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Evaluation Of The Impact of A Serious Game On Children With Cognitive Disabilities Using Parental Opinion

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Abstract *- Children with cognitive disabilities often find themselves disengaged during the learning process. Due to an overload of information and inability to focus, these differently-abled individuals find education to be less accessible as compared to people without any cognitive dysfunctions. Studies conducted in the past have used serious games as measures to counteract symptoms of conditions like dyslexia and down syndrome, often showing promising results. For the purposes of this study, a new mobile app - Atulit - was developed. The app contained several sections with multiple different activities accompanied by interesting animations and ways of positive reinforcement to make using the app more engaging. The effectiveness of this app and its impact on its users was evaluated using parental opinion, which was recorded using a pre-implementation and post-implementation survey. Descriptive analysis and one-way ANOVA tests were conducted on the data collected. Along with quantitative data, remarks, and comments about the app and its impact on the education of its users were also collected. The data collected and the inferences provide unique insights into the development of future serious games that employ better and more efficient methods of increasing focus in children with cognitive disabilities.*

Keywords *- Cognitive disabilities, serious games, mobile technology, Android app, education.*

I. INTRODUCTION

Children with mental disabilities often are subjected to lower academic performance in an educational setting as compared to those with typical development (SFN Freeman, 2000). Cognitive disorders, including but not limited to dyslexia, attention deficit disorder, autism, and learning disorders in general stem from one's inability to perform specific mental functions. According to the International Classification of Functioning, Disability, and Health, these can be divided as shown in Table[1]. (United Nations CRPD, 2017)

Table 1: Classification of Mental Functions according to the International Classification of Functioning, Disability, and Health

Categories	Subcategories
Global Mental Functions	Consciousness functions - Orientation functions - Intellectual functions - Global psychosocial functions - Temperament and personality functions - Energy and drive functions - Sleep functions - Global mental functions, other specified and unspecified
Specific Mental Functions	Attention functions - Memory functions - Psychomotor functions - Emotional functions - Perceptual functions - Thought functions - Higher-level cognitive functions - Mental functions of language - Calculation functions - Mental function of sequencing complex movements - Experience of self and time functions - Specific mental functions, other specified and unspecified

This problem was greatly amplified during the pandemic when the educational sector saw a paradigm shift to distant learning. With classes being conducted through online platforms like zoom, google meet, and Microsoft teams, students' retention was seen to be at an all-time low. According to Md Mahbub Hossain (2019), "At any given point of time, nearly 50 million Indian children suffer from mental disorders, and this number will increase if the adolescent population is considered as well." Keeping in

mind the massive size of the population belonging to this specific marginalized community, it was imperative for action to be taken for the development of ways to increase their engagement in education and retention of information.
According to remarks given by multiple parents during over-the-phone interviews, children do tend to show a general affinity towards mobile technology and games with increased participation. However, this hypothesis still needs to be verified with evidence as is done in this paper; thus, mobile technology and specifically mobile games present promising potential in catalyzing the education process of children with mental disabilities. A serious game is a special category of games specifically designed to be used as teaching tools in varied environments. (A J Alcazar, 2018)
According to a discussion with an occupational therapist, Mr. Anil Kabisathpathy (Arati Developmental Centre), early diagnosis and intervention are key when dealing with the said marginalized group of people. Thus, games, especially serious games, provide promising potential as facilitators.

When it comes to an educational context, the implementation of such technology also depends upon the accessibility of students to educational institutions that have the infrastructure to support this model of teaching. In a developing country like India, the educational infrastructure, in the state that it is in, requires a paradigm shift in order to provide access to education for children with cognitive and physical disabilities. According to Sandhya Limaye (S. Limaye 2015), “less than one percent of the children in India have access to an appropriate education." The Indian Ministry of Welfare has launched a plan for the establishment of special schools and providing grants to them. But this is despite them having countless disadvantages, with the inclusion of children with cognitive disabilities in normal classrooms always being a better option. These schools are characteristically in urban areas and provide little access to the rural population, generally being too expensive (S. Limaye 2015).

The inaccessibility to education exists not only in the form of financial disparity but also in the inability of children with cognitive disabilities to concentrate and retain information. As discussed earlier, games present a potential solution, with the prospect of catalyzing the educational process for this particular group of students. However, there still exists a void in the case of the availability of data and research on the effects of mobile technology on children between the ages of 3-5 years. As already established above, early intervention when dealing with cognitive disabilities, especially during the formative years, has increased benefits; thus, data pertaining to this age group would be invaluable for developing additional resources to accelerate the growth and development of the students. For the purposes of this study, an app, Atulit, was created containing several activities based on the FACP checklist designed by the National Institute for Mentally Handicapped for children classified into the pre-primary and primary sections based on mental age.

Atulit was designed to have its use with parental supervision rather than in a classroom. The majority of serious games created lack accessibility features, (C S Lanyi, 2010), performing rather poorly when assessed on scales designed to measure the user-friendliness and usability of an app, keeping a user base with cognitive and physical disabilities in mind. In Atulit, measures including but not limited to, extensive use of images, larger touch areas, and a minimal amount of text was taken in order to increase its usability, especially for children with cognitive disabilities like autism and mental retardation. (C S Lanyi, 2010)

Similar studies have been conducted specifically focusing on curing specific cognitive disabilities using serious games. In a study conducted by Luz Rello (2014), a Computer-based method of improving the spelling of children with dyslexia was tested. A game called DysEggxia was developed, which presented children with misspelled words to solve as exercises. This was tested with children for eight weeks against another game called Word Search. At the end of the study, children playing DysEggxia were observed to have significantly lower error rates. In another study conducted by Paul Hatzigiannakoglou (2015), a serious game called Junk-Food Destroyer was tested with children with Down Syndrome to teach them the benefits of eating healthy. The game used a first-person shooter concept to teach the distinction between healthy and unhealthy food to adolescents while ensuring accessibility.

Along with the aspect of designing a mobile app, this study also used the parental opinion to record the efficiency of the mobile app in increasing cognitive function and engagement in learning in the students. Two surveys given to the parents before and after the apps record various data points, both qualitative and quantitative, which reflect their opinion about the app, its impact on their children, and their opinion about the education their child is receiving. The data received from the surveys coupled with the statistics received from the app logging in the progress of its users into a database provides us with various insights about the serious games, mobile technology, and its place in the educational paradigm.
Atulit acts as a way of positive reinforcement for children who find their curriculum unengaging and aren’t able to focus on doing their daily tasks. The app consists of interesting animations when the user is navigating through the app and when they complete a particular task. It also consists of a point system that rewards the children for a job well done, which the school can have them redeem for rewards. These two factors, along with encouragement from parents and educators, can help these children get accustomed to their tasks, potentially increasing the speed with which they are able to complete the items listed in the

FACP (Functional Assessment Checklist for Programming) by the National Institute of Mentally Handicaped (NIMH).

II. METHODOLOGY

A. Design of the app Atulit

The idea of the development of Atulit stemmed from the inability of mentally disabled children (the kinds of challenges include but are not limited to Low IQ, Autism, and Cerebral Palsy) to undertake the tasks assigned to them in their curriculum and the inability of educators to incentivize them to do the same, especially during the COVID-19 pandemic. The mobile app acts as a supplementary tool for the parents and educators of these children and helps to induce greater engagement and interest. It was noted that children showed great interest when interacting with technology and, more specifically, with smartphones. Atulit uses this fascination with technology to engage children in the required activities, gamifying their learning process.

The app was created using the Android studio framework, Kotlin as the primary language, and Google's Firebase for running the backend.

Android Studio offers an intuitive GUI for the construction of an interactive interface of the app. As a framework powered by IntelliJ, it offers a great IDE for coding, along with support for vectors, images, and various other resources. It also offers an intuitive project management system for maintaining the Gradle and the manifest files. Created by Google, it contains support for Java as well as Kotlin. This feature was crucial in the development of this project since it is entirely built on Kotlin.
Kotiln was chosen over Java for this particular project due to its compact nature and reduction in the amount of code, along with increased efficiency.

Along with the above-mentioned software, GIMP, procreate, and illustrator was used for the creation of assets (images, vectors, animations) for the app, which provided an artistic touch to the interface.

One of the biggest defining factors of Atulit was accessibility. The target audience of this app included children with intellectual disabilities and their parents. The content on the screen, at all times, is structured in a manner that ensures that the user is not overwhelmed by the sudden inflow of information. Moreover, the user interface was designed keeping in mind its audience, whose ages ranged from 3-10 years old. Thus, to serve its purpose of being engaging, a bright and attractive color scheme was chosen along with multiple interactive cartoon characters and animations that would entice the children and stimulate their minds.

The app also allows the teachers of the respective children to monitor their progress. Firebase's Firestore is used to maintain a database of all the tasks that have been done by the student, along with the points earned and the accuracy of answering questions. This, however, also posed a problem when dealing with families living in rural parts of Odisha (a state in India), which have limited access to the Internet. Thus, it is probable that while using the app, the smartphone might not be connected to the internet, and the data wouldn't be able to sync with the Firestore database. To tackle this, the app stores all the unsaved data in a separate file and then syncs the file's data with the database when the app is launched.

The Dashboard view in the app links to the different activities. This is where the user can access all the tasks as well as view their points. The activities available on the app are as follows Description of the activities present in the Appendix:

1. Daily Chores
2. Body parts
3. Pointing at things
4. Counting
5. Computer education
6. More or Less

B. Design of the study

A mixed-method approach was used for this research study, using quantitative data collected from the app (Atulit) itself, along with two surveys sent to parents of the children using this app, along with qualitative data from interviews conducted with some of the parents of children with cognitive disabilities and an occupational therapist -- Dr. Anil Kabisathpathy.

A pre-implementation survey was sent out to the participants over the study in the form of an online form. The survey recorded basic information of its respondents along with the existing proficiency of their wards in specific tasks that the app focused on through its many activities. This data was recorded using a Likert scale on a scale of 1 to 5. Along with quantitative data, the survey also recorded qualitative data to questions with the aim of developing a basic understanding of the problems that parents and children faced with respect to education.

The post-implementation survey was followed by a three-week period during which the respondents (wards of the parents that answered the survey) used the app under the supervision of their parents. Throughout the time of their usage, the daily chores are done every day, the number of questions attempted in sections other than "daily chores," and the accuracy of correct answers to those questions were recorded on the database running in the backend. Data collected included the number of daily chores done each day, points acquired by each user, the number of questions the user got right and wrong, and accuracy (as a percentage).

At the end of the three-week period, the parents were given a post-implementation survey. The post-implementation survey, similar to the pre-implementation survey, recorded both quantitative and qualitative data points. The survey included variations of questions present in the pre-implementation survey framed to record the impact of the app on its users through parental opinion. In these questions, the respondents were asked to rate the impact the app had on their wards on a scale of 1 to 5. The survey also recorded answers to subjective data in the form of text-based answers providing specific information about aspects of the app which were effective in fulfilling their purpose and those that were not.

Participants of this study were parents of children who had been contacted through Dr. Anil Kabisathpathy, an occupational therapist at Aarati developmental center - an institution specifically designed for children with cognitive disabilities. The survey was distributed through a WhatsApp group in the form of a Google forms link. The ages of wards of the respondents ranged from 2 to 6 years old. Ultimately 11 people completed the pre-implementation survey, and 7 people completed the post-implementation survey.

The sets of hypotheses are as follows:
1a) **Null Hypothesis:** The participants showed no significant variations in proficiency in different activities before the implementation of the app.
1b) **Alternate Hypothesis:** The participants showed significant variations in proficiency in different activities before the implementation of the app.

2a) **Null Hypothesis:** The participants showed no significant variations in the improvements in proficiency in different activities after using the app

2b) **Alternate Hypothesis:** The participants showed significant variations in the improvements in proficiency in different activities after using the app

C. Limitations of the study
The study does not use a control group to test the results of the study due to ethical reasons stated further. Moreover, the study did see a high dropout rate, with fewer people answering the post-implementation survey as compared to the pre-implementation survey.

The respondents of the study were also roughly from a similar economic stratum and were contacted through a common source which was a developmental center run by an occupational therapist. There was also no means of enforcing fair usage of the app, and all the inferences made further in the study are based on the assumption that the children used the app under only passive parental supervision and were honest while marking daily chores in the app.

The post-implementation survey asked the respondents to rate the impact of the app on their wards rather than their absolute proficiency after using the app, i.e., change in the ability to perform a particular task rather than the existing state of that ability. This implies that a t-test on the ratings recorded from the pre-implementation and post-implementation survey would hold little significance since the quantities being compared are inherently different.

Telephonic interviews were also conducted with the respondents of the *pre-implementation* and *post-implementation* surveys. However, these conversations were not documented and thus could not be included within the scope of this paper.

D. Ethics
All the participants participated in the study voluntarily. In all the surveys answered by the respondents, revealing personal information like name, age, and sex was optional. The study did not include a control group of students who did not use the app due to ethical concerns regarding keeping that particular group of students devoid of a developmental tool that might be beneficial for them.

E. Data Analysis
Descriptive analyses of the data were presented to compare the mean ratings provided by the parents of their respective children about their proficiency in a particular task prior to using the app and the change in the proficiency of that particular task after using the app. One-way ANOVA tests were conducted on the responses from the *pre-implementation* and *post-implementation* surveys to determine whether the variations in means for specific activities were statistically significant or not. Finally, qualitative responses to the open-ended questions were analyzed.

Data was also collected from the app during the implementation period. The data was intuitively analyzed, and inferences were made from the accuracy ratings of several users who used the app for at least 5 days.

III. RESULTS AND DISCUSSION
A. Quantitative Analysis
A baseline for the user's existing state was established using parental opinion recorded using the *pre-implementation* survey. Using the ratings (on a scale of 1-5) and a descriptive analysis of the data recorded for each activity separately, a general understanding can be reached about the strengths and weaknesses of the population of children in specific activities.
The sections, presented in the order they appear in the survey, are as follows: Daily Chores ($M = 2$, $SD = 1.15$); Counting ($M = 3.6$, $SD = 1.84$); More or less ($M = 2.5$, $SD = 1.72$); Body Parts ($M = 3.8$, $SD = 1.48$)

The following table (Table 2) presents the descriptive statistics of the data collected from the *pre-implementation* survey:

Table 2: Descriptive statistics of the ratings recorded for various sections of the app from the pre-implementation survey.

	Daily Chores	Counting	More or less	Body parts
Mean	2	3.6	2.5	3.8
Median	1.5	4.5	2	4.5
Mode	1	5	1	5
Standard Deviation	1.15	1.84	1.72	1.48
Skewness	0.46	-0.73	0.42	-0.73
Range	3	4	4	4
Minimum	1	1	1	1
Maximum	4	5	5	5
Count	10	10	10	10
Largest(1)	4	5	5	5
Smallest(1)	1	1	1	1

A one-way-ANOVA test was also conducted on the data received from the *pre-implementation survey* to determine whether the variation in the means of the different activities was statistically significant.

The following table (table 3) presents the results of the one-way ANOVA test conducted on the data recorded from the *pre-implementation survey.*

Table 3: Results of the one-way ANOVA test conducted on the ratings for different sections recorded from the pre-implementation survey.

ANOVA: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Var*		
Daily Chores	10	20	2	1.3		
Counting	10	36	3.6	3.38		
More or Less	10	25	2.5	2.94		
Body Parts	10	38	3.8	2.18		
ANOVA						
	SS	*df*	*MS*	*F*	*P value*	*F crit*
Between Groups	22.475	3	7.497	3.057	0.048	2.87
Within Groups	88.5	36	2.46			
Total	110.975	39				

(Var = Variance)

F(3.057) = (greater than the F critical value of 2.87), p-value P(0.048) < 0.05. Thus, we can confidently conclude that there was significant variation in the means of the ratings recorded for the various activities, and thus infer that the users were more proficient in some tasks than others. It was observed that the users were the most proficient in the "body parts" section (M = 3.8, VAR = 2.18) closely followed by "counting" (M = 3.6, VAR = 3.38). Thus, the null hypothesis can be rejected, implying that participants showed significant variations in the proficiency in different activities before using the app.

A *post-implementation survey* was conducted after a 3 week implementation period for Atulit. The respondents (parents) were asked to provide ratings on a scale of 1-5, with 1 meaning that the app had no impact on their wards and 5 meaning a significant positive impact.
The sections, presented in the order they appear in the survey, are as follows: Daily Chores (M = 3.33 , SD = 1.03); Counting (M = 4.17, SD = 1.33); More or less (M = 3.83, SD = 1.47); Body Parts (M = 3.17 , SD = 0.98).

The following table includes the results of the descriptive analysis conducted on the data recorded from the above-mentioned *post-implemented survey.*

Table 4: Descriptive statistics of the ratings recorded for different sections of the app in the post-implementation survey.

	daily chores	Counting	*more or less*	*body parts*
Mean	3.33	4.17	3.83	4.17
Median	3	5	4.5	4.5
Mode	3	5	5	5

Standard Deviation	1.03	1.33	1.47	0.98
Skewness	0.67	-1.21	-0.71	-0.46
Range	3	3	3	2
Minimum	2	2	2	3
Maximum	5	5	5	5
Count	6	6	6	6
Largest	5	5	5	5
Smallest	2	2	2	3

Along with a descriptive analysis, a One way ANOVA was also conducted on the data received from the *post-implementation* survey to determine whether there are statistically significant variations in the ratings given to specific activities.

The following table (table 5) includes the results of the above-mentioned one-way ANOVA test.

Table 5: Results of the one-way ANOVA test conducted on the ratings recorded from the post-implementation survey

Groups	*Count*	*Sum*	*Average*	*Var*		
daily chores	6	20	3.33	1.067		
counting	6	25	4.17	1.77		
more or less	6	23	3.83	2.167		
body parts	6	25	4.17	0.967		
	SS	*df*	*MS*	*F*	*P value*	*F crit*
Between Groups	2.79	3	0.93	0.62	0.61	3.10
Within Groups	29.83	20	1.49			
Total	32.625	23				

(Var = Variance)

F(0.62) < F critical value (3.10), p (0.61) > 0.05.The ANOVA conducted on the ratings recorded from the *post-implementation* survey indicates a p-value higher than 0.05, and thus we can reasonably infer that there were no statistically significant variations among means of different activities and thus there was no significant difference in impact caused by the app on its users with different activities. Thus, we accept the null hypothesis, implying that participants showed no significant variations in improvement in proficiency in different activities after using the app.

The following table (Table 6) tables juxtapose the ratings received from the *post-implementation* and *pre-implementation* surveys. It displays the means of the recorded ratings.

Table 6: Comparison of mean ratings of activities before implementing the app and after implementing the app.

	Pre-implementation	(Improvement rating) Post-implementation
Daily Chores	2	3.33
Counting	3.6	4.17
More or less	2.5	3.83
Body parts	3.8	4.17

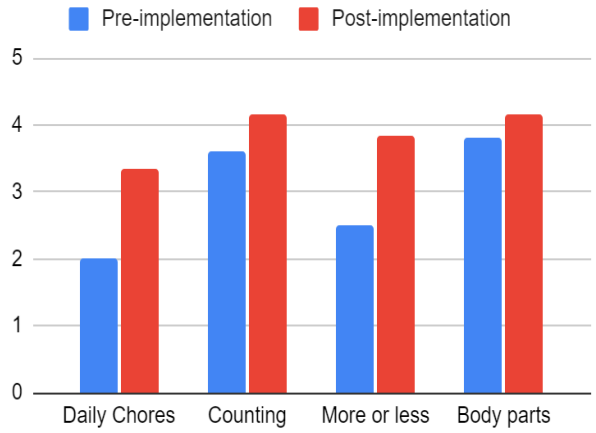

Figure 1: The bar graph represents the change in mean ratings of the daily activities before and after the implementation of an app

Inferences about specific groups of ratings can be made from the table and figure presented above. It can reasonably be inferred from the ratings provided by the respondents in the *pre-implementation survey* (M = 2) on a scale of 1-5 that a significant number of respondents were not able to complete their daily chores on a daily basis without external motivation. After using the app, a

significant improvement can be seen in their ability to do the same from the ratings recorded in the *post-implementation* survey (M = 3.33), indicating a considerable improvement.

From the ratings submitted by the respondents of the *pre-implementation* survey (M = 3.6), it can reasonably be inferred that for a significant number of users(children), their ability to count from 1-6 was less than proficient but was still better than their ability to complete their daily chores without external motivation or support. From the improvement ratings given by the parents (M = 4.17), it can be inferred that there was a significant improvement in their children's ability to count from 1-6.
From the ratings recorded in the *pre-implementation* survey (M = 2.5), we can establish that prior to using the app, for a significant number of users, their ability to differentiate between quantities that were greater from those that were smaller was quite less than proficient. However, they seemed to show considerable improvement after using the app indicated by parental opinion (M = 3.83).

From the ratings recorded in the *pre-implementation* survey (M = 3.8), we can reasonably infer that students were the most proficient, out of all other activities, in identifying body parts before using the app. However, from the ratings recorded from the *post-implementation* survey (M = 4.16), it is also apparent, according to parental opinion, students showed considerable improvement in the ability to identify basic body parts after using the app.

Due to irregular data caused by dropouts and periodic inactivity, statistical analysis on the data collected during the implementation period of the app would not be feasible. A precursory analysis of the data does, however, provide some useful insights. Recorded daily accuracy of each participant was observed to be above 50% in most cases which would indicate that the users found the questions to be easy or repetitive, which could lead to them getting disinterested and dropping out. This is even supported by the qualitative responses recorded in the *post-implementation survey*, which indicated repetitive questions to be the most common complaint by the users.

The respondents of the *pre-implementation survey* were also asked whether they thought their wards showed affinity towards smartphones and games with the options to answer as *Yes*, *No*, and *Maybe*. 73% of the respondents answered as *Yes*, 9% answered. *No*, and 18% answered as *Maybe*.

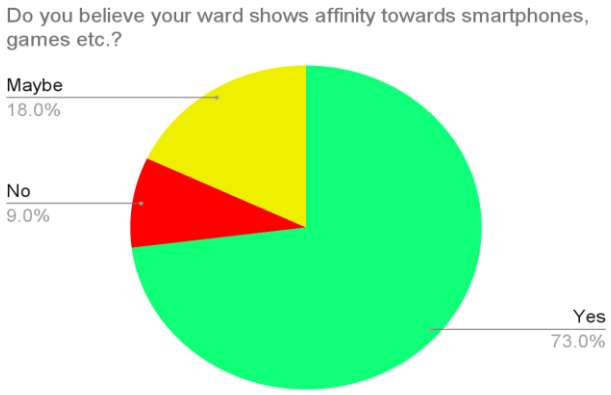

Figure 2 : The pie chart represents the fraction of respondents who answered yes, no, or Maybe when asked whether their ward shows affinity towards smartphones and games.

This supports a prior claim made in the paper: Children tend to show an affinity towards smartphones and games.

The respondents were also asked to rate their satisfaction with the education their child was receiving on a scale of 1-5, with 1 representing extreme dissatisfaction and 5 representing extreme satisfaction. From the recorded ratings (M = 3.1), it can be reasonably inferred that the respondents showed moderate satisfaction with the education their wards were receiving.

The following figure (Figure 3) represents all the responses received for the above-mentioned question in a column chart.

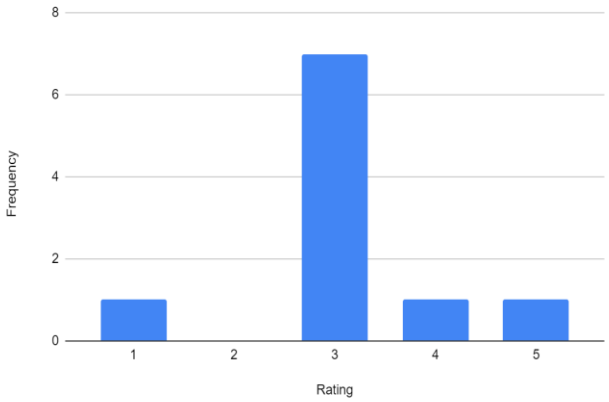

Figure 3: The bar graph represents the ratings given on a scale of 1-5 by the respondents when asked about their satisfaction with the education their child was receiving.

The respondents of the *pre-implementation* survey were asked to rate the impact of the COVID-19 pandemic on their wards' learning on a scale of 1-5, with 1 meaning that their education has been un-impacted and 5 representing a

huge impact. From the recorded ratings (Mean = 4.4 Mode = 5), it can be reasonably inferred that according to parental opinion, a significant fraction of the participants of this study were considerably impacted by the COVID-19 pandemic.

The following figure (Figure 4) represents a frequency versus rating column graph of the responses received for the above-mentioned questions.

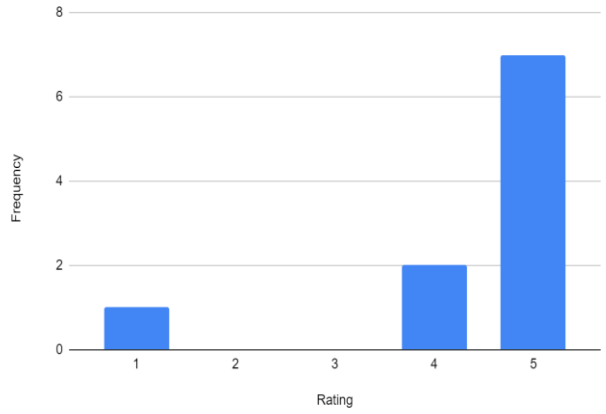

Figure 4: The column graph represents the frequency of the recorded ratings for when the respondents were asked to rate the impact of the COVID-19 pandemic on their wards

From the above representation of the responses received, it can easily be inferred that the COVID-19 pandemic had a huge impact on the education of wards of the respondents, which thus supports a prior claim made in this paper.

The following table (Figure 5) represents a histogram of the daily accuracy ratings recorded for different individuals who used the app for at least 5 days.

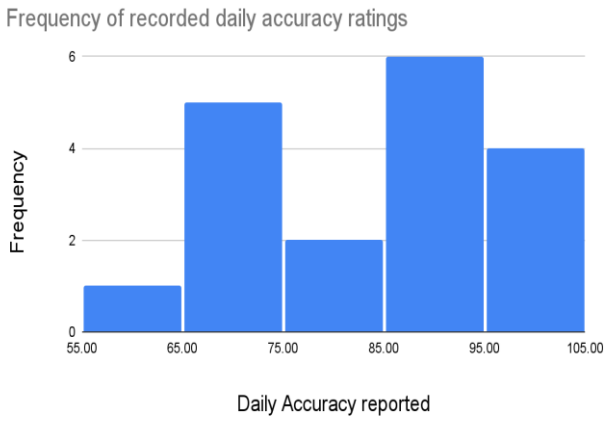

Figure 5: The column graph represents the daily accuracy ratings recorded for users of the app during the implementation period of the app - Atulit

The above graph is observed to be slightly skewed towards the right, indicating that the respondents found the questions inside the various activities in the app to be relatively easy. This would support the theory (made further along in the paper) explaining high dropout rates during the implementation period because of a lack of challenge.

B. Qualitative analysis

In addition to quantitative data, qualitative data in the form of text-based answers and interviews conducted over a call was also collected from the parents. The qualitative data proved to be useful in providing specific information about different aspects of the app that were exceptionally effective or efficient in fulfilling their intended purpose or needed improvement. These qualitative responses also provide specific data points for future research to be conducted in improving the state of education for children with cognitive disabilities by providing specific areas in which the children struggle or some aspects of the education they are receiving that need improvement.

Respondents to the *pre-implementation survey* were asked to list (using text-based responses) some "areas of daily life" that their ward struggles in. Notably, a majority of the respondents regarded speech and communication ("speech," "speech and understanding", "responding", "response") as a sphere their ward struggled in. Other responses, in the order of decreasing frequency, included completing daily chores like brushing, toileting, etc. (“daily functions like brushing, toilet, wearing clothes, shoes… needing support”), “sleeping at night”, and anger management (“anger management, tactile issues”).

Respondents to the *pre-implementation survey* were also asked to list (using text-based answers) some aspects of the education being given to their wards that they would like to see improved upon. The responses included - [the need for a] system that recognizes special children, socialization, communication skills.

Respondents to the *post-implementation survey* were asked to list (using text-based answers) specific aspects of the education their child was receiving, which the app was able to complement positively. The responses included, "number counting", "cognitive skill", "attention", and "daily living activities".

The respondents were also asked to list some improvements they would like to see in the app, which would help it perform its function even better. The responses included complaints regarding repetitive questions and requests for more questions to be added. This supports a concern discussed earlier, wherein one of the reasons for a high dropout rate could be that the users found the puzzles and questions too easy and thus were leaving.

The following table (Table 7) represents the positive and negative responses received as feedback for the app from the *post-implementation survey*.

Table 7: Qualitative remarks provided by the respondents of the post-implementation survey

Positive feedback	Negative Feedback
"It makes a child learn in easy way."	"More puzzled can be included."
“Attractive with pictorial representative, very educative, interest in learning”	**“**Lot of repetitive questions for every activity

Telephonic interviews with parents were also conducted. A unique response that surfaced during these interviews was the lack of audio cues. From the feedback received, it can be reasonably inferred that the app would certainly be more efficient with further changes and the addition of content.

IV. CONCLUSION

In conclusion, serious games show promising results as supplementary educational devices for children with cognitive disabilities. Parental opinion definitely suggests that there was an increase in proficiency of their wards to perform daily tasks in addition to basic tasks like identifying body parts, counting, and differentiating quantities. It was also noted that participants showed significant variation in their proficiency in different activities before using the app; however, they did not show any significant variations in the improvement of their proficiency in different activities after using the app. The development of Atulit, in addition to the results and insights gathered from this study, holds the potential to pave the way for future research into the implementation of serious games alongside the existing educational paradigm. Despite all the limitations in conducting the study and high dropout rates, analysis of the data collected from the *pre-implementation* and *post-implementation* surveys shows statistically significant results suggesting a considerable impact of the app - Atulit on its users.

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APPENDIX

1. Pre-implementation survey

Pre-implementation questionnaire

This survey records baseline statistics before the usage of the app. None of the information provided in this form will be made public except for the ratings given on the scale of 1-5 on some questions. Please answer all the star marked questions.

* Required

1. Name (of your ward)
2. Gender *
   Mark only one oval.
   - Female
   - Male
   - Prefer not to say
   - Other:
3. Age *
4. School / Institution name
5. On a scale of 1-5 please rate how frequently does your ward complete their daily chores without supervision *
   Mark only one oval.

   1 2 3 4 5

   1 : Needs to be prodded and supervised to complete basic tasks ◯ ◯ ◯ ◯ ◯ 5: Completes all daily tasks without any supervision
6. On a scale of 1-5 please rate how well does your ward know counting till 10 *
   Mark only one oval.

   1 2 3 4 5

   1: Cannot count at all ◯ ◯ ◯ ◯ ◯ 5: Can effortlessly count till 10
7. On a scale of 1-5 please rate how well can your ward identify more or less (5 is more than 2, 1 is less than 3, etc.) *
   Mark only one oval.

   1 2 3 4 5

   1: Cannot tell more or less at all ◯ ◯ ◯ ◯ ◯ 5: Can point out more or less for any two numbers
8. On a scale of 1-5 please rate how well can your ward identify body parts *
   Mark only one oval.

   1 2 3 4 5

   1: Cannot identify body parts at all ◯ ◯ ◯ ◯ ◯ 5: Can identify all basic body parts (eyes, nose, ears, etc.)
9. Would you say that your ward seems interested in games, smartphones, etc.? *
   Mark only one oval.
   - Yes
   - No
   - Maybe
   - Other:
10. How satisfied you are with the current education your child is receiving? *
    Mark only one oval.

    1 2 3 4 5

    Extremely Unsatisfied ◯ ◯ ◯ ◯ ◯ Extremely satisfied
11. How much has your ward's learning been impacted due to the pandemic? *
    Mark only one oval.

    1 2 3 4 5

    Unimpacted , same as it has always been ◯ ◯ ◯ ◯ ◯ Impacted a lot
12. Which areas of daily life does your ward struggle in? *
13. What are some aspects of the education being given to your ward that you would like to improve upon?
14. Would you be open to participating in an interview after the study has been completed to share your thoughts and opinions?
    Mark only one oval.
    - Yes
    - No
    - Maybe
    - Other:

2. Post-implementation survey:

Post implementation

* Required

1. Name (of your ward)
2. Gender *
   Mark only one oval.
   - Female
   - Male
   - Prefer not to say
   - Other:
3. Age *
4. School / Institution name
5. Which aspects of the education being given to your child were improved upon by the app (Atulit)?
6. On a scale of 1-5, please rate how often your ward completes their daily chores while using the app. *
   Mark only one oval.

   1 2 3 4 5

   1 : Still needs to be prodded and supervised to complete basic tasks ◯ ◯ ◯ ◯ ◯ 5: Completes all daily tasks without any supervis
7. On a scale of 1-5, please rate how well your ward has learnt to count after using the app. *
   Mark only one oval.

   1 2 3 4 5

   1: No improvement at all ◯ ◯ ◯ ◯ ◯ 5: Significant improvement in counting and identifying numbers

3.

8. On a scale of 1-5, please rate how well your ward has improved on identifying more or less (5 is more than 2, 1 is less than 3, etc.) *
   Mark only one oval.

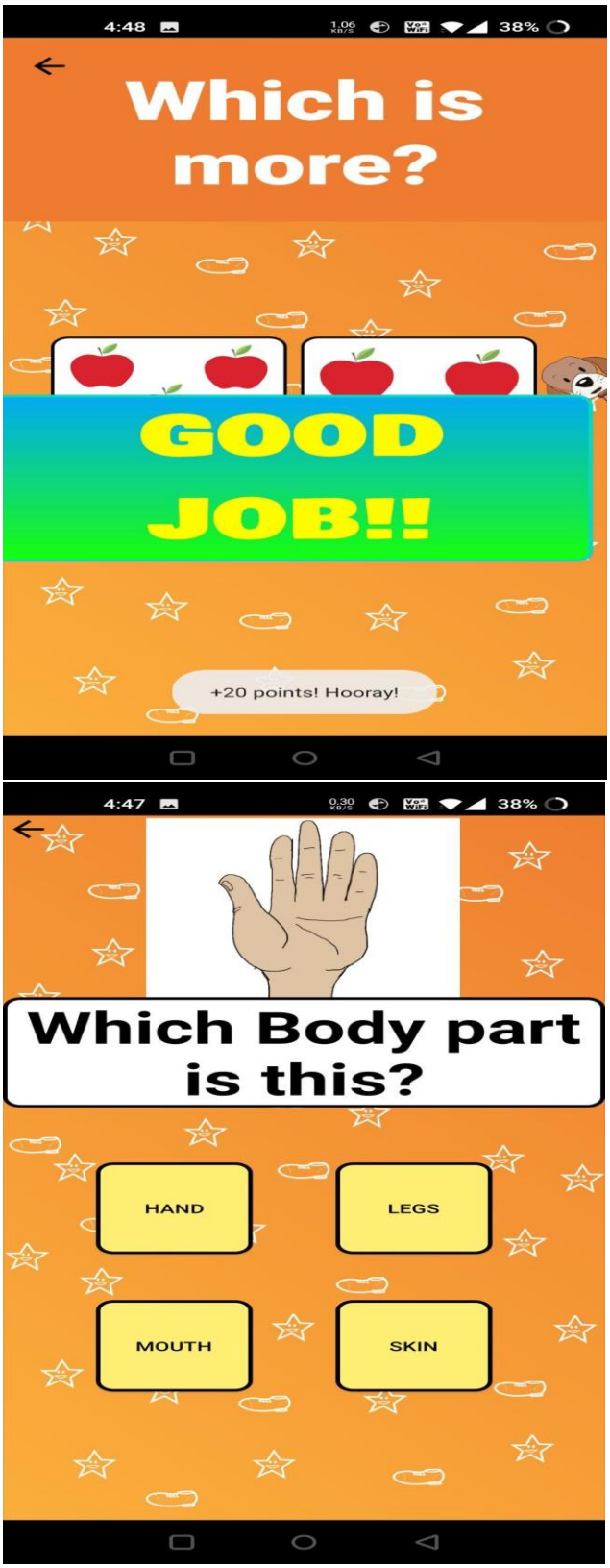
   1 2 3 4 5

   1: No improvements at all ◯ ◯ ◯ ◯ ◯ 5: Significant improvement or near proficiency
9. On a scale of 1-5, please rate how well your ward has improved in identifying body parts. *
   Mark only one oval.

   1 2 3 4 5

   1: No improvements at all ◯ ◯ ◯ ◯ ◯ 5: Significant improvement or near proficiency
10. What was something you thought the app got right? What did you like about the app?
11. What was something that you would like to see improved upon in the app?

4. Screenshots from the App - Atulit:



5. Additional information about the user experience of the app: When the user launches the app for the first time on their smartphone, it takes in the Name and roll number of the student. This data is saved in a file on the device and synced with the database whenever the smartphone is connected to the internet. The roll number acts as an identifier for the backend software and the admin (available to only the educators) which would help identify the student throughout the platform. After the first time, the user is navigated to the dashboard of the app during each subsequent launch.

Description of the activities:

Daily Chores
The FACP checklist contains multiple attributes as tasks that the children need to perform up to a certain mark in order to be considered proficient in that particular item. Being promoted from one level to another requires a specific percentage of the checklist to be completed by the student. One of the primary categories under which these tasks are listed is daily tasks. These tasks require the students to be able to complete their daily chores without a certain level of assistance.

"Daily Chores" is one of the sections in the app that gamifies the tasks of doing daily chores by ensuring positive reinforcement in the form of animations and points given to the user. All these tasks can only be completed in the app once per day and thus renew every day. These get logged on to the database running on the backend acting as key indicators of daily usage of the app later on in the study.

Body Parts
"Body parts" is a question and answer-based section that presents basic body parts like nose, mouth, eyes, ears, etc. in the form of images along with four options containing body part names. The users are required to select the correct option which is then followed by a rewarding animation along with a specific number of points.

Pointing at things
"Pointing at things" is a section in the app aimed at cultivating familiarity with everyday objects among its users. The app presents everyday objects such as balloons, a pencil, an ice cream, etc. in the form of images in a fashion similar to the section mentioned before. On selecting the correct option, they are rewarded with an animation and a specific number of points.

Counting
"Counting" is a section aimed at cultivating the skill of counting in children by presenting a number along with four images containing different numbers of apples arranged in a design that is popularly used on the faces of dice. The users need to select the image displaying the number of apples that are shown to them in numeral form. On selecting the correct option, they are rewarded with an animation and a specific number of points.

More or less
"More or less" is a section that is inspired by one of the items in the FACP checklist which requires the students to be able to tell numbers that are greater from those which are less. The users are presented with two images containing different numbers of apples, one of which can be selected. On selecting the correct option, the users are rewarded with an animation and a specific number of points.

Computer education
"Computer education" is a section aimed at cultivating a very basic understanding of computers in children. It shows the user images of computer peripherals along with two options containing possible names for the image, one of which is correct. On selecting the correct option, the users are rewarded with an animation and a specific number of points.

All of the points obtained by the students are logged into the database running on the backend provided the app is being used on a device with a stable and continuous internet connection. The number of questions done by the user, the number of questions they got right, the number of questions they got wrong, and the net accuracy of the students are also logged into the database running on the backend. The latter part of the data is logged every day with the date on which it was logged. This comes in handy when evaluating the data received from the app for estimating engagement and evaluating the impact of the app on its users.