He struggles because he’s dyslexic.” This did not present any real problems for the evaluation and even those without official diagnosis clearly benefited from the intervention but it does underscores the difficulty with labels in the context of literacy interventions.

3.3.4. Student stories/Vignettes

The evaluators also discussed several observational cases (vignettes) of specific students. They each represent a type from which it is possible to learn something about the use of the game.

Greek student stories

Vignette 1 ADHD (boy)

One boy with ADHD started out by just randomly playing. At the end he was able to focus on playing the games without getting distracted.

Vignette 2 Motivated by competition (girl)

Wanted so much to win the competition. Teacher commented that she was crying sometimes and was asking to take the tablet home to play. She was the only student who was very interested.

Vignette 3 Diagnosis through intervention (2 boys in different classes)

These two boys did not have an official diagnosis and the teacher did not have a definite profile of their difficulties. Through the game we were able to understand the difficulty – after the screening test – the initialised profile gave a good indication of the difficulty and was a good guide for the teacher, as well. It was useful to see a dyslexic profile where mental difficulties had once been suspected.

Vignette 4 Finding motivation (boy)

A boy from Year 6 didn't want to go to school at all because he was facing too many problems. He also did not want to attend specialist classes and only took part because of pressure from his mother. His relationship with the specialist teacher was also not very good. At first, the teacher did not think this his participation was a good idea. However, after the start of the project, the student always came on time and even made a lot of progress. At end of project, his mother reported that the child wanted to attend more lessons. When asked if he felt like he learned something he said, that he learned a lot and added that the game helped him find another way to learn. He had always felt that learn was something he is forced to do but using the games he found enjoyment and motivation saying: 'I learned to like learning.'

Vignette 5 Vacillating teacher

Expressed high interest in getting involved in the project. Attended the training session and had many questions. Once the project started he was reluctant to continue but the reasons were lack of WiFi, bad relationship with head of school, etc. Finally he said that he did not believe that this kind of intervention was useful. After discussions and school visits – he consented to run the game in March. He never motivated the students to run the game. 3 students wanted to play 3x a week but there were always some issues. But at the end of the programme he asked for extra tablets.

Vignette 6 Reluctant improver

One student won the contest of who would use the game the most at his school. This meant that he received a free tablet. However, he asked to remove the game from the tablet and when asked he said he didn't play the game anymore. He said he was forced by his mother and his play was motivated by the prize. Nevertheless, he still showed improvement.

UK student stories

Vignette 1: Can I buy the tablet (girl)

A girl (who played the most in her school) came to the final interview asking if her mother could buy the tablet from us because she found it such a useful tool for learning. She had also bought a cover for the tablet and personalised it.

Vignette 2: I played every day (girl)

A girl (who missed 1 month of the guided sessions due to a family emergency) said she played the game twice every day (once in the morning and once when coming back from school) because it helped her with her reading and writing so much. “I really like this game, can I install it on my own tablet?” were the first words out of her mouth when she came for the final interview.

Vignette 3: I read when I’m doing chores (twins, boys)

Two participants in one school were twins. They managed to break one tablet each at different times but they always had one in the family. They both liked the game as well as the reader, one having read all the texts provided.

Vignette 4: My favourite game is the reader (boy)

While the reader was generally popular among students, one boy was immediately taken with it. It was clear that he found the experience of being able to experience text via speech exhilarating. At the end of the first session he asked if he could spend more time with the “reading game”. Also, when asked what they learned about using the tablet, he immediately proceeded to describe one of the texts he’d read.

Vignette 5: My specialist teacher says I’ve improved (girl)

One girl who was also receiving specialist remedial lessons in literacy was able to list a number of improvements to her reading. She said that she felt that she had improved very much since she started using the system with even her specialist teacher remarking on the improvement.

Vignette 6: I hate everything in school but PE (boy)

The most reluctant student was occasionally openly hostile to the process when the school session clashed with his Physical Education lessons. He even commented that “PE is the only thing I like in school”. His final assessment included the words: “I didn’t like this because it is about reading and reading is boring.” He did not use the tablet at all during independent study. However, during the mid-term interview he admitted to liking audiobooks and was able to articulate detailed feedback on the games. He had absolutely no patience with anything he did not understand and in the state of frustration refused to listen to any instruction. However, when finding a game that engaged him, he could focus on it. He also admitted to liking the reader during the school sessions. However, he preferred audiobooks. He is a key example of someone who could greatly benefit from the iLearnRW system but for whom the system needs to be complete. He was too far in his disaffection to tolerate any imperfection in the system and any association in learning was too damaging.

4. Discussion and conclusions

4.1. Discussion of the research questions

Q1: Is the software usable and functional?

The answer to this question is complex. The software was definitely usable and fulfilled the key function necessary. It far exceeded what can be expected of a prototype developed without an extensive infrastructure.

Also, it was felt that the evaluation broadly justified the overall approach taken in the development. The feedback of the students was generally positive and their suggestions for improvement were constructive.

However, at the same time, the process of evaluation uncovered a number of deficiencies. Some of these were simple bugs many of which were corrected during the evaluation. Others (such as the level of feedback provided) were due to compromises made during the implementation process.

One of the key issues is the surfacing of abstract phonic information and information about progress to students in a way that supports them in their learning and motivates them to learn more. The evaluation showed the software to be on the right track but still requiring significant development.

On the whole, the software is sufficiently usable to be used in practice (as is being planned by both UK and Greek partners) in some limited contexts where support is available to both teachers and students. These findings are also echoed by research reported in Appendix 1.

Q2: Does the software require teacher guidance?

We have shown that in principle, the software can be used independently. During the evaluation, the prototype software required significant support due to bugs and compromises made during the implementation. However, after three months use in guided sessions, most of the UK students were able to use the software independently and perceive it as beneficial to their learning.

- Finally, the analysis of data indicated that the students who applied the ILearnRW software system under the researchers' support, they achieved higher improvement in those linguistic categories composed by high degree of difficulty.
- One of the conditions that could be regarded as the most effective to the improvement of the learning process, were the support and the guidance given by the researchers both to the teachers and students.

Research reported in Appendix 2 shows examples of teacher support that was valuable. It was impossible for us at this stage to disaggregate the impact of direct teacher support on the children's understanding of game mechanics from the role of pedagogical interventions in literacy improvements.

Q3: Is the software effective in improving users' reading/writing skills?

We have several data points that suggest that, yes, the software does improve its users' reading and writing skills. We have significant improvements in the users' reading and, in particular, writing skills. This is supported both by improvements on the screening test over six months and self-reporting by the students interviewed in the UK.

Students in both countries saw statistically significant improvements in their reading skills and in Greece in other skills as well. And although, in the UK writing skills improvements did not reach

statistical significance, many students attributed their improvements in writing to the use of the software. Some even felt that the software was responsible for their increased test scores.

The difference between the Greek and English results also suggest that being exposed to more words and more gameplay through the software, leads to more sustained results.

There were some initial concerns about the level of explicit writing instruction, however, the results showed that the software is directly beneficial to the improvement of writing skills at multiple levels. It increases, writing fluency and confidence as well as accuracy of spelling. More research is needed to confirm these preliminary findings and to uncover more about the processes involved.

Q4: How is the software best used in real educational settings?

We have identified several scenarios in which the software can be effectively used. The software is immediately useful as a supplemental tool in specialist sessions directed by the teacher. The software is also suitable as an additional tool to be used by children independently. See also additional research reported in Appendix 1.

As it stands, the software is not directly usable as an independent holistic intervention. However, it has the potential to become one although it would still require some teacher intervention and support.

The iLearnRW system is not perfectly aligned with the school curriculum in either country. In addition, in Greece it was perceived to clash with the traditionally applied teaching methodology by some teachers whereas in the UK, teachers were generally positive. However, the improvements in reading and writing associated with the use of the software suggest that its use should be recommended even in formal educational contexts, particularly when its effects on confidence, engagement and enjoyment are taken into account. Research reported in Appendix 1 provides some examples of how teachers chose to integrate the system into their teaching outside the formal parameters of the evaluation. Even in other contexts (see deliverable 7.2 for details), teachers who were given the system could see how to incorporate it into their teaching as supplement but it was not seen as being ready to be the core of a literacy intervention at this stage.

A system such as iLearnRW may face particular challenges in the Greek mainstream schools where it may represent too big a leap in innovation for some. A significant number of teachers were not used to integrating technology as the main teaching method and struggled with understanding how using apps can be integrated into the curriculum. This is in part because they generally have a lot of experience of using traditional learning and teaching strategies. In contrast, levels of training and qualifications across UK schools are far less uniform and many teachers welcome additional support.

Q5: Does the software promote confidence and independence in children?

The final interviews with children in the UK definitely allow us to answer this question in the affirmative. When asked, all children but one, said that their confidence increased. They were able to describe specific ways in which they found the software to be supportive of their confidence and self-esteem.

The Greek evaluators also reported a strong preference of many of the children for using a more engaging approach such as tablet games to the traditional pen and paper approach.

4.2. Dissemination of results and further research

The data generated by the evaluation is extremely rich and varied. There are few studies with such extensive data base. We have identified several areas where we feel, it would be beneficial to report

our results in an academic settings. We are planning to submit three papers reporting on the results of the evaluation. They will focus on the following areas:

- Speech-assisted reading on a tablet
- Pedagogies of literacy games on mobile tablets
- Student conceptualisation of literacy acquisitions

We are also considering further research projects to elaborate some of the issues identified during the evaluation.

The partners are considering applying for further research grants to deepen the knowledge generated through the evaluation. The iLearnRW provides an ideal platform for gathering this evidence and this has to be seen as one of the outcomes of the project.

Dyslexia Action has already submitted two funding bids to investigate the effects of speech-assisted reading on achievement.

4.3. Conclusions

Overall, the evaluation produced positive results both for the children involved and the project as a whole. It demonstrated that the overall approach taken by the iLearnRW project was justified and provided significant feedback to the field of computer-aided literacy. It also clearly outlined need for future development and research. Several partners have already discussed ways in which the outcomes of the project can be used as a springboard for further developments.

Based on the results, feedback from users and observations, it was agreed by the evaluation team that the iLearnRW games have great potential in literacy instruction and should receive further development in a product stage.

The UK evaluation further underscored the power of speech-assisted reading using the Reader app. The ability of speech-assisted reading to make available even difficult texts to students is potentially transformative and should be investigated further.

5. Appendices

5.1. Appendix 1: Design-Based Research Findings

5.1.1. Research Goals

In order to establish how the iLearnRW software could be successfully introduced into UK primary schools prior to the wider summative evaluation we recruited three UK primary schools to take part in an initial trial of the software. Our goal was two-fold (1) to understand how the software could fit within existing literacy interventions in schools and what support teachers required to successfully utilize our software with their pupils and (2) to improve the pedagogical design of the games. This process was split into three stages, pre-trial interviews, during trial observations, and post-trial interviews.

As reported in D7.2, the three schools varied in their profiles and range of pupil needs. School A was located in an affluent area of south-west London, had low numbers of children at the early stages of learning English and just above average numbers of students with special educational needs. This school was judged to be outstanding by Ofsted. School B was located in a deprived and ethnically diverse area of east London, had a high proportion of children at the early stages of learning English and an average number of children with special educational needs. This school was judged to good by Ofsted. School C was located in a deprived and ethnically diverse area of north London, had high numbers of pupils with English as an additional language and above average number of student with special education needs. This school was judge to be good by Ofsted.

5.1.2. Goal 1: How can the software fit within existing literacy interventions in schools?

Pre-trial interviews

Prior to commencing the trial of the software we interviewed teachers at the three schools to find out how they currently support pupils with literacy difficulties. At schools B and C the teacher responsible for delivering specialist literacy interventions across the school was interviewed. This role did not exist at school A and additional literacy support outside of lessons was covered on a more flexible basis by specialists from outside agencies, teaching assistants and volunteer readers, therefore at school A both the literacy coordinator and the Year 5 class teacher were interviewed. A researcher conducted the interviews, and these were audio recorded and transcribed.

Schools B and C explicitly followed the national strategy intervention for literacy, which consists of three waves of teaching and support, and promotes the use of a range of invention programs and approaches (ref – An evaluation of National Strategy intervention programs, Ofsted, 2009). Wave 1 focuses on providing quality and inclusive teaching that differentiates where necessary and can also include some small group or 1:1 teaching where appropriate. Wave 2 consists of targeted special educational need (SEN) provision and involves undertaking an evidence-based intervention over a set period of time, with the aim that the pupils should have caught up by the end of that intervention. Wave 3 involves specialist SEN provision through an intervention program that is highly personalized, based on the specific needs of the pupil, structured in small achievable learning steps and also closely monitored. It is targeted at pupils who have not been able to catch-up through the first two waves and is delivered 1:1. Both participating teachers at Schools B and C delivered Wave 3 intervention sessions. The teachers at school A did not follow explicitly follow this approach, however their

description of their approach to literacy teaching and support general corresponded with the wave 1 approach as it consisted of strategies such as differentiation and occasional small group/1:1 support. This was potentially in part due to the lower severity of the special educational needs of the pupils at this school.

During the interviews the literacy coordinator at School A discussed a need for understanding how the software maps to the particular level the children are identified as working at and suggested looking at the specific objectives detailed within the national curriculum, which shows the progression for each year group and would allow this form specialist support to be integrated into whole class teaching. She also talked about integrating the software into homework and was keen to get the parents involved. The class teacher described how any existing 1:1 support that the pupils in his class currently received for literacy was for a specific skill e.g. writing interventions or reading practice, but that additional small group interventions would be delivered throughout the year by him during assembly time (30 minutes) on as needed basis as he got to know the children. These findings had several implications for integration support:

- Clearly demonstrate the link between the English national curriculum objectives and components of the iLearnRW software
- Provide a parent user guide to support the use of the software at home
- Prepare a plan to integrate the iLearnRW software into the small group intervention format

In contrast the Wave 3 teachers at Schools B and C discussed the highly structured regular nature of the intervention sessions they delivered. These sessions were 2-4 times a week and lasted 30-40 minutes. The teacher from School B described how she focused on 1 or 2 objectives per session which were transferable across reading and writing and the teacher from School C explained that she would only do one new thing per session which was the principle of the literacy session, and that this would be multisensory so you would address this one objective in different ways. The learning objectives were extremely specific and personalized to the pupil, e.g. focusing on the sound ‘ee’. The teacher from School B also discussed how each session would include 2 to 3 different activities which could include games, speaking activities, reading books as well as using a desktop computer to access computer programs such as Lexia, watching literacy videos or using websites such as BBC Bitesize. The teacher from School C mentioned she had started using an app on her phone with some of the pupils, but had limited access to other forms of technology. The teachers shared with us their lesson plans, which they produced and detailed the timings, specific activities and learning aim of each session. These were designed to maximize the time they had available and everything was prepared in advance so as not to waste time during the sessions. These findings had several implications for the integration support:

- Provide a teacher user guide with a breakdown of the specific language skills that each component of the software addresses to enable the teachers to identify in advance which activities will map to their session objective
- Produce sample lesson plans based on the existing format used by teachers to show how the software could be incorporated into the current intervention structure

During trial observations

Within School A at the time of the trial the class teacher was not yet due to begin his small group intervention sessions until later in the year and so it was agreed that a researcher from the project would instead simulate the format of the sessions with the pupils. Therefore although this arrangement allowed us to gain insight into the pupils’ use of the technology we were not able to establish the support that teacher would require in this context.

Within both Schools B and C although the teachers had attempted to incorporate some technology within their sessions they had not used tablets and also nothing as complex as the iLearnRW software. During the initial teacher training sessions it became clear that the teachers had worries about how to they would be able to support their pupils to use the software given the large amount of content and functionality it incorporated, which initially they found a little confusing. This required the further provision of support through researchers modeling the use of the software with each of their pupils which allowed teachers to observe, take notes and reflect on how they would be able to use the software themselves and how they could best support their pupils.

During the trial the teachers from Schools B and C were also observed using the software with their pupils during their invention sessions. It became clear from these observations and discussions with both teachers afterwards that the extensive teacher options were causing confusion for the teachers due to the sheer number and it being unclear the exact impact some of the options would have on the chosen game, this also sometimes resulted in the teacher selecting a level that was too difficult for the pupil. The observations further highlighted the amount of time that was being wasted between games during which the teachers would be attempting to chose an appropriate game to play next. The teacher from School B also said that she felt she wasted time playing some of the games that after selection she realized were not actually appropriate for that particular pupil. Lastly both teachers were observed augmenting the technology through the different support strategies they provided, for example the teacher from School B supported the playing of a game that presented words that in paper-based activities would be deemed too difficult for one pupil by reading out the different options and asking the pupil to select the word that contained the blend he was working on which enabled him to still experience success within the game and also exposed him to a greater range of vocabulary. The teacher from School C was observed providing further learning opportunities during one game by requiring the pupil to read out the word after he had selected the specific sound in the word. These findings had several implications for the integration support:

- Model a session with pupils to help teachers understand how they might exploit the software with different pupils
- Provide an initial list of recommended games for each pupil that best match their current learning objective and provide suggestions of the different teacher options that can be selected to alter the different layers of difficulty
- Include different strategies that teacher can use to augment the pupils' learning through the technology (further work would be required to collect these strategies)

Post-trial interviews

The pupils from School A were able to access the software during class and at home, however we encountered a number of problems with this. During the post-trial interviews the class teacher discussed how although the pupils initially took the tablets home to use the software there, occasionally pupils forgot to bring them back into school for the sessions and also one pupils lost the box and was told she couldn't take the tablet home until this was found, this resulted in the other pupils also not taking their tablets home as they were worried about losing/forgetting them. Also none of the pupils used the software during class and the teacher explained that this was because during the period in which the pupils had access to the software as the lessons were more writing focused and then the teacher spent time reading the class book aloud to the pupils so it didn't seem to obviously fit with the nature of these lessons. This suggests that the software may be more appropriate to be used during the more specialist 1:1 interventions than during whole class teaching, which are suitably differentiated to be accessible for all pupils.

Both teachers from School B and C explained that they chose to integrate the software as a consolidation/revision activity rather than for introducing new concepts during their sessions and suggested that they found it beneficial for this type of activity. They also both felt that the software was suitable for use within 1:1 settings being supported by a specialist teacher. The teacher from School B highlighted that the content was structured in a slightly different way to her approach where she would select words to use during sessions based on their specific composition of consonants and vowels. She further explained that the language terminology was slightly different to the program she followed and this required her to identify the mapping between the two e.g. dipthong instead of alternative vowel diagraph. Both teachers discussed the limited time that was available during the sessions which gave little opportunity to dedicate to learning more complex gameplay, with the teachers preferring the simpler "pick up and play" games such as Monkey Hotel. There was also little time for the narrative aspects of the games with neither teacher encouraging the children to explore this side of the software. The teacher from School B in particular felt initially overwhelmed by the number of options that she could, which again could consume valuable lesson time, and explicitly expressed that it was helpful to be given ideas of which combinations of games to use for specific pupils. She also said that she relied on the user manual heavily at the beginning and the teacher from School C stated she really liked having this list to check which character/skill she was going to work on. The teacher from School B would have liked more information regarding the different levels to help her better select the appropriate level. The teacher from School C would have been helped by having an overview of the child's progress through the system in terms of where they started and where they are now. These findings had several implications for the integration support:

- Adapt sample lessons plans for teachers to give examples of how software could be used to consolidate the key learning objective rather than using it to introduce the concept
- Provide a mapping of the structure of the iLearnRW intervention program onto other commonly used literacy intervention programs, providing examples of words included at each level/skill and clarifying specific terminology
- Include a description of the meanings of the different gameplay levels along with example content
- Provide more information about starting points and typical progression through the software to help teachers situate the achievements of their pupils within the bigger picture of the intervention

5.1.3. Goal 2: How can the pedagogical design of the game be improved?

The findings we report are informed by the two phases of interviews conducted during the trial of the software and upon the end of the study. This work is a continuation of the formative evaluation undertaken as part of D7.1. Teacher recommendations from the interviews were thematically clustered into groups which we present below.

Level of challenge

Game features impacted on the pedagogical design unwitingly increasing challenge in certain language areas, or removing challenge in others:

Mini game	Problem description	Elaboration
Junkyard	Doesn't specify the learning objective	Without having a learning objective displayed, the student doesn't know what they are learning

Bike Shed	The doors should be closer in order to practice automaticity	The doors the student has to locate in order to knock out the syllables are spaced a long way from one another. This inceases the amount of time spent walking around the map rather than practicing syllable counting. It prevents the students from developing the automatic processing of syllables
Bridge	The game is too slow	The pace of the game means that the proportion of time performing educationally meaningful activities is small compared to the total length of the game
Bridge	There is an indicator of how many items the player should fix	In the top right hand corner of the game there are a number of spanners. The number of spanners matches the number of letters, which need to be selected. This makes the game mechanics transparent. Particularly when working on a prefix or suffix, children know they have to select that number of letters at the beginning or end of the game
Music Hall	Irrespective of the location of a word in the sentence, the timer does not adapt	When a word is missing at the start of the sentence, there is less time to identify, select and move the letter pattern into the gap. This makes it harder to complete, compared to when the word gap is at the end of the sentence
Music Hall	The distractors must vary when a new target item appears	The same distractor appears in every round of the game. This makes it trivial to select the correct answer (i.e. the one which didn't appear in the previous round)

Support for understanding linguistic terms and skills

Different teachers use different terms to describe the same linguistic rule. Terms used within the game must be explained to the teachers as well as the children:

Mini game	Problem title	Elaboration
Field	Doesn't explain what the add, drop, change, double rules are	There is a lack of information about the suffixing rules as these labels are displayed on the cows without any explanation of what they mean
Gameworld	There is no information about the difficulty that each character represents	Information should include details about the linguistic area the character represents

Different types of feedback

The games must be able to provide different feedback when the child does not answer or answers incorrectly:

Mini game	Problem title	Elaboration
Post Office	No feedback at end of game	Without feedback, the student does not know what they did well and what they need to improve
Bridge	No feedback at end of game	Without feedback, the student does not know what they did well and what they need to improve

Junkyard	The feedback does not recognise 'not answering' as an incorrect answer	Not attempting to split a word is treated as a correct answer within the final feedback screen
Music Hall	When the game shows an incorrect attempt, it doesn't highlight that no attempt was made to select a word	The word gap becomes red if a segment was not selected. This doesn't differentiate it from when an incorrect segment was selected

Content selection

The game content selection algorithm sometimes did not choose the right level or type of content:

Mini game	Problem title	Elaboration
Music Hall	The child was offered word choices which could both be correct	The game presented the letter h- and the endings 'and' and 'ad' both of which could be correct
General	Choosing advanced content	In single player mode, a low ability child had not completed much when Junkyard with prefixes selected the first word as 'abbreviation' which is too advanced
Ghostbook	Characters from each linguistic difficulty are not always unlocked	Some of the users had difficulty areas where they did not have an unlocked character. This meant that they could not improve in that area and unlock other characters under that difficulty area
Music Hall	The teacher chose the pattern -ng but only 1 of the words in the game contained this letter combination	While a teacher selected a particular letter combination, the presented content did not match this selection

Making teacher options relevant

During the Manor Park post study interview, the teacher asked for less options even though she liked having fine grained control over all details of non-tablet based activities. It is important to design the teacher options to be understandable/usable/meaningful for teachers.

Mini game	Problem title	Elaboration
Ghostbook	It is not clear what is meant with "no. of distractors", and what the levels for difficulty and speed options refer to	In the teacher options, the phrase "Number of distractors" isn't meaningful to teachers. The options for "difficulty" and "speed" have been presented as a scale, which introduces confusion as to the final game outcome

5.2. Appendix 2: Case Study Research

5.2.1. Introduction

Between 8-10% of children attending compulsory education are diagnosed or suspected to have dyslexia (Rose, 2009). Dyslexia is caused by a phonological deficit with evidence suggesting that remediation is best accomplished with drill and practice teaching methods aimed at developing children's strategies for tackling word level difficulties (Griffiths and Morag, 2014). Despite the

growing movement of integrating children with dyslexia into mainstream classrooms in the UK and in Europe (Lindsay, 2007), the persistent nature of their reading difficulties often necessitates children's occasional removal from the class to receive tuition led by an expert tutor (Griffiths and Morag, 2014). With evidence suggesting equivalent reading gains between group and one-to-one tuition, schools are more likely to adopt the less costly, former approach.

A key barrier that teachers face during these sessions, particularly with older children, is children's lack of motivation to engage in literacy (Zisimopoulos and Galanaki, 2009). This highlights the importance of early intervention. It also suggests that literacy activities must be designed to appeal to children's interests. Attempting to tackle the barrier of motivation, a recent study explored how drill and practice literacy games benefited children with reading difficulties by offering them a socially valued medium (Holmes, 2011). Set in the context of children's home, game-based learning was found to enhance children's motivation although the use of games did not come without challenges. The requirement to choose appropriate games that support the child's zone of proximal development, alongside the importance of ensuring that the learning task was structured and clear, meant that a delicate balance needed to be met between children's independent play and parental guidance.

This study supports previous findings in the learning sciences and technology-enhanced learning showing that social interactions are a facilitating condition to learning (Littleton, 2010; Webb, 2010; Vygotsky, 1987) and a platform for enacting psychological functions before they are internalised by the child (Vygotsky, 1987). The study conducted by Holmes additionally cautions against deterministic views of game-based learning that seek to quantify learning gains and provides a nuanced portrayal between what games can offer in the way of motivational and pedagogic features and the ways in which they necessitate particular forms of social interaction and support. The present work reports on a study conducted in a school setting during which two groups of primary school children with dyslexia used a set of literacy games personalised to target their individual difficulties. We build upon the work by Holmes (2011) by examining situated exchanges between students, tutors and peers in order to understand how the game fosters particular types of social interaction and learning.

5.2.2. Considerations for Game-based Learning and Students with Dyslexia

During the past decade, much debate has centred on how games foster learning. Egenfeldt-Nielsen (2007) takes a historical view to show that behaviourist modes of learning underpinned early game genres (e.g. memory games), described by reinforcement and reward systems. This gave way to cognitivist learning theories whereby the learner's abilities and skills became the focal point. Intelligent games provided a way to detect and respond to the needs of each learner. More recently, constructivist perspectives on games have gained traction where meaning making alongside the learner's social and cultural context is emphasised. To this end, Squire (2006) observes that games prioritize a 'learning by doing' approach during which the player is involved in cycles of action and perception allowing meaning to emerge within the constraints of the game system. He argues that games should be used in education in order to support problem solving and situated understanding through the development of identities that enable players to enact their understanding; an example of a physics games is given in which the learner takes the identity of a scientist confronted with solving a problem. Squire (2006) is critical of 'exogenous' games in which the game context is subjugated to a motivational role rather than offering a meaningful context, and games that approach learning as a transmission of knowledge. Taking a different integrative perspective, Egenfeldt-Nielsen (2007) explains that new game paradigms build upon the foundations of older ones.

The evolving academic landscape on game-based learning can be attributed to the changing theoretical lenses employed both to design games and to understand them. When it comes to choosing or

designing games for remediating the difficulties of special education needs students, however, particular considerations apply. Neurological conditions, such as ASD, ADHD and to our current interest dyslexia, present variable traits and are thus best thought of as a continuum (Benton et al., 2014; Rose, 2009; Gooch et al., 2015). Thus, a cognitivist approach offers a tool through which to personalise the game in order to target the difficulties of the individual student (Holmes, 2011; Gooch et al., 2015). Additionally, even though the exploratory nature of constructivist games has been shown to offer vital learning opportunities, pedagogies that aim to ameliorate neurological conditions advocate clear structure, goals and constant repetition of skills (Griffiths and Morag, 2014; Gooch et al., 2015) akin to the much critiqued drill and practice. This goes on to suggest that game-specific modes of learning must align with special education pedagogies and evidence-based practice. Despite some researchers' pessimistic outlook on drill and practice games (Squire, 2009), Holmes (2011) found that this genre of games reinforced the skills of children with reading difficulties, provided a constant stream of feedback and gave them more independence increasing as a result their self-esteem.

Looking beyond how games have been designed to how they have been used in educational settings, the integration of games in the classroom has been a long-standing aspiration, but one that has yet to materialise (Holmes et al., 2015). Frameworks for integrating games in formal education settings have been proposed (e.g. deFreitas and Oliver, 2006). However, Van Eck (2006) explains that the delayed uptake of games in schools is partly attributed to the predominant focus of empirical research on efficacy (e.g. Connolly et al. 2014) with less attention given to why games are engaging and effective, or how they can be best integrated into the learning process and context. The educational context of students who struggle with reading often entails group literacy interventions whereby a tutor concurrently manages the learning process of several children. While on the surface it may seem that literacy games might offload tutors' responsibility for managing learning activities, as Holmes' (2011) study suggests games are not the panacea to children's learning. It is thus unclear if and how games used during group intervention lead to particular forms of social interaction and in turn how this encourages learning.

Even though there has been little research on the role of social interaction in technology-mediated special education for dyslexia, a large body of empirical evidence supports the view that social interaction with tutors and peers leads to greater educational benefits. For example, research on (structured and unstructured) peer learning has found that it is an effective learning method irrespective of the age group or setting (Blum-Kulka and Dvir-Gvirsman, 2010; Soller, 2001; Littleton, 2010). Peer learning creates more symmetrical relationships to those a child may have with an adult and as a result encourages more varied, frequent interaction (Blum-Kulka and Dvir-Gvirsman, 2010). The peer culture shared between students serves to sustain student interest and motivation in learning activities, and also enhances their academic achievement and attitudes (Blum-Kulka and Dvir-Gvirsman, 2010; Johnson e al, 1981). Taking a broad view on learning, peer interaction supports children's social, emotional and moral development (Johnson et al, 1981). Similarly, the important role of adult tutors in mediating learning has been a long-standing concern (Vygotsky, 1987) with research showing that adult mediated activities enable children to engage in more complex activities that are appropriated by the child over time (Wertsch and Stone, 1985).

5.2.3. Methodology

5.2.4. Research Questions and Approach

The present research examines the use of adaptive literacy games by children during a group literacy intervention. While the technology was designed on the basis of cognitivist learning theories that emphasise the individual, the learning context invited social interaction between children and tutors.

The research question explores how this genre of literacy games benefits, undermines and shapes social interaction and learning. Previous research has studied social interaction both experimentally and in natural settings (Blum-Kulka and Dvir-Gvirsman, 2010). A limitation to quantitative paradigms is the focus on outcomes rather than process, and thus given the current focus, our research follows an exploratory mainly qualitative case study approach with the 'intervention group' forming the unit of analysis.

5.2.5. Words Matter Game

The game, Words Matter, is an intelligent tutoring system targeting children's word decoding, spelling and fluency. The underlying mechanics of the game includes a user profile comprising of seven skills: *consonants, vowels, blends and letter patterns, syllables, suffixes, prefixes and confusing letters* (see Gooch et al., 2015). Each skill (e.g. *suffixes*) is classified at two levels: difficulty (e.g. *adding a suffix*) and sub difficulty (e.g. *the –ing suffix*) forming a total of 409 profile entries. The child's profile is initialized before game play with a screening measure that places them at the right learning trajectory, enabling the game to pull in appropriate game content.

Words Matter presents an open world encompassing nine mini-games set in a kind of afterlife that is informed by the central American festival Dia de los Muertos. Known in English as the Day of the Dead (DotD), the core message of DotD is of remembrance and acceptance of death, with death being viewed as a continuation of life. Words Matter begins with the player finding out that the world of the dead needs the help of the living in order for their world to continue existing. The player has been gifted the skill of being able to see, hear, and talk to the dead. It is therefore up to the player to help the world of the dead. Much of this help takes place through assorted mini game challenges, each of which require the demonstration and practice of literacy skills. We initially became interested in DotD because of its aesthetics. On further exploration of what the festival signified, particularly, reflecting on the central role of communication in DotD, we decided to draw on it to inform our game world as it could be interpreted as aligning with the pedagogical goals of our game.

Given the extensive scope of the profile, a core design issue that drove our decisions concerned the ability of the game to engage players with diverse needs. For some players, hours to days could be spent with the game. For others, weeks to months could be spent with the game. We therefore needed to establish a game play context and style of play that would both scale up and down. Taking inspiration from young people's interest in collectibles, social networking, and gamification, we came up with the concept of the ghostbook. Ghostbook serves as a portal for navigation to literacy difficulties through twenty game characters that correspond to the seven main skills and are slowly unlocked as the child continues to practice the main skills.

Each game character offers a way to monitor literacy achievements, first in the form of a progress bar attached to the character and second in the form of friends that can be found once the player has clicked on the main ghostbook character. Each potential friend maps to a difficulty and sub difficulty in the profile. As children practice and master literacy skills they earn photos featuring their avatar with a ghostbook friend along with a caption of the specific sub difficulty they practiced as a means to raise their awareness. Once earned, photos are recorded two levels deep in the ghostbook. Ghostbook characters simultaneously serve as a means of motivation and attachment formation to the game, a portal for navigation, and were designed to facilitate metacognitive reflection on literacy skills by opening up the user model for the child's understanding.

Ghostbook friendships are formed through the practice and mastery of literacy skills, as they are encountered in nine different mini games. Before we describe each game, it is worth contrasting the shared and divergent mechanics across games. Game mechanics are sequences of player actions that lead to changes in the game and subsequent feedback. Sequences of actions differed across the games. Whereas some game mechanics included game actions that supported the attainment of the pedagogical skill (single sequence), other games had additional game goals and thus sequences of game actions (multiple sequence). All of the games offered feedback to the player in the form of a visual cue (green or red) indicating if the child had completed the task correctly. Table 1 presents a description of each game, mechanics and skills covered.

Table 1 – Skills covered in each mini game

Mini game	Description	Skills	Mechanic
Junk Yard	Requires the player to help clear a junk yard, which fills up with word matter. A tetris-based game, words must be split into segments according to the difficulty being practiced. This converts words into usable objects to be stacked.	Suffixes / Prefixes / Syllables	Multiple
Music Hall	The player helps a band perform a song, which prompts yet more members of the band to show up, thus drawing a progressively larger crowd of listeners in a nearby building. A drag and drop game, it requires words to be completed by dragging in the correct missing segment.	Consonants / Vowels / Syllables / Suffixes / Prefixes	Single
Train Station	A train labeling game, which requires a word to be split into segments according to the difficulty being practiced by typing each segment into a different carriage. This helps passengers board the correct carriages on trains.	Prefixes / Suffixes / Syllables	Single
Town Square	The player's goal is to help the mayor cross the town square, which is formed from unstable shifting word matter, only some of which feature a pattern the mayor can step on. A puzzle-style game, where you need to create a path of tiles containing the correct sound or letter by swapping the tiles.	Consonants / Vowels / Blends and Letter Patterns / Confusing Letters	Multiple
Field	A sorting game, which requires word flowers to be sorted into different machines that describe properties of a particular word. This helps a farmer character to transform words into word energy.	Vowels / Syllables / Suffixes / Confusing Letters	Single
Mail Room	The player assists a post office clerk who has become overburdened with a surplus of Día de los Muertos mail from the living to their dead relatives. A sorting game, which requires parcels to be sorted into baskets that are labelled with words containing the segment displayed on parcel.	Consonants / Vowels / Prefixes / Suffixes	Single
Bike Shed	The player has to help a postal worker deliver her parcels while avoiding playful monkeys that try to capture them. The player has to first avoid monkeys roaming the streets to reach a door. It requires parcels to be delivered by tapping out syllables on a recipient's front door before a monkey captures the parcel.	Syllable	Multiple
Bridge	In *Bridge*, the player helps an engineer to reinforce a bridge made of unstable word matter, in order to avoid it collapsing when traffic passes overhead. The player	Consonants / Vowels / Blends and Letter Patterns	Single

	fixes the weak parts of the word bridge by identifying the correct segment within a word.	/ / Syllables / Suffixes	
Monkey Hotel	A group of monkeys have infested part of the town. A monkey trainer has noticed that the monkeys have some aptitude for language, so she is trying to train them to read, rewarding them with bananas for successful responses. A banana throwing game which requires the identification of words from amongst a set that correspond to the specific difficulty being practiced.	Consonants / Vowels / Blends and Letter Patterns / Prefixes / Suffixes / Confusing Letters	Single

5.2.6. Participants and Research Context

The research took place at a primary school in North London. Eight children (4 male, 4 female) all in Year 6 (11-12 years old) participated. All children had received diagnoses or were suspected to have dyslexia. Children played the Word Matter game for a period of two months in two separate groups (Group A and B). Additionally, each child's tablet was loaned to them for the duration of the study and children were encouraged to play at home. To avoid biases to behaviour arising from a novelty effect with the game, data collection started after week 6 and lasted for 3 weeks. Two tutors facilitated the sessions for the duration of the intervention, and for the first two weeks of data collection: a *dyslexia tutor* who worked in specialist education professionally and a *researcher tutor* who had been involved in the development of the games and had acquired expertise in the dyslexia domain as a consequence. The third week was facilitated only by the researcher. Additionally, a researcher-observer (the first author of the report) attended two of the sessions to establish a familiarity with the children and their use of the game.

Table 2 – Summary of Participants and Week by Week Schedule

	Week 1	**Week 2**	**Week 3**	**Group**
Dyslexia tutor	•	•		
Researcher tutor	•	•	•	
Alfred	•	•	•	A
Damien	•	•	•	A
Daniela	•	•	•	A
Tara	•			A
Samuel	•	•	•	B
Kieran	•	•	•	B
Nancy	•	•	•	B
Pam	•	•	•	A – week 1 B – week 3

Table 2 summarises participants' attendance across the three weeks for each of the groups. The week before the data collection began the dyslexia tutor delivered an instructional session to reinforce children's understanding of the game characters and the linguistic skills they represented. At the start of each study session, the tutors set up children's tablets and prompted the children to play. Game play took an average of 30 minutes per session. Children sat on a small table either next to each other, or across each other. Interactions with tutors were emergent as tutors did not follow a predefined protocol for providing children with support. Similarly, given the personalised nature of the game, interactions between children were unstructured and spontaneous.

5.2.7. Data Collection and Analysis

Logs of children's game play were recorded for each mini game played. Logs comprised of the date and time, type of mini game played, time played, ratio of successes, number/type of words played and their profile entry. Data collection also consisted of video and audio recordings of each session that were later transcribed.

The first author of the case study report who had unobtrusively observed some of the sessions conducted the video analysis. The analysis yielded 116 critical incidents of children's language and interaction with each other and their tutors while playing the game. Given the overlapping conversations between children, video incidents were replayed multiple times during which the researcher attended to a different child or pair of children in order to capture all ongoing interactions. The interpretive process was undertaken by the same researcher who focused on how and why specific game elements such as narrative, rewards, mechanics and actions shaped language, social interaction and learning. The analysis wherever possible was supported with additional data from the logs, which were sometimes triangulated with children's expressions of their performance while in other cases they provided a richer context of the game (e.g. through knowledge of the words the children were playing).

Even though an unbiased perspective on the data was deemed necessary in order to maintain objectivity, it was also recognised that the primary interpreter's detachment from the sessions and the game design could lead to biased interpretations. Therefore, after the initial analysis was conducted, the researcher-tutor present in the sessions and the lead game designer for Word Matter reviewed the incidents, with the former providing a richer contextual understanding of children's interaction and the latter offering a more nuanced understanding on how the game may have shaped these interactions.

5.2.8. Findings

5.2.9. Games and Game Events As Mechanisms to Connect and Compare

Given the nature of Words Matter, children were not always playing the same mini game and thus didn't have a shared experience. This contributed to personal game experiences, which children exploited to promote social interaction with their peers. During the sessions children would often speak aloud when they encountered interesting, or unexpected game events. The other children would then get drawn into the experience of their neighbour briefly pausing their own game play to observe the main protagonist's screen, contribute to playful conversations and in some instances co-play the game. For example, while playing the postal game, Kieran gave a banana to a monkey in order to freely deliver a package. He exclaimed jokingly: "*A monkey was chasing me, literally chasing me, then I gave him a banana and he stopped!*" prompting Samuel to lean closer and look at his view. Given the prototype nature of our game, sometimes children would encounter bugs. When the bugs introduced aesthetic enhancements (e.g. enlarging the graphics), advanced capabilities in the game (e.g. unlocking characters), or even unexpected experiences they became the envy of the peer group by drawing attention to the main protagonist.

Alongside promoting their individuality, children strived to find common ground with their peers. One way to achieve this was to retrospectively share difficult experiences with particular mechanics and games. For example, during one of the sessions the dyslexia tutor helped a child with the Junk Yard mini game, explaining how to move some Christmas Trees (junk). A few children joined in to explain how and why these trees were difficult to move. Another strategy to create common ground was to establish if others were playing the same game and to share preferences for certain mini games or

game aesthetics. This exchange at times became playful and humorous, as children enacted for example the haunted theme of the game. When preferences about mini games converged, children's choices were sanctioned and reinforced at a group level.

Dyslexia tutor: How are you getting on? It's going good? Do you like the games?
Samuel: I love them.
Dyslexia tutor: You love it?
Nancy: I think the junk game's the best what you made.
Pam: Yeah, same.
Samuel: Yeah, yeah. Yeah, yeah, yeah.
Samuel: Who thinks the junk game is awesome? Me.
All: Me.
Nancy: Who thinks junk game is their favourite?
All: Me.

However, it was found that some children tended to favour games they found easier. For instance, in evaluating one child's claim that the Mail Sorter game was "boring" compared to Junk Yard, we found that her score was higher on the latter as compared to the former. Set against the context of children's variable skills and mastery of games, there were disagreements over mini game preferences that sometimes introduced feelings of vulnerability. During these discussions it was revealed that the skill practiced in some mini games was perceived to be too easy by some of the children. In expressing this to the group, these children shed light into the different ability levels across the group, introducing a comparative element that was met with defensive responses.

Samuel: I'm playing junk. I can't stop playing it.
Nancy: I love junk. That's the best game.
Samuel: The junk game!
Kieran: That's easy.
Samuel: What?
Kieran: The junk game.
Nancy: It's interesting. I got once 20 rows completed, like, lines completed.

5.2.10. Shifting the Locus of Failure and Success

Children continuously verbalised their performance in the game, both failures and successes. However, rather than attributing *failure* to their own abilities, they often talked about failure in terms of changes effected in the game, approaching it as a natural part of play and in some occasions celebrating it. The attribution of failure to the game seemed to be reinforced the most in those games in which linguistic skills and non-trivial game mechanics were juxtaposed as opposed to intertwined. That is, once players had made use of a linguistic skill, they were then required to use an additional game mechanic to progress. As one child explained: "It's just that once you do the words, it gets you something to do." Embedding these two separate goals into the game invited multiple interpretations as to players' failure. A notable example came from the Junk Yard game where children developed new language to express and even boast about their difficulties in organising junk after they had split a word.

Nancy: I am full of junk!
Pam: Nancy, Nancy, look. This is what I was doing, because ... And I have junk everywhere, everywhere!
Nancy: I go on the third one.
Pam: Yeah, same, third. And I have junk.

When they described their *achievements*, children would spontaneously talk about positively affecting the game story (e.g. adding new band members to the Music Hall), receiving new pictures with game characters, unlocking new characters, working on longer words and finishing tasks quickly. While mostly supporting a social performance that often occurs around games, the reflective quality of these expressions depended on children's understanding of the game. Pictures dominated many of children's discussions. However, once a picture was earned it was recorded in a separate page, only accessible if the child clicked on the relevant character. Given the large number of characters in the game, children rarely accessed their pictures retrospectively to inspect their progress. Similarly, even though in one of the intervention sessions children had been shown the skills associated with each character, during the sessions we observed, children were unable to draw the link between the characters and the linguistic skills they had mastered, or were working towards. Conversely, a more discernable pattern of progress was the one between progress and content. In the words of one child: "Because I play this all the time, I get really long words."

Peer Interaction Around Game Performance

Comparison of Individual Game Performances

The "performance talk" described above often occurred when children did not share the same mini game experience. Given children's difficulty to draw comparisons with others' game performance, these exchanges tended to be short-lived with listeners providing lightweight encouragement, or ascertaining the game context. In other cases, direct comparisons between children could be more easily drawn. Earning pictures was a unifying feature across all mini games, enabling a crude interpersonal comparison of progress. As a consequence, pictures had social currency. When a child boasted about earning a picture, others were quick to ensure their pictures were also recognised at a group level. On occasion, children happened to play the same mini game concurrently resulting in a stream of overlapping talk and competition, often structured around the synchronous game feedback on each child's screen.

Pam: I'm green.
Nancy: I'm on red.
Pam: I'm on red.
Samuel: I'm on my second green.
Pam: I'm on my second red now.

When sharing their successes, children sometimes became overly competitive and untruthful about their achievements. In those cases, the group as a whole demoted, questioned or made fun of their claims in an attempt to *regulate* excessive boasting and competition.

Nancy: I get the hardest words! Kieran, look how long my words are!
Samuel: "Understand", that's easy.
Kieran: My word would once cover up the whole page.
Samuel: Same.

Even though in most cases performance comparisons fuelled competitive interactions, in one instance they motivated one of the children to progress further in the game. Initially curious about the number of game characters her friend had, with the help of her friend, she identified which characters were missing in her game. After working out a successful strategy that allowed her to acquire them, the two children held their tablets side by side to ensure that their ghost books were identical.

Tara: I got most of the characters.
Daniela: You need to get two more then you have all of them
Tara: I've just got to unlock Travis, where's Travis?
[Daniela leans over and does something on Tara's screen to help her]

…
Tara: Yes I've unlocked the rest of the ghost book characters.
Daniela: Okay Maya… so I've got Monica, Peter, Nigel…
[The girls continue to look at each others' screens comparing characters]

5.2.11. Ownership, Disconnection and Co-Construction of Game Performance

The game had been played for the duration of the study (and designed to be played) by individual children. During the final week of the study, however, many of the children forgot their tablets resulting in an improvised decision by the facilitators. Children were asked to share one tablet, belonging to Pam, to play the game in three pairs (two in Group A and one in Group B). This configuration introduced new tensions and opportunities, in part shaped by the rigidity or flexibility of children's interpretations of what constitutes game performance. At the onset, all of the children spontaneously recognised that the game was Pam's. Pam, who was the most active player at home, took pride of her game progress and experienced a strong sense of ownership over the game. When paired with Nancy, she was unwilling to approach the game as a collaborative medium as a result expressing antagonistic behaviours to protect her previous game performance. Although she shared the tablet with Nancy, Pam controlled the choice of games, provided constant instructions on effective game play strategies, at times interrupted Nancy's game play by resuming control of the tablet and accused her of downgrading the performance.

Nancy: [Laughs] Oh my god a monkey just came up to me!
Pam: Don't lose all my bananas!
Nancy: Did you see that? A monkey just came up to me.
Pam: I always have to go really far and then I catch it…
…
Nancy: There are no bananas
Pam: Because you wasted all of them.
Nancy: Oh my god there's a monkey.
Pam: Because you wasted them all.
Nancy: You did! You told me to click, click, click.
Pam: No I didn't.
Pam: [Nancy pinches her] Aw, that really hurts. Why did you do that?
[Next: Nancy appears to be pinching herself checking if it hurts]

Ownership of game performance was experienced in different ways by the remaining two pairs of children. One of the pairs agreed to take turns; as one child played independently, the other quietly watched and waited for his turn. Since the game performance was not owned by the observing child, there was less incentive to promote the player's game performance. Consequently, one of the children became disruptive shortly after his friend had started playing, seeking to intentionally tarnish his game performance. Conversely, even though the third pair of children also agreed to take turns, both of the children participated in the game play. While one child drove the interactions, the observing child held the tablet, encouraged the player, and provided advice. In this example, even though the game score was not recorded in their profile, children re-constructed their performance as a socially shared outcome. Yet, both pairs of students bemoaned the fact that the photos they had earned could not be transferred to their profiles.

Social Interaction and Learning

Game Mechanics As Scaffolds

Game mechanics acted as a scaffold for children's learning supporting their externalisation of the problem solving process. Similar to how children shared their game performance, they would often verbalise the words they were working on, the linguistic rules they were applying, and the outcomes they observed in the way of game feedback. This stream of speech supported the learning process in several ways. First, it revealed when trial and error approaches to game play did not work, shed light on gaps in the child's understanding and problem solving, alerting the tutor in particular that the child was having a problem.

Nancy:	Was that right? Yay. Idea [sounds out the three sounds in the word]. Idea, that's a double [double is a game action that maps to a linguistic rule], I think… No… Yay. Sort of.
	[Tutor approaches the child]
…	
	[Alfred is playing the Field game. Damien leans closer and looks at Alfred's tablet]
Alfred:	[Addressed to Damien] 'I' What letter is that? is it E?
Damien:	I don't know. You are hearing it [Alfred is wearing head phones and he can hear the letter sound that he subsequently needs to match to a word in the game]
Alfred:	Guess, guess, guess…
	[Damien leans in and taps on Alfred's tablet]
Damien:	This one
Alfred:	You got it right
Damien:	A a a! [Makes a winning gesture]
	[Tutor approaches the pair]
Tutor:	Do you know how to play this?

Additionally, when children collaboratively used the game during the third week of the study, game mechanics served to structure their collaboration; children's language and action was shaped by the learning task embedded within each mini game. In Junk Yard, the task consisted of splitting words at the syllable break and thus children tended to voice the solutions to the problem, i.e. the word splits. This focused children's attention on strategies that would support fluency and automaticity. For instance, one pair of children jointly agreed that the optimal strategy for them to win the game was to quickly split the word into syllables. In Field, on the other hand, children needed to decode a word before choosing the applicable linguistic rule. Children playing Field tended to read aloud the whole word before going on to appraise its pattern. This established common ground in the task, but it also allowed children to correct each other when errors were made.

	[Playing Field]
Damien:	Yeah, man, manning [game content: manning]
Alfred:	I think it's this [chooses a correct game action]
Damien	That one
Alfred:	Yes!
Damien:	Lie [game content: lied]
Alfred:	Lied. I think it's a change [refers to a game action that maps on to a linguistic rule]

Game Status, Replayability and Interactivity Supporting Diagnosis and Solutions to Problems

In contrast to how game mechanics acted as scaffolds for externalising and sharing the problem solving process, sometimes children silently struggled while playing the game. This was expressed as idle game play, or behaviourally with children becoming disruptive in the group (e.g. singing). Tutors or other children would often serendipitously discover the difficulties of these group members. The

'game status' would form the basis for the observer's diagnosis of the child's problem spurring a learning opportunity where a knowledgeable other – either another child or one of the tutors – would suggest new problem solving strategies that affect changes in the game. The shareable surface of the tablet encouraged a dialogic interaction whereby the tutor's modelling of the strategy would be intertwined with the child's appropriation feeding into cycles of tutor modelling, child action and tutor feedback. As the example below demonstrates, in light of all children's use and interest in the mini games, one child's difficulty sometimes led to self-organised opportunities for group learning.

[Kieran stops playing his game and leans into Samuel's screen who is playing the Junk Yard Game]
Kieran: You have a lot of trash, mini man [says this in an affectionate tone]
Samuel: I know, big man [Samuel seems not to be bothered by his friend's remark]
[Tutor approaches and observes the screen]
Tutor: What about when you move that out of the way [taps on the screen] and then moving the bucket down and then the other bucket on top of it [points at the screen while Samuel is playing the game], does that help?
Kieran: Oh wow, you can go up!
Tutor: Yeah, you can move them up and across.
[Samuel continues to play the game]
Samuel: Oh, come on.
Kieran: Really, can I see?
[Kieran moves junk in Samuel's game, which Samuel doesn't seem to mind]
[Samuel resumes controlling his game]
Tutor: No, you have to wait till you've… But you have to be careful because if you stack up too high, if you stack them up above the fence, you lose the game [taps on the screen and moves junk around].
Kieran: [Addressing Samuel] It's almost above the fence. You must try to keep it down.

Children also used the game as a re-playable way of explaining the problem they encountered to the tutor. In these instances, children would attempt to emulate a problem they encountered at an earlier time, while explaining their understanding of what was happening. Often such problems were not about the linguistic rules underlying the game, but rather about possible bugs or game states the interpretations of which were ambiguous. The ability to re-play the problematic game sequence enabled children and tutors to share a negotiated space. Within this space, they attempted to jointly understand the nature of the problem while trialling out possible solutions that could explain what they observed. In one case, while replaying and recounting a game problem for his tutor, one of the children reached a resolution before the tutor could intervene.

[Kieran is playing a game in which once train carriages have been appropriately labelled with segmented parts of the word, passengers board the train and it departs. This loops until the game is over.]
Kieran: How come after this the passengers come back? Look, look, it goes…
Tutor 1: I can show you how to delete the rest of the carriages.
Kieran: I know how, it just takes away (overspeaking)
Kieran: Look, it goes automatically. And look, how come the people come back? What's the…?
Tutor 1: Oh, they're waiting to get on the train
[Tutor 2 approaches]
Kieran: I know, but then – look, look [pointing to the screen], I'll put I, yes. Look, they go on. Look, I [Tutor 1's explanation doesn't fit with the game state Kieran is observing. Kieran emulates the problem by typing in one of the carriages.]
Tutor 2: Is it I or L? Because don't forget on the keyboard they look the same.

Kieran: Do they?
Tutor 2: So did you put I or L in? [Tutor 2 tests whether the game state is caused by a spelling error]
Kieran: I put that… Look, once that goes, they come back again.
Tutor 2: Who come back?
Kieran: The other people.
Tutor 2: But there might be more people at the scene. [Tutor 2 re-interprets the problem and offers an explanation that fits]
Kieran: Oh, and then they come back!
Tutor 2: Yeah, but those aren't the people from the train.

Intractable Game Problems

During the study, children also faced intractable game problems, resulting in them turning to an adult for help. A minority of these problems were unresolvable technical issues arising from the prototype nature of the game, and it was the responsibility of the adult to quickly resolve them. However, intractable game problems also stemmed from the nature of the learning task whereby children needed to both understand the linguistic rules *and* how to apply them within the game system, sometimes through a series of complex steps. In those cases, tutors' responsibility was to discern and address the children's difficulty in the game. The variable complexity of each mini game encouraged different predictions as to the source of children's problems leading to different tutor strategies. In the first example below, the child finished playing Junk Yard with a success rate of 25%. Since the task in this game consisted of a simple selection between a number of choices, the tutor assumed that the child's difficulty was in the application of the linguistic rule. After introducing the goal of the task, the tutor modelled the task by applying the appropriate game action to two similar words, drawing connections between words. This enabled the child to subsequently conduct the task independently increasing her performance to 90% in that game. In the second example, the child played the train dispatcher game. Recognising that this game offered a less transparent game mechanic, after introducing the goal of the game the tutor went on to test the child's understanding of the linguistic rule before establishing that the child's difficulty was indeed with the game mechanic.

Nancy: This is hard. I don't understand this game [refers to Junk Yard].
Tutor: Okay, which one?
Nancy: I don't understand this game.
Tutor: Okay. So this is about suffixes. You should select the categories that correspond to each word, okay?
Nancy: I don't know which one to put in.
Tutor: Getting, okay. Is it a double? [the tutor is using the table to model the task]
Nancy: This is hard [the child does not understand the rule]
Tutor: There you go, you see. Because you did this, it – [the tutor points to the word and the game action on screen to reinforce the connection]
Nancy: Yeah, but it gets red sometimes, or sometimes green. So if I put it in this, I guessed it, it's going to get red maybe [the child verbalises the limits of trial and error]
Tutor: Yes, because it's not – you see, it's like the one before
Nancy: Mann-ing.
Tutor: You see, you double the last consonant before you write your suffix [the tutor points the last consonant on the screen]
Nancy: Oh!
…

Damien: Um, I don't get this game [refers to Train Dispatcher]
Tutor: Ok, do you want me to explain it?
Damien: Yes
[Tutor takes control and starts working on the tablet]
Tutor: There is a couple of versions of the rules so you need to pay attention when it opens. So look, we are looking at the guy in the corner (points), so in this version you are looking for the suffixes which is the ending part of the word for this one. But what do you think the ending of this one is?
Damien: y? (laughs)
Daniel: Yes that's right so in the first carriage you type 'eas'...
Damien: a, easy
Daniel: and in the second one y. Y is a suffix because the other word is ease. So another example if you have catching in the first one you would have catch.
Damien: -ing
Daniel: and -ing the second one. Ok?

5.2.12. Discussion

The previous section captured the nuanced relationship between game, social interaction and children's learning based on which we now consider new opportunities and challenges for game-based learning in group interventions, alongside opening further avenues for research.

The Learning Experience

Many children with dyslexia are demotivated to participate in literacy as they are called to confront their most persistent difficulties. Because of this, a design decision had been made during the development of Word Matter to de-emphasise children's focus on performance by designing the game to grant collectibles (e.g. photos) as opposed to rewards (e.g. points). Nonetheless, children in the study re-appropriated the game and appeared to be motivated *through competition* as they continuously compared and contrasted socially constructed performance indicators within their group. This competitiveness escalated in the few occasions that all of the children concurrently played the same mini game, suggesting that perhaps children's access to multiple games may reduce direct comparison between them and thus competition. It also manifested in our study when two children were paired up to play a single game, with the tablet owner seeking to protect her score by limiting the other child's access and opportunities.

Despite the fact that children socially regulated extreme spurts of competition, it could be argued that their tendency to engage in comparison with others during game play might threaten those with low self-esteem. However, looking at the most salient patterns in the study, we found that children talked about their individual performance openly and fearlessly voicing their successes and persistence, alongside their failures. Thus, playing the game *socially* legitimised and promoted children's recognition of their achievements and failures changing the culture of their educational intervention. Adding to this cultural change were children's unique and shared aesthetic game experiences that fostered connectedness at the group level and through peer affirmation strengthened their investment in specific games. By featuring a compelling narrative, our game supported playful peer interactions that worked in parallel with children's learning of literacy.

Our findings also carved out further research avenues in the way of understanding how games can influence children's error attributions: mini games that presented multiple game mechanics encouraged children to talk about failure more in terms of game state changes rather than attributing their failure to progress to themselves. We postulate that this may have been due to the ambiguity

introduced within the game about the source of the error. If future empirical research establishes this link, it could offer designers with a new approach to design 'emotionally safe' game experiences for user groups who suffer from low self-esteem.

The Learning Process

Game play offered new affordances that were exploited in social interaction to support children's learning processes. Specifically, we found that the games provided scaffolds to articulate and voice aloud problem solving processes that were readily taken up by children. Private speech serves an important role in child development (Vygotsky, 1987) and indeed by externalising his thinking one of the children was able to independently resolve a problem. Placed in the context of social interaction, children's on-going reporting of their reasoning and actions fostered additional outcomes. It alerted the tutor that a child was having a problem, and sometimes it gave the tutor insight about the nature of the problem. This encouraged tutors to provide unprompted and targeted support as and when needed. When children worked together on a single game, games scaffolded coordination of collaboration, joint decision making on cognitive strategies, and enabled children to diagnose each others' errors in situ and to offer support with children flexibly adopting to the focal point of each mini game. For example, whereas in Junk Yard children recognised that playing fast (fluency) was desirable, in Field children leaned toward reading aloud each word (accuracy).

Whereas in the example above the game formed the basis for children's externalisation of their learning, we also found that the game artefact served as a record of their performance allowing an observer to diagnose the source of the difficulty. The game was also used by children as a tool to 'replay' and share with the tutor a game challenge. These two affordances led to a series of dialogic interactions between child-tutor and game. Whenever the cause of the game problem was ambiguous, there was active engagement on the part of the child to craft possible hypotheses. As children and tutors jointly negotiated problem definition and solution, the child was elevated to an equal standing in the interpretive process. Demonstrating how particular game qualities supported learning, our observations highlight new avenues for extending the design of personalised drill and practice games, which game designers can in the future deliberately exploit.

Next to the many opportunities that our research introduced, however, there were also several challenges that warrant further attention. Similar to findings reported by Holmes (2011), despite a tutorial presented at the start of each game, children were often not sure how to play resulting in the adult taking a more asymmetrical, structured teaching approach. This in no doubt highlights the importance of iterative usability testing during game development, and perhaps suggests that technology cannot always replace traditional pedagogies. Moreover, despite some game features being designed to enhance meta-cognition (e.g. game characters, photos), they were not used in this way by children. A prominent example were the game characters, which were in effect an open learner model of the child's progress. While the characters gave children an easy way to discuss their performance, they did not reinforce monitoring and self-evaluation of their skills. This might have been due to the large number of characters available in the game, which could have became taxing for children. Another possibility might be that open learner models require deliberate consideration outside the game to become meta-cognitive aids. To this end, previous research has pointed out the importance of post-game facilitation whereby experiences in the game are reflected upon with the support of a tutor (DeFreitas and Martin, 2009). Finally, our study sheds light into the dynamic nature of school-based research by showing how a single player game can be stretched deliberately or unintentionally into a collaborative game. We demonstrate the learning benefits of collaborative game play and possible opportunities, but also vividly illustrate the tensions introduced when personalised and thus 'owned' games are shared with others.

5.2.13. References

1. Rose, J., 2009. Identifying and Teaching Children and Young People with Dyslexia and Literacy Difficulties. Report for the Department of Children, Schools and Families.
2. Griffiths, Y. and Morag, S. (2011). Reviewing evidence - based practice for pu dyslexia and literacy difficulties. Journal of Research in Reading 36 (1).
3. Zisimopoulos, D. and Galanaki, E., 2009. Academic Intrinsic Motivation and Perceived Academic Competence in Greek Elementary Students with and without Learning Disabilities. Learning Disabilities Research & Practice, 24(1), pp. 33-43.
4. Lindsay, G. (2007). Educational psychology and the effectiveness of inclusive education/mainstreaming. British Journal of Educational Psychology, 77, 1–24
5. Holmes (2011). Using game - based learning Media and Technology 36 (1).
6. Littleton, K. (2010). Learning through interaction. In: Peterson, Penelope; Baker, Eva and McGaw, Barry eds. International Encyclopedia of Education. Oxford: Elsevier.
7. Vygotsky, L.S. (1987) Thinking and Speech. In R.W. Rieber & A.S. Carton (Eds.) The Collected Works of L.S. Vygotsky, Vol. 1, Problems of general psychology (N. Minick, Trans.) (pp.39-285) New York: Plenum Press.
8. Egenfeldt-Nielsen, S. (2007). Third Generation Educational Use of Computer Games. Journal of Educational Multimedia and Hypermedia. 16 (3)
9. Squire, K.D. (2006). From content to context: Video games as designed experiences. Educational Researcher, 35(8), 19-29.
10. Gooch, D., Benton, L. Khaled, R., Lukes, D., and Vasalou, A. Creating Bridges: The Role of Exploratory Design Research for an Intelligent Tutoring System. Accepted at Interacting with Computers.
11. Benton, L., Vasalou, A., Khaled, R., Johnson, H., and Gooch, D. (2014). Diversity for Design: A Framework for Involving Neurodiverse Children in the Technology Design Process. Proceedings of ACM CHI Conference on Human Factors in Computing Systems.
12. VanEck (2006). Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless. EDUCAUSE Review 41 (2)
13. de Freitas, S., Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? Computers and Education, Special Issue. 46 (2006) 249-264.
14. Thomas M. Connolly, Elizabeth A. Boyle, Ewan MacArthur, Thomas Hainey, and James M. Boyle. 2012. A systematic literature review of empirical evidence on computer games and serious games. Comput. Educ. 59, 2 (September 2012), 661-686.
15. Blum kulka, S., & Dvir Gvirsman, S. “Peer Learning”. In M. Endacott (Ed.), International Encyclopedia of Education (3 ed.): Elsevier. 2010.
16. Soller, A. (2001). Supporting Social Interaction in an Intelligent Collaborative Learning System. International Journal of Artificial Intelligence in Education, 12.
17. Johnson, D.W., Maruyama, G., Johnson, R.T., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement:A meta-analysis. Psychological Bulletin, 89(1), 47–62.
18. Wertsch, J. V., & Stone, C. A. (1985). The concept of internalization in Vygotsky’s account of the genesis of the higher mental functions. In J. V. Wertsch (ed.), Culture, communication and cognition: Vygotskian perspectives. Cambridge: Cambridge University Press.

5.3. Appendix 2: Final interview questionnaire prompts

1. Tell me how you've been using the game?

Where did you use it?

How did you use the games?

How/when did you use the reader?

2. Has it improved your reading or writing?

Do you feel more confident in your reading now?

How did you feel before?

How did using this change your writing? Speed? Spelling? Composition?

Has it changed how you read?

Has it changed what you do in school?

Any other comments about changes in reading / writing?

3. What will you do next to continue improving?

Did you learn anything new about using tablets for learning/study/school?

Do you think you will do more reading on a tablet?

Do you think you will look for more learning games?

What technology do you have at the moment?

Phone: iPhone Android (note brand) Windows phone

Own Shared with sibling Family other

Tablet: iPad Mini iPad (big 10inch) Android 7” 8” 9” 10”

Own Shared with sibling Family other

Computer: Laptop Desktop

What do you think will change?

4. Tell us about how you liked the mini games.

Which of the games did you learn the most from? And what did you learn?

Which of the games did you most enjoy playing?

Any other comments/suggestions?

5.4. Appendix 3: Teacher feedback questionnaire in Greece (Greek original)

Ερωτήσεις για τη συνέντευξη με το δάσκαλο (εκπαιδευτή) (αφού τα παιδιά έχουν αποχωρήσει από τη συνεδρία / αίθουσα)

Σχόλια για το Σύστημα

1.Πιστεύετε ότι το σύστημα ήταν εύκολο να χρησιμοποιηθεί από τα παιδιά; Υπήρχε κάποιο σημείο που νομίζετε ότι μπορεί να ήταν ιδιαίτερα πολύπλοκο για αυτά;

2.Παρατηρήσατε εάν τα παιδιά αντιμετώπισαν τυχόν δυσκολίες στην κατανόηση της λειτουργίας των παιχνιδιών; Είναι οι οδηγίες σαφείς;

3.Πιστεύετε ότι τα παιδιά αντιμετώπισαν προβλήματα στην ανάγνωση κάποιου κειμένου;

4.Πιστεύετε ότι ήταν εύκολο ή δύσκολο για τα παιδιά να περιηγούνται στο σύστημα;

5.Νομίζετε ότι οι ήχοι ήταν κατάλληλοι; Υπήρχαν κάποιοι που θα τους αλλάζατε;

6.Υπάρχει κάτι που μπορεί να είναι πολύ ενοχλητικό για τα παιδιά (να διασπά την προσοχή των παιδιών);

7.Θεωρείτε ότι τα παιδιά είχαν κίνητρο να χρησιμοποιήσουν το σύστημα; Περιμένετε να συνεχιστεί αυτό για μια παρατεταμένη περίοδο;

8.Πιστεύετε ότι η πρόοδος κάθε παιχνιδιού μέσω των επιπέδων δυσκολίας προχωράει πολύ γρήγορα ή πολύ αργά;

9.Πιστεύετε ότι η ανατροφοδότηση είναι κατάλληλη / επαρκής;

10.Πώς νομίζετε ότι θα αισθάνεται ένα παιδί όταν κάνει κάτι λάθος / σωστό;

11.Νομίζετε ότι το σύστημα υποστηρίζει το παιδί να κατανοήσει και να ξεπεράσει τα λάθη και να μάθει από αυτά;

12.Τι πιστεύετε για το «βιβλίο των φαντασμάτων»:
- Είναι σαφές πόση πρόοδο έχει κάνει το παιδί;
- Το παιδί αντιλαμβάνεται την πρόοδό του;

13. Υπάρχει σωστή ισορροπία μεταξύ του παιχνιδιού και της γλωσσικής ανάπτυξης;

14. Ποιες δεξιότητες νομίζετε ότι προβάλλει κάθε ένα από τα παιχνίδια; Είναι ξεκάθαρο με ποια δεξιότητα ασχολούνται τα παιδιά; Είναι σαφής ο εκπαιδευτικός στόχος του κάθε παιχνιδιού;

15. Υπάρχει κάτι στην εφαρμογή αυτή που νομίζετε ότι μπορεί να έχει αρνητικές συνέπειες στην αυτοεκτίμηση του παιδιού ή στη μάθησή τους;

Σχόλια για τους μαθητές:

1. Θεωρείτε ότι το σύστημα μπορεί να υποστηρίξει τη μάθηση των παιδιών με ΜΔ στο τμήμα ένταξης?.....
   στην τυπική τάξη?.....
2. Μπορείτε να ενσωματώσετε το λογισμικό στο πρόγραμμά σας?
3. Θεωρείτε ότι το παιδί μπορεί να χρησιμοποιήσει μόνο του το λογισμικό?
4. Παιδιά με τι είδους δυσκολίες θεωρείτε ότι μπορούν να χρησιμοποιήσουν το λογισμικό? Με ΕΜΔ?.....Μόνο με Δυσλεξία?.....Χωρίς ΕΜΔ?.....
5. Θα αλλάζατε κάτι για να το προσαρμόσετε σε έναν μαθητή με συγκεκριμένες δυσκολίες?.....
6. Θα δίνατε για κάποιο λόγο το λογισμικό για χρήση στο σπίτι?.

5.5. Appendix 4: Teacher feedback questionnaire in Greece (English translation)

Feedback on System

1. Do you think the system was straightforward for the children to use? Was there any part that you think may have been particularly confusing for them?
2. Did you notice the children having any difficulties understanding how the games worked? Are the instructions clear?
3. Do you think the children had any problems reading any of the text?
4. Do you think the children found it easy or challenging to navigate the system?
5. Do you think the sounds were appropriate? Were there any you would change?
6. Is there anything that may be too distracting for the children?
7. Did you think that the children appeared motivated to use the system? Would you expect this to continue of a prolonged period?

8. Do you think the progression through the difficulty levels of each game seems too fast or too slow?

9. Do you think that the feedback is appropriate/sufficient? How do you think it would be make a child feel if they get it wrong/right? Do you think the system supports the child to recover from errors and learn from them?

10. What do you think about the ghostbook? Is it clear what progress the child has made? Do you think the child understood this?

11. Does the balance between play and literacy development seem ok?

12. Which skills do you think each of the games address? Is it clear which skill children are currently working on? Is it clear what the learning aim is?

13. Is there anything about the app that you think may have a detrimental effect on the child's self-esteem or their learning?

Use Cases

1. Do you think the system would support the learning with SEN sessions? Within mainstream classes? How?

2. Could you integrate this with the current curriculum?

3. Do you think it the children would be ok to use the system independently?

4. Which children could you foresee using the system with? Dyslexic? SEN? Non-SEN?

5. Would you change anything to make it more suited to particular children?

6. How often would you use it?

7. Would it be something that could be used at home?

5.6. Appendix 5: Number of logins per student

5.6.1. UK student logins

Student code	School code	Number of logins
Student 1	School 1	**23**
Student 2	School 1	**39**
Student 3	School 1	**21**
Student 4	School 1	**39**

Student 5	School 1	**51**
Student 6	School 1	**2**
Student 7	School 1	**8**
Student 8	School 1	**15**
Student 9	School 1	**74**
Student 10	School 1	**28**
Student 11	School 1	**178**
Student 12	School 1	**20**
Student 13	School 1	**32**
Student 14	School 1	**60**
Student 15	School 1	**5**
Student 16	School 2	**5**
Student 17	School 2	**28**
Student 18	School 2	**8**
Student 19	School 2	**6**
Student 20	School 2	**54**
Student 21	School 2	**1**
Student 22	School 2	**25**
Student 23	School 2	**15**
Student 24	School 2	**3**
Student 25	School 2	**4**
Student 26	School 2	**5**
Student 27	School 2	**32**
Student 28	School 2	**9**
Student 29	School 2	**39**
Student 30	School 2	**65**
Student 31	School 2	**41**
Student 32	School 2	**19**
Student 33	School 2	**11**
Student 34	School 2	**11**
Student 35	School 2	**43**
Student 36	School 2	**1**
Student 37	School 2	**1**
Student 38	School 2	**33**
Student 39	School 2	**24**
Student 40	School 2	**44**
Student 41	School 2	**13**
Student 42	School 2	**97**
Student 43	School 3	**31**
Student 44	School 3	**136**
Student 45	School 3	**16**
Student 46	School 3	**23**
Student 47	School 3	**8**
Student 48	School 3	**9**
Student 49	School 3	**36**
Student 50	School 3	**9**
Student 51	School 3	**31**
Student 52	School 3	**16**
Student 53	School 3	**15**
Student 54	School 3	**31**
Student 55	School 3	**22**
Total		**1615**

5.6.2. Greek student logins

Student 1	14
Student 2	7
Student 3	9
Student 4	14
Student 5	17
Student 6	23
Student 7	134
Student 8	73
Student 9	75
Student 10	144
Student 11	13
Student 12	7
Student 13	153
Student 14	35
Student 15	81
Student 16	79
Student 17	152
Student 18	108
Student 19	91
Student 20	135
Student 21	221
Student 22	79
Student 23	118
Student 24	202
Student 25	109
Student 26	4
Student 27	109
Student 28	81
Student 29	118
Student 30	111
Student 31	518
Student 32	13
Student 33	57
Student 34	4
Student 35	5
Student 36	19
Student 37	31
Student 38	35
Student 39	52
Student 40	191
Student 41	80
Student 42	5
Student 43	37
Student 44	40
Student 45	51
Student 46	55
Student 47	44
Student 48	2
Student 49	126
Student 50	96
Student 51	65
Student 52	9
Student 53	77
Student 54	50
Student 55	27
Student 56	19
Student 57	73
Student 58	82
Student 59	40
Student 60	46
Student 61	22
Student 62	164
Student 63	94
Student 64	66
Student 65	265
Student 66	19
Student 67	14
Student 68	136
Student 69	47
Student 70	123
Student 71	5
Student 72	5
Student 73	36
Student 74	328
Student 75	76
Student 76	93
Student 77	50
Student 78	74
Total	**6082**

5.7. Appendix 6: Brief descriptions of games

Descriptions of games from guidance materials for teachers.

Language: Suffixes / Prefixes / Syllables

Junkyard

A tetris-based game, which requires words to be split into segments according to the difficulty being practiced.

Serenade Hero

A drag and drop game which requires words to be completed by dragging in the correct missing segment. Can be used for:

Language: Consonants / Vowels / Syllables / Suffixes / Prefixes

Train Dispatcher

A train labeling game, which requires a word to be split into segments according to the difficulty being practiced by typing each segment into a different carriage.

Language: Prefixes / Suffixes / Syllables

Bridge Builder

Fix the weak parts of the word bridge by identifying the correct segment within a word.

Language: Consonants / Vowels / Blends and Letter Patterns / / Syllables / Suffixes

Monkey Hotel

A banana throwing game which requires the identification of words from amongst a set that correspond to the specific difficulty being practiced.

Language: Consonants / Vowels / Blends and Letter Patterns / Prefixes / Suffixes / Confusing Letters

Square

A puzzle-style game, where you need to create a path of tiles containing the correct sound or letter by swapping the tiles.

Language: Consonants / Vowels / Blends and Letter Patterns / Confusing Letters

Field

A sorting game, which requires word flowers to be sorted into different machines that describe properties of a particular word.

Language: Vowels / Syllables / Suffixes / Confusing Letters

Post Office

A sorting game, which requires parcels to be sorted into baskets that are labeled with words containing the segment displayed on parcel.

Language: Consonants / Vowels / Prefixes / Suffixes

Knocking Maze

A parcel delivery game, which requires parcels to be delivered by tapping out syllables on a recipient's front door.

Language: Syllable

5.8. Appendix 7: Table of Figures