Integrated intelligent LEARNing environment for Reading and Writing

D5.3 – Serious Games

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Abstract	This deliverable describes the final mechanics and functionalities implemented in the iLearnRW game. A formative evaluation of a first prototype is detailed, and the changes made to the design based on the collected feedback are reported. Other aspects of the development besides mechanics refinement are also described, including the creation of the narrative and audiovisual elements, and the middleware of the game.

Keywords	Game development, formative evaluation, audiovisual assets, narrative, middleware

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Project information

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Table of Content

1. Introduction

In earlier deliverables of iLearnRW we described the main mechanics and components of the game and their connection to user requirements and teaching practices in dyslexia interventions (deliverable D5.1 and D3.5). Furthermore, we defined a pedagogical module able to recommend activities and content given the particular profile of a student (deliverable D4.3).

In this deliverable, we present the realisation of the design and its integration with the pedagogical module. While this deliverable does not address any research question in particular, it serves as an initial evaluation of the design methodologies and it presents how the teaching strategies and guidelines defined by experts were harmonised with game design principles.

First, we describe a formative evaluation of a complete prototype conducted with 8 students with some degree of reading difficulties. The feedback collected during that session served to validate the adequacy of most design decisions but also inspired some changes on the original game scenarios. Therefore, we also describe the final game mechanics that slightly vary from the original game scenarios described in D5.1. In addition, opposed to that deliverable, here we present the low level interaction details of each game.

In addition to the mechanics and interactions, we also include a section to describe the development of the audiovisual assets, the narrative elements and the middleware and libraries that form the software implementation. The general audiovisual style is showcased but, as the implementation of the game follows an incremental process, the graphics presented in this deliverable are not as polished as those that will be used in the evaluation of the iLearnRW system.

The relation between the other components of iLearnRW and the game has already been described in detail in deliverable D4.3, A more technical description of those links is provided in deliverable D6.1. In this deliverable, instead, we focus on the interplay between iLearnRW and the game from the perspective of the player and the middleware of the game. The reader of this deliverable is also referred to the initial game design document (D5.1) which describes the core design principles of the iLearnRW game and introduces all terms and game features used herein.

2. Formative Evaluation

A formative evaluation was divided in two sessions and was conducted in the UK. The goal of these sessions was to obtain general feedback about different elements of the game (refer to D.5.1) from children with reading difficulties within the target age range.

2.1 Participants

The first session included four 9 year-old children (all female): two had dyslexia and the other two received additional literacy support/were being considered for dyslexia diagnosis. The second session included four children (all male) between 9 and 10 years of age. They were below their expected reading levels and some of the boys had additional learning needs.

2.2. Prototype

The game used in this evaluation features a game world where the player can move around to find games. Non-player characters are static and simply wait at the locations where an activity can be initiated. A primitive version of the social network simply serves as a shortcut to find the different characters/activities in the world. By clicking on a character photo, the player's avatar is auto-guided to the corresponding location in the world.

In terms of game activities, the players can play Solomon's Junkyard, Serenade Hero, Whack-a-monkey, Harvest, Moving Pathways and Mail Sorter. Words and sentences for each activity were hardcoded. Mails Sorter featured a combination of spoken and written words while the rest only featured written words. Tutorials are presented as text before the game starts, and once the games finish the player is taken back to the game world.

2.3. Protocol

The researcher introduces the project and explains the protocol, after which the teacher and the students are guided through the consent form. A tablet is given to each pair of students with an off-line prototype of the iLearnRW game, and they are asked to complete the following activities:

- t**Explore the game world**: the students have to take turns to use the software freely for 10 minutes. They are asked to report any thoughts of ideas that they have while they are playing the game. The researcher observes each pair and takes notes using the forms provided.

- e**Test the games**: each pair of students spends approximately 4 minutes playing each of the game scenarios. After finishing the game once, they are asked to complete the feedback sheet, and assistance is provided where needed.

- **Discuss the games**: tablets are taken away and a verbal discussion is conducted following a list of questions.

The next steps of the research are explained to the children and then the teacher is interviewed once the students have left the session. The audio from both the verbal discussion with the children and the teacher are recorded (only if consent is given).

2.4. Results

Overall all children in the first session really enjoyed playing the games and wanted to know if they could repeat the session everyday. Only one girl was a little bit negative in some of her comments, but it appears connected with the fact that the tested prototype does not show a proper progression. The teacher was also really positive about the potential of integrating the system into the curriculum and the fact it offered something for older children who were still working at a level typical of much younger children.

Participants on the second session, in contrast to the other group, were very resistant to writing or drawing any of their feedback and were less able to articulate their ideas for improvements during the verbal discussion and had more difficulty focusing on the tasks. One of the things that had an impact on the group was that two of the boys were older (the girls were all in the same class) and so this meant the younger boys were quite quiet during the discussion and tended to agree with everything they said – even though it appeared that they did not actually agree.

The more relevant feedback can be summarised as follows:

Game World

- They really wanted to be able to customise the character they played as.
- They liked the music/sounds effects and the fact it was 'peaceful' and they also wanted to have somewhere they could go within the world to 'take a break' from the games.
- They wanted to be able to actually enter the house within the game world.
- They found it relatively easy to navigate around the world.
- The boys did not really understand why the characters were skeletons and thought it was a bit weird.

Game Scenarios

- The children did not read any of the instructions, even if they were read out loud they would have probably not paid much attention to them. They did struggle understanding how some of the games worked.
- In terms of the specific game activities:
    - Junkyard: this seemed to be the most difficult for the children, they did not understand what they had to do in terms of splitting the syllables, they also did not understand the junk-Tetris style game (n.b. none of them had heard of the Tetris game) and thought that had to build a big pile of junk.
    - Serenade Hero: one girl did not understand the point of the band members appearing, but in general this game was the most straightforward for them.
    - Whack-a-monkey: the girls were slightly frustrated with the lag when they touched the screen to throw the bananas.
    - Harvest: some of the girls and the boys tried to move the word rather than the flowers and also did not know where to drop them and struggled to pick them up when they did not fall in the machine. One girl thought she had to drop it down the funnel.
    - Moving pathways: All children had to ask for help to start with the game and they also found it difficult to move the board around (i.e. in terms of scrolling). One girl

discovered the rotating tiles but the other pair of girls and the boys did not discover that feature.
- Mail sorter: it was difficult for them. The words were not appearing on the boxes and this appears to have been the core part of the problem.

2.5. Inspired changes

In response to the feedback summarised above, we made the following decisions:

Game World

- We expect that all issues regarding lack of feeling of progression and strangeness of the theme will be solved once the functionalities referred to narrative are implemented. Note that we had decided that several characters in the world will feature quests with a simple plot that will introduce the player to the game world.
- All games will have an intro scene that will give a better feeling of *entering* the physical location.
- A special location representing the character's house will be included in the game world. Players will be allowed to enter this house and it will serve as an interface to customise their character. While this feature is not related to literacy, we believe that it will make the game more engaging.

Game Scenarios

- The text used as placeholder tutorials will be replaced by visual slideshow overlay as recommended in deliverable D3.5. However, watching the tutorial will not be obligatory, in order to promote self-discovery.

- In terms of the specific games:
  - Junkyard: as the initial research recommended to promote self-discovery (deliverable D3.5), we believe that the feedback received is not negative from a pedagogical perspective. Once the tutorial, score screen and final graphics are in place, it will be easy for students to figure out the object reordering and segmentation mechanics after one attempt. Furthermore, once the narrative is added, it will be clear that the player has to help Solomon to retrieve objects (and not just pile them up). Finally, explicit segmentation and reordering phases will be implemented to make sure that both mechanics are discovered.
  - Serenade Hero: once animations are added to the band members'rmovement, as well as the winning and losing reactions, we expect that all players will be able to understand the plot behind this game.
  - Whack-a-monkey: the time that takes the banana to reach its target will be reduced.
  - Harvest: the polished version of the graphics will make more obvious how to use each element of the screen.
  - Moving pathways: in the prototype, the path of words is available from start making rotation unnecessary. Once the initial path is shuffled, we expect that players will find the rotation functionality as they are forced to do it in order to progress. Furthermore, we will add an intro screen that will show some of the tiles rotating. Finally, the

direction of the scrolling feature will be inverted to match the most common use of this feature in other touch-screen applications.

- Mail sorter: whenever text-to-speech is used, a visual asset (*the speech gadget*) will be used, helping players to understand that particular patterns are only represented by sound.

3. The iLearnRW game: mechanics

As described in deliverable 5.1, the iLearnRW game features two intertwined interfaces to access the game scenarios: the *social network* and the *world view*. The social network (i.e. *Ghostbook*) serves as a means to document and represent skill development and game progress while also allowing direct access to activities, bypassing the need to navigate in the game world (i.e. *Play mode* without *Adventure mode*). The world view provides a more game-like interface where the player engage in activities as part of the discovery of the world and its characters. In this section we describe the final elements of these interfaces, as well as the detailed mechanics and interactions of the game scenarios developed.

3.1. Social Network

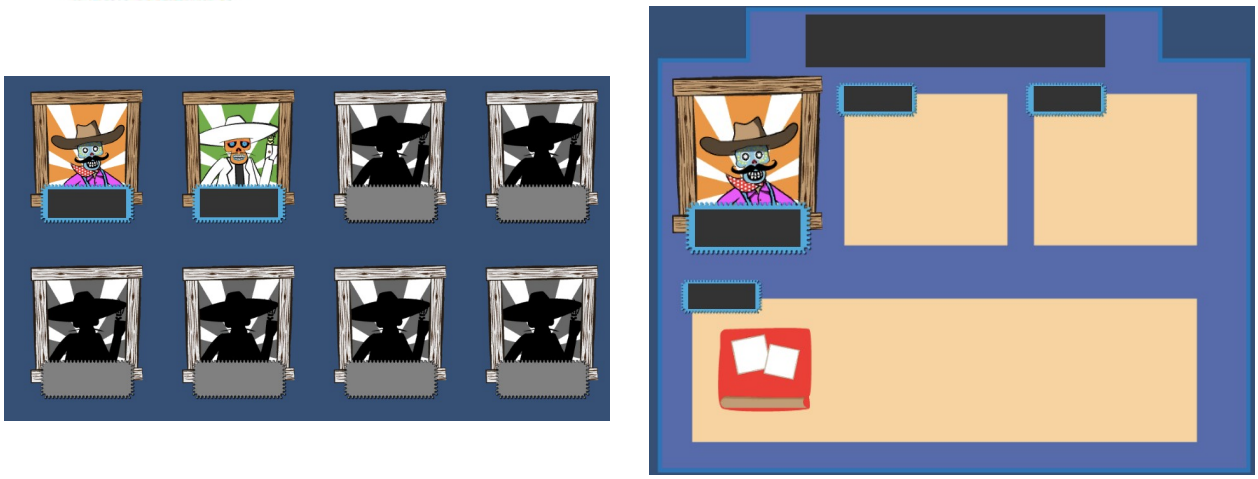
The functionalities described in the game design deliverable are supported through three interfaces: *contact list*, *character profile* and *timeline.*

The contact list shows all the characters that have been unlocked in the game world and foreshadows those that are still missing (see Figure 1a). Clicking on a character that has been unlocked opens up her profile (see Figure 1b). Each character represents a range of difficulties within the same language area, and its profile page represents the progress that the student has made on those difficulties. For each of the difficulties already practised, a photo album is included in the page. Each album contains up to four pictures depending on the severity indicated by the student model, e.g. with severity 0 on the -ing suffixing difficulty (i.e. the student has mastered the difficulty), the corresponding album contains four pictures while if the severity is 3 (maximum level of severity) the album contains only one picture. This implementation unifies the concept of semi-unlocked characters and level of friendship, as the strength of the relation with a character is implicitly represented by the amount of pictures.

Clicking on the albums shows the contained pictures which are procedurally generated combining graphical assets of character and the player's avatar. When an entry of the student model changes, the game generates a notification that new pictures have been *tagged* (if the severity has decreased) or that some pictures have been *untagged* (the severity has increased). The untagged notification signals to the player that she needs to work more on a particular difficulty, potentially being triggered as a result of the player not working on the difficulty for a long time. At the same time, it does not have the same strong negative connotation than a character becoming semi-unlocked (i.e. unfriending the player).

As well as displaying the pictures, each album page serves as a shortcut for working on its associated difficulty. The player can choose the game to practise the difficulty only if she is logged in with the teacher, and it will be automatically chosen if playing without supervision. The album page also provides direct access to literacy information about the difficulty. This information may be presented to the player as tips that can help her to acquire more pictures.

In addition to the albums, the profile page shows a minimap of the locations where the player has met this character before. This minimap can be used as a shortcut to play a particular game (with any of the difficulties represented by this character).



(a) Contact list **(b) Profile page**

Figure 1: Ghostbook interfaces

Besides the contact list and the profile pages, the player can also visit a timeline page where she can access games played in the past and review notifications of pictures tagged or untagged. This feature also supports teachers, who can keep track the changes of the student profile if they played on their own. In addition, the timeline interface contains notifications of upcoming events. These events are generated by querying the the server, which through the pedagogical module, specifies what the next activity and difficulty should be. The difficulty is translated into a character and the activity into a game world location. If the player selects an event, she is taken back into the game world and teleported to the location.

3.2. World View

We have developed the world as a vast city street map where houses and other constructions are connected through paved roads (see Figure 2). The avatar of the player is always centred on the screen; to move, the player has to tap on a location of the road, which will prompt the avatar to move automatically to that location. The player cannot scroll the map forces her to choose her path step-by-step to reach any location outside the view; this decision reinforces the feeling of being playing a game rather than only selecting literacy activities.

The world view contains 9 special locations that represent each of the game scenarios. These are the junkyard and its backyard, the post office and its bike garage, the endless bridge, the train station, the red house, the main square and the garden. The player cannot enter these locations directly; instead, she must interact with the characters that populate and roam around the world.

Each special location has a main character attached to it, and that location will be locked until the player meets the representative character. These characters will expose the background story behind that location, introducing to the player to the world's lore, mythology, and rules. The encounters with these characters are directed by the game alone to ensure a coherent and paced discovery of the game world (i.e. undesired behaviours such as meeting all characters within the first hour play can be avoided).

Figure 2: World View example: conversation with the junkyard owner before starting the game.

Once the world is introduced, the same procedure used to create events in the social network will be used to create encounters, this is, the language area, difficulty and game recommended by the server will be used to direct where a character will show up and what game will ask the player to play. After helping a character, it will hover around the same location for a while allowing the player to re-play that particular game. In general, players are allowed to ignore characters'nrequests and instead exploring the world to talk to other characters that they find more interesting. The pedagogical module can still be used to influence the characters that are present at any given time in the world, limiting the free play feature to a number of options.

Interactions with characters can be initiated by tapping on them. In order to reduce the amount of text used in the game we decided to implement these interactions using voice recordings. Motivated in part by budget restrictions but also to reinforce the concept that the player is the only person that can understand the characters in the world, the characters only speak through speech bubbles that contain images or symbols. Then the voice of the avatar responds with an explanatory remark. For instance, the owner of the junkyard can initiate the conversation with a speech bubble displaying the post office, and the avatar may reply by saying "Oh, so you need a hand with your mail? Sure!". As the number of characters is large and all the narrative need to be accessible in Greek and English, the solution of having only the avatar voiced reduces the number of different voices needed to four (English and Greek male and female voices).

Finally, the house of the player is another special location that allows the player to customise her aspect.

3.3. Game Activities

In this section we describe the final version of the game mechanics. We flesh out the game scenarios outlined in deliverable D5.1, and describe how they are integrated together and with the world mythology. We have carefully added elements of the narrative to these games and created recurrent elements that are shared across games (e.g. word essence and monkeys) which contributes to the sense that these are not simply random activities used to work on different skills. In addition, some mechanics described in D5.1 have been altered following the feedback received in the playtests.

All activities start with an optional tutorial that is implemented following the recommendations defined in deliverable D3.5, this is, the tutorial is a series of slides representing visual aids laid over the interface; the player can visit these slides anytime and in any order to recall what the different elements on the screen are used for. Text has been replaced by arrows and graphical elements whenever possible.

After each game, a score screen is shown presenting the tally of correct and incorrect answers proposed by the player, as well as other information relating to the difficulties addressed by the game, such as tips on strategies to apply. This supports the player's metacognition, in that it allows the players to explicitly review and reflect on the literacy material worked on during the activity. By featuring this feedback after each game round as opposed to during, we believe that players are more likely to pay attention to it, as featuring the feedback during the game is likely to be distracting and disruptive. However, some games allow us to introduce implicit feedback during the games, as described below.

A recurring element across games is the *speech gadget*, a machine that represents when the sound of a word needs or can be played. In the remaining of this section, we described in detail the exact behaviour of each game and highlight text presentation, multi-sensory teaching and literacy feedback and reinforcement considerations.

3.3.1. Solomon's Junkyard

This game is the final version of *Drop Chops* games scenario and the *Karate Chops* learning activity. This game is located at the junkyard. The player has to help the owner to convert words into usable objects by splitting them up (see Figure 3).

Mechanics

- Words appear at the top and slowly float down in a rectangular pit space
- Words are a series of letters, each inside its own square block.
- The player can swipe across a word at a letter boundary to segment it at that point
    - If it is a correct segmentation, then the word splits, which is represented as a crack on the word.
    - If if is an incorrect segmentation, a strike is accumulated
- Once all syllables are segmented correctly, the maximum number of strikes is reached or the player runs out of time, each syllable turns into an object of the same length as the number of letters.
    - Objects representing correctly segmented syllables can be dragged around the screen, provided nothing is in their path, e.g. use basic collision.
    - Objects representing syllables that were not segmented on time or within the number of allowed attempts, are greyed out and cannot be moved (although they fall whenever no other objects are underneath).
- If any object touches the top of the pit, the game is over.
- Before the next word appears, the player can move around the movable objects.
    - Once a row is filled with objects it is automatically cleared
    - When any object lands on the bottom of a pit or on top of another object, it stops, e.g. physics and collision detection.
    - If a space is cleared underneath an object, the object should fall down.

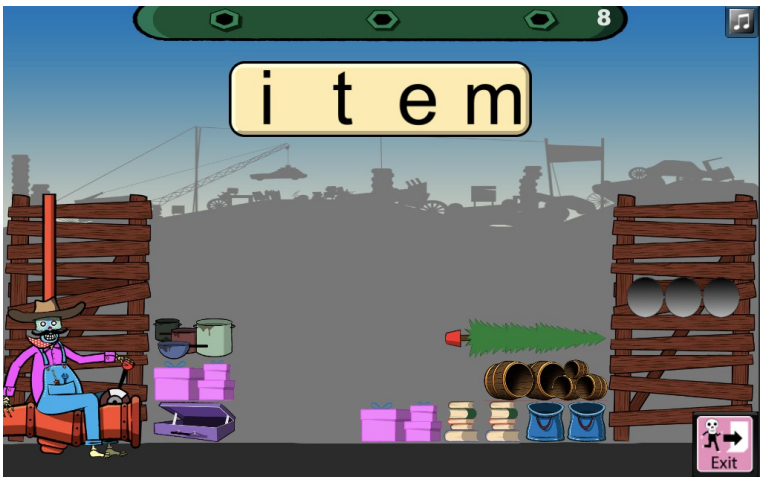


Figure 3: Solomon's Junkyard

- Both object movement and dragging are snapped to an invisible grid, where each grid space is the same size as each letter block.
- The game ends when the player clears a number of rows of the pit is filled.

Multi-sensory teaching
In this game the words need to be always written but they can be accompanied by the spoken sound upon request (through the speech gadget) or when they first appear. In addition, a subtle reinforcement is given by representing open syllables as open objects and closed syllables as closed objects.

Feedback and reinforcement
Once the segmentation time is up, the player can observe that the syllables of the word are transformed into objects one by one, in the correct order. Furthermore, if some splits are missing, a skeleton hand splits those syllables for the player.

Presentation of text
The maximum font size for this activity is fixed; words are always displayed with that font size unless they are too long to fit on the screen. The words are always within a bounding box fixed in a location with fixed uniform background.

3.3.2 Serenade Hero

This game is the final version of the game scenario of the same game and two separate learning activities: *Fix the Footpath* and *Bridge Builder*. As those activities feature the same mechanics but applied to sentences and words respectively, we decided to support both with the same game and implement an alternative mechanics to replace the *Endless Runner* game scenario (designed originally for *Bridge Builder*).

This game is located at the red house where the spouse of the serenader lives. The role of the player is to help the serenader to articulate the words in his song, which prompts other members of the band to show up to complete the song (see Figure 4).

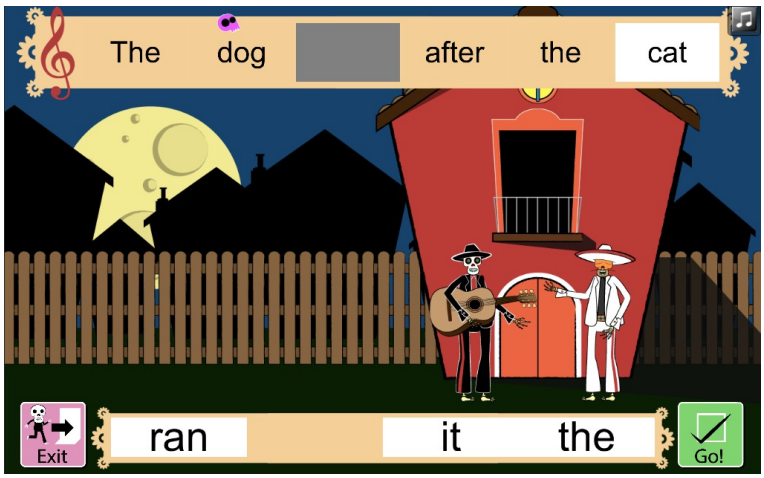


Figure 4: Serenade Hero

Mechanics

- A sentence/word with missing words/syllables appears on the top of the screen; the missing items appear at the bottom of the screen mixed with other items.
- A skull-like index scrolls through the sentence from left to right
- The player has to drag one word/syllable from the bottom of the screen into the gaps
    - When the skull passes a correctly filled gap, a band member enters the scene
    - When the skull passes an incorrectly filled gap or empty gap, a band member leaves the scene
- The game ends when:
    - The band is complete, which leads to the music being played and character coming out of the balcony to meet the band
    - The player runs out of attempts; the band simply disperse.

Multi-sensory teaching and other implicit teaching resources

The words that have to be selected can be written, spoken or a combination of the two. The skull, in addition to serve as a timer, indicates the order in which sentences are read.

Feedback and reinforcement

The tally displayed after the game shows the player what she did wrong.

Presentation of text

Text is presented on the same font size, always justified to the left and with natural spacing between words with the exception of gaps (which present a uniform size to avoid helping the player to choose an option only based on the size).

3.3.3. Mail Sorter

This game is the final version of the game scenario of the same name and the learning activity *Pelmanism*. This activity is located at the post office and the role of the player is to help the post chief to distribute the parcels to the postmen that will deliver them (see Figure 5).

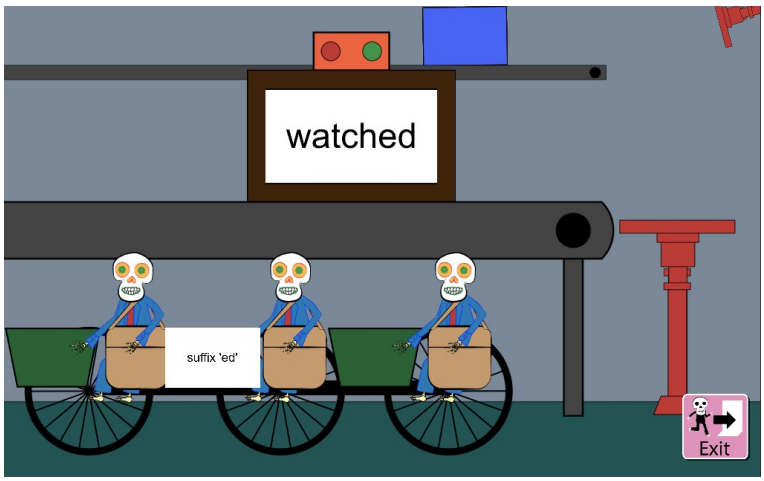


Figure 5: Mail Sorter

Mechanics

- A number of postmen (3 to 5) on a tandem enter the screen with a hidden pattern/word.
- For each postmen, a parcel with a hidden matching pattern/word is placed on the conveyer belt.
- The postmen show their pattern for a few seconds when the player taps on their basket.
- The content of the parcels is shown when they enter the X-ray machine
- The player drags the parcels from the conveyer belt into the baskets
    - If the matching is wrong, the post chief appears and puts the parcel back into the conveyer belt
    - If the matching is right, positive feedback is played
- When every parcels is correctly distributed, the tandem leaves and a new tandem and set of parcels appear.
- The player has to dispatch as many tandems as possible on a given time.

Multi-sensory teaching and other implicit teaching resources

In this game, both the parcels and the baskets can be represented through written and spoken text or a combination of the two.

Feedback and reinforcement

In this game the player is forced to discover all the correct matchings before moving on to the next set of words/patterns. Additional feedback is not required.

Presentation of text

Both the parcels and the X-ray machine show text with a fixed font size over a uniform coloured background.

3.3.4. Harvest

This game is the final version of the game scenario of the same name and the learning activity *Sorting Potions*. This game is located at the garden and the player has to help the harvester to transform words into word energy (see Figure 6).

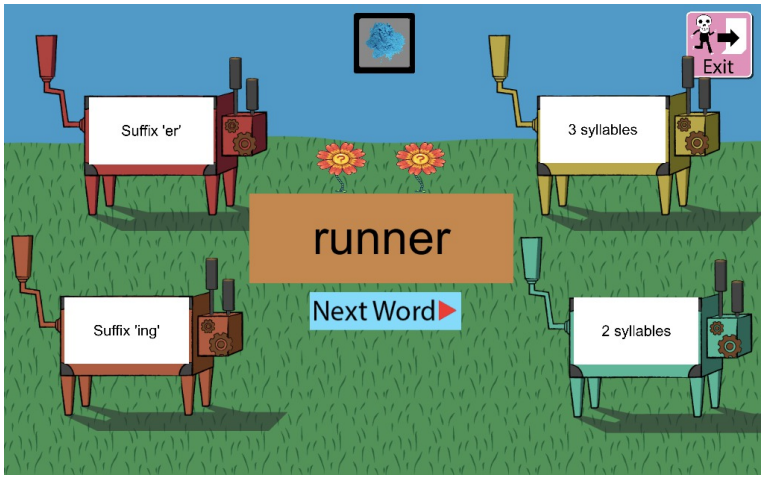


Figure 6: Harvest

Mechanics

- A target word appears in the center of the screen with a number of flowers over it.
- It is surrounded by four descriptions that may or may not apply to it, which are splayed around it in a circular organisation
- The player's task is to classify the word appropriately, which involves dragging each of the flowers over an accurate/true description, i.e. one of the flowers in "runner" can be dragged over a description that says "Suffix 'er'"fand the other over a description that says "2 syllables"
    - If the player makes a correct classification, the flower transforms into *flower energy* that is added to the score, and the machine is no longer able to be activated
    - If the player makes an incorrect classification, the machine stalls and the flower comes back to the original position.
- Each machine breaks down after a number of wrong flowers, limiting the score that the player can obtain. The machines are repaired after a while, but at the cost of flower energy.
- If the player has processed all the correct possible classifications for the current target word, a new target word appears.
- Each target word has a time limit during which it must be classified, otherwise it can no longer be classified. At this point, a new target word appears.
- If the player becomes stuck, they can choose to advance the word themselves.
- The characteristics are drawn from the word's dictionary entry. These include:
    - Syllable count
    - Letter patterns
    - Prefixes
    - Suffixes
    - uVowel sounds
- Note that the characteristics are composed of a set of correct characteristics as well as incorrect characteristics.

Multi-sensory teaching and other implicit teaching resources

In this game, both the machines and the target word can be represented through written and spoken text or a combination of the two. Furthermore, the colour of the machines can be consistently

associated with the same classes (e.g. yellow is always reserved for 3-syllable words and green for 2-syllable words).

Feedback and reinforcement
In this game the player is forced to discover all the characteristics of the word. Additional feedback is not required.

Presentation of text
Both the target words and the characteristics are shown with a fixed font size over a uniform coloured background.

3.3.5. Moving Pathways

This game is the final version of the game scenario of the same name and the learning activity *Minefield*. This game is located at the town's main square and the player has to help the major to get to her fellow citizens (see Figure 7).

Mechanics

- A hexagonal grid of letters or words exists on the screen.
- The content of the tiles are a mix of a "target" pattern and several distractors:
    - E.g. such as **"**b**"**, and other visually similar letters (such as d, p, o, etc.)
    - E.g. such as **"**er**"**rand other visually similar letter groups (such as er, et, etc.)
- The player's objective is to move a character (the major of the town) through the grid, from an entry point towards an exit point (a crowd of her fellow citizens) in a given amount of time.
- The player can scroll the screen to focus on different parts of the grid (e.g. locate the crowd).
- The character can only stand on tiles with the correct target pattern (i.e. b but not d)
- The character can move from one tile to another by tapping on the centre, but only if the tile it is currently standing on touches the other tile, and next tile also features the target.
- Often there will be no contiguous path of target letters/letter groups on the grid.
- In this case, it will be necessary to perform tile rotations. Tile rotations can only occur around vertices where 3 tiles meet and where one of the tiles features the target letter/letter group. This action is performed by double tapping the point that connects 3 tiles (which forms a circle).
- Rotation is not allowed if the character is standing in one of the three target tiles.
- Once the crowd is reached, the content of the tiles is reset and a new crowd appears.

Multi-sensory teaching and other implicit teaching resources
Both pattern and the content of the grid could be represented by written or spoken patterns; spoken only played on request by tapping on the speech gadget.

Feedback and reinforcement
The path of correct patterns tapped is maintained in green, facilitating that the student keeps track of all the right decisions made so far.

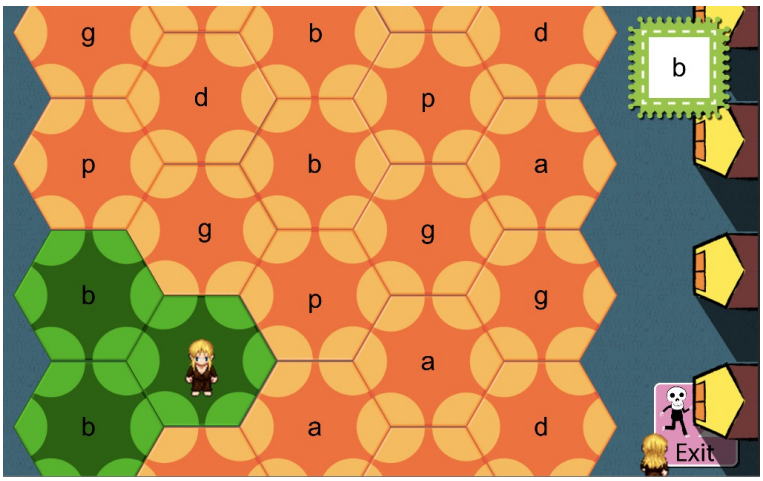


Figure 7: Moving Pathways

Presentation of text
Font is fixed; the background colour is uniform but changes on the grid. The size of the tiles as well as its number can be regulated to impact the number of patterns visible at any time on the screen; students with more severe difficulties may require a smaller number of patterns at a time.

3.3.6. Whack-a-monkey

This game is the final version of the *Whack-a-mole* teaching activity. While the original description of the game scenario *Whack-a-mole* specified a whack-a-mole machine that would be placed on a carnival fair within the world, we decided to change the context to avoid including a carnival within a Day of the Death theme. We wanted to avoid misleading the players into thinking that both traditions are somehow related.

Instead, we designed an alternative context for the same game mechanics, where a group of monkeys have infested the backyard of the junkyard. A monkey trainer has noticed that the monkeys have some aptitude for language, so she is trying to train them how to read, rewarding them with bananas for successful responses (see Figure 8).

Mechanics

- A number of static objects appear on the screen
- The target word/pattern is displayed on the top of right side of the screen
- Monkeys appear in random order from behind the static objects and show a word or pattern for few seconds.
- The player has a limited number of bananas that has to throw to the monkeys that match the target.
- The player throws a banana to any location by tapping on it.
    - If a banana hits a monkey with a pattern that matches the target pattern, it will grab it and leave the scene.
    - If a banana hits other monkeys, it will splash on their face
    - If the banana does not hit a monkey, nothing happens

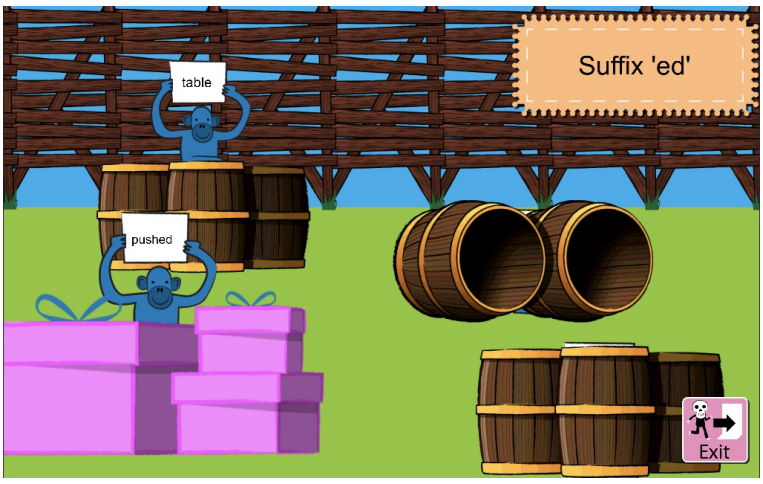


Figure 8: Whack-a-monkey

Multi-sensory teaching and other implicit teaching resources
The target pattern can be both written or spoken text (played whenever the player hits the speech gadget). On the other hand, patterns on the monkeys need to be only written to avoid sounds being played at the same time.

Feedback and reinforcement
The fast pace nature of this game does not allow for immediate feedback other than right/wrong.

Presentation of text
Both the target pattern and the words held by the monkeys are shown with a fixed font size over a uniform coloured background. Although the text held by the monkeys moves when appearing, then it stays fixed for few seconds.

3.3.7. Bridge Reinforcer

This game is the final version of the *Highlighting Curling* learning activity and the *Eye Exam* game scenario. We use a context similar to the *Endless Runner* game scenario (now removed) but using its original theme (*Bridge Builder* learning activity). In the new context, the player is helping an engineer to reinforce a bridge to avoid it collapsing when cars pass over it (see Figure 9).

The context of a doctor's office (*Eye Exam* game scenario) was removed because it implicitly (and misleadingly) suggested some kind of link between visual impairments and reading difficulties. Similarly, we decided to re-adopt a bridge idea because a bridge served as a more distinct world location than the context of *Endless Runner*.

Mechanics
- A bridge made of squared blocks is displayed on the screen.
- The central tiles contain a word (one letter per tile).
- If the bridge is longer than the screen, the player can scroll the view by swiping anywhere but on the bridge.
- At the bottom of the screen a target pattern is displayed.

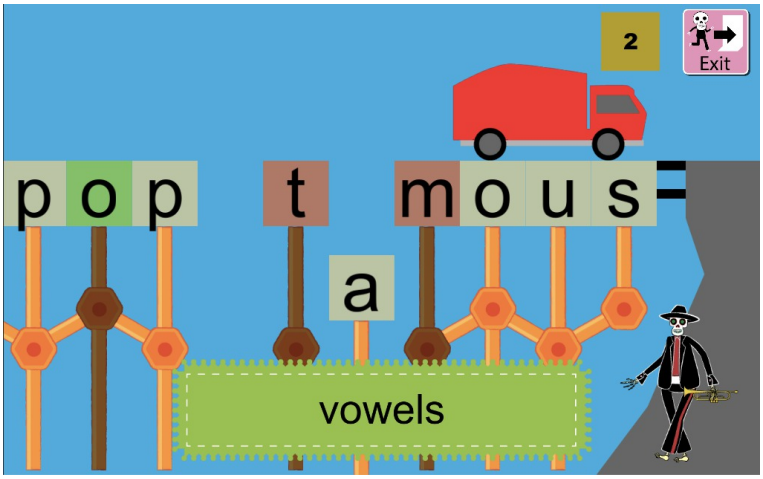


Figure 9: Bridge Reinforcer

- The player has to highlight the target pattern by tapping or swiping over the tiles.
- When ready, the player hits the go button and the engineer reinforces from left to right the highlighted blocks, and a vehicle starts crossing.
  - Correctly highlighted blocks passed by the vehicle are highlighted in green
  - Incorrectly highlighted blocks passed by the vehicle are highlighted in red
  - Blocks that are part of the target pattern but were not highlighted, fall after the vehicle passes.
- If the player made some mistakes, she has to try again, otherwise a new bridge is created afterwards.
- The player has to reinforce as many bridges as possible on a given time.

Multi-sensory teaching and other implicit teaching resources
The target pattern can be both written or spoken text (played whenever the player hits the speech gadget). The bridge blocks always represent text.

Feedback and reinforcement
After the student has highlighted parts of the word, she is guided (from left to right) through her highlighting. Then, all correct and incorrect blocks are clearly indicated, again from left to right. Finally, the student has to fix her errors.

Presentation of text
The target pattern and the letters in the blocks are shown with a fixed font size over a uniform coloured background. The separation between blocks is not perceivable, thus not difficulting the reading task.

3.3.8. Train Dispatcher

This game is the final version of the teaching activity and game scenario of the same name. The game is located at the train station and the player has to help the passengers to hop on to the correct carts.

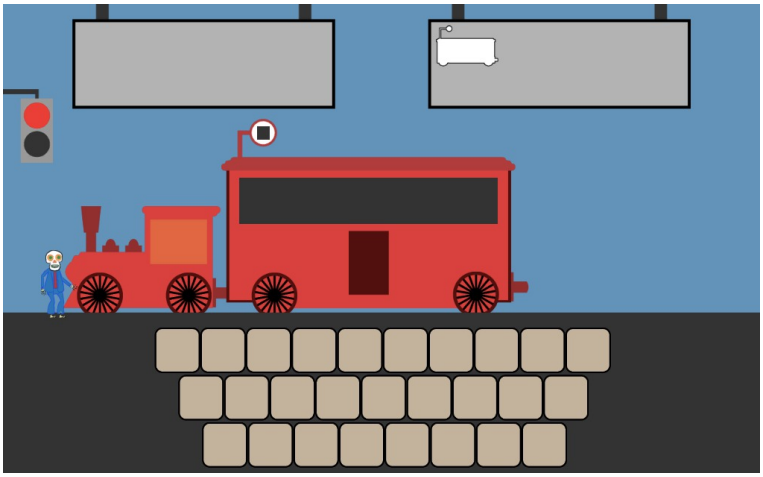


Figure 10: Train Dispatcher

Mechanics

- A train station is shown on the screen
- A locomotive enters the station with a number of carts attached to it
- A word is displayed on the top left panel of the screen.
- The player has to select as many carts as there are syllables in the word
    - Carts can be added to the train by tapping on the cart symbols available on the top right panel
    - Carts can be removed by swiping over the connection between two carts
        - For each removed cart, a new symbol appears on the right top panel
- The player has to type each syllable of the word on a cart, in the correct order
- The cursor is by default on the first cart
    - The player can tap on any cart to place the cursor on it
    - If the player hits enter, the cursor moves to the next cart
- When the player is ready, she hits the go button and groups of passengers enter the scene
    - Carts with a correct syllable are filled with passengers
    - Carts with incorrect syllables or no syllables remain empty, and the groups of remaining passengers remain on the platform
- After passengers have entered the train
    - If all carts with syllables are correct, the train leaves the station
        - Extra carts added to the train with no syllables are automatically detached and left on the station for few seconds
    - If some carts remain empty (wrong syllable typed in), the player has to try again, but only incorrect carts are now available
- Once the station is cleared, a new train enters
- The player has to dispatch as many trains as possible by a given time

Multi-sensory teaching and other implicit teaching resources

The target pattern can be both written or spoken text (played whenever the player hits the speech gadget). When the student fills a cart, the cursor automatically moves to the right, indicating the correct order or reading/writing a word.

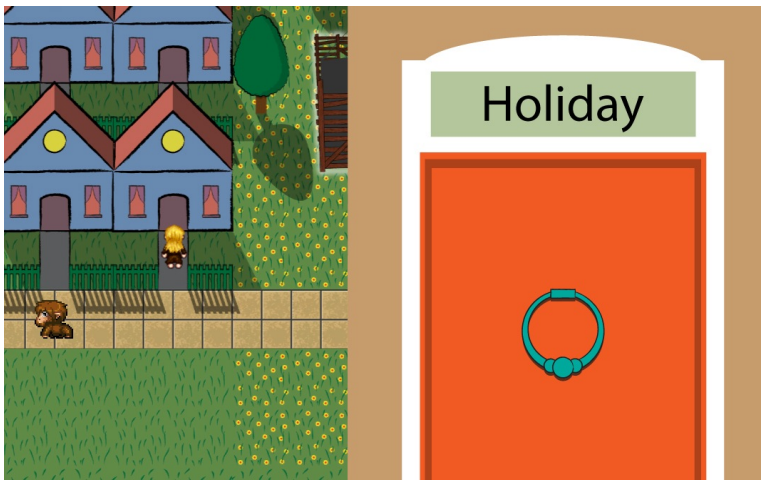


Figure 11: Mail Delivery

Feedback and reinforcement
In this game the player is forced to type all correct syllables of the word. Additional feedback is not required.

Presentation of text
The target word is shown with a fixed font size over a uniform coloured background. The keyboard displayed uses the same font that the student has selected for the rest of the interface.

3.3.9. Mail Delivery

This game implements new mechanics not included in any game scenario. It is inspired by the *Knocking Maze* that was defined by the experts but not presented in previous deliverables as one of the nine learning activities. Through consultation with our DA colleagues, we have decided to implement *Knocking Maze* in lieu of *Endless Runner,* as the skills and difficulties developed in *Endless Runner* were sufficiently covered by other minigames, whereas *Knocking Maze* focused on less catered-for skills and difficulties. In *Knocking Maze*, the player traverses a maze and open paths by knocking on labelled doors the same number of times as there are syllables on the door's label.

In *Mail Delivery* we implement the same mechanic but contextualise it within the game world in close relation to the narratives of *Whack-a-monkey* and *Mail Sorter*. In *Mail Delivery*, the player has to help a postman to deliver his parcels while avoiding playful monkeys that try to capture the parcels. The player has to first avoid monkeys roaming the streets to reach a door; once at the door, the player has a limited time to knock on the door before a monkey captures the parcel (see Figure 11).

Mechanics

- A postwoman character gives a bag of mail to the player, stating that all the mail in the bag needs to be delivered within a specific block of streets.
- Each piece of mail in the bag is associated with a target destination
- The screen shows a special view of a block of game world streets and locations
    - Other characters are removed
    - Monkeys patrol particular streets following fixed and repetitive paths

    - One house is marked as the target destination
- The player has to navigate the streets of the game world to get to the target house while avoiding the monkeys
    - If a monkey touches the player, she loses the parcel and comes back automatically to the position of the postman, who gives her a new one
- When the player reaches the target house, a door appears on the right side of the screen, with a word written on top
- The player has to tap on the door as many times as there are syllables in the word before a counter reaches zero
    - If the player knocks the correct number of times, the door opens and a character takes the parcel
    - If the player knocks an incorrect number of times (including zero), a monkey appears and takes away the parcel
- The player has to deliver as many parcels as possible during a limited time

Multi-sensory teaching and other implicit teaching resources

The target pattern can be both written or spoken text (played whenever the player hits the speech gadget). In addition, this activity adds touch as an additional sense, as the player uses tapping not to select an item on the screen but to express a number and rhythm. A knocking sound is played with each tap, further reinforcing this action.

Feedback and reinforcement

The tally displayed after the game shows the player what she did wrong.

Presentation of text

The target word is shown with a fixed font size over a uniform coloured background.

4. Implementation details

In this section we describe additional details of the game development process beyond the game design considerations.

4.1. Audiovisual design

The Day of the Dead theme meant that the game came with a very strong aesthetic already determined. The challenge on the art side, therefore, was to turn the somewhat dark and macabre imagery into something more child-friendly, whilst retaining the sense of mischief and mystery inherent to the theme. The assets were all given bright, flat colours with a palette based on traditional Day of the Death colours (purples, pinks, oranges and yellows), and the characters were all drawn with outlines that simulated coloured chalk/crayon drawings, without looking too childish. In a recent iteration of the artwork, all characters were given more cartoony proportions - with oversized heads and stumpier bodies, a change which immediately made them appear friendlier.

In order to accommodate varying display sizes and formats, the games were designed to allow the active gameplay area to be resized dynamically. The extreme left and right hand sides of the screen were either kept free of essential elements, or were populated with assets that would move further in/ out according to the current dimensions of the device running the game. Similar considerations were employed for the placement of important GUI elements at the top of the screen: these would move up/ down as necessary. Finally, the static backdrops were designed to be large enough for the biggest resolution, whilst also functioning correctly for the smaller sizes.

Despite these considerations, the visuals have been optimised for 7-inch screens as described in the specifications of the system (deliverable D3.3), especially the presentation of text. While larger screens should not present issues, smaller ones (e.g. mobile phones) may not provide the best experience. Care was taken to ensure that any areas involving text were kept as plain as possible, and coloured with various versions of off-white, and occasionally low-opacity flat colours. Dyslexia-friendly fonts that fit the visual aesthetics where selected, and players will be allowed to choose their preferred one.

Sound effects were kept cartoony and bright sounding, and the music was heavily inspired by *mariachi* bands - featuring numerous trumpets, hand percussion, acoustic bass and violins. While sound effects and graphics have been fully developed in-house, the voice assets used to tell the stories have been acquired from professional voice-over services to assure the best possible quality. Text-to-speech has been only used within the games where any word available in the dictionary may appear as spoken. Following experts' recommendations, background music has been limited to parts of the game that do not involve phonological work (i.e. game world and beginning and end of the games).

4.2. Middleware

The software development process focused not only on realising the requested digital game and server integration deliverables but more importantly embodied development principles allowing for future augmentation. Ease of maintenance and scalability is provided by designing the system in modular fashion and decoupling distinct features. Three decouplings in particular give important benefits to end users:

4.2.1. Separation between activities and the game world

Each game activity contains its own package, encapsulated from the rest of the system. An activity launcher links with available activities. The launcher acts as an interface for calling particular activities. This setup allows for the addition of new activities as well as the tweaking of existing ones with minimal maintenance. More importantly, this design abstracts the invoker of the activity launcher. Activities can be launched either by the game itself within its world view or by a dyslexic or aid personnel such as parents and teachers via its in-game social network. The former triggers activities with a fun motive related to the game world's narrative. The latter triggers the activities with emphasis on drill sessions. In this manner the system offers fun exploration at one's own pace while also providing a mode to exploit activities to address specific difficulties.

4.2.2. Separation of languages

Multi-language support was seen as crucial in order to increase the system's target audience. Language is used in three main forms. Firstly, game related text provides information about game characters, quests and help. Secondly, exercise text is used as content for the dyslexic game activities. Thirdly, audio is used in occasions where text needs to be read aloud to the player. These three groups form the basis of the implemented localisation modules. Game text and audio for a particular language are created and placed in unique directories which follow a predefined format. The current version of the system obtains exercise text from an external server which provides activity suggestions. For offline play, the system caches a small pool of exercise content and stores the data under the appropriate language directory. Decoupling the language elements from the game also allows easy translation into new languages by experts without accessing source code.

4.2.3. Separation of game and content server.

Apart from interacting with the player, the system also communicates with an external server. An incoming connection allows the game to ask for activity suggestions for its player. Once suggestions are received a corresponding notification appears in the game indicating that players should help certain characters by performing their related exercises. As activities are played, various data is logged about the player's experience. At the end of a session an outgoing connection is used to push logs to the server for analysis. Two distinct interfaces provide server services to the game's world view and activities respectively. This allows for seamless usage of the content server within activities while abstracting away from the underlying networking modules. It also provides the possibility of releasing a full offline version decoupled from server needs if a desired corpus of data is made available for bundling with the game's build.

Before the game starts, students are requested to introduce their username and password, which are used to query the server to collect state of the social network (which is a direct mapping of the student profile) and the current progress on the game story (stored using the logging service). All relevant activity in the game is logged into the system. In particular, after each activity ends the tally of correct and incorrectly solved words and sentences are logged and a student profile update is requested.

The words used on each activity are always requested before the activity starts. When spoken assets are required, the native TTS system of Android is used. Sound clips are created and imported automatically, allowing the game to control the timing of the played sounds to the millisecond. The game system also allows us to share student preferences on voice, speed and speech with the reader.

4.3. Story plot

Our game foregrounds characters and character relationships as ways to keep players motivated in ongoing play. Each of these characters maps to a set of specific difficulties: for example, one represents long vowels, another represents syllable split rules. Each of these characters are encountered within the game world or in relation to its activities, and each is associated with a particular character traits and backstories that are revealed through the process of the player becoming friends with them on ghost book, or encounters in the game world.

We have used a participatory design approach to develop these stories. Project partners from IoE organised a character-focused storytelling workshop around the theme of the Day of the Dead. In this workshop, children were introduced to the Day of the Dead festival. They were then provided with art materials for developing characters, character profile sheets, and encouraged to develop stories surrounding, for example, the relationship between their dead and living characters, how these characters communicated with one another, and potentially what happened when these characters were reunited. A workshop adopting a similar structure was then carried out by the Epirus project partners. Both workshops resulted in the development of character descriptions and stories. At the moment of writing this deliverable UoM is in the process of identifying elements from the workshop outputs that could be woven into the final game world and its characters. As much as possible, we would like all of the characters to be informed either directly or indirectly by the children's workshop outputs.

5. Future Work

At the moment of writing **all** game functionalities have been already implemented and any development work left consists of polishing the audiovisual assets as well as fixing all possible bugs before the evaluation of the system starts. More playtest sessions in Greece and Malta are scheduled for the months before the evaluation version of the system is deployed in September 2014 (month 24). Based on the feedback collected with the first evaluations, only minor additions and polishes of the game assets as well as minor tweaks of game mechanics and literacy feedback within the games are expected. During this period (July to September 2014), the exact narrative used in the game will also be finalised and translated to Greek, in addition to polishing the literacy feedback available during the game activities and within the social network.

Appendix A: Formative Evaluation Materials

A.1. Children's Consent Form

Research project title

ILearnRW: A computer program to help with reading and writing

Description of the research

- We are working on a research project that has been developing a new computer program to help children improve their reading and writing skills
- This new program includes lots of different games that you can play
- We would like you to test them out and let us know what you think about them

Taking part in our research

- You have been chosen to take part in this games testing group by your teacher
- I will be asking you to work in pairs to play some of the games and then fill in some worksheets about what you like or dislike about the games
- I will then have a discussion as a group about your thoughts and ideas after you have finished playing all of the games
- I will be writing notes whilst you play the games
- At the end of the session when we discuss the games I will be audio recording this so we don't miss any of your great feedback or suggestions.
- During the session I will also be taking some photographs for our website, but please tell me if you don't want to be in them.
- Taking part in the games testing session is your choice and if you do not want to take part or wish to leave during the session then just tell me or your teacher
- If you have any questions or problems during the session then please tell me or your teacher

Information from games testing session

- We will be sharing your ideas and suggestions with the games development team at the University of Malta and they will be making changes to help improve the games

CONSENT FORM

Please read the statements and tick the boxes if you agree with them

	I understand the information sheet	
	I have had enough time to think about the information	
	I understand that I am volunteering to be involved and can leave the computer games testing session at any time without giving a reason	
	I understand that the information I give may be shared with others who work on the research project	
	I agree to take part in the games testing session	
	I am happy to be audio recorded during the discussion	
	I am happy to be in any photographs	

_____

(Please write your full name)

_____

(Date)

A.2. Parents' Consent Form

Dear

My name is Laura Benton and I am a researcher at the Institute of Education. I am currently working on a research project called iLearnRW (http://www.ilearnrw.eu), which is aiming to develop new tablet-based software to help children improve their reading and writing skills. We are currently trialing our software and would like your child to help us with this. They have been selected to take part by their teacher as they are currently receiving additional support for reading and/or writing.

We will be visiting your child's school on two days (18th June and 9th July) to run a 'games testing' session with a group of 4-6 children as well as a teacher from the school. Each session will last no longer than 1 hour and will involve myself (and potentially another researcher on the iLearnRW project) observing the children trying out a number of different literacy games on a tablet computer and then asking them to tell us about what they thought of the games and how they could be made better.

We would like to audio record our discussions with the children to ensure we capture all of their feedback and also to take some photographs during the session, if you are happy for us to do so please indicate on the form below. If you have any concerns about this we can alternatively take written notes and ensure that your child does not appear in any photographs, please feel free to contact me to discuss any concerns. Because we are collecting this information for research purposes, we need to inform you about how the data will be used and ask you for your consent. We will also be asking your child at the start of the session if they are happy with this too.

The information which we collect will be entered into a database and will only be accessed by authorised personnel involved in the iLearnRW project. All data collected from the verbal discussions will be treated as confidential. The information will be retained by the Institute of Education and Dyslexia Action and will only be used for the purpose of research, and statistical and audit purposes (in collaboration with the National Technical University of Athens, University of Malta, Technological Institution of Epirus, Lucian Blaga University of Sibiu, and Dolphin Computer Access). By supplying this information you are consenting to the Institute storing your child's information for the purposes stated above. The information will be processed in accordance with the provisions of the Data Protection Act 1998. All data will be stored in accordance with the Data Protection act for 10 years, after which time it will be destroyed. No identifiable personal data will be published.

The results of this research will be written up for conference papers and peer-reviewed journal articles, and further information will also be made available on our website: http://www.ilearnrw.eu.

By signing this form you are confirming that you have read and understand this letter. Participation in this project is voluntary and you are free to withdraw your child at any time without giving any reason. If you withdraw your child then their data will be removed and erased.

Thank you very much!

Best wishes,
Dr. Laura Benton
Institute of Education

Please complete the form below and return to your child's class teacher as soon as possible.

I understand the above information and consent to my child taking part in this project (please tick) □

I am happy for my child to be audio recorded as part of this research project (please tick) □

I am happy for my child to appear in photographs, which may be reproduced and used for promoting or publicizing the iLearnRW project and may include printed publications, presentations and our project website (please tick) □

Parent Name: _____
Child's Name:_____

Parent Signature: _____
Date:_____

If you have any further questions about this research or concerns regarding your child's participation then please contact me:

Dr. Laura Benton
Research Fellow, Institute of Education
Email: L.Benton@ioe.ac.uk

A.3. Teachers' Consent Form

Dear

Thank you for your interest in participating in the preliminary evaluation stage of the iLearnRW research project, which is looking to trial new tablet-based literacy software for children with dyslexia that has been developed as part of our research project.

During this preliminary stage of the evaluation we would like to gather feedback from both pupils and teachers on the early versions of our tablet-based literacy software, which will then be shared with the project developers to help to improve the software further. This will involve us visiting your school on 2 occasions to run a 'games testing' session with a group of 4-6 children with dyslexia or children who have been receiving additional literacy support. Each session will involve us observing the children trying out a number of different literacy games and then asking them to tell us about what they thought of the games and how they could be made better. We would also like to ask you about your thoughts on the software and how it could be improved to make it more appropriate and engaging for the pupils you work with.

We would like to audio record the discussions with both yourself and the children, if you are happy for us to do so, or alternatively written notes can be taken. We would also like to take some photographs during the sessions. Because we are collecting this information for research purposes, we need to inform you about how the data will be used and ask you for your consent.

The information which we collect will be entered into a database and will only be accessed by authorised personnel involved in the iLearnRW project. All data collected from the discussions will be treated as confidential. The information will be retained by the Institute of Education and Dyslexia Action and will only be used for the purpose of research, and statistical and audit purposes (in collaboration with the National Technical University of Athens, University of Malta, Technological Institution of Epirus, Lucian Blaga University of Sibiu, and Dolphin Computer Access). By supplying this information you are consenting to the Institute storing your information for the purposes stated above. The information will be processed in accordance with the provisions of the Data Protection Act 1998. All data will be stored in accordance with the Data Protection act for 10 years, after which time it will be destroyed. No identifiable personal data will be published.

The results of this research will be written up for conference papers and peer-reviewed journal articles, and further information will also be made available on our website: http://www.ilearnrw.eu.

By signing this form you are confirming that you have read and understand this document. Participation in this evaluation is voluntary and you are free to withdraw at any time without giving any reason. If you withdraw your data will be removed and will be erased.

Thank you very much!

Best wishes,

Dr. Laura Benton
Institute of Education

I understand the above information and consent to being interviewed as part of this research project (please tick) □

I consent to being audio recorded as part of this research project (please tick) □

I am happy to appear in photographs, which may be reproduced and used for promoting or publicizing the iLearnRW project and may include printed publications, presentations and our project website (please tick) □

Participant Name: _____ Date:_____

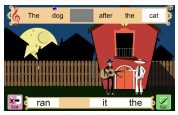
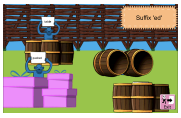
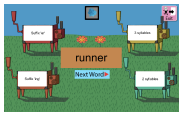
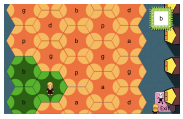
Participant Signature: _____

If you have any further questions about this research or concerns regarding your participation then please contact us:

Dr. Laura Benton
Research Fellow, Institute of Education
Email: L.Benton@ioe.ac.uk

A.4. Evaluation Form

Session 1 Timetable

Activity	Time
(1) Introduction to the project	5 minutes
(2) Exploring the game world 	10 minutes
(3) Testing the games (a) Junkyard  (b) Serenade Hero  (c) Whack-a-Monkey  (d) Harvest  (e) Moving Pathways 	20 minutes
(4) Discussing the games 	15 minutes

General Observation Notes –Researcher to complete

Were there any bugs with the system
Did you have any technical issues with setting up the tablets in the school?
Did you notice any particular difficulties the children had interacting with the tablet? What were they attempting to do when this occurred?

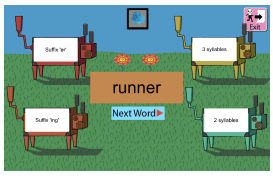
Game Observation Notes during Structured Time –
Researcher to complete (print 5 copies) – children play each game once

Name of Game
Were all the pairs able to successfully access the game without any help? If not what problems did they have? How many times did the children ask for additional help from an adult (teacher or researcher)? What for?
How many times did the teacher intervene without a child asking for help? What for?
How motivated/engaged did the children appear to be when playing the game? (i.e. body language, interactions with others about the game)
Were the children successful or unsuccessful at completing the activity? How did they react to this?

(2) Exploring the game world

Write or **draw** any **thoughts, ideas** or **comments** you have in this box

(3) Testing the games (example)

Harvest	

Write your **names** in this box:

1. How much did you like or dislike playing the game? Pick one of the faces to show how much you like or dislike it.

2. Would you choose to play the game again? Tick a box.

Yes	
No	

3. Did you have any **problems** when you were playing the game? Write them in the box below.

4. What did you think was **good** about the game?

5. What did you think was **bad** about the game?

6. Did you **learn** anything from playing the game?

Yes	
No	

7. Write down anything you **learned** from the game in the box below.

8. If you were a game designer would you change anything about the game? List your **ideas** in the box below.