SYDE 462 - Improving the Cognitive Assessment of Individuals with Down Syndrome

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Abstract **-** Specialized educational resources for individuals with Down Syndrome are lacking. This problem space was explored in detail through surveys and interviews with both the primary and secondary users. Several problems were discovered in this space of which, the lack of an affordable, easy to use and engaging cognitive test was deemed critical. This problem was further explored and an improved form of this assessment using web based games was proposed. The design process was broken down into three iterative phases. The first was defining the problem, followed by validating the solutions and finally iterating on the final solution. Throughout the phases, five main approaches were used to help with the analysis and iterative process. The approaches included user surveys, user Interviews, Wizard of Oz testing, usability testing, and user testing. Engagement, key usability issues and scoring correlation with standard methods were the primary testing protocols used for validation of the final designed solution. The results and limitations of the designed solution are touched upon and a few reasonable next steps are laid upon for the future.

Keywords – Down Syndrome, Game-Based Assessment, Cognitive Testing

INTRODUCTION

Down syndrome is a chromosomal disorder that impacts 1 in 700 births in the US alone. It is the most common chromosomal cause of mild to moderate intellectual disability [1]. Currently, the modern form of assessment of cognitive abilities is through pen and paper (i.e. a Cognitive Test Battery) [4]. However, this current state of the art is very costly where a typical assessment can range anywhere from $300-$4400 for initial assessments to a full diagnostics assessment [5]. Furthermore, an average assessment is approximately 90 minutes per day which can range from 1 to 5 days depending on the scale of it [5]. This makes the assessment process very time consuming. Last and most importantly, cognitive tasks are typically viewed as effortful, frustrating, and repetitive, which often leads to participant disengagement [8]. This, in turn, can negatively impact data quality and/or reduce intervention effects [11]. Due to the three main aforementioned downfalls of the current assessment process, an improved form of assessment is proposed.

The primary users were identified as individuals with down syndrome who will use the tool for assessment purposes. The team's goal was to make the assessment tool the most engaging for these primary users while also maintaining the level of accuracy in the scores they obtain in it. The secondary users are the parents or guardians of the individuals with Down syndrome. For them, the goal was to reduce the cost and time per assessment to as low as possible such that they can be taken more frequently. Any reduction in cost and time from the current assessment would be considered an improvement. From the user interviews conducted with the secondary

users, it was found that individuals with Down syndrome typically only get assessed 1-2 times in their lifetime. This really depicts the lack of effectiveness of these current assessment tools. Therefore, by improving the cost and time taken per assessment, there is less of a barrier for taking the tests more frequently thus, providing the parents and guardians with more feedback on the progress of the development of their child.

PROJECT SCOPE AND OBJECTIVES

The goal of this project is to design, develop, and build a system that will accurately assess an individual with Down syndrome's cognitive functioning while reducing cost, time and improving its engagements. Using existing, off-the-shelf, technology, a proof-of-concept system has been developed that will provide the user's parents with the necessary information on the cognitive development of their child. Such information will include: orientation, memory, language, spatial ability, attention, and calculation [2].

A game-based assessment was built based off the tasks of a standardized test for cognitive functioning. The Mini-Mental State Examination (MMSE) was selected as it was both widely used and a very simple but powerful assessment tool that could be easily replicated using games [12]. The objective was to minimize the delta between the scores obtained from the game-based assessment and the scores obtained from the current form of assessment.

This capstone project will be complete on March 19, 2018 and in order to meet this deadline, some simplifications were made to the final prototype. To begin, only 3 tasks (out of 11) were selected to be converted into a game from the MMSE test to demonstrate the accuracy of product. Due to the time constraint, only a small number of Down syndrome subjects were available to take the test and provide a baseline for the assessment prediction model. In addition, although the game engine selected allowed development for multiple OS platforms (Windows, Linux, OSX), the team focused on web specifically because web was more accessible from all platforms and from any smart device. Furthermore, the primary objective was to validate the accuracy of mimicking assessment tasks through game-based applications. Supporting other OS platforms would deviate from the critical path of achieving this objective while providing minimal value since the majority of users could still access it via web.

SUMMARY OF SOCIAL, ECONOMIC, AND ENVIRONMENTAL IMPACTS

SOCIAL IMPACTS

A primary social impact of the design is the specialized cognitive developmental support the primary user would receive. Through the use of the game-based assessment, the secondary user can now focus on where the weaknesses of the primary user are. However, in order to achieve this, the assessment tool developed needed to have a high level of correlation with standard methods. The solution included a machine learning based model that could better approximate the final assessment score based on the scores obtained in the game-based assessment. This approach was inspired by a study that was found proving that performance in

most areas of cognitive functioning could be predicted based upon overall intellectual disability [3]. However, weaknesses were found in predicting expressive language and verbal working memory thus, for the scope and simplicity of this project, these aspects were omitted and the team focused on predicting registration, attention, and calculation and recollection.

Next, individuals with Down syndrome are very susceptible to feeling uncomfortable around new and unfamiliar faces. This social phobia, is a form of an anxiety disorder that is known to have an impact in the individual's cognitive performance [6]. One explanation for the massive popularity of games is that they can provide easy access to a sense of engagement and self-efficacy which reality may not deliver [9]. The goal of incorporating a game is such that the need for visiting new therapists and feeling uncomfortable can now be avoided as the assessment can now be taken at the comfort of the individual's home in an alternative reality that they feel more engaged and comfortable in.

ECONOMIC IMPACTS

A major economic impact is the empowerment of the primary users to become more involved in a knowledge-based economy. A study claimed that one of the basic requirements for education in the 21st century will be to prepare students for participation in a knowledge-based economy; knowledge is the most critical resource for social and economic development [14]. Therefore, with an improved assessment, the primary users can receive better feedback on areas of improvement in cognitive functioning to help prepare them to become more active members of the economy and society.

Currently, there are 340,000 individuals in the US living with Down syndrome [21]. For each unemployed individual in the general population, it costs the government about $10,000/year to support [22]. This creates an economics impact of $3.4 billion/year. With the improvement of cognitive functioning, more individuals with Down syndrome can become employed thus, significantly reducing this economic impact. This was proven by a study [18] that assessed the current employment status of 117 individuals with bipolar disorder. It was found that employment status was significantly associated with cognitive performance [18]. One negative impact that would arise from this is that there is an increase in people who are capable of working which makes an increase in the competition for jobs.

Next, the use of standardized tests (i.e. MMSE) helps eliminate any bias or skewed results associated with economic status of the individual. This was proven through a study which found their use of standardized tests provided consistent results across individuals with a wide range of socio-economic backgrounds and differences in ethnicity [4].

ENVIRONMENTAL IMPACTS

Now that assessments can be taken at the comfort of the individuals own home, there is less pressure on them when taking the test. An exploratory study [13] examined several links between home learning environment and school readiness. Their results indicated an association with home learning environment and improvements in school readiness. In particular, increases in a parent's understanding of play and ability to facilitate a child's learning lead to positive behaviour outcomes including increased independence and creativity [13]. A

negative impact with this, on the other hand, is that individuals with Down syndrome may feel they do not need to attend school. This is due to the fact that the assessment can be taken at home and families can just hire their own specialized assistant to teach their kids. This lack of exposure to real world social interactions (i.e. with other students) can have a negative impact on the primary user [19]. When designing the solution, this concern arose which is why the team focused on making the games storyboard based off of real life experiences, like grocery shopping. The idea of this approach was to help prepare the primary user with virtual experiences that can then help them if they encounter it in real-life [20].

Lastly, from user interviews, it was determined that playing computer games is one of the most favourite activities of children with Down syndrome. This means that an environment that includes elements such as fun and entertainment might have a positive impact on their learning. In addition, computer games have several motivational and fun elements, and children prefer playing games more than other instructional materials. Results of a study focusing on the influences of computer games on students' learning revealed that playing computer games has had a positive impact on children's learning. This was because games have a great influence in terms of constructing a connection between virtual life and real life thus, encouraging critical thinking [16].

SUMMARY OF ENGINEERING ANALYSIS AND DESIGN METHODS

The design process was broken down into three iterative phases. The first was defining the problem, then validating the solutions, and finally iterating the final solution. Throughout the phases, five main approaches were used to help with the analysis and iterative process. They were user surveys, user Interviews, Wizard of Oz testing, usability testing and user testing.

PHASE 1: DEFINING THE PROBLEM

The first approach taken, when defining a narrowed down problem space, was to conduct user surveys. Through some initial research, it was thought that one-on-one tutoring was the best form of interactive learning that could be used as a solution to the problem. To validate this, the team sent out a survey to local students with the goal of learning more about the tutoring process. The initial survey received over 60 responses and the main finding was that students seemed to learn best when the content taught was tailored to their personal level of understanding.

Next, the team conducted user interviews with tutors in order to learn more about what tutors found ineffective/effective when they teach. The team spoke to over 25 tutors both in-person and over email. Some critical findings with this approach was that there was no way to assess students' progress. Thus, improvements in the students' development cannot be tracked and the tutor cannot determine which specific areas they need help in. This made it clear that there was a lack in the standardized assessment process to easily assess and further track the progress of the primary user. In order to validate this realization, the team partnered with the Waterloo Regional Down Syndrome Society (WRDSS). With the help of this organization, the team was able to conduct user interviews with the secondary users; the parents/guardians of

the primary users. The team's goal was to learn more about how children with Down syndrome are currently being assessed. Four parents were interviewed, from which major insights on the current assessment process were discovered. Contrary to the team's hypothesis, cognitive assessments for the primary user were available however, had three main drawbacks: cost, time, and engagement. The current form of assessment was found to be too expensive, too time consuming, and extremely disengaging for the primary users.

Through the use of user surveys and user interviews, the team was able to determine that there was an issue with assessing cognitive abilities of the primary user. More specifically, three main aspects of the current assessment process that needed to be improved upon were cost, time, and engagement. An improved assessment tool aids the development of the primary user by first identifying where they specifically need help. The right resources can then be put into place in order to provide the necessary support.

PHASE 2: VALIDATING THE SOLUTIONS

After narrowing down the scope to developing an assessment tool, the next phase was to validate the best approach for assessing individuals with Down syndrome. First, the team conducted user surveys with the primary users' parents. The goal with this approach was to determine how the primary users currently interact and engage with things. The survey received over 55 responses and it was determined that the primary users loved attention-grabbing attributes such as music, bright colors and animations. Furthermore, the survey results showed that over 50% of the users spent over 10 hours of the week on technology (see Figure 1 below). This meant that the users were avid technology users.

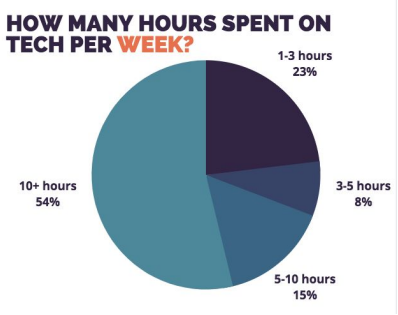

Figure 1 - Technology Usage Survey Results

With a better understanding of key attributed need for the assessment tool, the team went on to conduct a Wizard of Oz test. The goal of this test was to determine the best way to assess a person by validating various methods of a posing questions. These methods were: a chat AI, a written survey, an in-person interview and an interactive game. The hypothesis was that the chat AI would be the best solution since it was technologically advanced and the team thought users would love interacting with technology that mimicked humans. In reality however, when conducting the full test on 6 students all participants felt the chat AI was too unnatural and awkward. In addition, they found the in-person interview to be too long (this would also be to expensive from the cost point of view to conduct). The surveys were liked due to the short length but were found to be menial. The interactive game turned out to be the best variant as it was engaging and students did not mind the time it took as long as they enjoyed it. Furthermore, it could be developed at a low cost, thus making cost a factor controlled

internally. These results matched up with the initial research to team did, as mentioned in the introduction section above.

Through user surveys and Wizard of Oz testing the team was able to determine that a game was the best form of assessment as it proved to be an improvement over the current form of assessment in engagement, cost and time. Moreover, this form resonated well with the attributes the team found to be engaging for the primary user from the user surveys. This is because games often have music, bright colors and other attention-grabbing features.

PHASE 3: ITERATION THE FINAL SOLUTION

With a decision made to develop a game-based assessment as the final solution, the final phase focused on conducting user testing. For this test, two simple games were built in order to mimic two tasks of a Mini-Mental State Examination (MMSE). The goal was to measure the correlation of the results obtained from the user playing the games against the results obtained from the user's MMSE scores while surveying the engagement of the games. User testing was conducted on three users with Down syndrome and the final results are discussed in the following section below.

Through the user testing of the final solution, the team was able to have three iterations of the games built and tested. With each iteration, the feedback obtained helped to enhance the engagement of the next iteration. However, there are still significant improvements to be made which are discussed under the recommendations section below.

DESIGNED SOLUTION

A game-based assessment tool to determine the level of cognitive impairment of users was developed as the final design solution. The tool was developed using web based technologies which was motivated by several factors, the most important being:

1. Accessibility and discoverability: The web can be accessed from any internet enabled device such as personal computers, tablets, and smartphones thus making the tool easily accessible to the vast public. A web based product would also enable marketing and advertising to a larger audience [17].
2. Control over technology: Freedom to choose the technologies for the development the product due to the presence of many open source libraries.
3. Control over analytics: Lastly, control over the quality and quantity of analytics that is collected from the product as it is not restricted by a third party such as an App Store.

SYSTEMS ARCHITECTURE

The assessment tool was built using native web technologies such as Web Audio API for sound[25], WebGL for graphics[26], and WebRTC for inputs[27]. Phaser, a game engine was used to utilize the web APIs mentioned above through a single, uniform interface. Phaser also supported development on multiple screen sizes natively and was free which allowed the overall development of the prototype to be free of cost. It is often best practise to bundle all

the Javascript files together into a single file[28]. This is done to minimize page load times since the browser only needs to load a single file as opposed to many. Webpack, was used for this task as it handles concatenation, minification and bundling of Javascript files[29]. Finally, Phaser requires the use of a web server to serve up static assets (css, images, javascript files), Webpack comes with a built in web server which was used for the purposes of the prototype however this can be easily be replaced with a production grade server such as Unicorn[30], Apache[31] or Nginx[32].

As mentioned above, MMSE was used as a reference whilst developing the games. Three games were developed, each representing a test from three different categories of MMSE namely *Registration*, *Attention and Calculation* and *Recall*. Open source Phaser games[33] were used as a source of inspiration for designing the game logic and assets. Modifications were made to the games in order to define custom win and lose states based on the requirements dictated by the corresponding MMSE test. The scoring logic for each game was modified based on the MMSE scoring technique. Code was added to transmit metrics from game such as time taken to complete level, score, all answers (right and wrong) and total wrong answers (ie. repetitions until right answer was selected) which can be later used for analysis. Finally, the 3 games were combined into one such that they are played in a specific sequence, mimicking the way in which a MMSE evaluation would be carried out. Each game also went through several iterative changes based on the feedback received from user testing.

Figure 2 - Overall System Overview

SUMMARY OF DESIGN VALIDATION

For the final prototype, a game-based assessment was selected. This was motivated by both a study found online [4] as well as, a Wizard of Oz test conducted by the team. The study found online covered 31 gamified cognitive tasks used across a range of disorders and cognitive domains. It found, that gamified training appeared to be highly engaging and boosted participant motivation [4]. Furthermore, the results of the Wizard of Oz testing conducted by the team found, based on user feedback, that game-based assessments were the most

engaging form of posing a question to a user. The details of the Wizard of Oz testing were discussed in the summary section above.

TESTING FOR ENGAGEMENT

User engagement is an important aspect to maintain a level of motivation for users to complete the game-assessment, while improving the quality of data collected [5]. When designing games, some engaging characteristics of educational tools include: challenge, fantasy, and complexity [23]. However, these engaging attributes are not specifically targeted to educational games for individuals with Down syndrome. For this reason, the team's goal for the first user test was to validate if challenge and complexity were also considered engaging attributes by individuals with Down syndrome. Unfortunately, fantasy was too complex to develop in the game and could not therefore be validated.

With the user centered design method of observation in mind, two young adults with Down syndrome were invited to play the game. The goal of this fundamental research [24] opportunity was to casually observe the users in order to better understand what keeps them engaged and to validate whether "challenge" and "complexity" improved engagement. Through attentive observation of the users' behaviour, the team was able to rule out "challenging" and "complexity" as engaging attributes for individuals with Down syndrome. In fact, while playing a challenging game, the users showed many signs of frustration, including facial expressions and verbal cues. The individuals' constant failures made them feel discouraged to continue playing the game. On average, it was observed that when users missed collecting several objects in a row, they felt that the game was too hard and they began to feel very frustrated and unmotivated. The team used this information to ensure that the next iteration of the game was made to be easier. This was done by decreasing the speed and increasing the visibility of moving objects in games.

TESTING FOR KEY USABILITY ISSUES

Using the insight gained from the user observation session, the team was able to perform an initial iteration on the design. A heuristic evaluation was then completed in order to identify and resolve key usability issues. This evaluation was done by evaluating the current design against Nielsen's 10 Usability Heuristics for User Interface Design [35]. The agreed-upon set of usability best practices helped the team detect and resolve key usability issues. Some of the characteristics of the designed solution did not match Nielsen's Usability Heuristics [35] and were therefore highlighted and improved in the next iteration.

For example, some outlined issues included the fact that no instructions were given to the user in the game. It was observed in the first user testing session that through exploration, users were eventually able to figure out how to play. However, as they were playing, they kept asking questions about whether they were doing the right thing. In order to eliminate any possible confusion, the lack of "help and documentation" was outlined as an issue in order to be fixed in the next iteration. The fix included was in the form of a short, clear, and informative on-the-screen set of instructions. In addition, the developed game was slightly inconsistent due to the alternating use of keyboard and mouse between the various levels. This was another usability issue that was highlighted to be resolved in later iterations.

On the other hand, some proper usability best practices were validated through the heuristic evaluation. For example, the team outlined that by displaying a constant, on-the-screen update of the score to the user, “visibility of system status” was properly incorporated.

COMPETITIVE TESTING

In order to measure the success of the developed system, the team conducted a user research session to evaluate the usability of the competitor’s product [24]. The test focused on the users’ behaviour as they attempted to complete the Mini Mental State Examination (MMSE). As the users completed the MMSE, they expressed feelings of boredom and uninterest. This helped the team further validate that a survey-like, paper assessment was not found to be engaging by users. The overall outcome of the session produced user MMSE results which were used in order to be compared with the results of the developed game assessment.

EVALUATING SYSTEM USABILITY

In order to test the ease of use of the developed game, the team considered distributing a Systems Usability Scale (SUS) following the user testing sessions [37]. SUS was selected due to its convenience and reliability with a small sample. The team’s goal was to obtain analytical results that could be compared with industry benchmarks to evaluate the developed system’s usability. However, analytical evaluation methods are usually not intended for children or young adults with Down syndrome since they are less able to concentrate and perform abstract logical thinking than adults [36]. Therefore, the SUS statements were converted to questions in order to receive an answer from the users in the form of a statement instead of using a rating scale. For example, some SUS statements such as “I think I would like to use this system” were altered to “did you like playing this game?” and verbally asked to users. Users usually answered with single word answers making it difficult to identify trends. Since the rating scales were not used, the team could not produce quantitative conclusions from the tool. However, one of the three testers claimed that they would not play the game again. The team identified this as a concern and hopes to enhance engagement in future prototypes.

MEASUREMENT OF SUCCESS

To measure the success of the team's objective, two metrics were recorded with each user test; the assessment score obtained from the game and the MMSE test. These observations were then plotted against each other to facilitate the detection of correlation. Although the data set was small, the team found that the game that tested recall best mimicked the score of the actual assessment with the game that tested registration following closely (see Figure 3 and 4 below). It was very difficult to test the attention and calculation task since the users tested could not do subtraction hence, that metric was unusable. In the future, an alternative approach will be given if such a situation arises during a user test, where they will be asked to spell a five-letter word backwards; this was a suggestion based off of the MMSE.

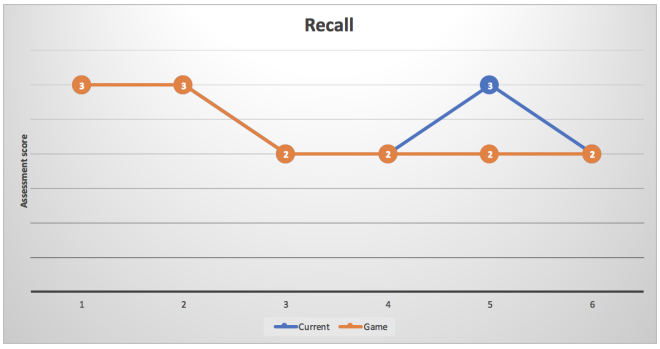

Figure 3: Recall score comparison

Figure 4: Registration score comparison

LIMITATIONS OF DESIGNED SOLUTION

The MMSE is a very simple test which only categorizes a person as having mild, severe or no cognitive impairment. In practise, further detailed assessment of the student needs to be conducted to determine their current level of understanding of specific skills and topics. This detailed assessment will be enhanced by the machine learning models that the developed tool utilizes to accurately predict which topics should be taught to the student and at what level of difficulty. The game assessment is also incomplete since only two of the eleven tests on the MMSE were replicated. Some of the tests (such as the ones under the *language* categories) requires the use of speech recognition and tracking the movement of face and limbs. Such actions were deemed out of scope for this project given their complexity and the lack of technical knowhow of the team on the matter.

The prototype currently only runs locally on the team members' computers. This is because the prototype is still under active development and is not ready for public use. As a result, it has not been deployed on a publicly registered domain, making it inaccessible to the general public for larger scales of testing and data collection.

Although a hundred parents were invited to test the prototype, only three responded and agreed to meet with the team. The demographic of the primary users was also limited which made the issue particularly challenging to solve. Moreover, the prototype was only tested by teenagers which was a subset of the actual target users (children and young adults).
Another challenge was the lack of data available on individuals with Down syndrome which limited the ability to develop the machine learning aspect of this project. Requests were made for datasets of existing assessment scores from organizations however they were unable to provide any information since these organizations act as a community for help and support rather than a clinic with proper data collection. The alternative was to collect the data manually however that would take a significant amount of time as a large number of active users would be needed to generate datasets that accurately represent the population.

The MMSE is typically conducted in a hospital by a medical professional. The assessment carried out by the games are not validated by any medical professional which may deviate too far from the tasks of the original test thus failing to assess the user correctly. Furthermore, the results

collected from the assessment are solely based on the user's answers and does not take into account visual and auditory cues. This may result in inaccurate assessment due to poor adjustment of weights to reduce bias.

Finally, the data collected from the assessment is not persisted in a database. Thus after each session, the results need to be noted manually for further analysis. The team has faced some issue integrating Phaser which is a client side library, to communicate with a database through a server side web framework such as Express.js[34].

CONCLUSIONS AND RECOMMENDATIONS

ENHANCE USER ENGAGEMENT

In order to excite users about playing the game, the team hopes to enhance the overall game engagement. This recommendation stems from one of the claims made by a user testing the developed solution on how they would not play the game again because it was "not fun". In order to better understand why the user did not like the game, the user was asked to describe their personal favourite game. From this information and further research, the team found that "fantasy" was an attribute that increases game engagement [23]. In order to make the game more engaging, in further iterations, the team hopes to incorporate more of a fantasy theme. Some fantasy guidelines include character agility and charisma. Things such as physical power, emotional strength, fighting, flying, and climbing would help develop a more fantasy-like character [38]. Another way to increase engagement is to tailor the theme presented to users according to the type of user interacting with the game. For example, based on the age, gender, and user's interests, they could play a different game.

GENERALIZE THE TESTING & IMPROVE THE PREDICTION MODEL

In addition, the team hopes to generalize the testing of the developed solution with younger children who do not have Down syndrome. In general, it will be easier to test with younger children than it is to test with individuals with Down syndrome. The team can test with the younger siblings of friends and classmates. Because of the larger population of user testers available, the team will be able to analyze a larger data set which will enhance the accuracy of the results. An added benefit of this is the larger sample size of data that the team could use to train the assessment prediction model. This would allow the model to be exposed to more instances of input therefore, providing a higher likelihood of approximating the actual assessment scores. To further improve the model, the algorithm can be iterated with various other classification techniques while tweaking hyperparameters to best tune it to the larger dataset. Although a time-consuming process this would best tailor the model to the data making for a better prediction on unseen input.

INCREASE USER MOTIVATION

Furthermore, in order to decrease the user frustration levels, the team will include words of encouragement throughout the game. It was observed that users became demotivated and frustrated when they took too long to achieve the goal of the game. In order to decrease the level of frustration and anxiousness, positive feedback in the form of encouraging words will be

added to the screen if the users spend longer than anticipated on a certain task. An average of how long users usually take to complete a certain task will be obtained in order to compare it with the length of time a certain user took to complete the task. If the time is longer than the average, words of encouragement and motivation will start to appear on the screen and be presented in the form of audio. Through our user testing, the team was providing this positive reinforcement verbally and manually. It was found that this method encouraged the users and kept them motivated to keep trying to meet the goal.

IMPROVE ASSESSMENT TECHNIQUE

Furthermore, moving forward the team should use an enhanced form of testing other than the MMSE. The MMSE was selected because of its simplicity. However, this specific assessment is used to diagnose general cognitive impairment and is not Down syndrome specific [4]. Other more specific assessments such as the Battery test will be adopted instead [6]. Although more complex, this will improve the overall accuracy of the newly developed assessment tool.

In addition, during the user testing session, the team asked the users' parents to complete the MMSE with the users. The examination however is usually performed by a professional at a hospital [4]. Completing the assessment by the parents introduced some error to the testing procedure as the team noticed the parents trying to help their kids reach the correct solution. Moving forward, the team should personally complete the MMSE with the users without the parents' presence. This will minimize the bias introduced since the parents will not be able to see their kids struggle and will not be tempted to help them.

ACKNOWLEDGMENTS

Our sincerest thanks to Dr. Doug Sparkes who helped the team explore the vast and complicated problem space and ultimately land on an important problem. His continued help and support through development and validation of the prototype was highly appreciated. Thank you Dr. Matt Borland for your continued guidance. Many thanks to Kate and Kari for their guidance and expert opinion. Thank you to Kim from the Region of Waterloo Down Syndrome Society for helping us secure user testers and distribute our user survey to over 100 families. Finally, the team would also like to thank all the user testers and their parents for taking the time out of their days,meeting with us, testing our prototype, and giving us incredibly valuable feedback.

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TEAM MEMBER CONTRIBUTIONS TO THE PROJECT

Team Member	Description of Contributions Including Tools used	Outcomes
Maathusan Rajendram	1. Developing initial prototype game 2. Research on Down Syndrome 3. Research on specialized education for children and young adults with Down Syndrome 4. Research on game development 5. Conducted user testing on initial game 6. Define spec for game objective based on MMSE 7. Brainstormed on integration of machine learning into the assessment tool	1. Had an initial game to test 2. Got to know our primary users, their problems, requirements 3. Got feedback on improvements that could be made on next iteration of prototype 4. Learned about the state of the art for cognitive tests, got to know their limitations and things that can be improved 5. Defined a measurement of success for the prototype 6. Built the game used in the final prototype 7. Define spec for ML model
Arumoy Shome	1. Research on Down Syndrome 2. Research on specialized education for children and young adults with Down Syndrome 3. Research on cognitive test batteries 4. Conducting user testing on prototype 5. Research on game development 6. Development and testing of prototype 7. Brainstormed on integration of machine learning into the assessment tool	1. Got to know our primary users, their problems, requirements, etc 2. Understanding the problem space 3. Learned about the state of the art for cognitive tests, got to know their limitations and things that can be improved 4. Got a lot of information about problems that our primary and secondary users face. Iteration was done on the prototype based on user feedback. 5. This was required as no team members had experience in this field. Helped in deciding which technologies /tools/libraries to use for development of our prototype. 6. Majority of my time was spent here, created the entire game platform

		using a game engine (Phaser). Created 4 games that mimic the assessments in MMSE. Iterated upon them several times based on user feedback. 7. Looked at different use cases of machine learning applied to our tool. Discovered that lack of datasets and realized that we need to collect the data ourselves before we can implement this.
Mira Sleiman	1. Secondary research on Down Syndrome 2. Primary research on Down Syndrome by organizing and conducting user interviews (Waterloo Region Down Syndrome Society) 3. Prepared and sent out a survey to over 100 parents at the WRDSS (the email was sent by WRDSS; the survey was via google surveys; 55 survey responses were received) 4. Scheduled and conducted user testing with individuals 5. Performed usability study against Nielsen's 10 Usability Heuristics 6. Define spec for game objective based on MMSE 7. Prepared user assets for the games 8. Designed project poster (photoshop) 9. Designed panel exam presentation	1. Was able to outline and determine user requirements, best practices for users 2. Got to hear first hand what it was like to live with down syndrome; learned a lot more about the current technologies and the users' wants and needs 3. Helped outline user requirements and validate some assumptions 4. Gained valuable feedback and translated the feedback into actionable development tasks 5. Was able to outline key usability issues and outlined the fixes to be made 6. Outlined the game characteristics in order to mimic the current assessment 7. The user assets helped the overall user experience of the game 8. Showcase project at symposium 9. Showcase project at panel exam