An Interactive App for Learning Numeracy and Calculation for Children with Autism

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the investigation performed by us under the supervision of Amit Kumar Das, Lecturer, Department of Computer Science and Engineering, East West University. We also declare that no part of this thesis has been or is being submitted elsewhere for the award of any degree or diploma.

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Letter of Acceptance

This thesis report entitled *"An Interactive App for Learning Numeracy and Calculation for Children with Autism"* submitted by Afshara Tashnim (ID: 2014-1-60-028), Samiha Nowshin (ID: 2014-1-60-077) and Fatema Akter (ID: 2014-1-60-086) to the Department of Computer Science and Engineering, East West University is accepted by the department in partial fulfillment of requirements for the Award of the Degree of Bachelor of Science and Engineering on December, 2017.

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Abstract

ASD - (Autism spectrum disorder) defines a group of people who have some level of disabilities. Basically it represents a number of people of our society who are disabled mentally or physically. They do not have the proper opportunities of education. Education is the most important thing for a nation if it wants to develop. It is hard for such children to cope up with the traditional school system education. To serve them a better life by fighting against those disabilities and gain the basic educational knowledge in mathematics, we have developed a system for these special children to help them in learning mathematics. We introduced AR - (Augmented Reality) in our system to maximize the result. AR makes real world environment elements lively in the application. It will help the autistic children to understand the real environment easily. For developing this system we went through some processes, collected data from different ASD schools then simulated those data to generate graph and to get the final results which shows the efficiency of this application. As our designed system is already experimented in some school and the achieved result indicates positivity, so it can be said as a proof of concept. The application is colorful and attractive so that it gets the attention of every autistic child. For using AR, learning will be easy and fun for them. Hence it is an application which directly interacts with children; it is definitely under the HCI (Human-computer interaction).

Acknowledgments

As it is true for everyone, we have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, we would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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Chapter 1

Introduction

1.1 Human-Computer Interaction

Human-Computer Interaction (HCI) refers to the interaction of a human with computer or machine. This interaction can be done in many ways and the interface between them is vital to smoothen up this interaction. HCI deals with designs and technologies that aim at interfaces through which interaction is done between machine and human. Desktop applications, browser, graphical user interface (GUI), voice user interface (VUI) etc. allows human to interact with computers and machines which wouldn't be possible without interface models. HCI simply End-User Computing Satisfaction as it studies human and machine in communication and draws from supporting knowledge on both sides. The poorly designed interface can lead to many unexpected problems. A classic example of this is the "Three Mile Island accident".

For years, distinct modes of generation have been used to enhance the great of lifestyles of people who have various developmental disabilities. However, the copious use of era for youngsters with autism continues to get hold of restricted attention, regardless of the truth that technology tends to be an excessive interest location for a lot of those children. Developing of computer technology to fight against autism is a challenging method nowadays. Interaction of computer with a human is highly usable in every sector of our life. Recently, Human-computer interaction (HCI) is using in health care a lot for those children.

The basic idea of Human-computer interaction is a method which is contemplative to design, assess of response, an embodiment of interaction systems for ASD child for any purposes, like healthcare, education and so on [1]. In support of these technological changes, the number of user populations has diversified and increasing. Interactive computational gadgets and applications are broadly available nowadays for everyday use, in anywhere, at any time by anyone. As we established a system that interacts with the human directly for an educational purpose which is also a covered field of HCI.

Autism children are highly fascinated by technology for learning something rather than traditional methods of learning. The children with a mental imbalance figure out better using visualization also intuitive methodology through the advanced system. Picture exchange communication system (PECS) and TEACCH program are one of the great standouts of the fruitful system of teaching where visualization plays an extensive part to learn. Hence using digital tools for educational purposes are worldwide famous to a special child. It has been clarified that children are most likely to use gadgets rather than playing with substantive toys.

1.1.1 Overview of HCI

Nowadays HCI is entered in almost every sector and is expanding its range at a high. To make life much easier HCI is being involved in almost every sector. Some examples are given below-

1.1.1.1 Data Get Interfaces

Route buttons alternately menus ought to further bolstering give acceptable exactly sort data to the clients for them with adequately complete their objective. A sample might a chance to be a floppy plate picture should demonstrate the sparing of a record. Designers ought to take after assemblies what's more not outline a truly new menu alternately catch thereabouts.

1.1.1.2 Lessening Working Memory Load

Restricted will oversee memory load that keeps track of the user's choices or input under that framework. This might permit them to undoubtedly get a formerly utilized technique or system for the framework so as with effectively Also adequately finish their objective (e. G. Bookmarking characteristic to web browsers).

1.1.1.3 Personal Satisfaction About Existence

When clients of a specific arrangement might settle on the utilization of it for simplicity alternately minimal learning, it diminishes the dissatisfaction starting with Taking in how those separate controls fill in or disappointment from powerlessness to finish their objective. This permits clients to be a greater amount fulfilled by the framework. An arrangement could a chance to be filled with a thousand furthermore one functionality, yet all the client's camwood utilization it undoubtedly and effectively, the framework might not make beneficial.

1.2 Augmented Reality (AR)

Augmented reality is an innovation that superimposes a PC created picture from a client's perspective of this present reality, consequently giving a composite view. It is a live immediate or roundabout perspective of a physical, certifiable condition whose components are "increased" by PC produced or extricated true tangible information, for example, sound, video, illustrations, haptic or GPS information.

1.2.1 Benefits of Augmented Reality in Education

1.2.1.1 Increased Classes Participation

Everybody will take part through an Augment's application and the understudies will have the capacity to approach models individually gadgets. When they can see the expanded models, they will have the capacity to get a handle on a superior comprehension of what they are contemplating and will be thoughtfully sounder. It is additionally a fun approach to push instruction and the understudies will be persuaded to take in more.

1.2.1.2 Less Expensive

Some instructive materials and supplies are very much costly. The 3-D physical models, huge and multifaceted representations, blurbs, and models are altogether truly extremely costly. Most schools don't have enough subsidies to gain the greater part of the extra learning material. And again, they get lost, stolen, lost and they likewise get exhausted simultaneously. When AR has been obtained and utilized, there is no compelling reason to burn through cash on the physical materials. Particularly since understudies approach the models from gadgets at whatever point they need - at home, the classroom or amid think about sessions.

1.2.1.3 Increased Memory

By basically checking, any understudy can access enlarged models. For instance, a piece of human life systems recorded landmark or even a molecule. Understudies can likewise approach sites promptly from the application. This enables the experience to make an entire and healthy learning cycle. This will enable the understudies to have the capacity to keep up more data for longer timeframes.

1.2.1.4 Nurture the Learning Process

By starting AR into the instructive educational modules, understudies will be more eager to learn. Since most understudies now will be currently conceived in the digitalized age, understudies will be more spurred and fortified through Augmented Reality. They will need to analyze and learn new thoughts and think all the more basic. This will enable the understudies to think all the more innovatively and find things about themselves that they didn't know existed.

1.2.1.5 Enriched Ways of Telling a Story

Simply think, by utilizing Augmented Reality narrating will turn out to be powerful to the point, that the understudy will have the capacity to envision the story and it will be enlivened. The effect of the entire thought will be significantly more and it will take narrating to a radically new life. This will likewise build the collaboration of the understudies.

1.2.1.6 Increased Sensory Development

In the event that you can see something change before you and feel it in the meantime, it will upgrade your mental and physical aptitude. Consequently, your tangible advancement will increment. Increased Reality gives content that you can cooperate with. You never again are only a minor eyewitness, yet you are permitted to end up noticeably a piece of the program. This is taking instruction to an unheard-of level.

1.2.1.7 Visiting the Past, Present, and Future

Envision having the capacity to visit what had happened, for now, and what could occur later on? The understudy would have the capacity to visit the past and apply hypotheses to visit the conceivable future, and furthermore in the middle of remain concentrated on current occasions. This is an awesome approach to learn history, old realms, chronicled fights, and individuals from around the globe.

1.2.1.8 Increased Activity

These days, kids have a propensity for depending on innovation for all intents and purposes everything. This never again has a feeling of development and has turned out to be truly sluggish. Luckily for Augmented Reality, gone are the days for kids to be steady love seat potatoes. With upgraded learning, AR has made an improved and an expanded intelligent route for understudies to escape the house and play and learn in the meantime. Because of cell phones and tablets, versatility has expanded. Through AR, the entire instructive experience is totally changed.

1.3 Autism

Autism is a mental situation, present from early childhood, characterized with the aid of trouble in speaking and forming relationships with other human beings and in the usage of language and summary standards. In the United States, latest assumption says, about one out of every 68 children is affected by autism [2]. In other states, autism is also seen as a considerable percentage. In South Korea, a study followed by the Yale University School of Medicine, researchers found that about 2.64% of South Korean children between the ages of seven and twelve have some different level of autism. In China, a work published in the Journal of Child Neurology was the first large-scale examination of the prevalence of autism. The work found that 1.61% of children under the age of fifteen years is having various level of autism spectrum disorder. In Australia, another study published in the Journal of Pediatrics and Child Health shows that 1.21% to 3.57% of Australian children aged six to twelve have been diagnosed with autism. So ASD is almost a universal problem nowadays.

1.3.1 HCI in the Education Sector for Autism Children

1.3.1.1 Expand Verbal Abilities for Applications

Extreme introverted Speaks, an extremely introverted science also support an association that trusts Look into Also expands awareness, accounted for that over 25 percent of people with ASD need aid generally nonverbal. Others need aid recognized likewise lowfunctioning communicators. To such students, there are applications known as "visual scene displays" that need aid mossy cup oak assistive for youngsters battling with verbal abilities Also instructors ended up additionally agreeable for technology, they could alter An educational module for understudies with a mental imbalance.

1.3.1.2 Advanced Devices with Push Certainty

Certainty dives as one for enhanced social abilities. ASD would often threaten eventually perusing those social parts from claiming classrooms. That is until they need aid provided for engineering.

1.4 Augmented Reality to Enhance the Efficiency of HCI in Education for Autism Children

As autism children are verbal, mentally and sometimes imbalance in hearing as well, an augmented system could be a great help for them to gain a basic education. Interaction of computer has always been a fun for children, it gives them the boost of learning new things by ignoring their disabilities and help them to enjoy the learning process. It also removes the monotony of traditional education. As children are way more difficult to handle, automatically children with autism is even harder to control. It's tough to teach them the basic educational knowledge. However, introducing an application in HCI with augmented reality for autism children is may be a great help to face the difficulties and turn those into enjoyment and learning new things eagerly. Even it can be a help for a teacher in the classroom.

1.5 Our contribution

To enhance the interest in education with HCI and AR for an autistic child we build an application which will help an autistic child to cope their difficulties. It will help them to learn numeracy and make it even more interesting. As it is designed for autism child, so that special design process is followed carefully. Different animation is added there as children are fascinated to the animated theme. It will also help them to practice handwriting by controlling their hand motor by dot matching. Voice option will help them to enjoy it more and some quiz option will help them to show a way of right and wrong. Finally, the main theme of AR will help them to relate the reality with their learning and help them to be enough strong and live a better life in society.

1.6 Conclusion

The paper explored the idea of numeracy and basic calculation for autism children by using some neoteric methods for better outcome and exactness. In the recent era, it has been found that children are fascinated by technology for learning anything as technology provides visualization techniques which are kind of fun for them to learn fast. The design principle and guidelines in designing UI for supplication is immensely important. A good UI design has envisioned the success of learning capability. Hence, in the later part of this paper, we will try to implement better UI designs that will make it sophisticated. It was observed that there is distinguishable procedure to teach autism child as they have a diverse category. As a result, it is tough to teach them equally because of having different emotion at any time. Therefore in future, we have a plan to detect the emotion of autistic child from speech recognition so that our system will be more fruitful. Moreover, in this paper, we just worked on addition and subtraction part, but shortly, we will also work on multiplication, division part and nomenclature as well.

Chapter 2

Related Works

2.1 Introduction

In the last few years, human-computer interaction (HCI) has been one of the most important interests for the researchers, and they have been developing the technology of mobile applications to bring a change in the lives of the children with autism. Their aim has been focused on making the technology more accessible and interactive for the autistic children. Previous research showed that the majority of autistic children are enthusiastic about the interaction through technology. For the autistic children, there are numeral advantages of using technolog [3]. Mobile learning applications technology can aid the autistic children to become confident learners. The augmented reality is also applied to make the user interface more interactive that helps the autistic children to interact with the user interface quickly, and this technology is expanding because it allows the users to interact with the real world [4].

2.2 Related Works

In this part, we present some works which are closely related to our works. We classify the related works to clarify the differencee of our work.

2.2.1 Necessity of good UI Design

It is necessary to develop a good UI design to create a good interaction between a user and a system. However, the UI design for the children with autism is challenging because a designer and autistic children do not share the same experiences in their life. Additionally, for the UI design, visualization is also an important part because children are always attracted to the bright and shiny animations. A scintillating visualization can support the autistic children to learn and communicate easily [5]. Children with autism were often referred to as visual thinkers [6]. It is also reported that the autistic children learn better through visuals rather than traditional methods [7]. A picture exchange communication system (PECS), Treatment and Education of Autistic and related Communication - disabled Children (TEACCH) programs are examples of the successful method of teaching which is mainly focused on visual learning [8]. Many autistic children are involved with visual media, and they are more interested in learning by this method. [9]

2.2.2 Mobile Applications for Autistic Children

The learning process for the autistic children can be improved by using mobile devices [10]. Many mobile applications have been designed for the autistic children to increase the counting skill ability. To achieve self-determination basic learning skill is needed. [11] Counting skill learning application and TaLNA is the mobile application which is developed to improve the autistic children self-independence, learning capability and quality of life. Fairus et al. introduced counting skill learning application to improve the counting ability using touchscreen mobile phones [12]. In 2016, they launched a mobile app TaLNA for the autistic children to assist the learning numeracy and necessary calculation through touch screen mobile phones [13].

2.2.3 Virtual Reality for the Autistic Children

Some VR applications have investigated social skill training for children with ASD [14][15]. Selvia Kuriakose and Uttama Lahiri introduced Virtual reality to design an application which is used for the children with autism to learn social tasks. They attempt to create a tool that can allow real-time measurement of individual's performance and mapped to individuals anxiety while they are interacting with the VR based social tasks [16].

2.2.4 Importance of Augmented Reality

Augmented reality (AR) is also giving support to the autistic children for imagining the real picture. It is an interactive technology and a supportive tool for the children with autism. By using augmented reality, it is possible to make an interactive and attractive user interface which can be controlled by hand without using any external devices [17]. This aspect is raising interest and curiosity to the tasks.

2.2.5 Augmented Reality Based Applications

Many researchers have been already conducted on this topic. An augmented reality game therapy for the autistic children have been introduced. The game therapy aims to enhance social interaction and hand-eye coordination [18]. Moreover, a game book has been designed to assist the autistic children to recognize and acquire emotions by engaging their attention. The game book will facilitate the interaction between autistic children and his/her imaginations as well as it will help to identify the correct emotional face to the specific situation [19]. Taryadi et al. introduced a training system using augmented reality for the Picture exchange communication system (PECS). It will help the autistic children to know about the new pictures or objects with related keywords [20]

2.2.6 Augmented Visual Support

Augmented visual support is also making the user interface more attractive for the children with autism. During object discrimination therapy teachers uses some visual aid which is not interactive to the autistic children. AR is engaging and interactive to support teachers during therapies. It is also helping the autistic child to improve their interaction level [21].

2.3 Conclusion

As the system is going to be used by the particular child's so, it is crucial to design an interactive user interface which will interact with the children. Augmented reality, the colorful UI design, Audio, and Animation can give the autistic children real-time feelings for the specific scenario. To design the UI, some rules should be followed to make the interface more interactive, attractive and friendly also [22]. A methodology has been discovered by the UK Department of Health for preparation of documents for the learning disabilities children [23]. Our mobile application PLaN has been developed for the children with autism to learn the basic numeracy and calculation through an interactive user interface. People in a huge variety of occasions, environments, and conditions also are benefited via it [24].

Chapter 3

Graphical Design Principle and Design Process

3.1 Introduction

Not every application is useful to everyone, and neither can fulfill every requirement. It can and should be developed for a particular group of people and should be able to do a specific thing properly. It is not possible to create an application for individuals but can be done for individual groups of people. What application will have and who will be the target users are decided way before staring at design let alone develop. And as per their needs, likings, disliking's the system is designed and developed. The whole working process again is done in various phases.

3.2 Design Process Phases

3.2.1 Target Identification

For our application, the target users are mild category autism children, and its specific task is to teach numeracy and necessary calculation like addition and subtraction. Application's outlook, content, process flow, user interface, color, maturity, etc. depends on the target users for whom the application is being developed. This is why the first criteria are to identify the target users and gather knowledge about them. After that according to their needs, preference, disliking, comfort, and test the designs are done.

3.2.2 Gather Knowledge about the Target

Identifying the target users and the task of the application the next thing to do was to get an expert opinion about the background knowledge, capability, nature, likes, dislikes, and the behavior of the users. Taking that into consideration the designer made a blueprint of the application. How the manual methods were applied for teaching were taken into account for the application content. By those traditional manual methods which were used for instruction and evaluating the elements and the tasks that should be in the design were finalized.

3.2.3 Relate with Existing Methods

Having the traditional methods then the modern techniques were studied. How can the application be more accepted, attractive, accessible and also helpful to the user? How to make it more interactive and easily relatable to real life. From the study, the content of augmented reality was included in the design.

3.2.4 System Flow Chart

Having all the content the basic design was made. Then the next task was to finalize the process flow. What should come after what and how should the application start and how to end. From beginning to end with the internal flow, everything was decided. The designers, developers, and researchers discussed and developed a flowchart suitable for it (figure 1). The tasks of the application were designed considering the primary focus which is to teach numeracy and calculation, addition and subtraction to be exact and being interactive.

The tasks include features to teach the children numbers, how to identify numbers, count and how to write them. Tasks to evaluate (figure 2.) them will appear after the learning sessions. Reinforcement will be given in the evaluation levels. Through which the application interacts with the user. Afterwards the calculation learning and

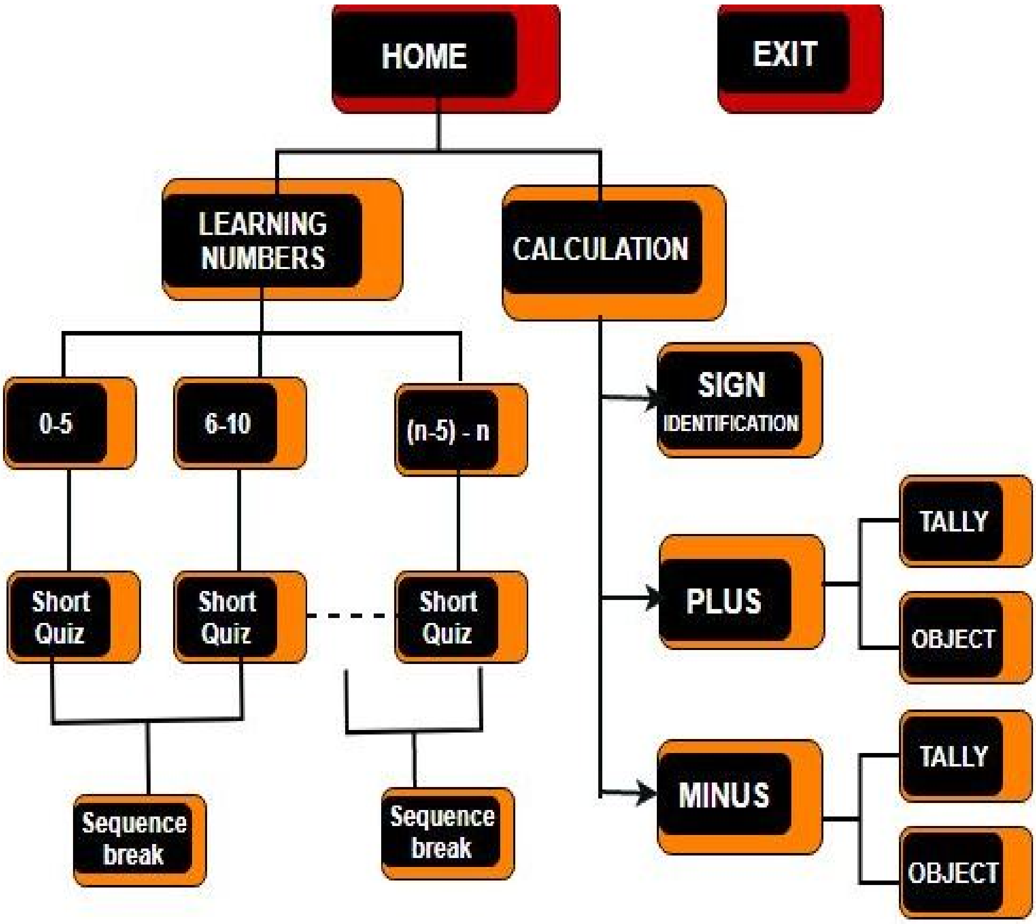


Figure 3.1: Design flow of PLaN application.

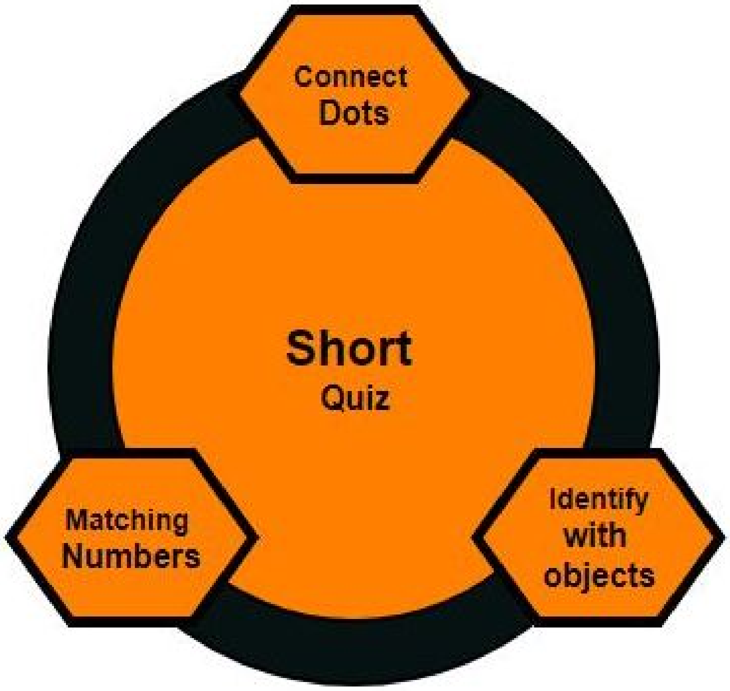


Figure 3.2: Design flow of Short quiz.

evaluation part will appear. The learning, evaluation and reinforcement part will be same as numeracy learning.

3.2.5 State Diagram of the System

After this, the state diagram was designed to make the application flow smooth and logical. Figure 3 and 4 represents the state diagram of our application. This demonstrates the process flow. The whole process is divided into two main divisions. Number learning and calculation. Thus there are two separate state diagrams.

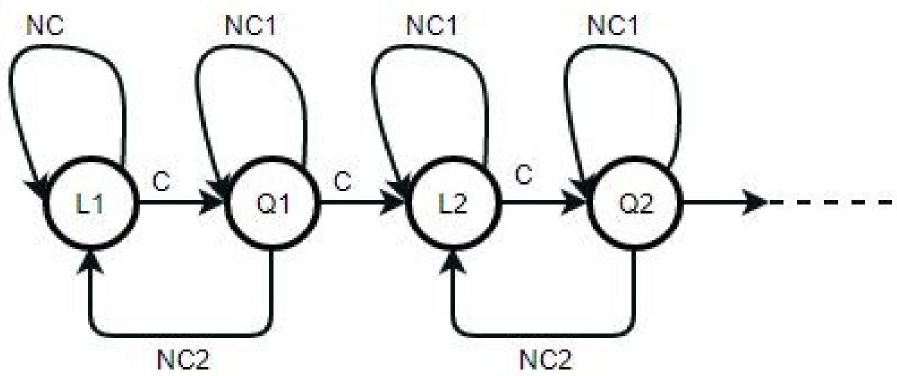


Figure 3.3: System Flow of Learning Number.

Figure 3 represents the system flow of number learning. Here there is again two subcategory. First one is to teach number then to evaluate the users who are designed in levels. In level one (L1) users will learn from 1 to 5. If the user completes this level, then he/she can go to next level which is the evaluation level denoted as quiz one (Q1) wherein many ways users will be attending some short quizzes to evaluate what they learned. But if the user can not complete this level he/she will not be able to go to the

Q1 level and instead will remain in L1. If the user is unable to achieve the Q1 level then for the first not completed (NC1) case he/she will be at the Q1 level. But the user cannot achieve the level for the second time means second not completed (NC2) case he/she will go to L1 level. Because for the second time being unable to complete we assume that user needs to learn more. And when a user ends Q1 he/she is allowed to go to next level which is L1 and here they will be taught numbers from 6-10. Achieving L2 enable a user to go to quiz two (Q2) level. And thus the level continues for 'n' numbers.

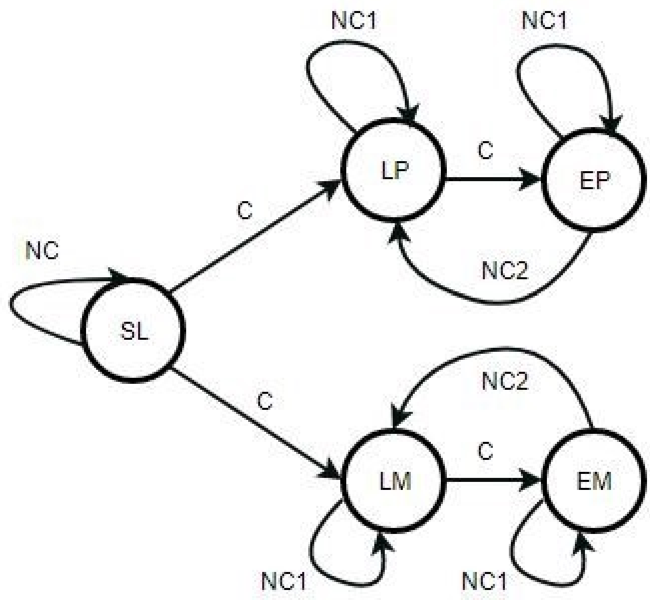


Figure 3.4: System Flow of Calculation.

Figure 4 represents the system flow of our second phase which is the calculation part. This is also divided in the subcategory. First is the signed learning (SL) where we introduce the user with plus and minus sign. Completing this allows the user to go either in learning plus (LP) or to learning minus (LM) level as per user's choice. In both cases, the user is taught how to do plus for LP and minus for LM. Completing these levels allows the user to go to the next level which is the evaluation part. Evaluate plus (EP) if the user completes LP and evaluate minus (EM) if the user completes LM. But if unable to complete then the user will remain on LP or LM level. If a user achieves the EP and EM level, then the calculation phase is over. If unable to complete then for the first time not completed (NC1) case he/she will be on EP or EM level and the second time being unable to complete NC2 case will take them to LP or LM level assuming that user needs to learn more.

3.2.6 Research on Existing User Interfaces

When the design and system flow part is done then next in queue is the user interface. Before building new UI, existing ones were taken as reference. All the same type of existing applications interfaces were studied well for idea generation. Making the application user-friendly and accepted by the users. Outer look is the most crucial factor in this case. A good UI is everything for an application. It is all about the first impression. It decides a lot for the future of the application on whether users will use it or not. Without liking the design, a user may not use it enough to understand and like the application.

3.2.7 Design UI Mock-up

Finalizing the UI design comes the time when all the ideas are to put on paper. Here the whole process design and features were discussed over and over again before making a mock-up to test the product by some end users. Designers studied and analyzed user's interaction with the interface. Before the actual application development, the mock-up was made as per the researchers and the ideas till this phase. It is to prevent any misunderstanding and the final editing of the application. This helped to improve the system in functional terms.

3.2.8 Mock-up Testing

After that the prototype was tested by users designers could analyze the features which they can improve more. For making the application more acceptable, usable and approachable for our end users. Passing all the phases now comes the testing phase. Testing is done so that the flaw and faults come to light. From the test results, the mistakes were corrected, and the system went through more analysis and error correction. The whole process was re-evaluated until achieving the acceptance level.

3.2.9 Application Development

When all the errors were fixed, and we had a final design of the application in front when it comes the turn of developing the application. The application was developed as per the final model containing all the contents, tasks and following the same flow that was in final design. After that, all the small bugs were corrected, and a final product was ready for data collection phase.

3.2.10 Application Test and Data Collection

Only developing it makes no change until one can get real data to check whether the application is good enough and fulfills its criteria or nor. This is why after development phase the app was taken for data collection. By some end users, real-life data were collected for the next period which is a simulation.

3.3 Graphical Design Principal

Graphical user interface (GUI) design principle ensures a better UI for applications. Concerning application features, some relevant aspects vary. PLaN's UI design is built upon ten principles. First one is 'User-Centric', likewise, for every this guideline, each requisition need a particular motivation. UI must be clear enough for the user to understand what it is actually about. This can be interpreted by no confusions (Ashni Sharma). The second principle is 'Cut out the Clutter', this concerns with users attention. Making the screen less complicated as possible by adding only those stuff that is mandatory for that page. Doing one action per screen does that. Keeping the main component will not distract user (Nick Babich). The third one is 'Visible Interface Element', this says to use sufficient color contrast such a way that interprets and emphasizes the content. Also, those low vision users can see and use it effortlessly. The fourth principle is 'Finger-Friendly Tap-Targets', this is about users repose. The mobile interface is small so for easy figure tap targets must be big enough. The fifth is 'Intelligent Consistency Principle', these talks to use same or alike screens for similar functions. This helps the developer to concentrate on making less and more attractive screens which can be slightly modified for a different use [25]. The next principle is 'Consistency of the Design Layout' according to this the application must have rationality throughout the design. It keeps the steadiness of application. The seventh one is 'Clarity', as per this principle the UI should have clarity. This means interface design is to be actually so that user can realize the purpose of it and is easy to use. Next is 'Visibility Reflects Usefulness Principle' this says to make those user control visible which are frequently used and hide those which are used less recurring. The ninth principle is 'Clustering Principle.' This is about the organization. Keep the sister controls separately visually this helps the user to find the required command easily as is separated into blocks which also helps in acquiring the conceptual organization system. The last is 'Hand Position Based Controls Design', 49% of user use a thumb to operate. Users are comfortable to interact with the thumb in some areas of the screen. This is why the frequently used controls, top-level menu and the standard actions should be placed there. Rules are established for the guiding principles for people with learning disability. The rules applied are as follows [26]:

1. Each idea needs both words and pictures, as both elements are equally important.

2. Pictures and words go next to each other, as this helps more people to understand

the information..

3. Make sure that it is clear which picture support which bits of text.
4. Pictures must be easy to understand.
5. Pictures should go on the left.
6. Drawings, photographs or other images can be the pictures.
7. Make sure that pictures are as big as possible.
8. Words must be easy to understand.
9. If difficult words are used, say what they mean in easy words.
10. Words go on the right.
11. Words must be written clearly.
12. Words must be big.
13. Each sentence should be as short as possible, not more than 15 words.
14. Each document must be short.

These principles are a must to follow while designing any interface for autism children. PLaN is made for autism children especially. Thus all the rules and principles were strictly followed while creating the UI. Some additional expert recommendations and opinions were also considered. Abide by all these laws the UI fulfills all requirements.

3.4 Conclusion

There are some systematic and sequenced steps that should be followed to accomplish any work smoothly and successfully. Same goes for developments. Depending on what is being developed and for what purpose the rules steps varies but the process are same. Even in our case we did the same. By following the design principle and systematic step by step works made the whole process easy and successful.

Chapter 4

User Interface

4.1 Introduction

PLan is a numeracy and basic calculation learning interactive application. It was designed considering that it is primarily for the use of autism children. PLaN will help an autistic children to better their daily life relating with numbers and mathematics. It is a useful application to learn basic numeracy and calculation both inside and outside the classroom.

4.2 Homepage

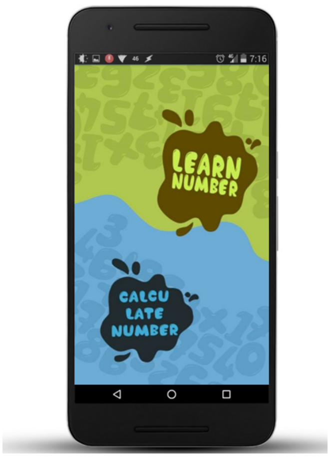


Figure 4.1: Home Page.

Figure 4.1 is the home page. The app is divided into two categories as shown in Figure 4.1. Learning number and the second one is calculated the number. From this page user will choose their required type.

4.3 Levels of Learning Numbers

Figure 4.2: Learning number levels.

Figure 4.2 represents the page users will find if their required category is learning the number. Here the process is divided into two subcategories learning and quiz. Users will eventually learn and will be evaluated numbers from 1 to n through many levels. In each learning level, the range of number is 5. And to assess them after each learning level there is a quiz of that level which decides if the user is ready to go to next level or not. There is also an augmented reality-based learning option.

4.4 Recognize Number

Level of leaning number is demonstrated in figure 4.3. In the center, the digit will appear with voice over. Below that same number of objects will appear too. There are two more buttons, next and previous through which the user can go to the next or previous

Figure 4.3: Recognize Number.

digit. There is a speaker button so that user can hear the digit over and over again as per their choice which is on the upper right side. Which makes this feature interactive. This feature along with the number learning will help with users counting, listening and also visual skills

4.5 Options for Short Quiz

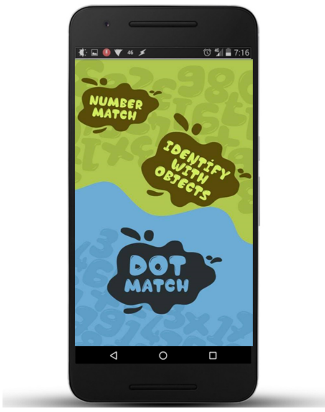


Figure 4.4: Quiz option.

Each quiz levels are subcategorized in three sectors, number matching, object identification and dot matching as in Figure 4.4, where three different types of the short quiz will evaluate the user whether he/she learned the digits in the learning level or not.

4.6 Match Number

Figure 4.5: Number Match.

By choosing the Number Match option, users will have figure 4.5 in front of them. In this feature, multiple choice type quiz will be conducted with numbers. In the center, a digit will appear, and there are four options where there are three more digits along with the correct one. The user will have to match the correct option. If the answer is correct a "Correct" reinforcement will appear and next question. If wrong a "Wrong" reinforcement will appear. This makes this feature interactive. This specific function of evaluating users learning ability is also evaluating their recognition and matching capacity.

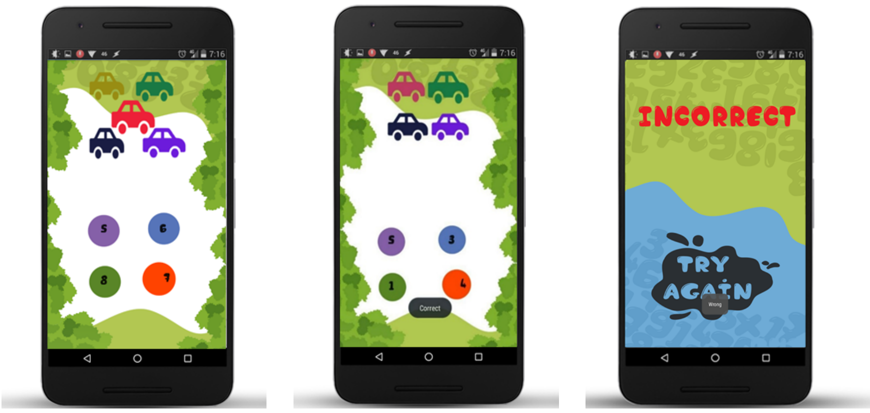


Figure 4.6: Object identification.

4.7 Identify with Object

If the user chooses the Identify with Objects, they will get the figure 4.6 page. Same as the previous one in this feature multiple choice type quiz will also be conducted, but with objects. In the center instead of a digit in this case number of objects will appear and there are four options where there are four options along with the correct one. The user will have to choose the correct option. For the correct answer, “Correct” reinforcement will appear and next question. If wrong a “Wrong” reinforcement will appear. This makes this feature interactive. Cognitive and counting ability of the users is also being evaluated by this feature along with number learning.

4.8 Dot Match

By choosing the dot match option user will get figure 4.7. In the center, there is a dotted pattern. In the upper left corner, there is alphabetic instruction and bottom right corner the digit is shown that the user will have to complete by connecting the dotted pattern. If succeed a reinforcement will appear congratulating the user is wrong then wrong will

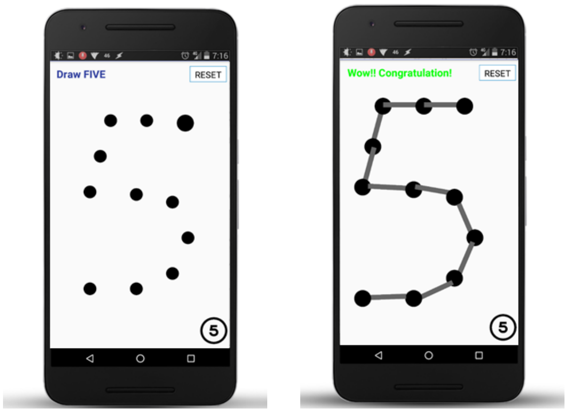


Figure 4.7: Connect the dots.

appear. There is also a reset option for the user in the upper right corner do repeat the task. This feature evaluates users hand motor and instruction understanding skill.

4.9 Augmented Reality

Figure 4.8: Augmented reality

Figure 4.8 represents the feature that user will get if they press the AR view button.

This feature is here to make the learning more realistic, to make it more interactive and also to gain users concentration more towards the application.To relate the world and objects to the learning of users. A flash card is scanned by the camera and number of objects matching with the digit in the flash card will appear on the screen above the flash card. The user can move, rotate and also zoom in or zoom out the object as per their choice. This improves their concentration, learning ability and relating the graphics object with the realistic one.

4.10 Calculation

Figure 4.9: Calculation page.

The calculation part again consists of three subcategories shown in figure 4.9. Sign for the sign recognition, plus for learning and evaluating plus and minus to learn and assess minus.

4.11 Sign Recognition

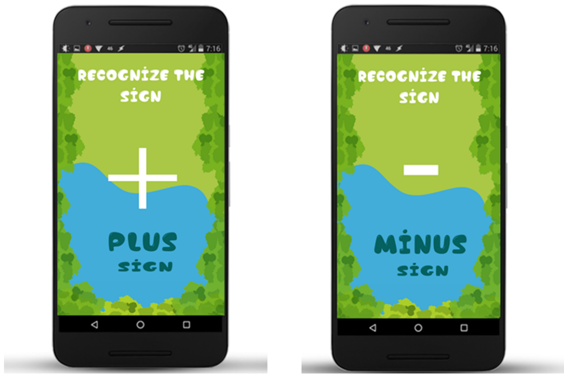


Figure 4.10: Sign recognition.

Figure 4.10 shows the Sign page. Here primarily we kept only the plus and minus sign because for multiplication and division one must know the number table and we are not teaching the users that this is why only plus and minus sign is here. In the center, the sign will appear and under that alphabetically the name of the sign. There is the next and previous button to change the signs.

4.12 Option for Plus and Minus Category

For both the plus and minus option, there are two subcategories under each of them. Figure 4.11 represents that page. Here the users are again presented with two options learning how to do plus and minus and a quiz to evaluate their learning same as learning number case.

Figure 4.11: Calculation option.

4.13 Learn Calculation

Figure 4.12: Learn Calculation.

Figure 4.12 is the learning plus and minus page. In both cases Plus and Minus user choosing the learn button will take them to this feature. Here addition and subtraction of two digits are shown in the center of the page, and the result is shown below. The next button randomly will change the digits and the answer with that

4.14 Evaluation (Plus)

Figure 4.13: Evaluation Page(Plus).

Figure 4.13 demonstrates the evaluation page of plus. From both Plus. If the user chooses the quiz button from plus this feature will appear to them. Here addition of two digits are shown in the center of the page under that users are given four options from which they have to choose the correct one. This is also a multiple choice type quiz. Users will get "Correct" reinforcement for the correct answer and "Wrong" for the wrong answer.

4.15 Evaluation (Minus)

Figure 4.14 demonstrates the evaluation page of Minus. Choosing the quiz button from minus this feature will appear to them. Same as the addition one here subtraction of two digits are shown in the center of the page under that users are given four options from which they have to choose the correct one. This is also a multiple choice type quiz. Users will get "Correct" reinforcement for the correct answer and "Wrong" for the wrong answer.

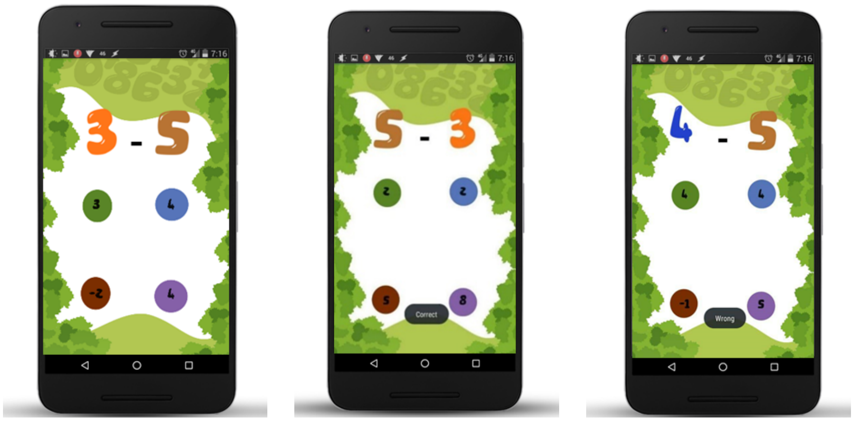


Figure 4.14: Evaluation Page(Minus).

4.16 Conclusion

UI represents the application. Without a good UI application is not preferred by the user. After all look does matters in this case. As our application is developed for the autism children so in this case the UI have a huge impact on the application. Each and every content, objects and color too are very well studied and then finalized keeping in mind about the target users. To get the application accepted and preferred by the users.

Chapter 5

Experiment and Performance Evalaution

5.1 Introduction

A research or system is not fulfil or accepted unless getting any realistic output or real life data. Only developing an application does not make it successful or useful for a task until it is tested and actual users have used it and gave feedback. Thus to test the actual usefulness and performance of our application we tested it by some target users and collected data for result analysis.

5.2 Experiment and Methods

5.2.1 Participants

To verify our application, measure the acceptance level and get real-life data we went to an autism center to test it with some children. Our test was conducted in two separate groups of children. Group 01 are the primary category. They still have a problem with performing day to day tasks. They are learning the basics before going to preschool. Group 02 are the preschool category. They can do the day to day task quite frequently and are ready to go to school. Means that they are at that level where they can relate to education. Total eight children were taken as a performer, three children from group 01 and five children from group 02. These children are four different categories.

5.2.1.1 Autistic Disorder:

They usually have significant language delays, social and communication challenges, and unusual behaviors and interests, intellectual disability.

5.2.1.2 Down syndrome:

The condition leads to impairments in cognitive ability and physical growth that range from mild to moderate developmental disabilities.

5.2.1.3 Asperger Syndrome:

They have some milder symptoms of autistic disorder. They have social challenges, unusual behaviors, and interests. But they usually do not have any language or intellectual disabilities.

5.2.1.4 Pervasive Developmental Disorder:

They usually have fewer and milder symptoms than those with autistic disorder. The symptoms cause only social and communication challenges.

For our present system, we took different categories of children being in two different levels so that we can have the data for a variety of children. And does not fall into a specific class

5.2.2 PLaN Numeracy and Calculaion Learning Application Experiment towards Autistic Children

The PLaN learning application has been tested to several numbers of autistic children in a special children school which is located in Dhaka, Bangladesh. For the experimental test, we need to be lead and guided by the respective teachers of that school. Many students were operating the application by their hand; sometimes they need our help to run the application(Figure 5.1). Most of the students were thrilled to hear the sounds of the app, and they like our user interface design also. Moreover, the performance of the children's was satisfactory.

After seeing the application, the teachers said that it is a useful application for the autistic children to learn the basic numeracy and calculation in and outside of the classroom

Figure 5.1: Application testing time towards autistic children.

5.2.3 Experimental Procedure

To observe and understand our application minimum required time is 15 minutes approximately per participant. During this time they interacted with the system and introduced with all the features. The experiment was conducted one by one. It was conducted by the performer and the application. Firstly the application was given to participant, and his/her moves were noted. After explaining a specific feature rest of the interaction was done by the participant. This explanation was not necessary for all the participants. Performer 01, 02, 03 and 06 needed some clarification. Especially for calculation, number identification, and object identification. The interaction time of each performer in each feature, their preference in each feature, learning outcome from each function was noted. Some extra parameters like the previous task of each performer mean the last task a performer did before conducting the experiment and relation with any change in environment with performer's attention was also noted. This whole process was repeated for eight performers in two different days as per the groups.

5.3 Result and Performance Analysis

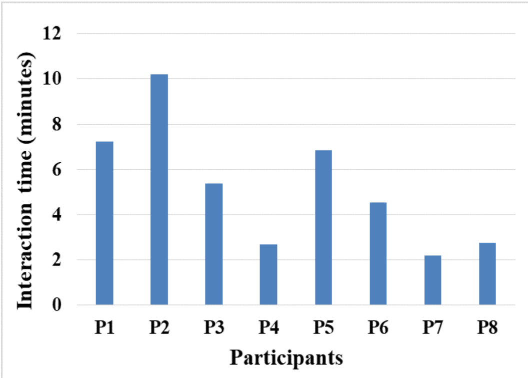
Interaction time with a feature was noted for each participant. The time was recorded from the moment one entered on this page until exit. The application being an interactive interface, so the interaction time is an important parameter. Learning outcome from a particular feature for the participants was also noted. Depending on how fast or slow a participant is learning and his/her feedback the learning outcome is divided in ('very slow'/ 'slow'/ 'moderate'/ 'fast'/ 'very fast'). This parameter is needed as ours is a learning application.

5.3.1 Recognize Number

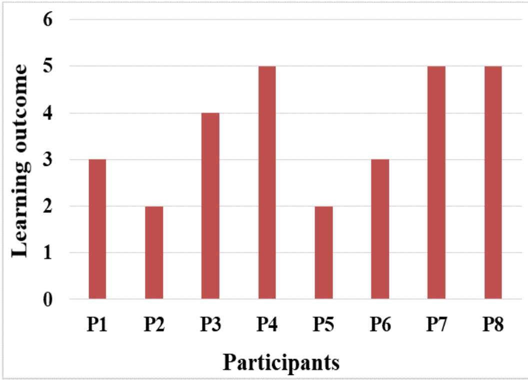
This is the number teaching feature. Interaction time and learning outcome from this feature are noted for each performer and put together in the table 5.1. Participants had a different preference for this feature. All 3 participants of group 01 preferred the voice over option only. From which the number can be heard over and over again. Group 02 participants had more verity of preference. Participant P4, P7, and P8 preferred the voice over, the next button pressing on which the following number appears and also the cars which are there so that they can match number objects with a digit number. Participant P5 preferred only the voice over option and participant P6 preferred the sound over and the cars. According to the table participant, P2 interacted for the highest time 10.20 minutes, and participant P7 communicated for the lowest time 2.20 minutes.

Table 5.1: Performance and preference of participants for recognize number feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	7.23	Moderate	Audio
	P2	10.20	Slow	Audio
	P3	5.39	Fast	Audio
Group 02	P4	2.66	Very Fast	Audio, Cars, Next Button
	P5	6.83	Slow	Audio
	P6	4.54	Moderate	Audio, Cars
	P7	2.20	Very Fast	Audio, Cars, Next Button
	P8	2.73	Very Fast	Audio, Cars, Next Button



(a)Interaction time.



(b)Learning outcome.

Figure 5.2: The impact of recognize number feature on eight participants.

From figure 5.2(a), we see that all most the participant's interaction time was quite good except P4, P7, and P8. Again from figure 5.2(b), we see that P2 and P5 learning outcome was the lowest. Comparing both figures, we can say that though P4, P7, and P8 interact with the feature for the smallest time still their learning outcome was the highest. On the other hand, P2 communicated for the highest time, but his learning outcome was the weakest.

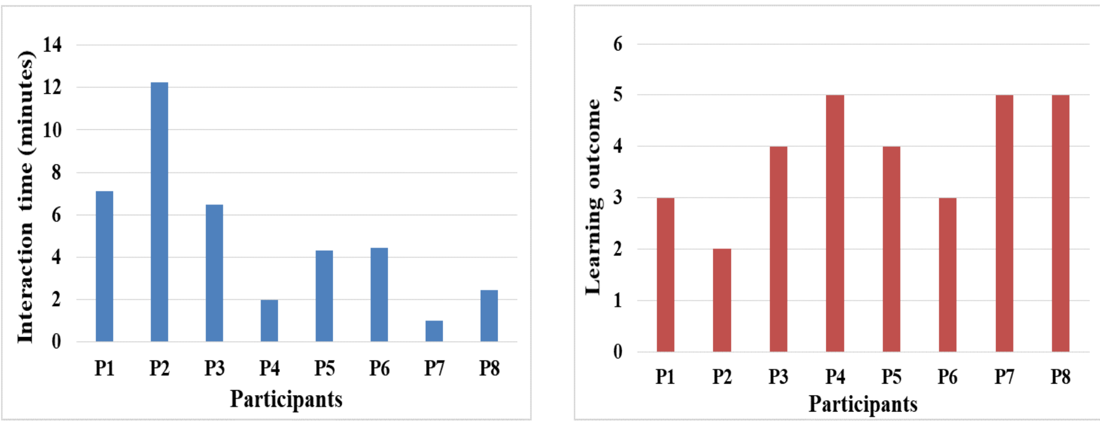
5.3.2 Object Identify Table

This is one of the quiz features. Performers have to match digit with given number of objects. Like the previous feature, the interaction time and learning outcome from this feature are noted for each performer and put together in the table 5.2. Participant's preference for this feature is, participant P1 and P2 liked only the buttons. They randomly pressed the buttons to get the "Correct" or "Wrong" message. Participant P3 liked the button, and also the objects were given. Participant P5 preferred only the Objects and rested preferred the given objects, button, and even the background of the feature attracted them. From the table, we can see that participant P2 had the highest interaction time of 12.25 minutes and participant P7 had the lowest interaction time of

1.00 minutes.

Table 5.2: Performance and preference of participants for object identify feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	7.10	Moderate	Buttons
	P2	12.25	Slow	Buttons
	P3	6.50	Fast	Buttons, Cars
Group 02	P4	2.00	Very Fast	UI, Cars, Buttons
	P5	4.32	Fast	Cars
	P6	4.44	Moderate	UI, Cars, Buttons
	P7	1.00	Very Fast	UI, Cars, Buttons
	P8	2.45	Very Fast	UI, Cars, Buttons



(a)Interaction time. (b)Learning outcome.

Figure 5.3: The impact of object identify feature on eight participants.

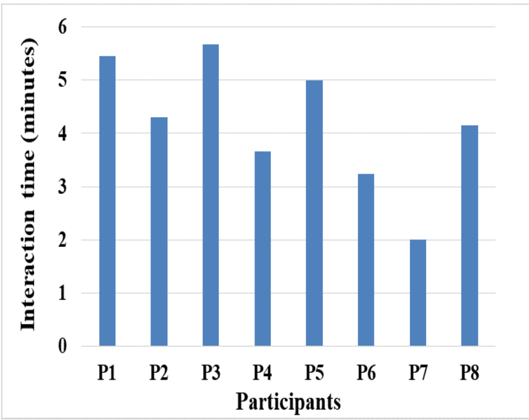
Figure 5.3(a) shows that P7 had the lowest interaction time. P4 and P8 also had less interaction time than rest of the participants. Again figure 5.3(b) shows that learning outcome of the participants for this feature was quite good except P2. And comparing both figures, we can say that P7 having the lowest interaction time with the feature had the highest learning outcome. But P2 having the highest interaction time with the feature had the most moderate learning outcome.

5.3.3 Number Identify Table:

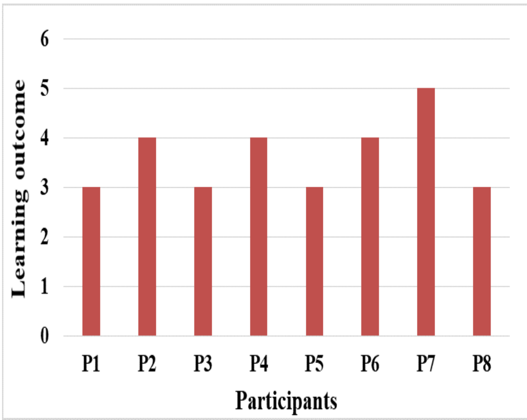
This is another quiz feature. Here performers have to match digit with given number. Same as previous features, the interaction time and learning outcome are noted for each performer separately and put together in the table 5.3.Participant's preference for this feature is, participant P1, P2and P3 liked only the buttons. They repeatedly pressed the buttons and saw "Correct" or "Wrong" message. Participant P5 preferred only the Digit with which the correct number is to be matched, and participant P4, P6, P7, and P8 preferred the showed digit, button and the background of the feature too. From the table, it is visible that interaction time of participant P3 is 5.67 minutes which is the highest and interaction time of participant P7 is 2.00 minutes which is the lowest.

Table 5.3: Performance and preference of participants for Number Identify feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	5.45	Moderate	Buttons
	P2	4.30	Fast	Buttons
	P3	5.67	Moderate	Buttons
Group 02	P4	3.66	Fast	UI, Numbers, Buttons
	P5	5.00	Moderate	Numbers
	P6	3.24	Fast	UI, Numbers, Buttons
	P7	2.00	Very Fast	UI, Numbers, Buttons
	P8	4.15	Moderate	UI, Numbers, Buttons



(a)Interaction time.



(b)Learning outcome.

Figure 5.4: The impact of number identify feature on eight participants.

Figure 5.4(a) shows that all the participants interaction time for this feature quite high except P7. Again from figure 5.4(b), it is visible that learning outcome of the participants for this feature was excellent on average. By comparing both figures we can say P1, P3 and P5 having the highest interaction time here have less learning outcome than other participants. But for P7 it was minimum interaction time with maximum learning outcome.

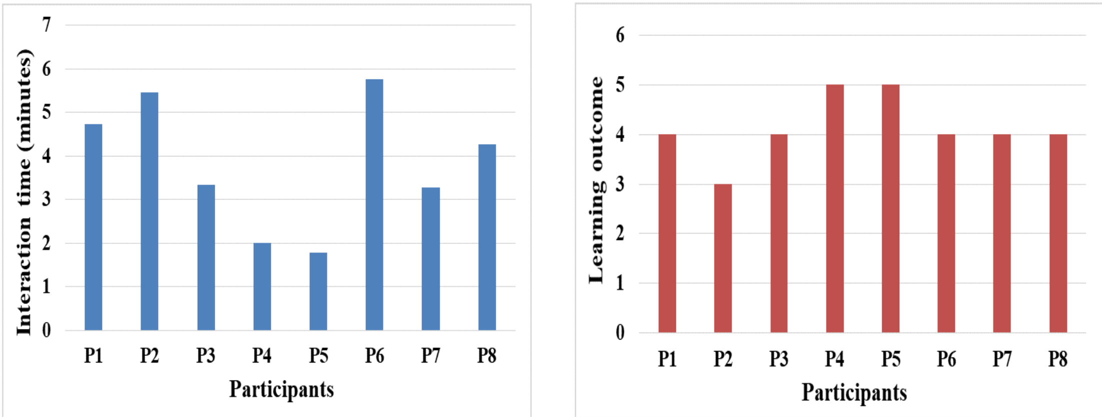
5.3.4 Dot Match Table:

This is another quiz feature. Here performers have connected the dotted pattern to make a digit. Like the previous features, both interaction time and learning outcome are separately noted for each performer and put together in the table 5.4. Participant's preference varied for this feature also. Participant P1 and P2 liked only the dotted pattern and connected it. Participant P3 along with the pattern like the reset button even by pressing which the connected pattern goes back to its dotted form. Rest of the participants preferred the pattern, reset button and also the reinforcement which cheers them. The table shows that participant P6 does the highest interaction and the time is 5.76 minutes, and that lowest interaction is done by a participant of participant P5 and the time for this case is1.79 minutes.

Table 5.4: Performance and preference of participants for Dot Match feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	4.72	Fast	Pattern
	P2	5.45	Moderate	Pattern
	P3	3.34	Fast	Pattern, Reset Button
Group 02	P4	2.00	Very Fast	Pattern, Reset Button, Reinforcement
	P5	1.79	Very Fast	Pattern, Reset Button, Reinforcement
	P6	5.76	Fast	Pattern, Reset Button, Reinforcement
	P7	3.27	Fast	Pattern, Reset Button, Reinforcement
	P8	4.26	Fast	Pattern, Reset Button, Reinforcement

Figure 5.5(a)shows that interaction time of the participants was quite high for all except P4 and P5. P4 and P8 also had less interaction time than rest of the participants. From figure 5.5(b) we see that learning outcome of all the participants for this feature was excellent. And comparing both figures, we can say that P4 and P5 having the lowest interaction time among all had the highest learning outcome.



(a)Interaction time. (b)Learning outcome.

Figure 5.5: The Impact of Dot Match Feature on Eight Participants.

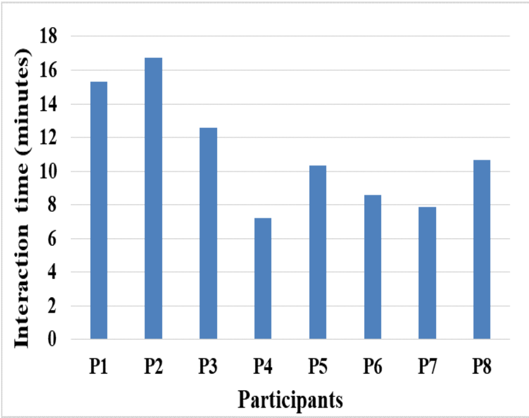
5.3.5 Augmented Reality Table:

This feature is for both, to give the children a real-life feeling and to teach them to identify some objects with a digit. This one is also a teaching feature. Same as previous features, interaction time and learning outcome are noted and put together for each performer separately. Participant's preference in this case is, participant P1 and P3 liked the fact that objects appear on different cards. All other participants along with that point also liked that they can move the objects as per their choice and also can zoom in and zoom out them. From the table 5.5, we can state that maximum interaction time was 16.76 minutes for participant P2 minimum interaction time was 1.00 minutes for participant P7.

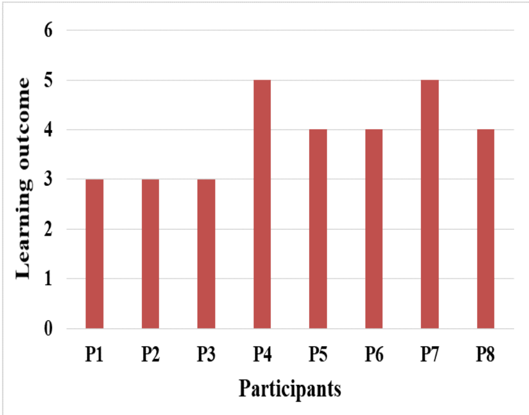
Table 5.5: Performance and preference of participants for Augmented Reality feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	15.34	Moderate	Objects
	P2	16.76	Moderate	Objects, Move
	P3	12.56	Moderate	Objects
Group 02	P4	7.20	Very Fast	Objects, Move, Zoom
	P5	10.33	Fast	Objects, Move, Zoom
	P6	8.59	Fast	Objects, Move, Zoom
	P7	7.86	Very Fast	Objects, Move, Zoom
	P8	10.67	Fast	Objects, Move, Zoom

From figure 5.6(a) we see that interaction time of the participants was the highest for all participants. P4 had less interaction time comparing with other 7 participants. And from figure 5.6(b) we see that learning outcome of all the participants for this feature was also excellent on average. Comparing both figures, we can say that among all the participants, P4 having the lowest interaction time with the feature had the highest



(a)Interaction time.



(b)Learning outcome.

Figure 5.6: The Impact of Augmented Reality Feature on Eight Participants.

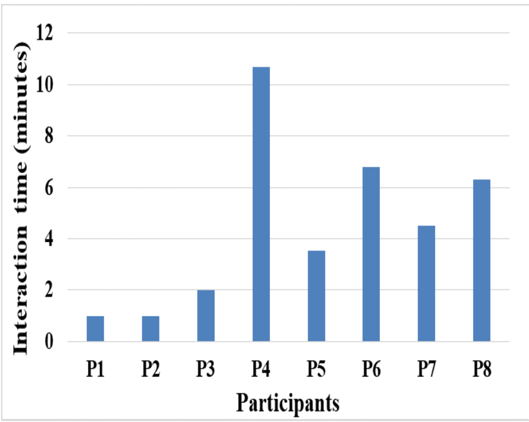
learning outcome. On the other hand P1, P2 and P3 who had the highest interaction time had the most moderate learning outcome.

5.3.6 Calculation Table:

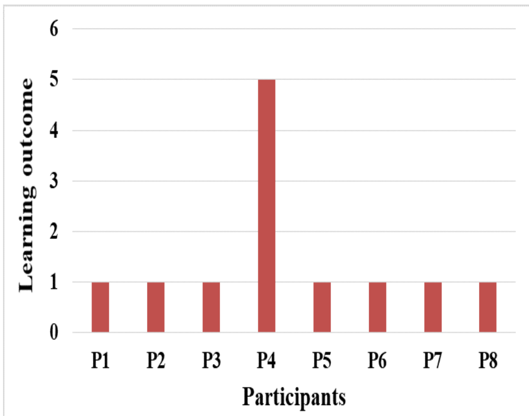
This is the calculation feature. Here performers learn and are being evaluated for addition and subtraction. Like as other features, the interaction time and learning outcome are noted for each performer separately and put together. This feature participant's preference is, participant P1, P2, P3, and P5 liked the buttons only. Participant P4, P6, P7, and P8 preferred the button and the background too. The table 5.6 shows that interaction time of participant P4 is 10.70 minutes which is the highest and interaction time of participant P1 and P2 is 1.00 minutes which is the lowest.

Table 5.6: Performance and preference of participants for Calculation feature.

ID		Interaction Time (minutes)	Learning Outcome	Preference
Group 01	P1	1.00	Very Slow	Buttons
	P2	1.00	Very Slow	Buttons
	P3	2.00	Very Slow	Buttons
Group 02	P4	10.70	Very Fast	UI, Buttons
	P5	3.54	Very Slow	Buttons
	P6	6.80	Very Slow	UI, Buttons
	P7	4.50	Very Slow	UI, Buttons
	P8	6.30	Very Slow	UI, Buttons



(a)Interaction time.



(b)Learning outcome.

Figure 5.7: The Impact of Calculation Feature on Eight Participants.

Figure 5.7(a) shows that for this feature on average interaction time interaction time was right for some participants and some it was not so good. For P1 and P2 it was very less. For P3 also, though P3's interaction time was more than that of P1 and P2. And figure 5.7(b) shows that learning outcome of the participants for this feature was not functional except P4. The reason behind this scenario is that among all the 8 participants only P4 had the required capability for this feature. Others were not at that level of using it. Now, comparing both figures, we can say that P4 had the highest interaction time and also the highest learning outcome.

5.3.7 Concentration Table:

Though this data is not required for our present work, still for future work these might be of help. Here for each participant, we noted the category of the participant, before attending to our survey what was the last task or last thing the participant did from which ones mental and physical condition at that moment can be guessed. Another parameter that was noted is whether any change in the environment had any effect on the participant's concentration or not. Means whether the participant was distracted from the application because of any change in the environment where he/she was using the application or not. All these three parameters were noted individually for each participant and put together on the table 5.7.

Table 5.7: Individual Participant's Condition.

ID		Last Task	External distraction	Categories
Group 01	P1	Dance Class	Distracted	Autistic Disorder
	P2	Music Class	No effect	Down syndrome
	P3	Assembly	Distracted	Down syndrome
Group 02	P4	Play	No effect	Asperger Syndrome
	P5	Math Class	Distracted	Pervasive Developmental Disorder
	P6	Math Class	No effect	Asperger Syndrome
	P7	Play	No effect	Asperger Syndrome
	P8	Play	No effect	Asperger Syndrome

5.3.8 Performance Table:

Here the performance of a participant is being measured from the time the participant interacted with a feature and the learning outcome form that feature for that participant. Interaction time is recorded in minutes. And we gave weights for learning outcome as 'very slow' (1), 'slow' (2), 'moderate' (3), 'fast' (4) and 'very fast' (5). We denote Performance as Prfm, Interaction time as IT, learning outcome as LO. So performance of a participant for each feature is,

$$Prfm = IT * LO, \tag{5.1}$$

According to this formula performance of each participant individually for all six features is calculated. And from that total performance of each participant is calculated. And are put together in the performance table (VIII). Total performance of a participant is the summation of performance in each feature. Recognize number (RN) = f1, Object Identify (OI) = f2, Number identify (NI) = f3, Dot match (DM) = f4, Augmented Reality (AR) = f5, Calculation (CL) = f6.

$$TPrfm = \sum_{i=1}^{j} Prfm(fi) \tag{5.2}$$

Table 5.8: All over performance of individual participants.

ID		RN	OI	NI	DM	AR	CL	Total performance
Group 01	P1	21.69	21.30	16.35	18.88	46.02	1.00	125.24
	P2	20.40	24.50	17.20	16.35	50.28	1.00	129.73
	P3	21.56	26.00	17.01	13.36	37.68	2.00	117.61
Group 02	P4	13.30	10.00	14.64	10.00	36.00	53.50	137.44
	P5	13.66	17.28	15.00	8.95	41.32	3.54	99.75
	P6	13.62	13.32	12.96	23.04	34.36	6.80	104.1
	P7	11.00	5.00	10.00	13.08	39.30	4.50	82.88
	P8	13.65	12.25	16.60	17.04	42.68	6.30	108.52

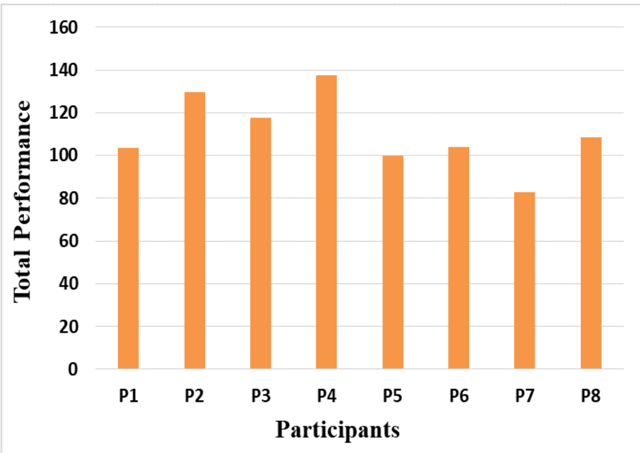


Figure 5.8: Total Performance Result for the Eight Participants.

Figure 5.8 represents the total performance of the application. During the experiment, each student interacted with each feature separately. Combining all the features of the application performance of each participant has been plotted after calculation. Most of the participant's performance level was above 100. Only two of them, P5 and P7 had below 100. Lowest performance was measured for P7 with 82.88. And P4 had the highest performance of 137.44.

5.3.9 Best average and worst performance:

From performance table 5.8, we see that participant P4 had the best performance and did well in overall all the features. And participant P7 had the worst performance by doing overall bad among these eight. For the average case, we can take the performance of participant P8. In figure 5.9 we combined the three cases and individual performance in each feature are plotted in the graph. Performance in augmented reality is respective higher for all instances than that of other features. And that of calculation is lowest except that of the best performer participant.

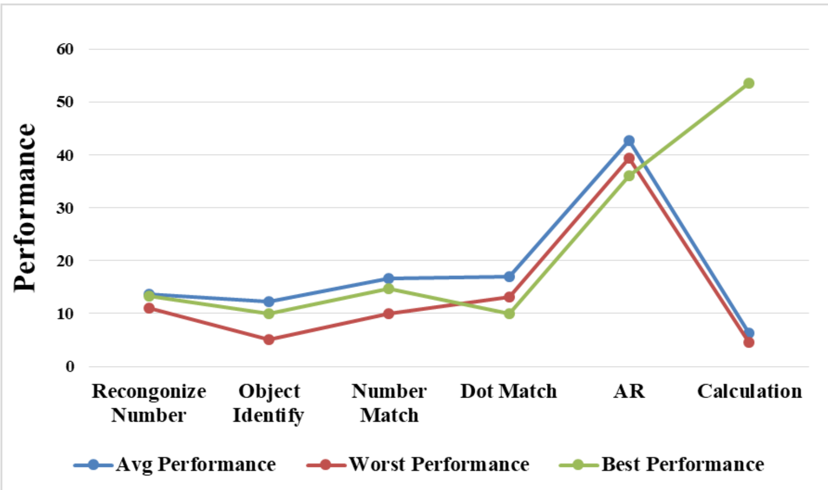


Figure 5.9: Performance assessments of the best worst and average participants.

5.4 Conclusion

From the experiment we had real life data and as per those we could measure the performance of our application as well as the acceptance level and the usefulness of the application. All the graphs and tables shows the result and performance of the application in a whole also as individual features for different types of users.

Chapter 6

Conclusion and Future Works

6.1 Introduction

Our present work has described a new educational system which can deal with the difficulties of education in the children with autism. With the help of augmented reality and HCI, we established an app which enhances the interest of education and this application is also helpful for autism child to cope their difficulties. It will help them to learn numeracy and make it even more interesting. As it is designed for autism child, so that special design process is followed carefully. Different animation is added there as children are fascinated by the animated theme. It will also help them to practice handwriting by controlling their hand motor by dot matching. Voice option will help them to enjoy it more and some quiz option will help them to show a way of right and wrong. Finally, the main theme of AR will help them to relate the reality with their learning and help them to be enough strong and live a better life in society.

6.2 Future Works

In future, we have plans to work on the following issues:

- To implement better UI designs with a dynamical change of color to bring the different look in each level, which will make it sophisticated.

- To detect the emotion of autistic child from speech/voice recognition. So that, our system will be more fruitful.

- To incorporate multiplication, division and nomenclature part.
- To add tally mathematical learning system for the calculation part.

6.3 Conclusion

In this paper, we have presented our AR based design app as a proof-of-concept application. The paper elaborates the idea of numeracy and basic calculation for ASD children by using some neoteric methods for better outcome and accuracy. In the recent era, it has been seen that children are too much dragged by technology for pursuing anything as technology provides visualization techniques which are kind of fun for them to learn fast. Moreover, we added augmented reality feature to the system to bring the utmost efficiency. The design principle and guidelines in designing UI for supplication is highly important. A good UI design has evoked the success of gaining capability. To sum up, it has been found that our designed system succeeds to overcome some problems with the simulated data, which was not discussed earlier elsewhere. We comprised an option where a short exam is available to gather the information of their success. As this procedure is embedded with augmented reality, the children are having much fun when learning anything, they are also able to relate the real-life scenario with some device generated data. Thus this work is intended to maximize its efficiency in near future by adding options.

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Appendix A

List of Acronyms

HCI	Human-Computer Interaction
ASD	Autism Sprectrum Disorder
UI	User Interface
PECS	Picture Exchange Communication System
GUI	Graphical User Interface

Appendix B

List of Notations

$\sum$	This is Summation
$L1$	Level One
$L2$	Level Two
$Q1$	Quiz One
$Q2$	Quiz Two
C	Completed
$NC1$	First Not Completed
$NC2$	Second Not Completed
SL	Signed Learning
LP	Learning Plus
LM	Learning Minus
EP	Evaluate Plus
EM	Evaluate Minus
P	Participants
RN	Recognize Number
OI	Object Identify
NI	Number Identify
DM	Dot Match
CL	Calculation

Appendix C

List of Publications

International Journal Papers

1. Samiha Nowshin, Afshara Tashnim, Fatema Akter and Amit Kumar Das, *"Now They will Play and Learn: An Interactive App for Learning Numeracy and Calculation for Children with Autism"*, IEEE Transactions on Human-Machine Systems. (Under Review)

International Conference Papers

2. Afshara Tashnim, Samiha Nowshin, Fatema Akter and Amit Kumar Das, *"Interactive Interface Design for Learning Numeracy and Calculation for Children with Autism"*, The 9th International Conference on Information Technology and Electrical Engineering (*ICITEE-2017*), Phuket, Thailand, 2017. (Accepted)