SignUp! : an interactive web application for learning American Sign Language

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Abstract. There are various ways to learn languages in general, but we noticed that learning sign language is not as accessible nor engaging as other verbal languages. Through this Human-Computer Interaction project, we introduce a web application where users can learn American Sign Language (ASL) in an immersive, gamified way by interacting with a leap motion controller. However, this project is in no way a substitute for in-person classes and merely acts as a complementary choice when this option is not readily accessible to the end user. Our findings have shown that the Leap Motion can be used to enhance the learning experience, by using its various features to interact with the application.

Keywords: Sign Language, Gamification, Learning, Human-Computer Interaction

1 Introduction

As technologies touching upon service design and user experience design evolves, people these days have more opportunities to expand their linguistic knowledge. The current market offers various languages to learn, such as English, French, Spanish, Chinese et cetera[1]. However, learning sign languages is still not as accessible and ubiquitous as other types of languages. Like verbal languages, sign languages are different between regions, and the service should have the capability to capture different gestural inputs and assess their correctness[2, 3].

To make the learning process of sign language more accessible and more engaging, we decided to implement an immersive and playful platform in accordance with the use of Leap Motion as our suggested solution. With the Leap Motion device, we are able to track the hand gestures of the users, and simultaneously allow them to interact with the system in this manner. Amongst the different sign languages, we focused on American Sign Language (ASL) considering it's the most popular sign language. We proceeded with the project based on our research question- *'How can leap motion be used to enhance the learning experience for sign language?'* In this article, the detailed problem statement will be discussed, followed by some details concerning the target users, and our approaches to elicit a user-centric and problem-based outcome. Furthermore, two prototypes have been created throughout the design process, and two usability tests were conducted for each of these. And finally, we compiled the results from the evaluations and substantiated our conclusions of this project. The overall objective of our project aims to make an engaging learning process for sign language. We distilled this goal into two different aspects. First, we incorporated a Leap Motion device to make the learning condition as similar as possible to the in-real-life setup. Second, we created an interface where digestible course structures, gamification, and sufficient feedback are actively provided to users.

2 Background and Problem Statement

These days, desktop and mobile devices have become one of the main means of learning languages. Through these computer-assisted or mobile-assisted language learning apps, such as Duolingo and Babbel, users can learn a wide selection of languages whenever and wherever they want. Furthermore, with the support of other interactive methods, like podcasts, discussions, and the availability of iterative learning, the apps could bring efficiency and effectiveness into their learning process. In the case of Duolingo, it attracts users through its lessons, which are a combination of activities and exams, and it actively applies various theories in education, psychology, active recall, repetition, multi-modality, and gamification [4]. However, compared to verbal language, being recognised and educating the language has been challenging in the case of sign language and the deaf and hard-of-hearing community.

Normally, when deaf individuals and others communicate it is not as effective or efficient as face-to-face communication. Rather, it often requires time-consuming methods, like writing down or other visual forms. Also, there are stigma and misunderstanding towards deafness and sign language among the general population. All these things make deaf individuals difficult to actively participate in society and lead to worsening the situation [5]. Although sign language education is less accessible than verbal language due to locations, availability of instructors and technology, in recent years, some apps or services are trying to mitigate the communication barrier; for instance, Lingvano, The ASL App, ASL Pocket Sign, Fingerspelling.xyz, ASL Tutor, etc. However, our case studies revealed that not many applications offer a wide range of free courses like Duolingo and display live inputs of users to clarify whether they are making the right gestures or not. In addition, coherent branding and entertainment factors were lacking in the aforementioned apps.

2.1. User Analysis

The target audience of this project is people in their 20s and students due to their familiarity with digital devices and the availability of participant recruitment in the evaluation phase. From the beginning of the project, a Leap Motion device and a service interface were discussed as the main gadgets of our project. Although it was not necessary to already have knowledge in ASL or how to use Leap Motion, having some familiarity with digital devices was important since the project encompassed a system where it required the Leap Motion.

Based on the collected data from informal interviews and case studies, we noticed the importance of including stimulation during the entire flow while using the app to motivate users; stimulation in this study indicates visual and motivational aspects. Offering content that is intuitive and less time-consuming with regard to the preferences of the target users was therefore consequently added to the project directives.

3. SignUp! Learning Platform for Sign Language

3.1 Multimodal integration to achieve improved learning potential

We have tried to address the issues of similar contemporary applications, which revolve mostly around a video-based learning environment. These, however, lack crucial elements such as interactiveness and feedback, to keep the user properly engaged with the application itself. Therefore, we have implemented a couple of features into the design and internal mechanics of our application to combat this

problem. A comparable approach has been dissected in this paper where its emphasis lies on the importance of interactive multimodal environments to improve learning [6]. Our approach to this problem will be further discussed in the upcoming sections.

3.2 User Interface

A recurring theme in contemporary applications is the utilized layout and structure of the app. These often incorporate a dashboard and a quiz layout as the basis of their application. We have not diverted in this aspect and use this configuration as a core part of our project. Furthermore, we have integrated this layout with our chosen method for navigation (using the Leap Motion device), to accommodate for the drastic changes in manoeuvring the cursor. The implementation of which was written in Python.

3.3 Navigation

The usage of the Leap Motion device is one of the highlights of this study. Considering the condition of a user who would interact with the system through the device, controlling the system with a keyboard or a mouse would break the whole immersion and the flow. Therefore, we decided to create an interface where navigating can be demonstrated only with the Leap Motion device. The current interactions that have been implemented with the device are: pointing with your finger to move the cursor, twitching the index finger to click, and making a circle gesture with your index finger (anti)clockwise to scroll down or up respectively.

3.4 Features

We have implemented a couple of different features in the application which have greatly increased both the satisfaction and learnability of the application and vastly highlights the gamification aspects of the project. This predominantly includes the various types of different game modes which it has to offer, like the quizzes, but additionally includes features to accommodate these types of games, and make them more memorable.

The three game modes specifically are ‘Translation’, ‘Recognition’, and ‘Matching’. The former two of which have been implemented in a quiz-style fashion. Unlike the former two, however, the latter game mode has been specifically designed for ASL and requires the user to have access to a leap motion device. This allows the user to position their hand above the device and shape their hand into a corresponding gesture to progress in the module, before continuing on to the next one. A similar approach

was mentioned in a previous paper about using machine learning to recognise gestures, which we have actually implemented [7].

The three different types of games all adhere to a consistent design to invoke a sense of familiarity in the user. This entails a general uniform layout which is shared among all of these and incorporates a common progress bar, a score tracker, and an end-of-game screen to output the user's performance. Furthermore, all of the games are interactive and provide instant feedback to the user whenever a wrong option is picked. This allows the user to immediately evaluate their previous choice and forces them to adjust their answer in the near future.

The accommodating features, which were referenced earlier in this section, are things we haven't properly expanded upon yet due to our focus on the gamification aspect of this project, but we've laid the foundations for features like a history page and a performance tracker. This allows the users to look into their previous performances, and compare their metrics appropriately to gauge whether or not they have improved. Furthermore, we've included the addition of some features where users can learn the topics before engaging in game mode. This contains the basis of a topic-learning page where gestures are categorized and shown in a logical order and also comprises a simple dictionary where the user can easily query a translation of a gesture by filtering and sorting through all the available options.

3.4 Usability Requirements

In order for us to measure the success of our approach, the assessment of usability requirements became part of our design process. These can then subsequently be narrowed down to only the most relevant requirements. We have outlined the ones we found to be most applicable to our project in table 1 of the appendix. All of these reflect on our original research question and are in some way or another affiliated with the use of the leap motion device. We can therefore deduce by these metrics, whether or not the usage of the device improves, or hampers the learning experience of the users.

For example, one of the metrics measures the time it takes for the user to get accommodated with the device. Most of the users were able to use the device comfortably after just a minute, which shows that its usage is still reasonably simple and intuitive enough for new users. Another metric, like the questionnaire, lets us quantify more subjective data. It shows us whether or not the user found the application to be particularly difficult to use, found it aesthetically pleasing, would use this application again et cetera. Other metrics can similarly also show us some insights into the many aspects of our application, and simultaneously lets us evaluate its usability in these.

4 Results and Evaluation

4.1 Setup: First Evaluation & Second Evaluation

We performed two different evaluations to help us answer our research question. These evaluations were conducted to answer two questions: the effectiveness of navigating the interface with the Leap Motion device and the effectiveness of the learning process. The first evaluation aimed to see the overall learning experience within the intervention of the Leap Motion device since the whole user experience is not only coming from the contents but also from the interaction between users and the device [8, 9]. The entire session consisted of three parts- around 20 minutes of usability testing, a questionnaire, and a brief interview. We found five willing participants who fit the criteria of the target group: people in their 20s and non-ASL users. During the test, the researchers observed the participant's performance and measured how long it took for individuals to conduct 10 tasks that they were touched upon in 'navigation/the layout', 'user interaction with the device' and 'learning'. The performance and the feedback after the test were used to help us make improvements to our second prototype. To evaluate the overall usability of our approach and its success, we used the System Usability Scale (SUS) score and comparison between the data and the usability specifications. The success of each question or task was assessed based on the scores we estimated before the evaluation.

The second evaluation kept the same overall core structure of the first evaluation like the usability testing, a questionnaire, and a brief interview. Five other participants who had not participated in the first phase joined. The screenshots of the prototypes and a list of the given tasks during each test can be found in the appendix.

4.2 Results

The following charts- a Usability Specification Table and a System Usability Scale chart- show an overview of the results from the two conducted usability tests.

Usability specification table

Task	Issue	Measured	Planned	#1 Evaluation	#2 Evaluation
Initial performance	Test out hand tracking	Time until user felt comfortable exiting tutorial	120s	78s	104s
Initial performance	Launch game	Time until the launch of a valid game	30s	44s	24s
Initial performance	Find a gesture in the dictionary	Time until gesture found	30s	28s	36s
Learnability	Error rate	Error rate per game (out of 50 questions)	> 25%	42%	42.8%
Throughput	Completion of a gesture	Average amount of time spent to perform a correct gesture	5s	10.24s	9.6s

Table 1. Summary: Usability Specification

Question Scale: 1 (Disagree) - 5 (Agree)	**Ideal score**	**Average (#1)**	**Average (#2)**
1. I think that I'd like to use this system frequently	4	**2.4**	**2.4**
2. I found the system unnecessarily complex	2	**1.4**	**1.4**
3. I thought the system was easy to use	4	**3.4**	**3.2**
4. I think that I'd need the support of a technical person to be able to use this system	2	**2**	**2.4**
5. I found the various functions in this system were well integrated	4	**4**	**5**
6. I thought there was too much inconsistency in this system	1	**1**	**1.6**
7. I would imagine that most people would learn to use this system very quickly	3	**2.8**	**3.6**
8. I found the system very cumbersome to use	3	**2.2**	**2.6**
9. I felt very confident using this system	4	**2.6**	**2.4**
10. I needed to learn a lot of things before I could get going with this system	2	**1.6**	**1.2**

Table 2. Summary: System Usability Scale

As the tables ‘Summary: Usability Specification’ and ‘Summary: System Usability Scale’ show, results from the first evaluation illustrate a moderate level of success. As positive remarks, the users mentioned that the system has a consistent UI design along with well-integrated features. Also, the average correct answer rate is 42% and the users spend less time navigating features on the system compared to our estimation. However, they also mentioned that they are not entirely confident in interacting with the system and have consequently indicated to be less likely to use the system frequently in the future. Some users experienced great difficulty with using the Leap

Motion device. This is corroborated by the results, as some users may take twice as long in certain tasks to comfortably use the device than others.

After the first evaluation, we reflected on our setup and the prototype and noticed that there were missing parts on the screen. This might bring an unprofessional initial impression to the participants. Also, the font size on some screens is a bit small for users to read and distinguish contents, especially the alphabet. Some buttons need to be larger since the whole interaction with the system was designed with the usage of the Leap Motion device in mind. Based on the insights we collected from the first evaluation, we updated the initial prototype and the test direction. For example, we improved the starting tutorial so as to be more informative. From the perspective of UI design, the colours of the buttons have now been adjusted to clearly display where exactly a user is pointing on the screen whenever they are navigating the application. Additionally, a section of one of the game modes tracking the current gesture and letter contained enhanced readability. Furthermore, we noticed that the given tasks are not aligned with the directions to answer the research question. Therefore, several factors of the test setup had to be changed- how the Leap Motion device was placed from facing the ceiling to facing users considering the actual context of sign language communication and the order of the given tasks to the participants. By doing so, we expected that the participants could go through the learning process more properly compared to the previous attempt and their performance can tell us more about the effectiveness of our suggestion for the engaging learning experience.

Compared to the results from the first evaluation, the average correct answer rate was slightly higher- 42.8%. This means that the redesigned prototype didn't affect learnability in any significant way. Although the performance improved compared to the first prototype, the results from table 1 and table 2 reflected users were still struggling with interacting with the Leap Motion device in terms of clicking and scrolling up or down. There was also a slight difference in the amount of time that users were taking to perform a set of 50 gestures between the first and second evaluation. The latter of which took 6.25% less time than the former to complete. We can attribute this result to a small improvement in readability as was explained earlier in this section.

5 Conclusion and Discussion

This project has suggested an interface with the Leap Motion device so that users can learn American Sign Language (ASL) in a more engaging way.

We have attained partial success from this study in terms of perceived user and navigational experience on the system we developed based on the results of the combined sus and usability specifications. We have been able to deduce a few conclusions based on the results from the first two evaluations. The first one is that

users were in dire need of a comprehensive starting tutorial, to precisely guide them on what to do in the initial stages of the project. Without this, users did not feel comfortable, or less comfortable with using a leap motion device. Future projects involving the Leap Motion, must therefore include clear instructions to help them get started.

Though the controls of the leap motion were not fully immersive, due to the hardware and software limitations which regularly interrupted the flow of the leap motion interactions, we were able to leave behind a slightly positive impression on the users. Many users have noted that even though the application still looked very rudimentary with respect to its contents, they have expressed interest in a similar future project involving more things like entire words and expressions. We could therefore consider this project as a small stepping stone into the world of ASL.

A considerable amount of time and resources were assigned for users to formulate familiarity with using the Leap Motion device during the evaluations. If the study contained more education-related perspectives as well as more gamification, the outcomes would have more credibility to give answers to our research question. We have as a result only touched upon the initial impressions of the users by making several games but have neglected to address the various aspects of gamification which are crucial to enhance the experience with these games. Things like daily rewards and notifications would therefore help us to improve the long-term satisfaction of the users.

6 Future Work

This project only includes ASL fingerspelling, a possible avenue for future work is the addition of images or videos, which are able to show complete words and phrases. This will allow the user to be able to choose between a wider variety of learning topics and have more capabilities to communicate with the actual ASL users. Furthermore, considering the diversity of sign languages in the world, it would be ideal if future projects could offer ASL and other sign languages.

Since gamification was one of the main strategies in this project, we have outlined the layout for any additional gamified features like the performance widget, history page, and scoreboard, upon which we haven't expanded yet due to the time constraints of this project. However, we expect that further projects could entail these features and be able to assess their effectiveness in the education field of sign language and Leap Motion-based applications. Additionally, some entirely new functionalities might be the addition of multiplayer interaction using Kahoot [10] style quizzes to improve the playful and immersive aspects of the system.

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Appendix

Figure 1. Overview of The First Prototype

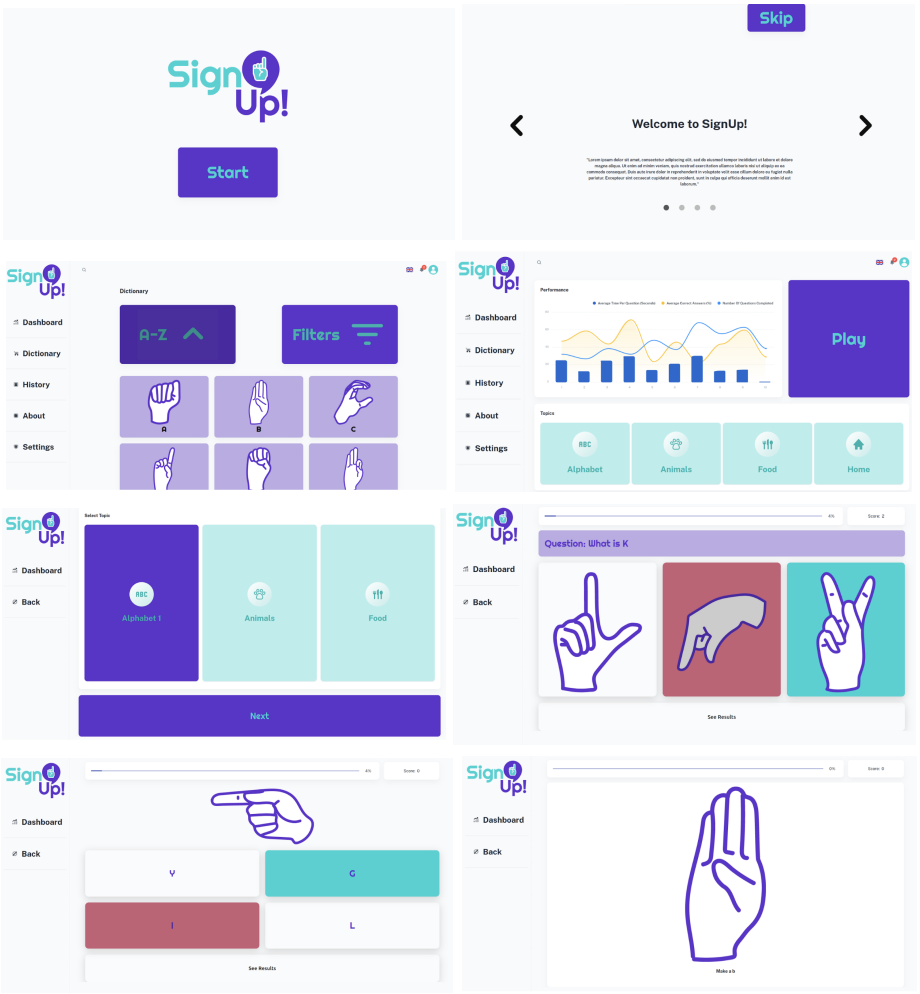

Figure 2. Overview of The Second Prototype

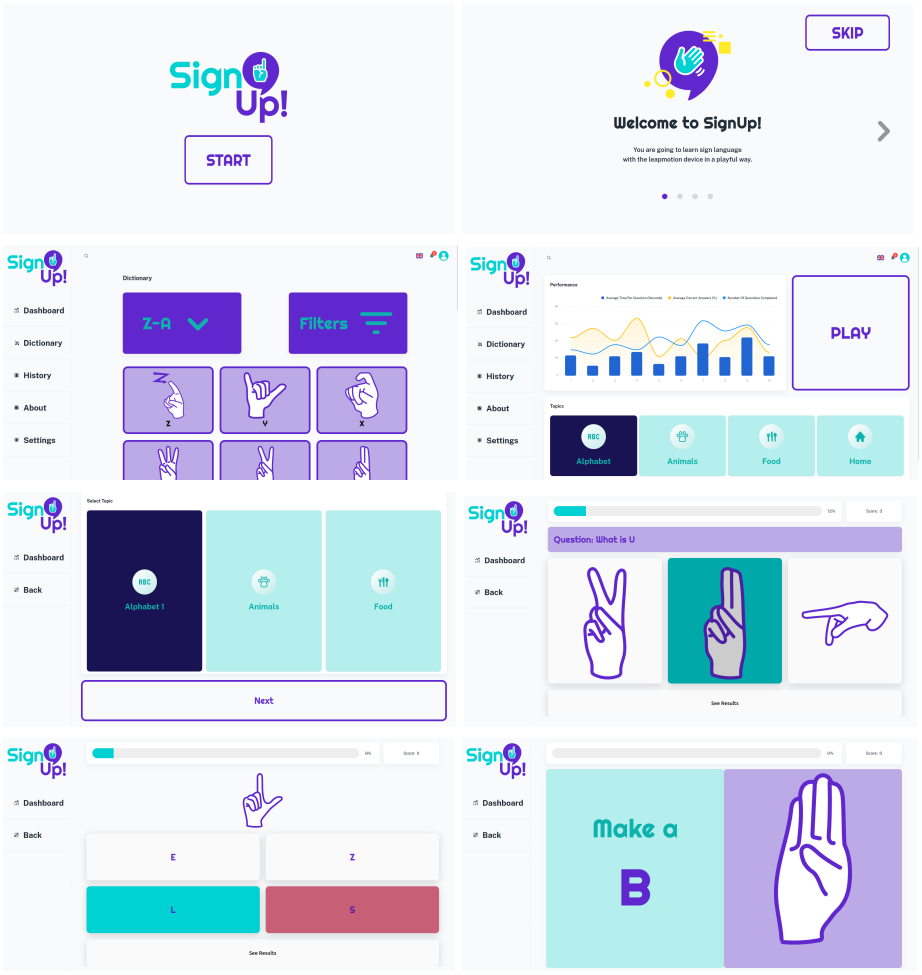

Table 1

Usability specification table

Task	Issue	Measured	Current	Worst	Planned	Best
Installation	Benchmark #1	Time until successful launch of the application	5s	30s	10s	5s
Initial performance	Launch game	Time until the launch of a valid game	30s	30s	30s	15s
Initial performance	Find a gesture in the dictionary	Time until gesture found	30s	30s	10s	5s
Learnability	Error rate	Amount of errors made per game (out of 50 questions)	27	38	<38	0
Throughput	Completion of a gesture	Average amount of time spent to perform a correct gesture	5s	10s	5s	2s
Initial impression	Questionnaire	Average score [1-5]	TBD	1	4	5
Long-term satisfaction	Questionnaire	Average score [1-5]	TBD	1	4	5

Code references

Github project link	Usage in our application
https://github.com/minimal-ui-kit/material-kit-react	The structure of the website
https://github.com/tedtalks_bits/todo-app.git	Quiz game mechanics
https://github.com/ssaamm/sign-language-tutor	Matching game mechanics
https://github.com/openleap/PyLeapMouse	Leap motion navigation