

# Sign-Lingo

## *Feasibility of a Serious Game for Involving Parents in the Language Development of Their Deaf or Hearing Impaired Child*

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**Keywords:** Feasibility Study, Serious Game, Sign Language, Kinect, Language Development.

**Abstract:** Family involvement plays a critical factor in the language development of a deaf or hearing impaired child. Hearing parents often have major difficulties in communicating with their child when it is deaf or hearing impaired. These difficulties often lead to issues in the language development of the child. In this research we investigate the feasibility of a serious game for involving parents in the language development of their deaf or hearing impaired child by using sign language together in a fun and engaging way. From the feasibility analysis we find that such a serious game is feasible and could help deaf and hearing impaired children to improve their language development.

## 1 INTRODUCTION

About 3 out of every 1,000 children are born either deaf or with a detectable level of hearing loss in one or both ears. More than 90% of these children are born to hearing parents (NIDCD, 2016). Language development requires a child to have access to communication (Marschark, 2001). Unlike children with no hearing impairment it is difficult or even impossible for deaf and hearing impaired children to use a spoken language. These children mainly use Sign language as communication for language development.

Hearing parents often have major difficulties in communicating with their child when it is deaf or hearing impaired. This obstacle makes it difficult for parents to be involved in the language development of the child. Previous research has shown that Serious games can be used to improve a child's language development by using natural language (Sørensen and Meyer, 2007). This makes one wonder whether or not a Serious game can also be used to improve the language development of a deaf or hearing impaired child by using Sign language.

The Kinect device offers the possibility to create a fun and engaging Serious game for both the child and its parents. So far only very limited research has been performed on Serious games that are intended to be played together by deaf and hearing impaired children and their parents.

In this research we conduct a feasibility study for a Serious game which helps involving parents of deaf and hearing impaired children to use Sign language together in a fun and engaging way. The main goals of the game, which we call Sign-Lingo, are to improve the child's language development and to improve the interaction between the child and its parents. Through this research it will become clear how feasible such a Serious game is.

## 2 RESEARCH METHOD

In this research a feasibility study is performed based on the CORETEST feasibility study framework (Meulendijk *et al.*, 2013). In this study the feasibility of all five aspects are explored. These aspects are:

- conceptual feasibility
- organizational feasibility
- economic feasibility
- technological feasibility
- societal feasibility

The feasibility of these aspects is explored by performing a qualitative study. Note that, instead, Aarnoutse *et al.* (2016) take a systematic literature study (SLR) approach to study their application's feasibility.

In this study the initial approach was to explore the field of Sign language and Serious games. From a literature study it became clear there is a problem in the language development of deaf and hearing impaired children. A feasibility study of a Serious game in which Sign language is used by deaf and hearing impaired children to improve their language development was then conducted. Among the studied literature are research journals, papers and books about Sign language, Serious games and studies about deaf and hearing impaired children.

In the feasibility study several models have been developed using the modeling tool ArchiMate (Beauvoir, 2016).

### 3 CONCEPTUAL FEASIBILITY

#### 3.1 Problem Exploration

In their work Kyle and Woll (1988) describe that the development of language can only occur when a child is provided with input it can perceive, and when the adult and the child are joint partners in creating communication. The importance of parent involvement in language learning is supported by the research of Moeller (2000) in which she shows that family involvement plays a critical factor in the language development of deaf and hearing impaired children, especially those with hearing parents.

The majority of deaf and hearing impaired children are born to hearing parents who do not know how to use Sign language to communicate. As a result, many of these children do not have full access to language during the early years of life most critical to language acquisition. Marschark (2001) states that having parents who can sign well and who read regularly with their deaf or hearing impaired child are extremely important factors in the child's development of literacy skills. This statement might explain the findings of Allen (1994) who found that only 15 percent of white deaf children who graduated from high school in the United States read above the sixth-grade level.

Akamatsu, Musselman and Zweibel (2000) found that fewer than half of the children who use Sign language in school also sign when they are with their families, and only a small fraction of those children are able to carry on normal everyday conversations with their parents. Marschark (2001) states that deaf children of hearing parents have fewer signed or spoken labels for things around them than hearing children of hearing parents, or deaf children of deaf parents. Special efforts, therefore, need to be made to expand the vocabularies of deaf children of hearing parents through print, sign and speech.

It is clear there is a problem in the language development of deaf and hearing impaired children with hearing parents. There is evidence that the involvement of parents plays a crucial factor in the

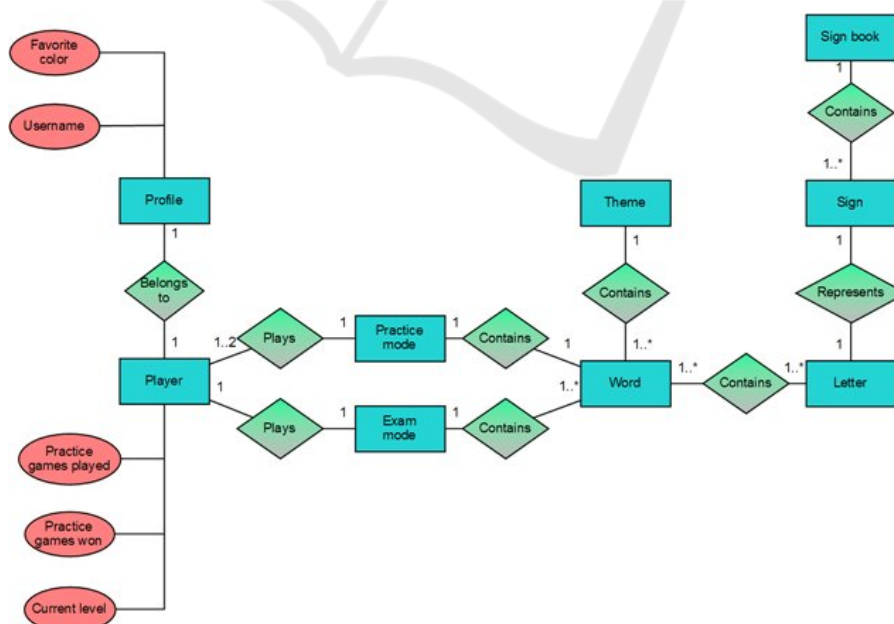


Figure 1: Conceptual model of Sign-Lingo.

language development of their deaf or hearing impaired child but that this involvement is insufficient due to the parents' lack in ability to communicate with their deaf or hearing impaired child.

### 3.2 Concept Modeling

In the previous section it has become clear there is a problem in the language development of deaf and hearing impaired children with hearing parents. In this section a conceptual model is presented of the proposed system. This model visualizes the main concepts of the system. The model is shown in Figure 1.

As can be seen in the model, the system contains nine concepts. These concepts are highlighted in blue rectangles inside the model. Within the model we can also find red circles which represent the attributes of concepts.

Each player has a profile in which general information of the player is stored. This information contains the name of the player and its favorite color.

A player has the option to play practice-mode or exam-mode. In both game modes the player needs to guess words by using Sign language.

Practice-mode is meant to be played together by both the parent and child. The goal of this game mode is to facilitate family involvement in the language development of the child. In this game mode the player who guesses the word first wins the game.

In their work Michael and Chen (2006) mention the importance to measure the progress of the player in a Serious game. The exam-mode is meant to be played by the child. The goal of this game mode is for the child to demonstrate its acquired vocabulary knowledge. In this game mode the child needs to guess multiple words correctly to advance to the next level. The difficulty of the words given in the game modes are based on this level.

Tennant and Brown (1998) explain it helps to fingerspell with a partner when contextual clues are used. Therefore, when starting a game mode, the player can select a theme. Examples of themes are animals, sports or family. Based on the theme the game presents words that are related to the selected theme.

From their pilot study Lee *et al.* (2005) found that the flow within a game is very important to keep the child interested in playing. In the Sign-Lingo game we have therefore included a sign book. This book contains examples of all the signs of the

Alphabet which can be consulted by the player. This makes it easier for both the parent and child to continue playing even when they do not know how to make a sign.

For every player the number of practice games played, practice games won and the current level are stored. The current level is an indication of the current language level of the child. These statistics can be used to track the progress and target problem areas in the language development of the child.

### 3.3 Process Modeling

Goldin-Meadow and Mayberry (2001) explain that to teach children to read, the first step is to make sure they have a language - any language. In case of a deaf or hearing impaired child this will be a Sign language. After a language has been obtained a child needs to learn the concept of mapping between the language it knows and print. In their research Padden and Ramsey (2000) identified a teaching method that they call "chaining". This method encourages children to see the relation between print and Sign language. Chaining consists out of four steps in which the final step is optional:

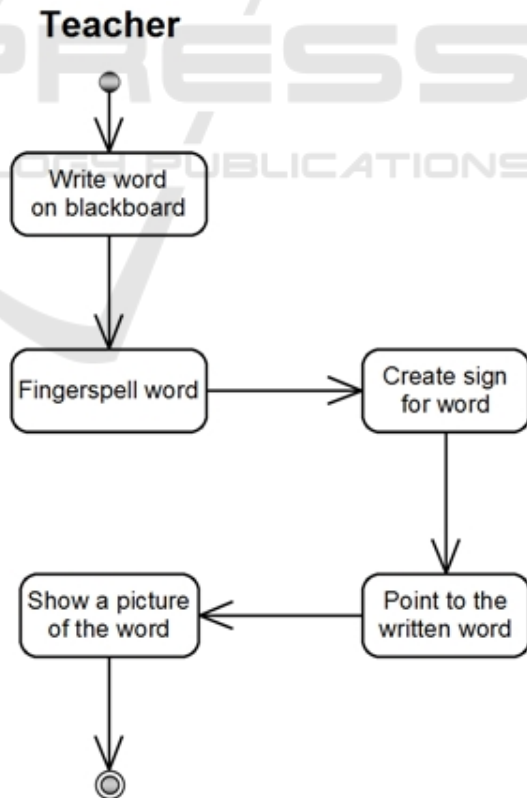


Figure 2: Chaining method.

1. Fingerspell a word.
2. Create the sign that represents the finger spelled word.
3. Point to the written word.
4. Show a picture which represents the word (optional).

Fingerspelling is used to express letters from the Alphabet. Tennant and Brown (1998) explain that fingerspelling is mainly used in Sign language to express names of people, places, brand names and titles. Fingerspelling is performed by creating the sign with the dominant hand. In the chaining method for example a teacher could fingerspell the word ‘d-o-g’, then create the sign that represents the word ‘dog’ and finally point to the word ‘dog’ written down on the blackboard. In addition to that the teacher can show a picture of a dog. This method creates an understanding between the visual spelling of a word (e.g. in English) and the Sign language spelling of the word. This method is presented in Figure 2 and incorporated in the Sign-Lingo game.

## 4 ORGANIZATIONAL FEASIBILITY

### 4.1 Market Modeling

In the previous section we modeled the system’s concepts and its interaction with its users. In this

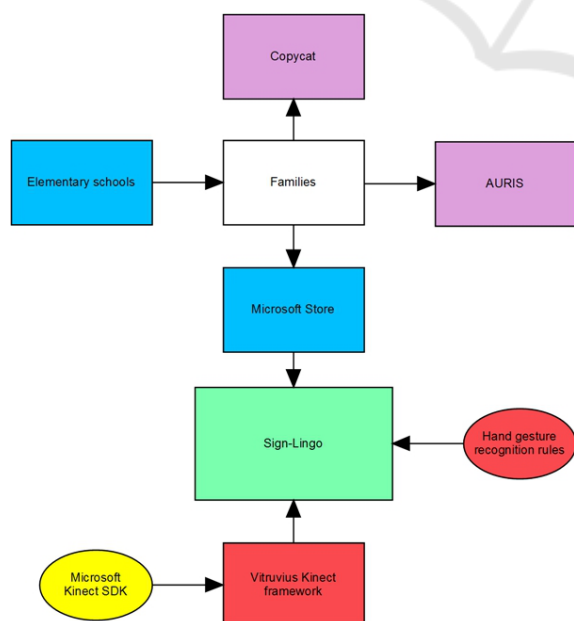


Figure 3: Stakeholder’s relationships of Sign-Lingo.

section the organizational feasibility is assessed by looking into the market in which the proposed system is intended to participate. Through this assessment it becomes clear who the system’s key players, competitors and potential partners are after which an organizational framework can be built.

The model presented in Figure 3 shows an overview of Sign-Lingo system’s stakeholders. This diagram visualizes the relations between the system and the stakeholders and how the system behaves in relation to third-party software.

In the model the red rounded box contains the rules that need to be incorporated into the system. The rounded yellow box contains third-party software that is required for the system to function properly. The red rectangles in the diagram represent the plugins which are required for the system to function. The blue rectangles represent the partners which are involved in the promotion of the system. The white rectangle represent the system’s users. Finally, the purple rectangles represent the competition of other Sign language games related to language development.

The system requires hand gesture recognition rules to recognize letters from the Alphabet in Sign language. The system makes use of the Microsoft Kinect SDK which is designed to help recognize gestures. The system will be built on the Vitruvius Kinect framework which simplifies Kinect development.

The system is used by families with deaf or hearing impaired children. These families can be reached through elementary schools. The system is downloadable from the Microsoft Store.

Existing research has been conducted mainly on the development of Serious games that help a person to learn Sign language (Escudeiro *et al.*, 2015; Fisher *et al.*, 2014; Wilson, 2013), but not specifically on helping a deaf or hearing impaired child in its language development.

When looking at games related to language development for deaf or hearing impaired children we find CopyCat (Lee *et al.*, 2005) and AURIS (Sarmaşik, Serbetcioglu and Kut, 2009) produce interesting results. What differentiates Sign-Lingo from these games is the fact that these games are not based on an existing language development method, do not facilitate family involvement and do not track the progress of the player.

### 4.2 Organization Modeling

In the previous section the key players in the relevant market were identified. In this section the

user roles are identified, and the attitudes towards the newly proposed system are explored.

Through the literature review several methods were identified which are used to help children learn to develop their language. It also became clear parent involvement plays a crucial role in the language development of a child.

Figure 4 presents the organizational model of the Sign-Lingo system. The large rectangles represent the architectural layers on top of which the Sign-Lingo system is designed. The yellow rectangles represent all the stakeholders and their roles.

From the model it becomes clear the Sign-Lingo system is developed using the Microsoft Kinect SDK. The system is used by the parent and child who both have the role of user. It also becomes clear from the model that the developer needs to implement hand gesture recognition rules into the system. In addition to that, these hand gesture recognition rules are tested by a Sign language expert to validate whether the Sign language recognition part of the system performs as expected. Finally, teachers of elementary schools have the role as a promoter. Their task is to introduce the system to families with deaf or hearing impaired children.

## 5 ECONOMIC FEASIBILITY

### 5.1 Development Strategy

In the previous section the market in which the Sign-Lingo system operates was investigated. To reach

out to families who could benefit from the Sign-Lingo system there are several options to consider. One option is to promote the system through digital channels such as application platforms like the Microsoft Store. Another option is to promote the system through other channels such as elementary schools for the deaf and hard hearing.

All partners have different objectives regarding Sign-Lingo. For example in case of the Microsoft Store the partner's interests are clearly commercial. In the case of elementary schools the interest is educational. The system will most likely need to have some relationship with the school's curriculum in order for the school to be willing to promote it.

Two different development strategies were created. These strategies can be run independently from each other. Below follows an overview of the two strategies.

1. Digital-channel strategy; the software is promoted on application platforms such as the Microsoft Store. In exchange for this promotion Microsoft wants a percentage of the selling price for every sold product. In addition to that a website is made for the Sign-Lingo system which explains how the system works and where the system can also be bought (*e.g.* Abdat, Spruit and Bos, 2011).
2. Physical-channel strategy; the software is promoted through elementary schools. These schools are contacted initially through

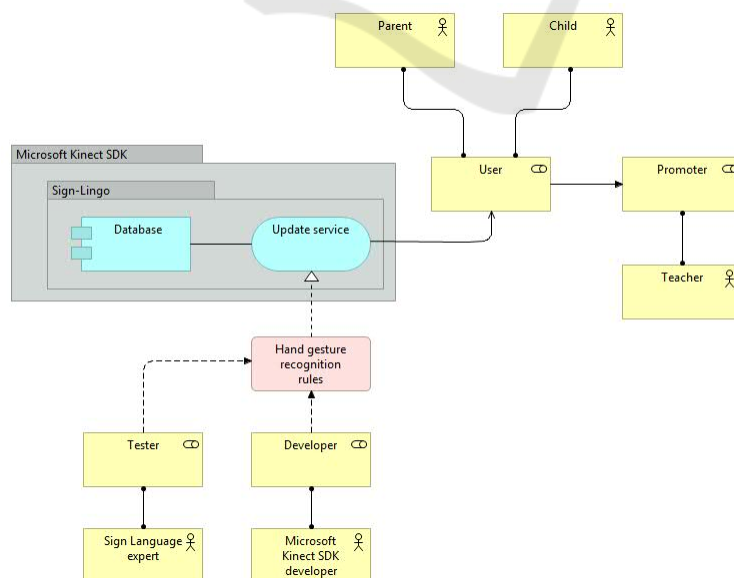


Figure 4: Organizational model of Sign-Lingo.

telephone calls in which the system and the concept behind it are presented to the school's management. Once a school agrees to promote the system teachers demonstrate the system to parents and their children and encourage them to use it.

What both strategies described above share, is the fact they both require partners in order to be successful. Without partnerships the system is unlikely to be used by anyone.

## 6 TECHNOLOGICAL FEASIBILITY

### 6.1 Technological Process Modelling

In this section the activity diagram of the use case 'Play practice-mode' of the Sign-Lingo game is presented. This is the most important and complicated use case in the system. The diagram is shown in Figure 5.

This process contains two actors: the player and

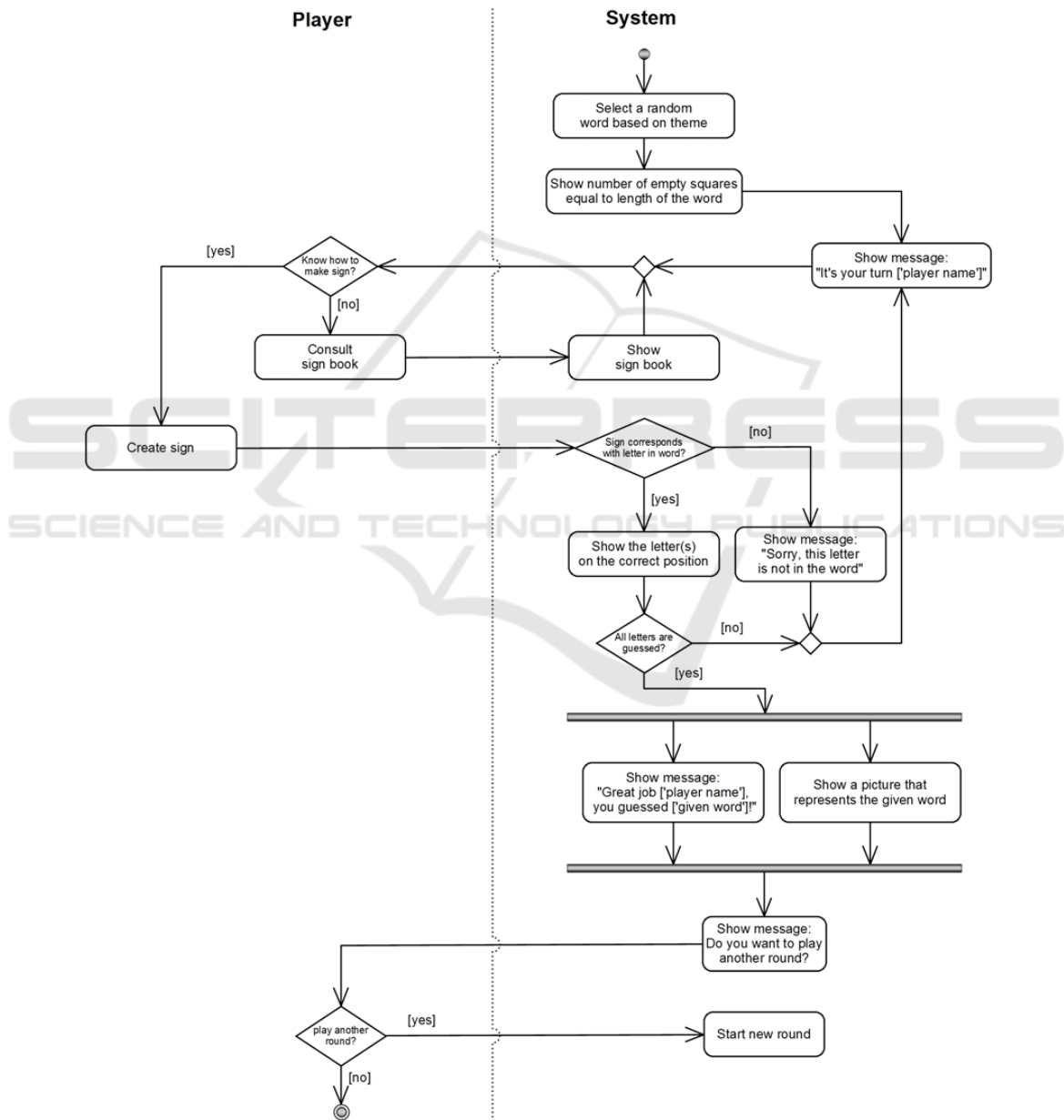


Figure 5: Activity diagram of the Sign-Lingo use case 'Play practice-mode'.

the system. Because this is a multiplayer game this process can be run by two players simultaneously. Before this process can be initiated the player needs to have executed the use case 'View game settings' in which the player has selected the theme and the word length. Based on these two parameters the system selects a random word from the system's dictionary and displays a lingo screen which contains empty squares equal to the length of the random word. The player can then start to guess the given word.

Each turn, the player needs to guess the word by creating a sign gesture that corresponds with a letter. When the player does not know how to create a specific sign he can consult the 'sign book'. The sign book contains an overview of all the signs of the Alphabet. When the player was successful in making a sign the system will recognize this and check whether the given word contains the signed letter. If the word contains the signed letter the system will show the letter to the player on the correct position in the empty squares. When all the letters of the word are guessed the system shows a message to the player which confirms that the word has been guessed correctly and shows a picture that represents the guessed word. The player can then decide whether he wants to play another round or exit the game.

## 6.2 Wireframe

Figure 6 contains a wireframe of the Sign-Lingo game. In this sketch two players are playing the game in practice-mode and need to guess the word 'DOG'. In their work Tennant and Brown (1998) explain clues such as the length of the word are helpful for a child to improve its receptive skills which makes this game type well suited for language development.

As can be seen in the sketch the players can see each other in the game, this makes it possible for the players to maintain eye contact. Tennant and Brown (1998) explain that maintaining eye contact is an important aspect to understand a signer.

The game keeps track of how many rounds a player has won. The game also shows a message to indicate whose turn it is to guess a letter. Once a letter is guessed correctly it appears on the screen and its background turns green. When one of the players do not know how to make a sign it can consult the sign book which can be found in the bottom left corner.

Over time, we aim to optimize gameplay using machine learning techniques for personalization (e.g. Vleugel, Spruit and Daal, 2010), and even investigate the added value of factors such as

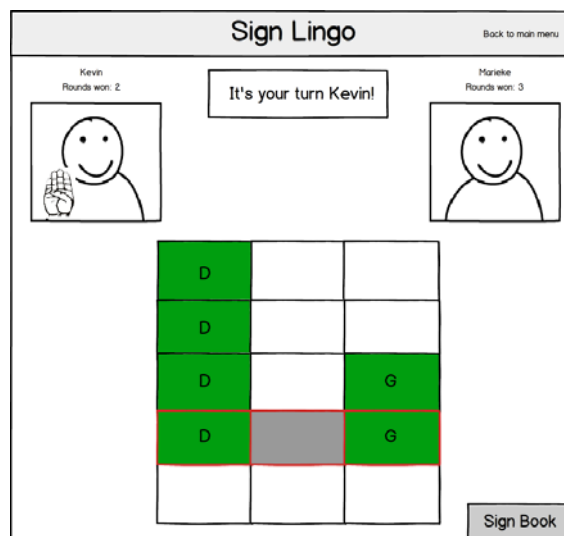


Figure 6: Wireframe of Sign-Lingo user interface.

playroom environment and its geographical location and local population density as possible language variation indicators (Heeringa *et al.*, 2007).

## 7 SOCIETAL FEASIBILITY

In the final step of the feasibility study we focus on how the proposed system can contribute to help deaf and hearing impaired children and their families. The gains can not only be described in monetary terms but in educational terms as well. These gains can be assessed by measuring the language level of children who use the proposed system and compare them with children who do not use the system. The monetization gains can be measured by estimating how much the education associated to the language development of a deaf or hearing impaired child costs and how much of the education can be replaced by the Sign-Lingo system.

## 8 CONCLUSIONS

In this paper we presented a feasibility analysis of a Serious game for involving parents in the language development of their deaf or hearing impaired children by using Sign language together in a fun and engaging way. To assess the feasibility the conceptual, organizational, economic, technological and societal feasibility aspects, known as the CORETEST, have been investigated.

From the CORETEST it became clear there is a problem with the language development of deaf and hearing impaired children and a Serious game could

help these children to improve their language development. The chaining method which is used to help a child to improve its language is well suited to be incorporated in this Serious game.

In future research the proposed system could be implemented and then tested in a case study with a sample group. In this case study the language level of deaf and hearing impaired children who use the system could be compared with the language level of deaf and hearing impaired children who do not use the system to see what the effect of the game is on the language level of a child.

Finally, we aim to incorporate the lessons learned into follow-up research on the feasibility of Serious games for medication adherence in children and quality of care in long-term care (e.g. Spruit, Vroon and Batenburg, 2014).

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