

## Adult Learning Sign Language by combining video, interactivity and play

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**Abstract.** One in every six persons in the UK suffers a hearing loss, either as a condition they have been born with or a disorder they acquired during their life. 900,000 people in the UK are severely or profoundly deaf and based on a study by Action On Hearing Loss UK in 2013 only 17 percent of this population, can use the British Sign Language (BSL). That leaves a massive proportion of people with a hearing impediment who do not use sign language struggling in social interaction and suffering from emotional distress, and an even larger proportion of Hearing people who cannot communicate with those of the deaf community. This paper presents a theoretical framework for the design of interactive games to support learning BSL supporting the entire learning cycle, instruction, practice and assessment. It then describes the proposed design of a game based on this framework aiming to close the communication gap between able hearing people and people with a hearing impediment, by providing a tool that facilitates BSL learning targeting adult population. The paper concludes with the planning of a large scale study and directions for further development of this educational resource.

**Keywords:** Virtual Reality; Adult learning; Serious Games; Games based Learning; Video Learning; British Sign Language.

### 1 Introduction

British Sign Language (BSL) is a complete visual-gestural language with a unique vocabulary, construction and grammar believed to be used by 151,000 of the UK population, 87,000 of these are Deaf [1]. Increasing the number of Hearing people to learn a sign language, would drastically reduce the barriers, discrimination, and plain ignorance that Deaf people face every day. Learning a visual language like BSL could be well supported by the use of highly visual resources, such as video or a rich graphical environment. Shepard and Cooper [2] and Mayer and Gallini [3] made the connection between visual clues, the memory process, and the recall of new knowledge.

Virtual reality (VR) holds exciting prospect to accommodate the needs of people with hearing disabilities [4] [5] [6] as it supports high motivation, it allows for a greater control over one's environment, it facilitates repetition and self-pacing. To further motivate and engage the learning process and stretch knowledge retention and skills, VR can be coupled with gamification [7], which is the application of game-design elements and game principles in non-game contexts. Game play stimulates brain activity, demonstrating retention of information and engagement that result to effective cognition [8].

The paper presents a background review of games that have been created to support learning BSL highlighting their use to train or assess, their success in fulfilling their intended purpose and the technologies they have been used to support those. Section 3, suggests a theoretical framework to be followed for the creation of an interactive game to support learning BSL combining the whole cycle of learning, instruction, practice and assessment. Section 4 presents a proposed game design addressing this framework making use of VR technology, coupled with Gestures recognition by a Leap Motion Controller and gamification. The paper concludes with directions of future work targeting to evaluate the validity of this proposed educational resource.

## 2 Related work

Several existing BSL educational games, using 2D technology and relatively low interactivity, target users who already hold some knowledge of the sign language aiming to engaging them in activities to practice their knowledge. “*Sign language test*” [9] is one such game, that shows an image of a sign and 5 options to choose from. “*Finger Spelling Game*” [10], displays a series of signs and asks the player to recognizing the whole word. “*Signing Time Kids*” [11] is a memory matching game with a countdown timer. Some other games attempt to teach novice players a sign language. Like “*Sign the alphabet*” [12], a learning by doing multiple choice game that displays a BSL sign and asks the player to recognise the respective letter. Answers are revealed as the game is played, users can be guessing, but their score is reduced. Similarly, “*What is this Letter Sign*” [13], alternates between displaying a written letter and three signs for the user to choose from, there is no scoring, but players are congratulated when providing a correct answer. The “*GreenBeanies App*” [14], provides a short story with clickable words that trigger a short video playing the sign for the word performed by a person. “*Sign my World*” [15], is a mobile 2D video game to aid deaf children to learn the Australian Sign Language (Auslan) and familiarize with the appearance of common nouns and verb signs. It contains a number of interactive objects that when clicked, an image and word are displayed, as on a flash card; followed by the video of the Auslan sign for that object.

Game technology combined with sign language recognition encourages deaf children to practice the American Sign Language (ASL) in an enjoyable way. Such an example is “*CopyCat*” [16]. To play children wear coloured gloves with wrist-mounted accelerometers and interact with a computer vision recognition system.

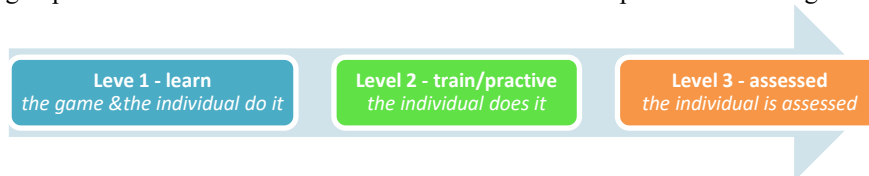
“*Virtual Sign Game*” [17] [18], is a game for learning the Portuguese sign language (PSL) that combines 3D, Kinect and gloves technology. The player controls a synthetic character that interacts with objects and non-player characters aiming to collect several gestures from the PSL that are performed by those characters helping the player to visualise and train existing gestures. “*MemoSign*” [19] aims to foster and promote the vocabulary acquisition for Deaf and Hard of Hearing (DHH) learners in both signed and spoken languages. MemoSign combines, Memory Match Game and avatar technology that render sign notations content in visual-gestural modality.

### 3 Theoretical framework

To create an educational resource that marries advanced technology combined with game elements to successfully support learning BSL an instructional scaffolding approach in learning [20] is proposed. This is the “the systematic sequencing of prompted content, materials, tasks, and teacher and peer support to optimize learning” [21]. Similar to scaffolding used in construction, the educational resource, that can be an 3D interactive game, puts in place temporary support structures to assist learners in the process of learning the BSL alphabet. It tailors the learning process to the needs of individual learners by enabling a self-paced exploration of the immersive environment. The structure of the scaffolded instruction implemented takes place in three levels:

- **Level 1 – learn – the game and the individual do it**  
The game demonstrates how to communicate using BSL in videos. The videos provide a realistic depiction of BSL alphabet and are embedded as objects in the game environment. The learners explore the environment to uncover the hidden objects and watch the videos. Additional scaffolds (i.e., repetition of a BSL gesture and a video inventory) enable learners to master individual BSL letters.
- **Level 2 – practice – the individual does it**  
In the practice stage individual learners demonstrate their mastery of the BSL alphabet by practicing recognising the BSL alphabet.
- **Level 3 – assess – the individual is assessed**  
Once learners feel confident with their mastery of BSL, all scaffoldings are removed, and they can assess their knowledge by playing a game against a virtual enemy.

Fig. 1 presents the structure of the scaffolded instruction implemented in the game.



**Fig. 1** The scaffolded instruction implemented in the 3D interactive game platform

## 4 Signum Battle - the 3D interactive game platform

### 4.1 The game design

**Genre.** The Signum Battle is a third person hybrid action – adventure – educational game, aiming to teach BSL alphabet in a fantasy mythological world. The player/learner takes on the role of a hero/explorer who needs to complete several learning quests to advance through the game. Adventure genre games usually require the player to solve a problem, but without much action happening, by action we refer to encountering drawbacks in the form of enemies or battles. Action genres constitute mainly of action derived activities and the game play is very much based on the player using their reflexes and being in a heightened state of alertness to fight enemies. Problem solving is essential for constructing links between information to reinforce learning. In addition, negative and positive reinforcement strengthen the motivation for learning which is supported by the combination of action and adventure genres respectively.

**Game demographic.** The target audience of this educational game is people that learn sign language later in their life. Taking into consideration that after Level 2 of the game there is suggestion to mild violence per the Entertainment Software Rating Board the band in which the game fitted best is E10+ [22].

**The lore.** The review of educational games to teach sign language revealed that none of the existing games have an engaging story and/or engaging environment usually found in popular games. Therefore those educational games come across as uninteresting. The backstory of the Signum Battle is that mermaids have used their enchanting song to lure humans into the sea, the survivors left in this fantasy world lived because their lack of hearing has empowered them to be immune to the mermaid's chant. The mermaids have become aware of their limitation and have summoned walking sea creatures, minions, to come into land to protect their territory and the humans they have trapped. A young heroine has stumbled into this world and decides to go on a mission to help them. To do so she needs to pick up the skills and magical powers of this language to attack the minions, reach the mermaids lair and rescue the humans. The language to be learned is the BSL. The backstory is used to: provide a framework for a mission based game structure; and help the players submerge themselves in a game they experience "Suspension of disbelief" [23] in order to be entertained. Furthermore, it was important to tackle the subject of deafness in an inclusive and non-patronising way. Thus, deafness is presented as positive and empowering element in the story of the game. This has been the case in many superhero stories; as for Marvel who included a deaf super hero in their comics, which according to Callis [24] for deaf children this pop culture representation is affirming. Hence, the people of this game world survived the evil song of the mermaids which lured men to sea, because they were immune due to their lack of hearing.

**Game controls.** The game is controlled by mouse clicks to move around and interact with objects in the environment. Gestures, using a leap motion controller, are used to practice the signs that have been learned or make selections in level 2. The keyboard is used to recognise signs. This game aims to be inclusive; therefore it includes audio, but is not reliant on it. Audio is used to engage able hearing players, but for every sound que there is an equivalent visual feedback.

**The game environment** – looks interesting and engaging reflecting the magical theme of the backstory. Hence the story unfolds in a forest where stone ruins (see Fig. 1(a)) were added to reflect the destruction that had come before.

## 4.2 The game Levels & mechanics

**Level 1 Learn.** Level 1 familiarises the player with the BSL signs. Signs drawn on stone tiles like ancient hieroglyphics are scattered in the environment among the forest ruins for the player to discover (see Fig. 1(b)), supporting exploration, engagement and immersion in the game. Picking up a sign activates a video that plays out the corresponding gesture for that letter, then the sign is added in an inventory. Players can open the inventory and play the signs as many times as they need to be confident that they know it. Currently, only 8 signs of the BSL alphabet have been implemented.

At this level the game mechanics used is exploration, discovery and collection of signs to advance to the next level. There is no time constraint, rewards or penalties. Once all the letters in this level have been collected the players can proceed to level 2.



**Fig. 2** (a) The forest environment in level 1 where the players collect the BSL signs; (b) inventory of the collected BSL signs and video playing the sign gesture.

*Level 2 Practice.* In Level 2, players transition from an open environment to a closed sheltered area (see Fig. 2(a)) where they can practice at their own pace the signs they have learned. The system prompts the player to correctly recognise the corresponding BSL sign of letters they have learned in Level 1 (in a form of a multiple choice questionnaire). Players select one of 3 cubes that appear on a table top in the training room using the leap motion (see Fig. 2(b)). Initially it was planned to use a BSL recognition algorithm for Leap Motion, but this was too difficult due to the use of two hands while creating gestures. The letters are presented randomly until the players perform

well, indicating they have learned the signs. There is no time constraint, rewards or penalties at this level. When the players feel confident they can progress to level 3.



**Fig. 3** Level 2 (a) The sheltered environment for practicing the signs; (b) The user recognizing the BSL signs using a leap Motion controller.

*Level 3 Assess.* Level 3 is the battle level where the player's recognition of the BSL signs is assessed. To win this level the players have to correctly recognise the BSL signs shown on top of the enemy/minion by hitting the respective key on the keyboard see **Fig. 3**. Correct recognition of the BSL signs keeps the enemy in distance (see **Fig. 3** right image), while failing to recognise them reduces the players' health, that after few wrong attempts dies and the level starts again. There is no time constraint at this level, the players play as long as they can last. Speech recognition could support faster identification of signs. However, selecting the respective key of a sign on the keyboard might serve learning better, as it helps the conceptual connection between letters and signs.

The enemy in Level 3 was inspired by a collection of sea monsters. The enemy is bigger than the player's avatar and fearsome to add to the fear factor of the game [22].



**Fig. 4** The battle, the players have to correctly recognise the BSL signs shown on top of the enemy/minion by hitting the respective key on the keyboard to keep the enemy away.

### 4.3 The technology

The game has been implemented in Unity. For the environment and textures we used, 3DsMax and Photoshop have been used, while for the game characters, Adobe Fuse

CC and Mixamo (an online tool with an extensive library of animations that can be attached to 3D characters). Gestures are recognized by a Leap Motion Controller.

## 5 Conclusions & future work

This paper presents a first attempt of providing a valuable resource to support people to learn the BSL alphabet in an enjoyable and effective way with the use of video coupled with advanced technologies and gamification. The resource uses a scaffolding approach in learning, putting in place temporary support structures to assist students in the process of learning and tailoring the learning process to the needs of individual learners by enabling a self-paced exploration of the immersive environment.

The paper presented the design of the first version of the prototype. Low usability of an educational resource's interface may have a major impact on its learning educational potential [23] [24]. Thus, at this stage of design and development of the Signum Battle we aimed to discover and improve user experience (UX) issues before proceeding with testing related to its educational validity. For this purpose we use virtual world (VW) heuristics evaluation [25]. Currently the prototype undergoes through further updates to address the VW heuristics evaluation results and resolve usability issues before proceeding to a comparative study engaging a large number of users to evaluate its educational validity of this resource, as well as user satisfaction.

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