M.Des Interaction Design Project III

The ABC's of Sign Language:
An informal approach to teach basics of Indian Sign Language to younger children

Project by
Mithun Murali, 216330008

Guided by
Prof. Ravi Poovaiah

IDC School of Design
अभिकल्प विद्यालय
IIT Bombay

Declaration

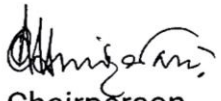
I declare that this written document represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea, data, fact or source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Mithun Murali
216330008
M.Des, Interaction Design
IDC School of Design, IIT Bombay.
May 2023

Project Approval Sheet

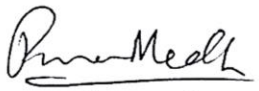
The Design Project III titled "The ABC's of Sign Language: An informal approach to teach basics of Indian Sign Language to younger children" by Mithun Murali, Roll Number 216330008 is approved, in partial fulfillment of the Masters's Degree in Interaction Design at the IDC School of Design, Indian Institute of Technology Bombay.

Project Guide



Chairperson

Internal Examiner



External Examiner

Table of Contents

Introduction

This project aims to bridge the communication gap between India's deaf and hearing communities. With an estimated 18 million deaf individuals in India, it is essential to foster acceptance and understanding among the hearing community regarding the deaf culture.

This project is not a quick remedy, but rather a long-term strategy to foster a generation that is more accepting of deaf culture. My concentration is on able-bodied younger children aged from 6 to 12 years old, as they are at a vital developmental stage and are receptive to new information. The goal of the project is to develop a simple and engaging activity to help younger children learn the fundamentals of Indian Sign Language (ISL). The activity will be intended to be interactive, engaging, and simple to comprehend so that the children may learn while having fun.

I began by conducting extensive research, which included interviews and discussions with a variety of professionals dealing with children and the deaf community, in order to determine the optimal strategy for developing an enjoyable activity for able-bodied children. This research was conducted with the intent of gaining knowledge and generating concepts for an ISL-learning exercise for children that is both enjoyable and successful. I also did research by observing the target age group of children to determine their learning styles, interests, and preferences. This helped me design ideas for activities that are tailored to the children's requirements, making them more interesting and effective. In the context of India, the project is of the utmost importance because the deaf minority is frequently excluded from mainstream society as a result of communication barriers. This project intends to overcome this gap by encouraging inclusiveness and knowledge of the deaf culture among the able-bodied community. After numerous rounds of conversation with experts, I feel that by developing a fun activity that helps able-bodied children learn ISL, we can improve awareness of the deaf community and encourage social inclusion.

Learning Indian Sign Language (ISL) can be a time-consuming and effort-intensive task. The vocabulary and sentence formation in ISL is very complex and still under development, making it challenging for people to learn the language quickly. However, exposing young children to the basics of ISL can help them develop a foundation that will make it easier to learn more advanced vocabulary and sentence structures later on. By providing an accessible and engaging way for children to learn ISL, we can create a generation that is more inclusive and supportive of the Deaf community. In conclusion, this project aims to create a fun activity that helps able-bodied children learn the basics of Indian Sign Language (ISL).

Scope

The scope of this project is to create a fun activity aimed at introducing the basics of Indian sign language to able-bodied children between the ages of 6 to 12 years old. The activity will be designed to be simple and easy to understand and will focus on teaching commonly used signs and phrases. The project aims to promote inclusivity and understanding of the deaf culture among the younger generation. It is not intended to replace formal education in Indian sign language, but rather to serve as a foundation, supplement, and enjoyable way to introduce children to the sign language.

Primary Research

Primary Research Methods:

- Interviews with subject matter experts in Indian Sign Language (ISL) and deaf education
- Brainstorming sessions with experts and members of an NGO focused on deaf education
- Participation in a workshop that included ISL teaching sections
- Interview with an ISL tutor/interpreter
- In-person discussions with primary school teachers from a special school for children with hearing impairments
- In-person interviews with parents of able-bodied young children

The primary research phase of this project was crucial to developing a deep understanding of the problem space and the needs of the users. However, conducting direct user research on young children can be challenging due to their limited ability to articulate their thoughts and preferences. Therefore, I focused on interviewing and brainstorming with subject matter experts, parents, and teachers to gain insights into the problem space.

The experts with whom I had interviews and brainstorming sessions provided invaluable insights into the field of Indian Sign Language (ISL) and the challenges faced by young children in learning it. Dr. Raju Govind Arakh, Director of **Ali Yavar Jung National Institute of Speech and Hearing**, Mumbai, provided insights into the current state of ISL in India and the challenges faced by children in learning it. Dr. Gayathri Ahuja, who is the head of ISL Cell at the same institute, provided insights into the teaching methodologies used to teach ISL to children.

Dr. Vaishali of **Tata Institute of Social Sciences**, Mumbai, provided insights into the challenges faced by children in learning ISL in a classroom setting.

To gain insights into the perspective of teachers, I had in-person discussions with Ms. Nandini Devi and Ms. Geetha S, both primary school teachers from the special school Karuna Speech & Hearing HSS in Calicut, and Mr. Dhananjayan and Mrs. Sindhu Nambiar, both primary school teachers at Chinmaya Vishyalaya HSS in Calicut.

They provided valuable insights into the challenges faced by teachers in teaching ISL to young children.

To gain insights into the perspective of parents of able-bodied children, I had in-person interviews with Mrs. Jyothi Ram, Mr. Premnath, Mr. Sethumadhavan, Mr. Noufal, and Mrs. Sheela. They provided insights into their experience with ISL and their willingness to engage their children in learning the language.

Overall, the primary research phase of this project was crucial to developing a deep understanding of the problem space and the needs of the users. The insights gathered from subject matter experts, parents, and teachers provided valuable information that guided the ideation and design phases of this project.

Primary Research Observation

During the primary research phase of the project, several observations were noted through interviews and discussions with subject matter experts, teachers, parents, and members of an NGO. These observations are presented below in the raw form, without any interpretation or analysis:

- Most parents and teachers are aware of the existence of Indian Sign Language but lack the knowledge and skills to teach it effectively to their children.
- There is a general lack of awareness and knowledge about the deaf culture and community in India, leading to a communication gap between the deaf and the hearing world.
- The existing resources for learning Indian Sign Language are limited and often inaccessible for the average person, especially those living in rural areas.
- Many parents and teachers are willing to incorporate Indian Sign Language into their curriculum but lack the necessary resources and training.
- Some misinformed parents assume that learning sign language will hamper their child's cognitive growth.
- There is a need for fun and engaging activities to teach Indian Sign Language to young children, as traditional methods can be tedious and ineffective.
- Children are more receptive to learning Indian Sign Language when it is presented in a playful and interactive manner.

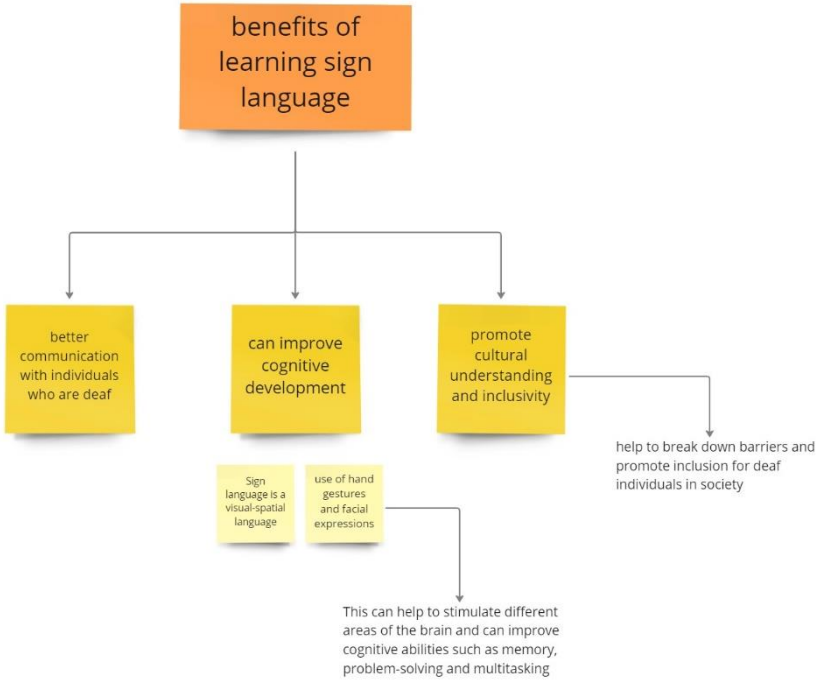


Fig 1: Benefits of sign language

- The children showed a high level of engagement during the ISL sessions. They seemed curious and eager to learn the new language. This was evident through their active participation, attentive listening, and enthusiasm in responding to the signs demonstrated by the instructor.
- The children demonstrated a good understanding of the signs being taught. They were able to comprehend the meaning of the signs and respond appropriately. However, it was noticed that some children took longer to understand certain signs compared to others. This suggests that individual differences in cognitive ability may influence the rate of learning.
- It was also observed that the children were more patient with each other when communicating through ISL, compared to verbal communication.
- The children demonstrated good retention of the signs taught in previous sessions. They were able to recall the signs and use them appropriately. However, it was noticed that some children required more reinforcement and repetition compared to others.
- There is a need for a simple and accessible platform to teach Indian Sign Language to young children, which can be used both in the classroom and at home.

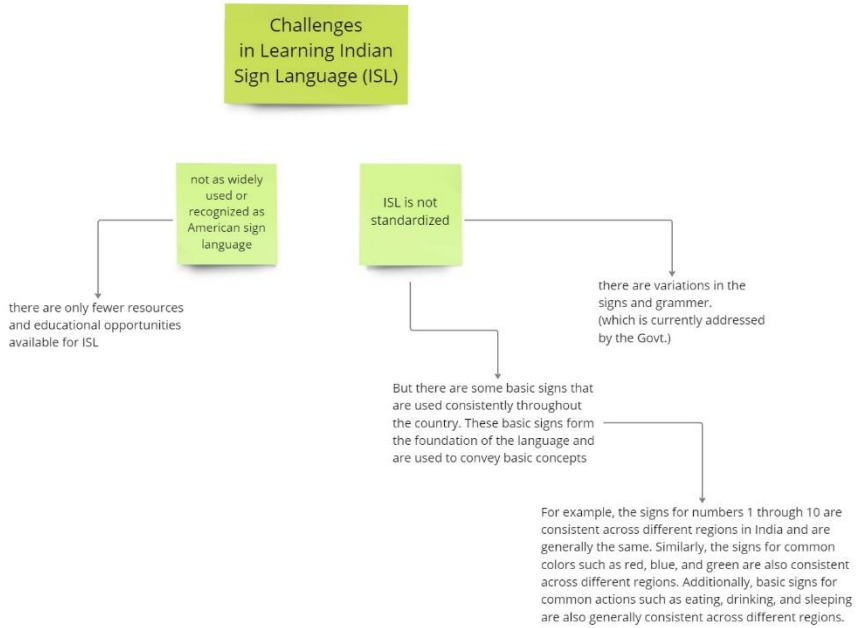


Fig 2: Challenges in learning Indian sign language

- Teachers and parents feel that teaching Indian Sign Language to young children can promote inclusivity and empathy towards the deaf community, and can also help develop their cognitive and motor skills.
- The use of visuals, illustrations, or animations can enhance the learning experience and help children better understand and retain the signs.

- The lack of standardization in Indian Sign Language can be a challenge for beginners, as different regions may have their own variations of signs.

These observations were made through a combination of in-person interviews, online meetings, and participation in workshops with subject matter experts and stakeholders. They provide a holistic understanding of the challenges and opportunities in the domain of teaching Indian Sign Language to young children.

It is important to note that these observations are not limited to a specific geographic region or demographic. They reflect the general sentiment and experiences of the stakeholders interviewed during the research phase. These observations serve as a foundation for the insights and recommendations that are presented in the following section.

Fig 3: Why sign language is not taught in regular schools

Primary Research Insights

In my research, I used the affinity mapping method to extract valuable insights from user research observations. This technique involved grouping and sorting the raw data collected during the research, such as observations, feedback, and comments from experts, into related clusters. By doing so, I was able to identify patterns, themes, and trends in the data and make sense of the information gathered. This approach helped me gain a deeper understanding of the users' needs, pain points, and preferences, which, in turn, informed my design decisions and recommendations for improving the product or service under investigation. Overall, the affinity mapping method was an effective way to transform the chaotic and unstructured data from user research into actionable insights that can drive meaningful change.

Based on the observations made, several insights can be drawn:

1. Early exposure to ISL may facilitate the learning of the language among able-bodied children. The high level of engagement, comprehension, and retention observed suggests that children have the capacity to learn ISL at a young age. This may help break down communication barriers between deaf and hearing communities and promote social inclusion.

2. Individual differences in cognitive ability may influence the rate of learning ISL. It may be necessary to tailor teaching methods to cater to the needs of each child. This could involve providing more reinforcement and repetition to children who require it, while simultaneously challenging those who learn faster.

3. The use of ISL may enhance communication and social skills among children. The patient and attentive nature of communication through ISL may promote a culture of empathy and inclusivity, which could translate to other areas of the children's lives.

4. Expert opinions suggest the long-term benefits of introducing ISL to able-bodied children at very young ages are exponential. Learning sign language help in the cognitive development, academic achievement, and social integration of young children.

5. Informal ways of learning ISL may be effective and accessible to a wider range of children. Many Indian

households and schools may not have the resources to provide expensive technology or specialized training for ISL. Therefore, incorporating informal ways of learning, such as through songs, games, and storytelling, may be a more practical and effective approach.

6. Collaboration between hearing and deaf communities may be necessary for successful implementation of ISL education. By involving members of the deaf community in the development of teaching materials and curriculum, the education can be more authentic and effective.

7. Language diversity may be beneficial for all children, regardless of hearing ability. Exposure to ISL may enhance the development of language and communication skills, which can benefit children in their interactions with people from different linguistic backgrounds.

8. Early intervention and support may be necessary for children with hearing impairments to ensure successful language development. Early exposure to ISL may help children with hearing impairments to acquire language skills and develop their identity as members of the deaf community.

9. Informal learning methods, such as playing games, watching videos, or using mobile apps, can be effective in teaching sign language and may be more accessible to a wider range of learners. These methods may also be more engaging and enjoyable for children, increasing their motivation to learn and practice.

10. Cost-effective and fun solutions for learning sign language may also be more sustainable and scalable, as they can be easily replicated and implemented in different settings. This could increase access to sign language education and promote social inclusion among diverse communities

In conclusion, the observations and insights derived from the research on introducing ISL to younger able-bodied children suggest that early exposure to the language may facilitate learning, enhance communication and social skills, and promote inclusivity. However, it is important to tailor teaching methods to individual needs and conduct further research to determine the long-term benefits of ISL.

Empathy Mapping: Understanding the Needs of Deaf and Able-Bodied Individuals

This section aims to gain a deeper understanding of the distinct perspectives and experiences of three different groups: deaf individuals, able-bodied adults, and able-bodied children. By analyzing the empathy maps and pain points of each group, valuable insights can be drawn to enhance communication, promote inclusivity, and foster better social relationships between them. The analysis is based on comprehensive research findings, direct observations, and input from experts and stakeholders in the field of deaf education and communication. The empathy maps and pain points presented here offer a comprehensive view of the challenges faced by each group and can serve as a foundation for developing effective strategies to bridge communication gaps and promote social integration.

Individuals with hearing difficulties may face several challenges such as limited access to information and resources due to communication barriers, difficulty in socializing and forming relationships with hearing individuals, feeling excluded and isolated in social situations or public events, lack of employment opportunities or discrimination in the workplace due to communication barriers, difficulty in accessing healthcare services and understanding medical information, dependence on family members or friends for interpretation and support, limited availability of sign language interpreters or lack of trained interpreters in specific domains (e.g. legal, medical), and inadequate education and resources on deaf culture and sign language for hearing individuals and the general public. These challenges may lead to a sense of frustration, isolation, and exclusion from society, highlighting the need for more accessible and inclusive solutions.

The following pain points are commonly experienced by able-bodied adults when communicating with deaf individuals. These challenges often lead to feelings of frustration, inadequacy, and exclusion, and can contribute to difficulties in building relationships with deaf individuals and the wider deaf community. Through a better understanding of these pain points, we can begin to identify ways to improve communication and promote inclusivity:

- Helplessness when trying to communicate with a deaf person who doesn't know sign language
- Overwhelming anxiety in situations where communication with a deaf person is necessary but challenging
- Inability to communicate effectively with deaf individuals
- Difficulty in understanding and connecting with the deaf community
- Lack of accessible resources to learn sign language effectively
- Exclusion from conversations or social situations involving deaf individuals
- Miscommunication or misunderstandings due to a lack of understanding of sign language
- Difficulty in finding interpreters or other resources to aid in communication
- Time constraints that make it difficult to learn sign language
- Fear of unintentionally offending or disrespecting the deaf community due to a lack of knowledge or understanding.

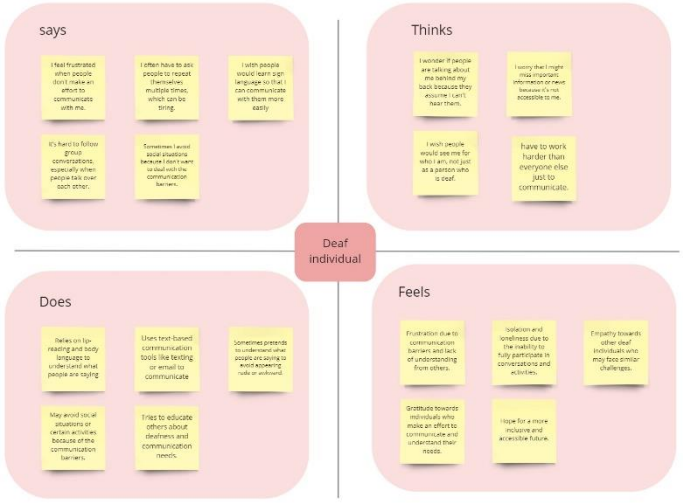


Fig 4: Empathy map of a deaf individual

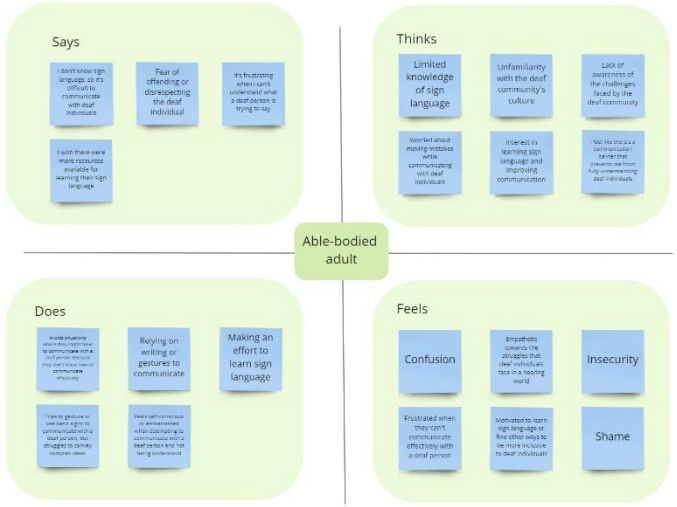


Fig 5: Empathy map of an able-bodied individual

Fig 6: pain points of a deaf individual

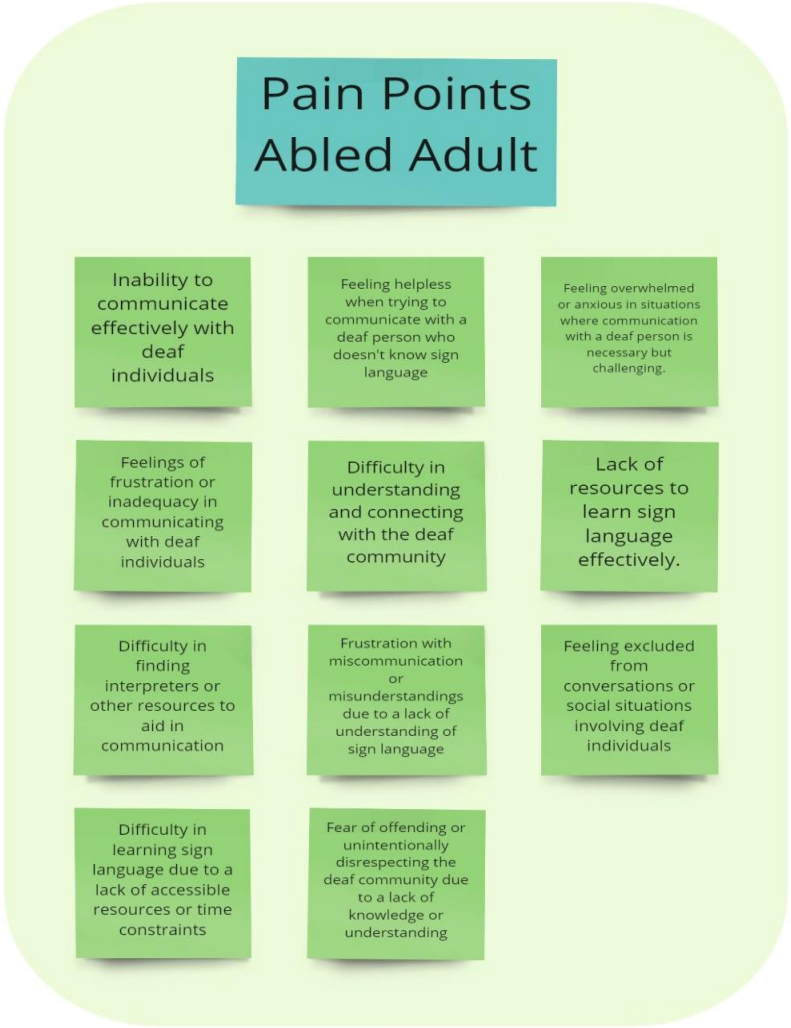


Fig 7: pain points of an able-bodied individual

Target Users: Able-Bodied Children

Selecting able-bodied children between the ages of 6 and 12 as the target users to teach sign language has several advantages over selecting adults. First and foremost, younger children have a greater capacity for language acquisition and cognitive development, making them more receptive to learning new languages like sign language. Research has shown that early exposure to sign language can facilitate language acquisition and promote communication skills among able-bodied children. This early exposure can help break down communication barriers between the deaf and hearing communities, leading to greater inclusivity and social integration.

Another advantage of targeting children is that they are more likely to view learning sign language as a fun and engaging activity rather than a chore. By incorporating interactive and game-based learning techniques, children can develop a positive attitude toward learning sign language, leading to greater motivation and retention of the language.

Furthermore, teaching sign language to able-bodied children can also promote empathy and understanding toward the deaf community. By learning about deaf culture and the challenges faced by individuals who are deaf or hard of hearing, children can develop greater awareness and respect for diversity. This can help foster a more inclusive and accepting society.

Finally, targeting able-bodied children can have a more long-lasting impact on society as a whole. By teaching sign language to children at a young age, they are more likely to retain this skill throughout their lives and potentially pass it on to future generations. This can lead to a more inclusive and communicative society, where deaf and hard-of-hearing individuals are not excluded or marginalized due to communication barriers.

Comparative Analysis: Teaching Sign Language to Children vs Adults

1. Communication Skills: Children who learn sign language can improve their communication skills from an early age, whereas adults may struggle to adopt new language habits.

2. Cognitive Development: Learning sign language can enhance cognitive development in children, including memory, attention, sensory, multi-tasking, and problem-solving skills. Adults may also benefit, but

children have a greater potential to learn and absorb new information and skills.

3. Social Skills: Children who learn sign language can improve their social skills by understanding the importance of nonverbal communication and body language. This can help them form stronger relationships and communicate effectively with people from diverse backgrounds. Adults may also benefit, but children have more time to develop these skills.

4. Exposure to Diversity: Children who learn sign language can develop empathy, understanding, and respect for diversity, including the deaf and hard-of-hearing community. Adults may also benefit, but children are more impressionable and open-minded.

5. Adaptation: Children are more adaptable and can easily integrate sign language into their daily lives and routines. This can lead to a more natural and long-lasting adoption of the language compared to adults who may struggle to integrate it into their existing habits.

6. Learning Potential: Children have a greater potential to learn new languages and skills, including sign language, compared to adults who may have already formed language habits. Additionally, learning sign language at an early age can improve language learning abilities later in life.

Ideation

After brainstorming sessions and analyzing feasible ideas, the following solutions were proposed:

1. Use of technology: The development of gesture gloves is going on rigorously at various organizations, which can detect and translate Indian Sign Language into written or spoken words, allowing children to learn and practice the language in a more interactive and engaging way.
2. Sign language videos: Create a series of educational videos that teach Indian Sign Language, incorporating fun animations and storytelling to help children learn and retain the language more effectively.
3. Interactive sign language books: Design interactive books that combine written text with sign language illustrations, allowing children to learn and practice Indian Sign Language in a fun and engaging way.
4. Sign language games: Develop a range of games that teach and reinforce Indian Sign Language, such as memory games, puzzle games, and matching games.
5. Sign language classes: Offer structured sign language classes for children, led by qualified instructors who are fluent in Indian Sign Language. The classes can be held online or in person, depending on the resources and facilities available.
6. Sign language posters: Create a series of posters that display commonly used Indian Sign Language phrases and vocabulary, providing a visual reference for children to practice and reinforce their learning.

Another round of iterations was completed with a greater focus on addressing the specific needs of younger children.

1. **Theater**: Encouraging deaf and abled children to participate in theater productions that incorporate sign language to foster collaboration and learning between the two communities.
   Advantages:
   - Provides a fun and interactive learning experience for both deaf and abled children.
   - Encourages the integration of deaf and abled communities and promotes socialization.
   - Can be a cost-effective method if the theater productions are organized by schools or community centers.

Disadvantages:

- May not be accessible for all children, especially those in remote or low-income areas.
- May not provide a comprehensive and structured learning approach for sign language.
- May require significant resources for organizing and producing theater productions**.**

2. **Gesture Gloves**: Developing gloves that can translate sign language into spoken words to facilitate easier communication between deaf and abled individuals.

   Advantages:

   - Provides a direct and immediate way of translating sign language into spoken words.
   - Can enable easier communication between deaf and abled individuals.
   - May be a useful tool for both personal and professional use.

   Disadvantages:

   - Can be costly to produce and purchase the gloves.
   - May not provide a comprehensive and structured approach to learning sign language, as it only translates individual signs.
   - Can be cumbersome or uncomfortable to wear for extended periods of time.

3. **Board Game with Sign Language**: Designing a board game that combines sign language and traditional gameplay to create an inclusive and fun way for deaf and abled children to interact.

   Advantages:

   - Provides an inclusive and fun way for deaf and abled children to interact and learn from each other.
   - Can be a cost-effective method if the board game is produced on a large scale.
   - Can provide a structured and engaging approach to learning sign language.

   Disadvantages:

   - May not be accessible for all children, especially those in remote or low-income areas.
   - May not be as immediate or effective for learning individual signs as other methods.
   - May require additional training or support for children who are not familiar with playing board games.

4. **Books with Sign Language**: Creating storybooks that include both written text and sign language illustrations to teach abled children sign language while enjoying a fun story.

   Advantages:

   - Can be a cost-effective method for teaching sign language, as books are relatively cheap and widely available.
   - Provides an engaging and fun way for abled children to learn sign language while enjoying a story.
   - Can provide a structured and comprehensive approach to learning sign language.

   Disadvantages:

   - May not be as immediate or effective for learning individual signs as other methods.
   - May not be as interactive or social as other methods.
   - May require additional support for children who struggle with reading or visual learning.

5. **Card Game with Sign Language**: Developing a portable card game that teaches basic sign language in a fun and engaging way.

   Advantages:

   - Provides a portable and engaging way for deaf and abled children to interact and learn from each other.
   - Can be a cost-effective method if the card game is produced on a large scale. Can be accessed by low income groups also.
   - Provides a structured and fun approach to learning sign language.

   Disadvantages:

   - May not be as comprehensive or structured for learning sign language as other methods.
   - May require additional support for children who struggle with visual learning or card games.

6. **Mobile App with Sign Language**: Creating an educational mobile app that includes sign language tutorials, quizzes, and games to provide a convenient and accessible way for abled children to learn sign language.

Advantages:

- Provides a convenient and accessible way for abled children to learn sign language.
- Can be engaging and interactive with features such as tutorials, quizzes, and games.
- Can provide a structured and comprehensive approach to learning sign language.

Disadvantages:

- May not be accessible for all children, especially those without access to mobile devices or the internet.
- May require additional support for children who struggle with visual learning or technology.
- Can be costly to produce and maintain the app.

Analyzing the ideas

After conducting brainstorming and ideation sessions, I sought out the advice of experts to determine the essential parameters against which I will evaluate each idea. Cost, ease of use, long-term positive effects, accessibility, and scalability have been recognized as the parameters for this study. I categorized the concepts according to each criterion and compared them in order to find the best realistic alternative that matches my overall objectives.

Firstly, I considered the cost of each idea and placed them in three groups: low cost, medium cost, and high cost. The cost of an idea is an important factor in its feasibility, and I aimed to choose ideas that are affordable and sustainable in the long run.

The second parameter I considered was the 'ease of use', which I classified into three categories: easy to use, moderate to use, and difficult to use. This helped me identify which ideas could be easily adopted by younger children, without the need for extensive training or complex instructions.

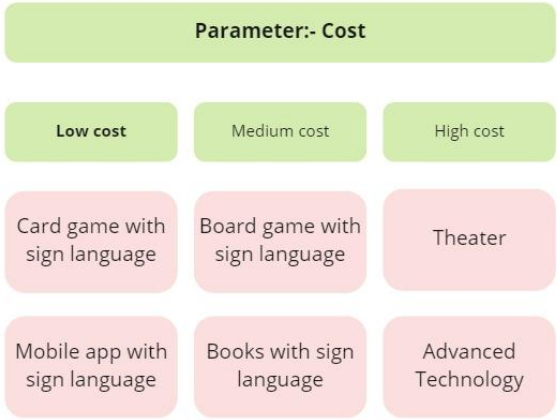


Fig 8: Analyzing the cost parameter

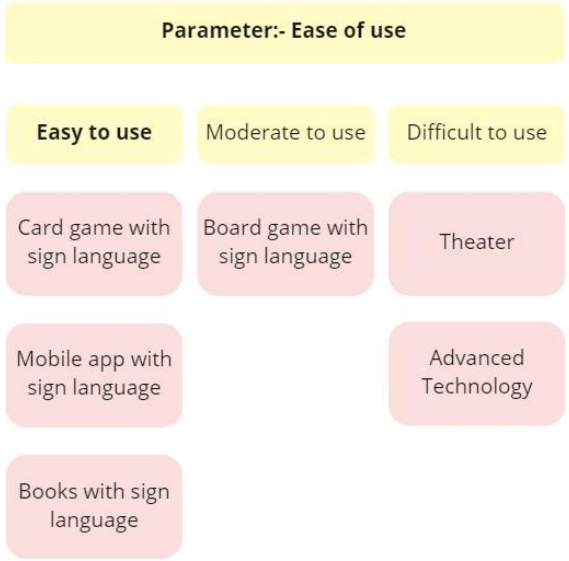


Fig 9: Analyzing the Ease of use parameter

The long-term positive effect of an idea is crucial, as I want to ensure that any solution that I implement has a lasting impact. I grouped the ideas into three categories based on their potential long-term positive effect: high, moderate, and short-term. This helped me identify which ideas could create lasting benefits for younger children, such as improved communication skills and enhanced cognitive development.

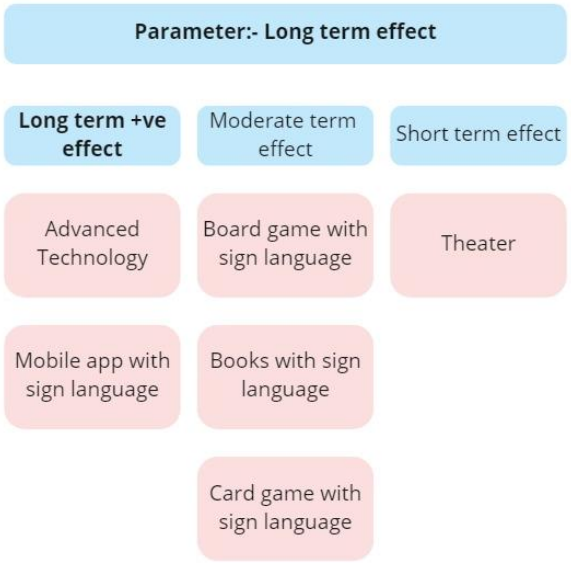


Fig 10: Analyzing the Long term use parameter

The fourth parameter I considered was accessibility, which we grouped into three categories: high, moderate, and low accessibility. Accessibility was an important factor as I aimed to choose ideas that were inclusive and could be easily accessed by children of all backgrounds, including those with disabilities.

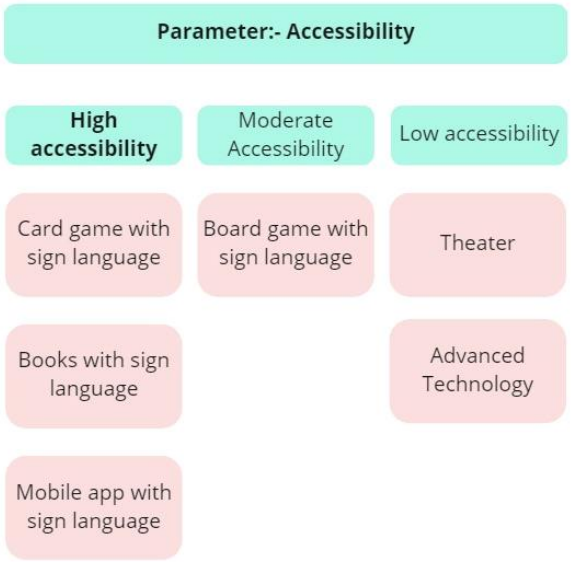


Fig 11: Analyzing the Accessibility parameter

Finally, I evaluated each idea's scalability, which was classified into three categories: highly scalable, moderately scalable, and not very scalable. This helped

me identify ideas that could be implemented on a large scale, to benefit a greater number of children.

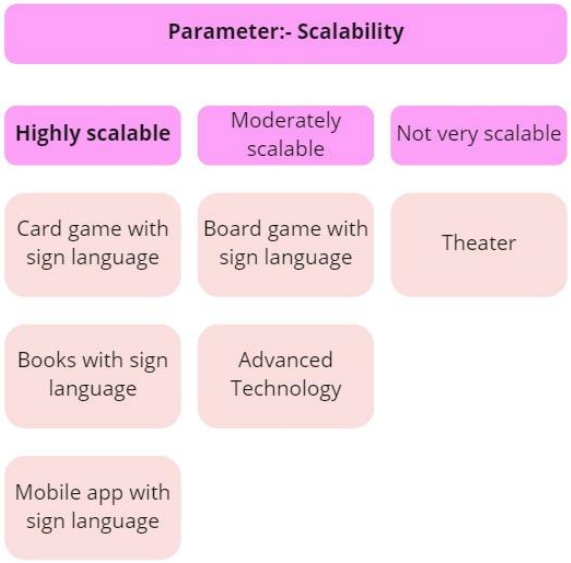


Fig 12: Analyzing the Scalability parameter

By analyzing the feasibility of each idea against these parameters, I was able to narrow down the most feasible option for teaching Indian Sign Language to able-bodied younger children. This narrowing down has been verified by all the experts and necessary changes has been made as per their opinion.

Weighted Scoring Method

I used the weighted scoring method to get a quantitative validation of the ideas by comparing them against the parameters. It provides a clear and structured approach to decision-making and is useful when there are multiple options to consider and when the evaluation criteria can be objectively measured. This method involves assigning weights to each parameter based on their relative importance to the project's overall goals. Then, each idea is scored on each parameter using a scale of 1 to 5, with 5 being the highest score.

To ensure objectivity, I involved 12 participants who were subject matter experts in the field. They provided their input and opinions on each idea and helped me in assigning the scores to each parameter.

After collecting the scores, I multiplied them by their respective weights to get a weighted score for each parameter. These weights were decided based on expert opinion. Then, I added up the weighted scores for each idea to get a total score. This gave me a clear picture of

which ideas performed better against the parameters and which ones needed more improvement.

Weights assigned to each parameter		
Cost	25%	0.25
Originality	20%	0.20
Ease of use	20%	0.20
Long term effect	25%	0.25
Frequency of use	10%	0.10

Fig 13: Weights assigned to parameter based on expert opinion

Option	Overall Score (∑)
Theater	2.25
Gesture Glove	2.62
Board Game	**3.15**
Card Game	**4.25**
Books	2.81
Mobile Apps	2.95

Fig 14: Overall score of different ideas

Click here to view the complete analysis.

Based on the quantitative and qualitative analysis, the card game and board game ideas were found to be the most feasible solutions for teaching Indian Sign Language to able-bodied children. The card game received the highest score of 4.25 out of 5, indicating its strong feasibility in terms of cost, ease of use, long-term positive effects, accessibility, and scalability. The board game also received a high score of 3.15 out of 5, showing its potential for effective language learning and social interaction among deaf and able-bodied children. These results provide valuable insights for decision-making and further development of the selected ideas. By implementing these ideas, I intend to create an inclusive learning environment that promotes communication, empathy, and understanding between different communities.

In conclusion, using the weighted scoring method was a valuable tool in my ideation and analysis process. It allowed me to compare and evaluate my ideas against important parameters and make data-driven decisions for my project.

Pilot Study

I conducted a short pilot study to understand the initial reaction to learning Indian sign language through fun activities like a card game. During the pilot study, my objectives were to evaluate the gameplay mechanics of the card game and assess its effectiveness in teaching sign language to able-bodied young children. Additionally, I aimed to identify any difficulties or challenges that children may face while playing the game and gather feedback from them on their overall experience playing the game, in order to identify areas for improvement.

There were 8 participants, ranging in age from 8 to 10, who were selected for the pilot study. To begin the study, I created 15 cards divided into three categories of everyday words: greeting, family, and emotion. Each card displayed photographs of a person showing how to make a sign on the front side.

In the "Greetings" category, there were sign cards for hello, good morning, good afternoon, good night, and thank you. Under the "Family" category, there were sign cards for the father, mother, brother, sister, and grandmother. In the "Emotion" category, there were sign cards for happy, sad, bored, angry, and excited.

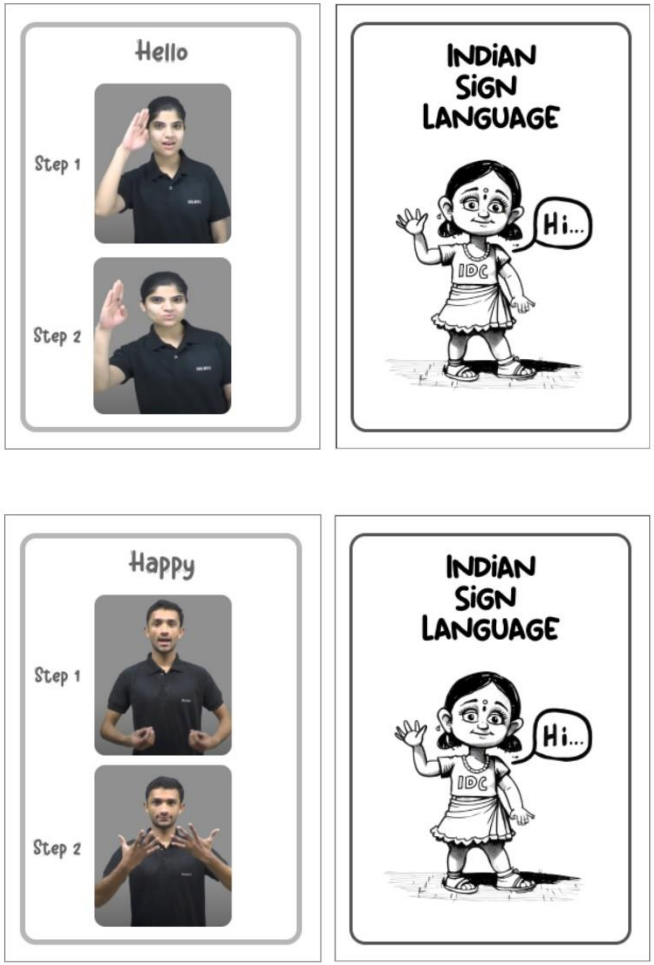


Fig 15: Cards in pilot study. Image source ISLRTC

To play the game, I divided the players into two teams, A and B, with two players on each team. I then shuffled the sign cards and placed them face down in a pile. One player from each team was designated as the guesser and the other showed the sign language. The teams took turns selecting a card from the deck and showing the sign to the guesser on the other team. The guesser tried to guess the sign, and if they guessed correctly, their team earned one point and they got to keep the card. A handout was given to the teams to refer to in case they could not guess on the first try. The handout contained all 15 signs in the pilot study and how to make the signs.

Throughout the pilot study, I observed the gameplay and noted any issues or difficulties that arose. I also collected feedback from the children on their experience playing the game, including what they enjoyed and what they found challenging. The results of the pilot study showed that the card game was an effective tool for teaching sign language to able-bodied children. The children found the game to be enjoyable and easy to use, and they learned the signs quickly. Additionally, the feedback provided valuable insights for improving the game mechanics and card design in my next iterations.

In conclusion, the pilot study was a success in achieving its objectives of evaluating the gameplay of the card game, assessing its effectiveness in teaching sign language, identifying any difficulties or challenges, and gathering feedback for improvement. The results showed that the card game was a viable and effective tool for teaching sign language to able-bodied children.

Observations from the pilot study:

Gameplay:
It is crucial to provide clear and succinct instructions for the game to ensure proper understanding. The majority of the children found the gameplay engaging and enjoyable. However, some children initially struggled to comprehend the game's rules. Once the rules were clarified, the children found them easy to understand. Some children suggested adding a time limit for guessing to make the game more thrilling.

Card Design:
The illustrations require more appeal to capture the children's attention. The designs need to be simpler and clearer to aid in better comprehension. Some children

found the photographs challenging to understand and require more clarity.

Engagement:
The majority of children found the sign language card game to be an engaging and enjoyable activity, highlighting its potential as a popular game for children. It was observed that many of the children wanted to continue playing the game even after the pilot study was over, indicating a positive response to the gameplay mechanics. Some children suggested the inclusion of a sign language manual as a lifeline option to assist with guessing, which could be a useful addition to the game for players who are still learning sign language. Additionally, the children enjoyed playing in teams and some suggested that having larger teams could make the game even more enjoyable, indicating that the game has the potential to be a fun group activity for children.

Learning outcomes:
The majority of children reported that the game was both enjoyable and effective for learning sign language. Additionally, some children demonstrated an improvement in their sign language abilities after playing the game multiple times. This implies that the game has the potential to be a successful and engaging educational tool for sign language. Children also displayed an interest in the challenges faced by deaf individuals in their daily lives and asked about the signs for various everyday objects.

Playtesting 1

Test Description

This ISL Activity is designed to check the effectiveness in learning basic Indian Sign Language for children aged 6-12 in a fun and engaging activity based on cards. The activity involves two teams, with two players in each team. One player is designated as the "teller" and the other as the "guesser." The teams take turns selecting a card from the deck, which displays photographs of a person making a sign for a word or phrase in Indian Sign Language. Here total 10 participants are divided into teams comprising of two players a Teller and a Guesser.

The teller from one team refers to the card and enacts the sign, while the guesser from the same team tries to guess the sign. If the guesser correctly identifies the sign, their team earns a point and they get to keep the card. If they are unable to guess, the card is passed to the teller in the opposite team. The team with the maximum number of cards at the end of the activity is declared the winner.
The activity is checked to see if the game can be played without a moderator to improve the children's knowledge of Indian Sign Language and promote teamwork and communication skills.

Test Location: St. Joseph’s Convent Primary School

Test Participants: 10 children aged 8-10 years

Test Objective

To evaluate the gameplay mechanics of the charades card game, assess its effectiveness in learning basic words in Indian Sign Language, and identify any difficulties or challenges that children may face while playing the game.

Test Parameters

- Game mechanics: How easy or difficult it was for the children to understand and follow the game mechanics.
- Memorizing sign language: Whether the children can memorize some of the signs after completing the activity.
- Engagement: How engaged and interested the children were while playing the game.

- Usability: Whether the game was user-friendly and easy to play.
- Design: Whether the graphical content of the game appealed to the children.

Test Constraints

Time: The testing session was limited to 15 minutes per group.
Resource: The testing was conducted with limited resources, and the game was played without any exposure stage to Indian Sign Language.

Test Results

- Game Mechanics: 80% of the children found the game mechanics easy to follow, while 10% found it a bit challenging to understand at first.
- Memorizing sign language: 80% of the children were able to recollect the signs that they are exposed to through the game, with 70% showing a noticeable improvement.
- Engagement: 90% of the children were engaged and interested while playing the game, while 10% lost interest after a few rounds.
- Usability: 90% of the children found the game easy to use and user-friendly, while 10% found it a bit challenging to navigate the cards.
- Design: 40% of the children found the photographs and overall design of the game appealing, while 60% felt that the elements could be improved and made more visually engaging.

Conclusions

The charades card game is an effective tool for improving communication skills in children, as 80% of the children were able to show improvement in remembering some of the signs from this activity. The game mechanics are easy to follow and user-friendly, with 90% of the children finding it easy to use and understand. The game is engaging and interesting to children, with 90% of the children staying engaged throughout the testing session. The design and illustrations of the game could be improved to make it more visually engaging and appealing to children, based on feedback from 60% of the children. The game can be played without a moderator, making it a convenient and accessible learning tool for children.

Modifications

- Improve the graphical content of the game to make it more engaging and appealing to children.
- Incorporate feedback from children to refine the game mechanics and overall gameplay experience.
- Test out different variations of the gameplay to make it more interactive and engaging, such as incorporating time limits for guessing or incorporating other challenges.
- Develop a guide or manual to assist with guessing for players who may be struggling with certain cards.

Playtesting 2

Test Objective

To evaluate the effectiveness of the ISL card game in teaching sign language to able-bodied young children with illustrations replacing the photographs on cards with the same mechanics repeated from previous test.

Test Location: St. Joseph's Convent Primary School

Test Participants: 10 children aged 8-10 years

Test Parameters

- Gameplay: How easy or difficult it was for the children to understand and follow the gameplay.
- Memorizing/Learning: Whether the children were able to learn the sign language concepts effectively through the game.
- Engagement: How engaged and interested the children were while playing the game.
- Usability: Whether the game was user-friendly and easy to play.

- Design: Whether the illustrations and overall design of the game appealed to the children.

Test Constraints

Time: The testing session was limited to 15 minutes per group.
Resource: The testing was conducted with limited resources, and the game was played with comparatively little exposure to Indian Sign Language from previous testing activity.

Test Results

- Gameplay: 90% of the children found the gameplay easy to follow, while 10% found it a bit challenging to understand at first.
- Learning: 90% of the children were able to memorize and retain some of the words in sign language concepts taught through the game, while 10% found it a bit difficult to remember the signs.
- Engagement: 100% of the children were engaged and interested while playing the game.
- Usability: 100% of the children found the game easy to use and user-friendly, but some of them suggested the size of the cards can be reduced.
- Design: 100% of the children found the illustrations and overall design of the game appealing.

Conclusions

The ISL card game with illustrations is an effective tool for teaching sign language to able-bodied children, with a majority of the children being able to learn and retain the sign language concepts taught through the game. The gameplay is easy to follow and user-friendly. The game is engaging and interesting to children, with all of the children staying engaged throughout the testing session.
The illustrations and overall design of the game are appealing to children, with all of the children finding it visually engaging. The game can be played without a moderator, making it a convenient and accessible learning tool for children to socialize.

Modifications

- Incorporate feedback from children to refine the game mechanics and overall gameplay experience.
- Include some tips next to the illustration for easy understanding of the formation of the signs.
- Develop a sign language manual to assist with guessing for players who may be struggling with certain signs.
- Test out different variations of the gameplay to make it more interactive and engaging, such as incorporating time limits for guessing or incorporating other challenges.

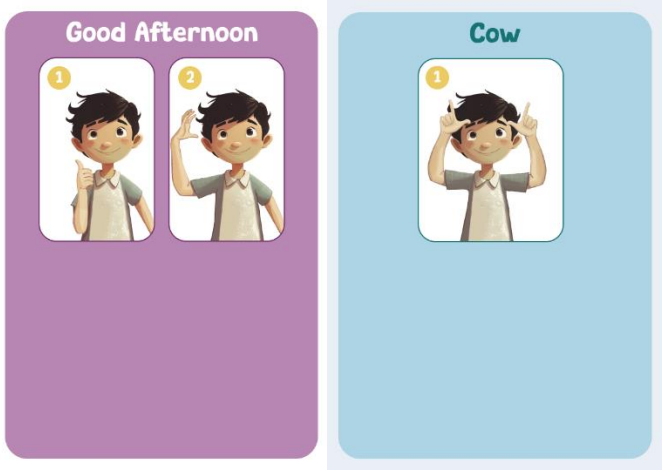


Fig 16: Two of the sample cards from playtesting #2

Playtesting 3

Test Objective

To evaluate the effectiveness of a handbook/manual in the learning of sign language to able-bodied young children in conjunction with the game.

Test Location: Kendriya Vidyalaya Premises

Test Participants: 6 children aged 6-10 years

Modified Mechanics

The handbook is introduced to the game as a lifeline, where each team has four lifelines to refer to the handbook in case the guesser cannot guess. Two extra cards are also introduced, namely the Swap card and Re-draw card. If the teller draws an 'swap card' from the deck, the team gets to swap a card from their collection with the other team. Collecting cards of the same category give a team extra 10 bonus points. So the swap card is strategically making the game more competitive and engaging. If the team gets a 're-draw card', they can save

it to use later, in case the teller doesn't know the exact sign of any drawn card. They ca use to salvage a chance. 'Re-draw card' is pushed back into the deck and shuffled after each use.

Test Parameters

- Handbook/Manual: To check how effective the handbook/manual is in aiding the children's learning and retention of sign language concepts through the game.
- Game Mechanics: Whether the children found the game mechanics easy to understand and follow.
- Learning: Whether the children were able to learn the sign language concepts effectively through the game and the handbook/manual.
- Engagement: How engaged and interested the children were while playing the game and using the handbook/manual.
- Usability: Whether the handbook/manual was user-friendly and easy to use.
- Design: Whether the illustrations and overall design of the handbook/manual were appealing and easy to understand.

Fig 17: Playtesting session

Test Results

Handbook/Manual: 83% of the children found the handbook/manual helpful in aiding their learning and retention of the sign language concepts taught through the game, while the rest found it somewhat confusing at first.
Game Mechanics: All of the children found the game mechanics easy to understand and follow after a couple of rounds. But 33% found it a bit challenging at first.
Learning: 83% of the children were able to learn and retain the sign language concepts taught through the game and the handbook/manual, while the rest found it a bit difficult to remember the signs.
Engagement: All of the children were engaged and interested while playing the game and using the handbook/manual.
Usability: 83% of the children found the handbook/manual user-friendly and easy to use, while the rest found it a bit challenging to navigate the pages.
Design: All of the children found the illustrations and overall design of the handbook/manual appealing and easy to understand.

Conclusions

The sign language manual is an effective tool in conjunction with the card game for teaching sign language to able-bodied children, as a majority of the children found it helpful in aiding their learning and retention of the sign language concepts learned through the game. The new game mechanics are easy to understand and follow after the first two rounds of getting used to this. The design and illustrations of the handbook/manual could be improved to make it more engaging and appealing to children, based on feedback from some of the children. The handbook/manual can be used as a standalone learning tool for children who may not have access to the card game.

Modifications Needed

- Improve the design and illustrations of the manual to make it more visually engaging and appealing to children.
- Explore the possibility of creating a digital version of the manual to make it more accessible to children who prefer learning through electronic devices.

- Test out different variations of the gameplay to make it more interactive and engaging, such as incorporating time limits for guessing or incorporating other challenges.
- The possibility of expanding the vocabulary in the handbook/manual to include more sign language concepts and words from everyday use.
- Develop additional learning materials, such as videos or interactive tutorials, to supplement the handbook/manual for children who may require additional support in learning sign language.

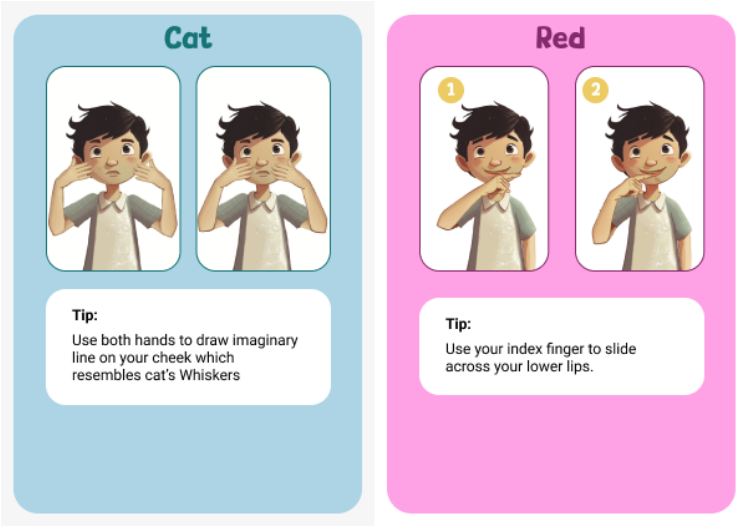


Fig 18: Modified cards

Playtesting 4

Test Description

Playtesting 4 focused on evaluating the effectiveness of the revised handbook and card game components in teaching Indian Sign Language (ISL) to able-bodied young children. The new components include additional everyday words in the handbook and card game that are relevant to Indian kids. The illustrations now feature both a male and a female character demonstrating the signs. Tips have been added to the cards and handbook to provide users with guidance on forming the signs.

Test Location: Kendriya Vidyalaya Premises

Test Participants: 10 children aged 8-12 years

Test Objective

To assess the impact of the revised handbook and card game components on the children's learning experience and their ability to understand and use Indian Sign Language effectively. Give away copies of the handbook

and cards to kids to measure the learning effectiveness in the next playtesting.

Test Parameters

- Learning Effectiveness: Measure the participants' ability to learn and retain the signs and vocabulary.
- Engagement: Observe the level of engagement and interest exhibited by the participants during the gameplay and interaction with the handbook.
- Usability: Evaluate the user-friendliness and ease of use of the revised handbook and card game components.
- Design and Illustrations: Gather feedback on the visual appeal, clarity, and effectiveness of the illustrations and design elements.
- Tips and Guidance: Assess the usefulness and effectiveness of the provided tips in helping users form the signs correctly.

Test Constraints

Time: The testing session was limited to 20 minutes per group.

Resources: The testing was conducted with the revised handbook, cards, and other necessary materials.

Test Results

- Learning Effectiveness: 90% of the children were able to learn and retain the newly introduced signs and vocabulary, with 80% demonstrating proficiency in using them even after the test is over.
- Engagement: All of the children displayed high levels of engagement and interest throughout the gameplay and interaction with the handbook.
- Usability: All of the children found the revised handbook and card game components easy to use and navigate.
- Design and Illustrations: 80% of the children found the illustrations visually appealing, clear, and effective in conveying the signs.
- Tips and Guidance: 90% of the children found the provided tips helpful in forming the signs correctly.

Conclusions

The revised handbook and card game components have positively impacted the learning experience of the children, as evidenced by their ability to learn and retain the newly introduced signs and vocabulary. The participants showed high levels of engagement and interest, indicating the effectiveness of the interactive gameplay. The usability of the components was rated

favorably, with the majority of children finding them user-friendly. The design improvements, including the addition of a female character and the inclusion of tips, have enhanced the visual appeal and clarity of the illustrations. The provided tips were found to be helpful in guiding users in forming the signs correctly.

Modifications Needed

- Fine-tune the illustrations to ensure even greater clarity and effectiveness in demonstrating the signs.
- Explore the possibility of interactive digital format of this activity, so that it will be appealing to older children.
- Further expand the vocabulary in the handbook and card game to include a wider range of everyday words and phrases.

Playtesting 5

Test Objective

To evaluate the long-term effectiveness and user experience of the revised handbook and card game components in facilitating the learning of Indian Sign Language (ISL) for able-bodied young children.

Test Location: Kendriya Vidyalaya Premises

Test Participants: 10 children aged 8-12 years

Test Parameters

- Long-term Learning: Measure the retention of signs and vocabulary learned through the revised handbook and card game.
- User Experience: Gather feedback on the overall user experience, including engagement, enjoyment, and satisfaction.
- Usability: Gather feedback on the ease of use, intuitiveness, and navigation of the handbook and card game.

- Effectiveness: Determine the effectiveness of the components in promoting communication skills and understanding of ISL.
- Recommendations: Gather feedback and suggestions for further improvements and enhancements.

Test Constraints

Time: The testing was conducted after a period of two weeks from last playtesting, to assess long-term learning.

Follow-up Interviews: Individual interviews are conducted after the testing to gather more detailed feedback and insights.

Test Results

Long-term Learning: 80% of the children demonstrated a high level of retention of the signs and vocabulary taught through the revised handbook and card game.

User Experience: 90% of the children reported high levels of engagement, enjoyment, and satisfaction with the learning experience.

Usability: All of the children found the handbook and card game components easy to use and navigate.

Effectiveness: 80% of the children reported an improvement in their understanding of ISL and how easy the basic signs are.

Recommendations: Feedback from the children included suggestions for incorporating additional challenges and expanding the content further.

Conclusions

The revised handbook and card game components have demonstrated long-term effectiveness in facilitating the learning of Indian Sign Language for able-bodied young children. The participants showed a high level of retention of the signs and vocabulary over the testing period. The overall user experience was rated positively, with children reporting high levels of engagement, enjoyment, and satisfaction. The components were found to be user-friendly and effective in promoting communication skills and understanding of ISL. The feedback received from the children provides valuable insights for further improvements and enhancements.

Overall, the playtesting sessions have provided valuable feedback and insights to enhance the effectiveness, engagement, and user experience of the ISL card game and handbook. The modifications made based on the

feedback have resulted in positive outcomes, improving the learning process and usability of the components. The playtesting process has contributed to the iterative design and development of this activity, ensuring its effectiveness in teaching Indian Sign Language to able-bodied young children.

Re-assessing the Scope

As stated at the beginning of this project, the scope was to create a simple activity aimed at introducing the basics of Indian sign language to able-bodied children between the ages of 6 to 12 years old. The activity has to be very easy to understand and has to focus on teaching commonly used signs and phrases.

From the combination of the Handbook and Card game, I was able to promote inclusivity and understanding of the deaf culture among the younger kids. This was clearly evident from the interactions I had with the younger kids before and after my playtesting sessions. There was a significant improvement in their attitude toward Sign Language once they came to know about it. Initially, since they were never exposed to Sign Language, they were a bit skeptical and was thinking this is a highly difficult way of communication. But when they came to know how to form basic words in Indian Sign Language, they are more open to know more about it.

This activity including the cards and the handbook is not intended to replace formal education in Indian sign language, but rather to serve as a foundation, supplement, and enjoyable way to introduce children to sign language. As stated earlier, my purpose was to bridge the gap between these two communities.

Embracing the Digital Dimension

Even though my initial aim was to build the foundation of basic Indian Sign Language (ISL) for younger able-bodied children through a non-digital card game and handbook, I also realize the significance of a digital version of similar activity to meet the needs of the elder audience. This will be particularly helpful for someone who aspires to move forward into advanced Sign Language learning.

Even though this is not coming in my project scope, in intend to explore the possibility of a mobile application to learn Sign Language. I decided to explore one of the applications which is already up and running under the Jellow Platform.

The **Jellow Talk Communicator** is an Android application designed to empower individuals with speech and hearing difficulties, including those with Autism. With its Speech to Text and Text to Speech features, the app allows users to convert spoken words into text and vice versa, facilitating communication in real time.

Fig 19: Jellow Talk Logo

Existing 'Jellow Talk' application download link:

https://play.google.com/store/apps/details?id=com.jellowcom.android.jellowtalk&hl=en&gl=US

The Speech to Text feature enables users to speak into the app, which then transcribes their speech into text format. This functionality is especially useful during conversations, classes, conferences, or any situation where continuous speech needs to be recorded and displayed as text. The continuous Speech/Listen mode ensures that users can record and view long conversations without interruptions.

Similarly, the Text to Speech feature reads aloud the text that is typed into the app, enabling individuals who have difficulty speaking to communicate effectively. This feature promotes instant and direct conversation between users who have speech and hearing impairments and

those who can speak and hear, bridging the communication gap and facilitating meaningful interactions.

Overall, the Jellow Talk Communicator serves as an augmentative and alternative communication (AAC) tool, offering a user-friendly interface and essential features to facilitate communication for individuals with speech and hearing challenges. By converting speech to text and vice versa, the app empowers users to engage in conversations, express themselves, and participate actively in various social and educational settings.

Enhanced Features for the Jellow Talk Application

There is already a lot of studies happening in developing Artificial Intelligence models to identify sign language. So I decided to make a speculative design for the Jellow Talk app which can be realized in the near future. The features that I intend to add are:-

1. Ready-Made Prompts for Seamless Communication
2. Learning option for Indian Sign Language

The ‘ready-made prompts’ is an option for users to create and store readymade prompts for commonly used terms or words significant for their daily needs. This feature is particularly useful for individuals who have difficulty speaking due to disabilities or medical conditions. The option has to be so minimal that the users can easily access and tap on the pre-created prompts, allowing the app to read out the word or phrase, and facilitating seamless communication for the user. This will help in saving time and effort for users, providing quick access to

frequently used words and enhancing their ability to communicate effectively.

The ‘ISL learning’ option is a dedicated section within the app for users to learn basic Indian Sign Language (ISL). The primary research inputs and the playtesting feedback is applicable in this case to findout the needs and wants of different age groups. Users are presented with various everyday categories, each containing a comprehensive list of signs to learn. An animated demonstration of each sign guides users on its formation. Users can then practice the signs by recording themselves performing the sign using the device's camera. The built-in AI evaluates the correctness of the sign from the video, providing real-time feedback.

Users can participate in sign language challenges, earning points for correctly performing signs. The app intends to feature leaderboards to foster competition and motivation among users. This digital format of learning offers an interactive and engaging learning experience for elder users, promoting active participation and mastery of Indian Sign Language. The challenge feature adds a competitive element, making the learning process more enjoyable and rewarding.

By incorporating these additional features into the existing Jellow Talk application, users can benefit from improved communication support through ready-made prompts, while also having the opportunity to learn and practice Indian Sign Language in an interactive manner.

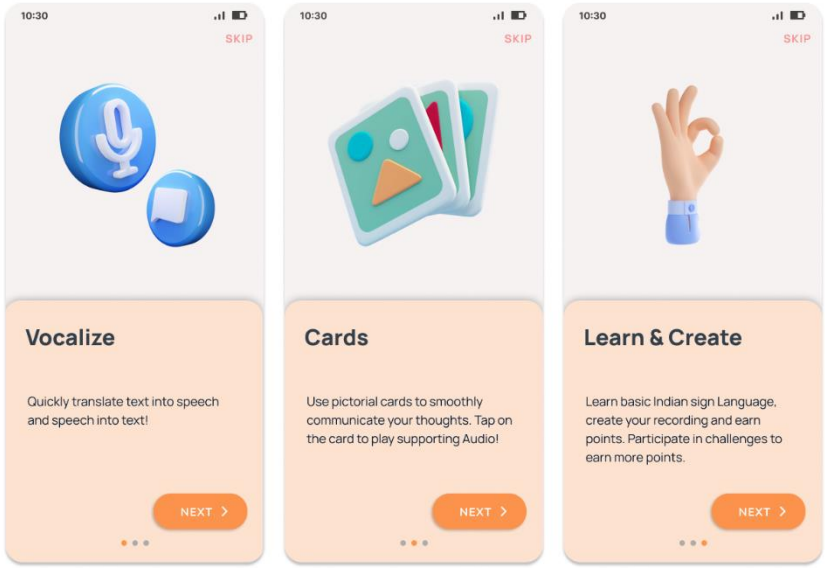


Fig 20: New Jellow Talk’s splash screen explaining the features

Click the below link to view the Figma prototype:

https://bit.ly/jellowtalk

Learning Option in Jellow Talk

As stated in the previous section, this option makes the user choose a category to start with. Each category contains a comprehensive list of signs to learn.

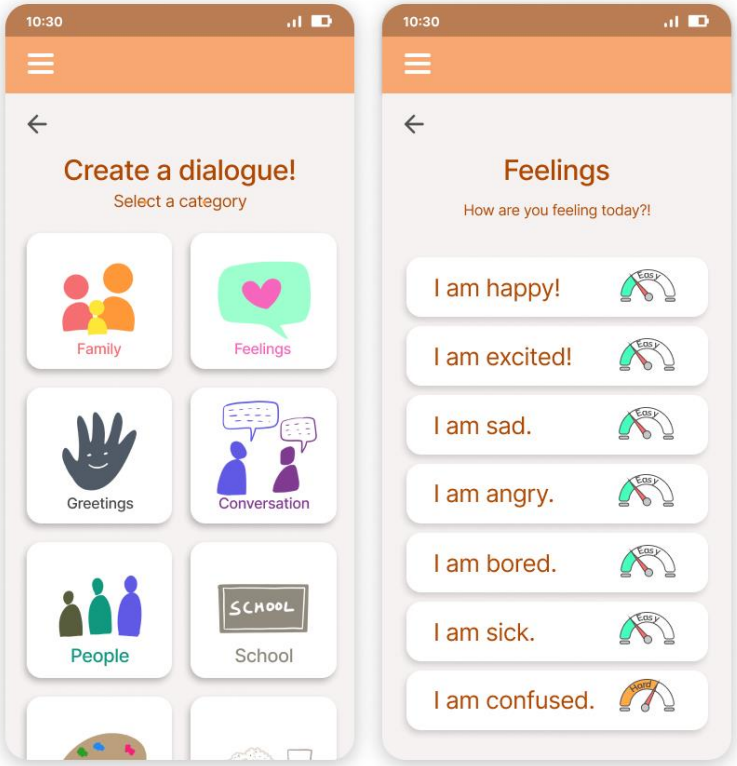


Fig 21: Category selection & sign selection

An animated demonstration of each sign guides users on its formation. Users can then practice the signs by recording themselves performing the sign using the device's camera. The built-in AI evaluates the correctness of the sign from the video, providing real-time feedback.

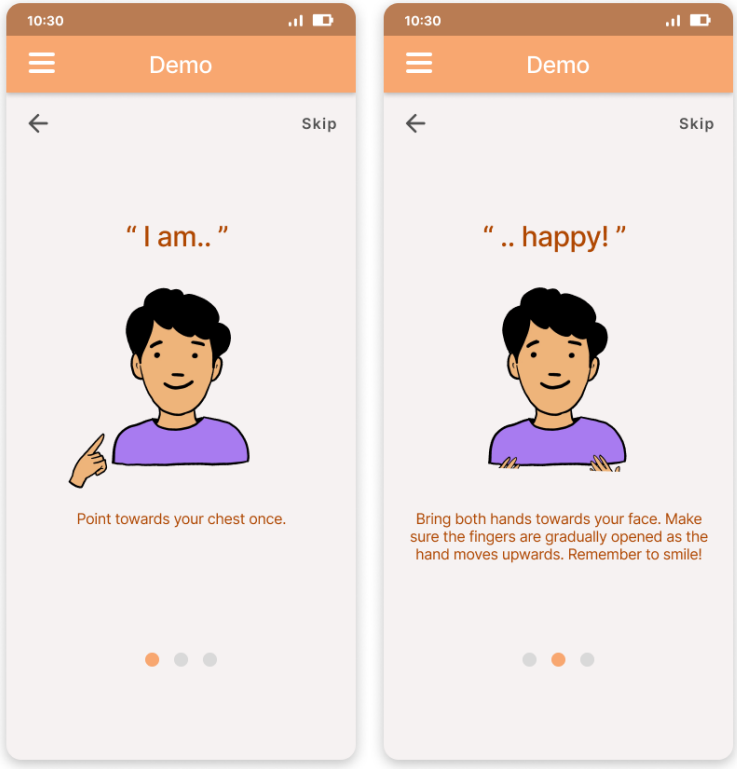


Fig 22: Animation showing the steps to make a sign

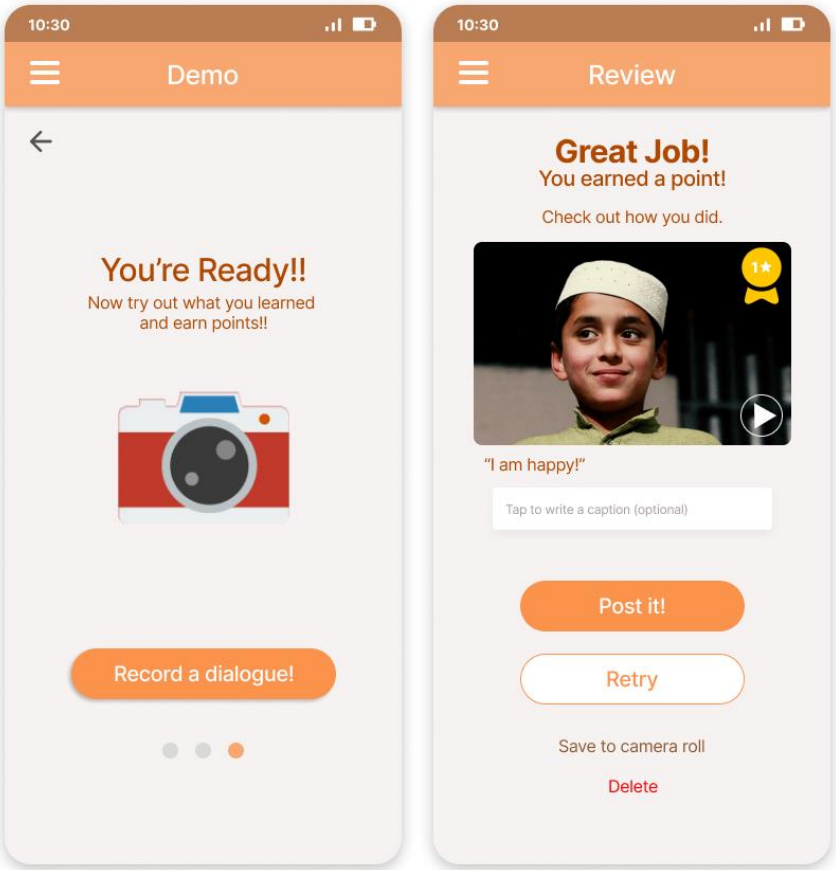


Fig 23: Record and review of users' sign

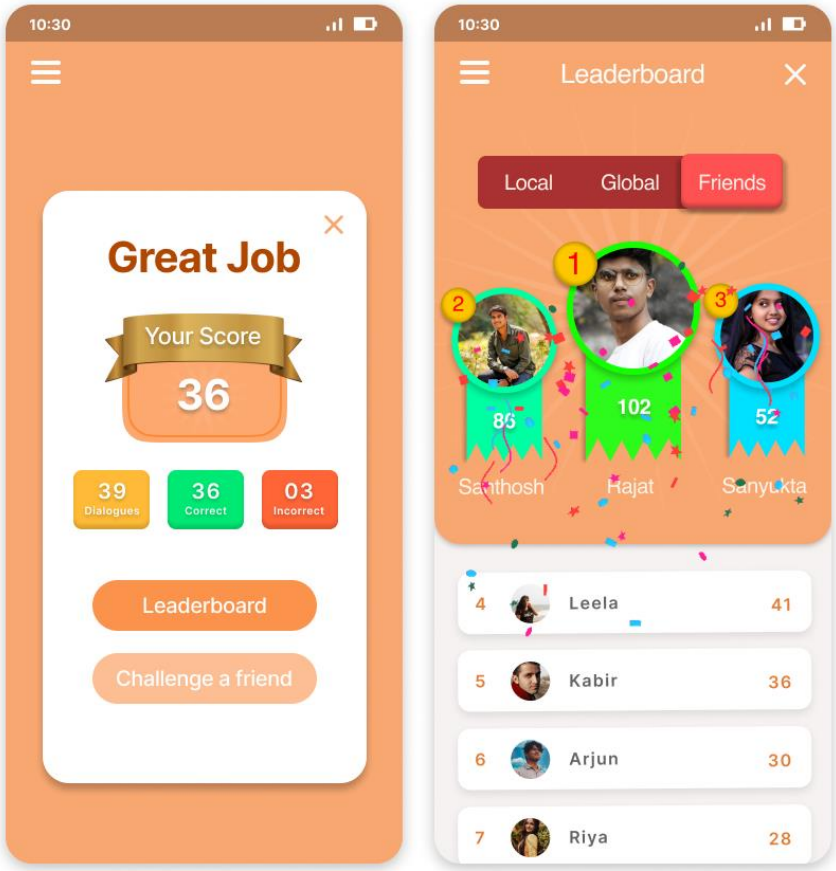


Fig 24: Options available for user – Leaderboard & Challenge a friend

The user evaluation of this prototype is in progress and will be completed before 22nd May 2023.

Challenges

Recruiting parents who had recently discovered their child's hearing or speech disability posed another challenge. Clear communication about the benefits and objectives of the project, as well as the involvement of the ISL Cell at the Ali Yavar Jung National Institute of Speech and Hearing Disabilities, played a pivotal role in building credibility and encouraging their participation. The lessons learned from navigating these obstacles will inform future iterations of the project, allowing for continuous improvement and expansion of the solution's reach and impact.

Future Steps

In the future steps of this project, it is crucial to consider the broader context of Indian Sign Language (ISL) integration into regular schools. The National Council of Educational Research and Training (NCERT) has recognized the importance of ISL as a valuable skill to be learned by students. Pilot runs have been conducted in different schools across the nation to explore the feasibility of incorporating ISL into the curriculum. However, progress in implementing this initiative has been running in a slow pace.

If the NCERT's plan to include ISL in regular schools becomes a reality, it opens up new avenues for the development of this solution. The existing card game and handbook can serve as a foundation for formal learning in schools. Additional words, phrases, and more advanced sign language concepts can be incorporated into future versions of the solution to cater to the structured curriculum.

Moreover, this solution extends its benefits to parents who might have recently discovered their child's hearing or speech difficulties. The accessibility of the digital app allows parents to support their child's learning journey and reinforce sign language skills at home. By breaking the stigma surrounding hearing and speech impairments, children can build upon their initial knowledge and progress to more advanced sentence formations and expressive communication.

The potential impact of this solution goes beyond the target audience of young children. Adults who may not have the time or inclination to engage in physical card activities or refer to handbooks can benefit from the convenience and flexibility offered by the digital app. By embracing a multimodal approach that combines digital technology with traditional learning tools, this solution has the potential to reach a wider audience and promote inclusive communication and understanding in society.

Reference

.

[1]	Kaj Kraus and Deanna Gagne. 2021. Learning ASL as a Late Second Language Depends on the Strength of the First Language Foundation http://www.lingref.com/bucld/45/BUCLD45-33.pdf
[2]	Zeshan, Vasishta and Meher. 2005. Implementation of Indian Sign Language in educational settings https://dl.acm.org/doi/abs/10.1145/3295750.3298943
[3]	Victoria Mousley and Stephenie Chaudoir. 2018. Deaf Stigma: Links Between Stigma and Well-Being Among Deaf Emerging Adults https://ieeexplore.ieee.org/abstract/document/8305926
[4]	Vasishta M, Woodward J,and Wilson K.L. 2008. Sign language in India: regional variation within the deaf population https://www.sil.org/system/files/reapdata/95/53/47/95534743464081586996546262623353152613/silesr2008_006.pdf
[5]	Siti Rahayu Mohd. HashimSiti Rahayu Mohd, 2007, Ranking method using multiple weighted score analysis https://www.researchgate.net/publication/265733128_Ranking_method_using_multiple_weighted_score_analysis
[6]	Elham Alsadoon, Amirah Alkhawajah, 2022, Effects of a gamified learning environment on students' achievement, motivations, and satisfaction https://www.sciencedirect.com/science/article/pii/S2405844022015377
[7]	Jorge F. Figueroa Flores, 2015, Using Gamification to Enhance Second Language Learning https://www.researchgate.net/publication/278328067_Using_Gamification_to_Enhance_Second_Language_Learning
[8]	Foad Hamidi, 2012, Digital Tangible Games for Speech Intervention https://www.eecs.yorku.ca/research/techreports/2012/CSE-2012-02.pdf
[9]	Adeyanju, Bello & Adegboye , 2021 Machine learning methods for sign language recognition https://www.sciencedirect.com/science/article/pii/S2667305321000454
[10]	Bhargav, Abhishek et al , 2021, An AI based Solution for Predicting the Text Pattern from Sign Language https://dl.acm.org/doi/10.1145/3474124.3474210