Opportunities for Serious Game Technologies to Engage Children with Autism in a Pakistani Sociocultural and Institutional Context

Opportunities for serious game technologies to engage children with autism

An investigation of the design space for serious game technologies to enhance engagement of children with autism and to facilitate external support provided

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Usability and design of serious game technologies have been widely investigated as academic interventions tools for children with autism. However, besides the technology, the sociocultural and institutional context also impacts the gameplay activities of children with autism as well as the external support provided by instructors. Therefore, this paper investigates i) the impact of sociocultural and institutional context over the engagement of children with autism with serious game technologies, ii) the types of external support children with autism are offered or require during gameplay session, and iii) the type of rewards and encouragers that can act as unbiased support to increase the engagement of the children with autism during gameplay.

This paper investigates these factors with an inductive analysis of educational gameplay activities of 23 children with autism in Lahore, Pakistan. Our study found that sociocultural and institutional context has substantial impact over the gameplay activities of children with autism. Children required both physical and verbal support during the gameplay activities, and institutional context influences the behavior of instructors as well. Finally, dynamic animations, rewards and encouragers can keep the children engaged for longer in the gameplay.

CCS CONCEPTS •**Human-centered computing ~ Human computer interaction (HCI) ~ HCI design and evaluation methods ~ Field studies • Human-centered computing ~ Accessibility ~ Accessibility design and evaluation methods • Human-centered computing ~ Interaction design ~ Interaction design process and methods ~ Contextual design**•

Additional Keywords and Phrases: Game-based learning, serious game technologies, children with autism, support, context, rewards, and encouragers

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1 INTRODUCTION

For many decades, Autism Spectrum Disorder (ASD) has been defined as a neurodevelopmental disorder that affects social interaction, verbal, and nonverbal communication of a person, and also involves restricted or repetitive behaviors[1,23]. In recent years, the rate of diagnosis of autism among children has increased; it has been reported by the World Health Organization that among every 100 children there exists one child with autism worldwide [2, 24]. This ratio is 1 in every 44 children in the US [54], and almost 400K children have been diagnosed with ASD in Pakistan as per the Autism Society Pakistan [53]. Beyond an increase in recognition and representation, the perspective of autism has evolved with the social model of disability, which proposes that autism itself is not the cause of social barriers. Instead, the limited opportunities provided to people with autism by the surrounding society create the barriers. Technology can contribute to minimize these barriers by supporting customized experiences appropriate to specific contexts. In an educational context, technology can be leveraged to support engagement with various educational and functional concepts through repetition and encourage young children with autism through gamification. Previous research has explored a range of technologies that can support children with autism to learn, such as augmented reality [3], virtual reality [4], computer-based games[5, 6], social robots [7, 8] and screen-based serious games [9 ,10, 11]. The prime purpose of a serious game is to motivate and engage people in learning, rather than pure entertainment. In the context of autism, serious game technologies have been studied for behavior intervention [13], skills development [14], and academic learning [15]. Subsequently, many researchers have evaluated design and usability of the serious game technologies for children with autism [16–20] and demonstrated it to be a useful tool for intervention and learning. Serious games are mostly designed for smart devices such as mobile phone and tablets [1], as they can target multiple functionalities and cognitive skills, they are generally affordable, and their use is easier to learn as compared to computers [12].

However, besides the usability and design of the serious game itself, some other important factors, such as the sociocultural context (with respect to training environment and technology, for example existing engagement with smart devices), and institutional context (environment of institution where the learning games are being played), can substantially impact how children with autism engage with serious game technology-based learning. Additionally, to engage with serious game technologies, children with autism may require or ask for some external support, which can itself be influenced by the institutional context. Based upon the diverse contexts and diverse preferences of learners with autism, serious game design and support required might be different for each child. Adapting technology to children's unique contexts is important to understand how their interests and needs can vary.

Few studies have mentioned how children's engagement with serious game technologies is influenced by the sociocultural context in which the children with autism have been raised and allowed to use a smart device [50,51]. To our knowledge, none has discussed the impact of ongoing institutional context in which serious games are being played. Furthermore, most of the studies are conducted in controlled contexts rather than in-situ contexts, thus lack practical validity. On that account, we argue that the sociocultural and institutional context could have substantial effects on the engagement of children with autism with the games in various ways. Children with autism are often observed to become easily distracted, therefore, it is important to study the context where these children could be engaged for longer in any gameplay activity, rather than merely their response to the game itself. Moreover, the context in which instructors are providing verbal or physical support could also influence the nature of the support they provide. For example, their attitude might change with the limitations of time frame of duties and responsibilities they have aside from supporting the children with autism. Besides investigating the contexts, it is also important to characterize the diverse types of support a child with autism require or asked for as they engage with game technology. Additionally, to better engage these children with serious game technologies it is also worthy to investigate game elements, such as context-based rewards and encouragers

that could develop the childrens' interest in the game and can act as unbiased additional support to keep them engaged for longer.

To address these questions, we built a curriculum-based serious game suite for tablets, incorporating seven mini-games. We presented the game to 23 children from 2 support centers (which mainly train children with autism) in Pakistan. The children were given the opportunity to engage individually with the game for around 20 minutes at a time, and an instructor was present during the gameplay session. We observed how children with autism played the serious game and how they responded to various aspects of the game (choice of game, asked or required help) in the presence of instructor (to provide help when required of asked for). These observations, conducted in a real context of use, contribute new perspectives on, i) the impact of sociocultural and institutional context over the engagement of children with autism with serious game technologies as well as on the attitude of instructors, ii) the kind of support children with autism require or ask for within the ongoing context from the instructor, iii) the type of rewards and encouragers can act as unbiased additional support for children during gameplay activity to engage them for longer.

Having established the importance of investigating the effect of sociocultural and institutional context over the engagement of children with autism, the related work section will elucidate what is known about the impact of context over engagement of children with autism with serious games, the behavior of instructors during gameplay sessions, and how children react towards different type of rewards and encouragers (static or dynamic). We will then detail our research probe and procedure, and methods adopted to conduct and analyze user studies, before delineating the observations and report our findings.

2 RELATED WORK

2.1 Serious Game Technologies as Intervention and Learning Tools

Serious game technologies can be used a tool to support intervention and academic learning of children with autism, due to their interactive nature, self-paced feasibility, real world depiction, and ease of use. as compared to traditional learning from the printed books. Previous research has demonstrated that children with autism enjoy game technologies in the same way as neurotypical children do [26]. Additionally, children with autism learn more rapidly [27, 28] and attentively through game technologies as compared to traditional techniques and methods. Various research studies have been conducted on serious game technologies because they act as both, a learning and an intervention tool for children with autism to target different academic concepts, cognitive capabilities, and functional areas. These areas include social interactions [18, 28, 29] emotion recognition [11, 17, 29, 30, 31], basic education [12, 16, 32, 33], joint attention skills [28, 34], fine motor skills, theory of mind, visual search, cognitive understanding, classification[28] and anxiety [35]. Evaluation and results from these studies have shown that serious games can improve learning in comparison to traditional methods. It is both an effective technology for the delivery of academic concepts and a supporting learning tool for children with autism as well as for instructors.

2.2 Role of Sociocultural and Institutional Context

Besides design and usability, it is also reported in the literature that gameplay behavior is highly context dependent [34, 36, 52]. However, to our knowledge no study has mentioned the impact of the sociocultural context with respect to technology usage (such as training methods and usage of smart devices) , nor the institutional context (ongoing situation during the gameplay) in which serious game technologies are being played. Most of the studies are conducted in controlled

contexts and lack real world validity. However, the context of the setting with respect to sociocultural and institutional environment could substantially impact the behavior of children with autism in many ways [48].

In Pakistan, the lack of awareness regarding autism among health care professional [46] and parents [47] often results in late diagnosis of autism, which in turn often leads to inadequate support. The support that exists is in segregated training institutions dedicated for children with autism, which don't offer many places and are mostly located in major urban cities. These institutions are beyond the access of most of the population, and particularly children in lower socio-economic areas [25]. Each of these institutions have their own context and methods to provide standard training to the children they support. However, the usage of technology-based intervention in the institutions is generally low, or forbidden [49], and is considered harmful for children with autism; there is an institutional belief that technology causes autism and nurtures speech delays and hyperactivity among children with autism. On the other hand, most children with autism use smart devices at home with the permission of their parents. Their usage and response to technology could vary between homes and institutions. As prior research suggests that the cultural context has an impact on behavior and learning of children with autism [50, 51], it is important to study the context where children with autism will be engaged in gaming technologies rather than merely their response to the game itself.

Furthermore, it is also evident from the literature that children with autism might need external support to play the games, as most of the studies mention the presence of career or support worker during gameplay activities [16, 39, 40]. The institutional context in which instructors support children with autism could also influence their behavior towards the gameplay activities. Instructors might support children differently based on the timeframe of their duties, their assigned responsibilities, and the additional support network around them [17]. Yet no known study has discussed the impact of institutional factors on the behavior and preferences of children with autism while they are being engaged with serious game technologies, or on the attitude of instructors who support them during their engagement with games. Additionally, since children with autism often require support to engage in serious game technologies either to understand instructions or the game rules [18], it is also worthwhile to explore the diverse types of support they request or require during their engagement with such games.

Furthermore, several studies have suggested that continuous rewards and encouragers are also important in learning games[21, 22] , and to keep the players curious [17] and engaged for longer periods of time. Few investigations have mentioned using rewards in their games; however none has explicitly discussed how children with autism respond to any kind of rewards or encouragers in diverse contexts. The design space in which these rewards and encouragers can be used as additional unbiased support to keep children with autism engaged for longer with serious game technologies is also worthwhile to explore.

3 USER STUDY: METHODS AND PROCEDURE

In order to explore all the factors mentioned above, a game suite was designed and developed to be used as an educational technology probe. The design was modeled on existing tangible learning strategies in order to support institutional acceptance and only introduce a new modality to the learning experience. We conducted gameplay activities with the probe in two different centers (of Lahore, Pakistan) in order to explore a diverse context as well as diverse children (23 in total). In order to deeply understand the complex relationships between individual children, individual instructors and each context, we conducted an inductive qualitative analysis based on observations and recordings of gameplay activities and QA sessions.

3.1 Serious Game Design

A serious game suite called *"Tinyhands"* was designed as a probe to present an observable learning game experience to children with autism. *Tinyhands* was designed after anonymously observing the teaching sessions of children with autism (how they learn) and the concepts used in the curriculum (what they learn), with the collaboration of a support center (introduced as Center A in the following section). The concepts presented in the game suite were selected based on contextual interviews conducted with the curriculum director at the support center. The purpose behind this design exercise was to provide a game suite that can serve as an educational tool as well as a recreational activity. The developed serious game suite consists of seven different *"mini games"*, each with 3 or 4 sublevels. These games included the concepts of matching (of related objects), adjectives (based on properties given), sorting (numbers, letters, and objects both in ascending and descending order), classification (based on classes provided), selection (of object/s requested), association (between two sets of objects), and emotion (recognition). Each mini game comprises questions that illustrate the concepts mentioned, and the options for one question were presented in the form of pictorial cards with images of objects (Figure 1) or numbers/alphabets (Figure 2).

The game suite was designed for flexible use, to acknowledge that all children learn concepts differently and at a different pace. If a child with autism did not want to play one game, he/she could leave the game anytime and select another game from the home screen. Each mini game has three to four sublevels and as the degree of difficulty in each sublevel increases, so does the number of options displayed on one screen and the number of possible correct answers. Based on flexible design, children could skip a level, or skip a question, at any time. However, children had to complete all the levels and solve all the questions to finish a certain game.

Each child was allocated a unique username in order to maintain game sessions over the period of trial. This allowed children to stop the game whenever they wanted and resume it from the level or questions that was left unfinished. This game suite was developed in Unity and was installed on a Lenovo ThinkPad tablet (1920*1200 res) running a windows operating system. In this study, the game suite was used as a probe in order to investigate the opportunities of serious game hjyh86technologies while considering the impact of sociocultural and institutional context over the engagement of children with autism and behavior of instructors. Therefore, further details of game design and development are beyond the scope of this paper.

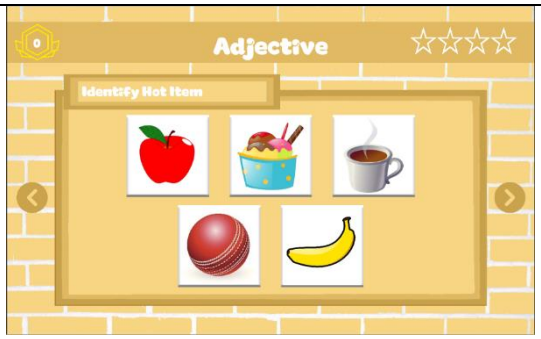

Figure 1: Game interface where a child needs to click the picture of an object.

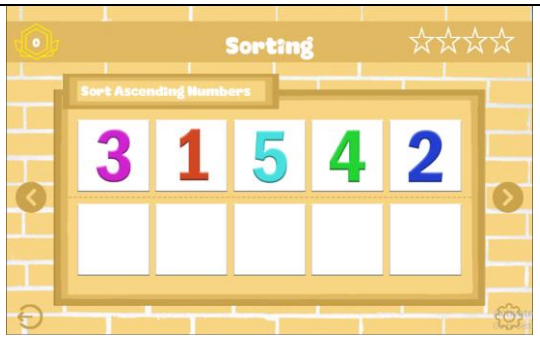

Figure 2: Game interface where a child needs to drag and drop the pictures

3.2 Participants Recruitment

A total of 23 children aged between 4 – 15 years (this age range was selected because during observations of educational sessions similar learning activities were noticed among this age range.) and 9 instructors were recruited from two different support centers (called Center A and Center B in this paper) located in two distinct areas of the city of Lahore, Pakistan (Table 1). The participant ratio of male and female was 4:1 ; the lower number of female participants reflects that the ratio of girls enrolled in the centers, resulting from autism being more commonly diagnosed among boys than girls. Children participants were recruited according to the following criteria:

1. Neurodivergent children were assessed as having autism by the center they were enrolled in.
2. They can use touch screen devices (by prior experience or by learning)
3. They are engaging in learning at least one of the seven concepts from the curriculum targeted (see 3.1)

The 9 instructors, who also participated in the study, were recruited from the centers where the research took place, and they supported the children with autism during the trials. There was no specific criterion defined for selecting instructors, but it worth noting that they all had experience of teaching children with autism. Individual consent forms were signed by parents of children and by instructors before the study commenced. Children with autism verbally additionally consented to taking part in the research at the beginning of each session. To summarize the observations and findings in the next sections, we will refer to children with autism from Center A with the code *PA* and instructors from Center A with the code *IA*. Similarly, we will refer children with autism from Center B with the code *PB* and instructors from Center B with the code *IB*.

Table 1: Participants Details

Center	Children	Instructors
Center A	14 (PA)	1 (IA)
Center B	09 (PB)	8 (IB)

3.3 Research Settings and Gameplay Sessions

The study was conducted within the centers' environment over a period of 6 weeks (weekend excluded). The researchers were granted special permission by the heads of both centers to use technology in the centers in order to conduct the

experimentations, as tablets and technology-based games are not normally authorized. The game suite *TinyHands* was installed on a touch screen tablet provided by the researcher. Children participants took part in multiple gameplay sessions over the period of time, so they were able, if they wanted to, to play all the 7 mini games in the *TinyHands* game suite. Children who were already familiar with all the seven concepts (matching, adjective, sorting, classification, selection, association, and emotion) played all the games and finished the game suite in a maximum of four sessions. Children who were familiar with fewer concepts only played the games that they could comprehend (for details see Table 2).

Each gameplay session was conducted with one child with autism along with one instructor to support the child. Child and instructor were sitting on chairs either side by side or in front of each other and the touch screen tablet was placed on a plain table in front of the child. To observe the gameplay session, the researcher was standing 4-5 feet apart from the sitting duo. Before the first gameplay session, the instructors were briefed about how they may introduce the games to children, and when can they give hints (e.g. after 3 incorrect attempts at answering a question). During the gameplay sessions, the researcher generally did not have any interaction with, or did not give any instruction to, children or instructors. However, the researcher only occasionally intervened in the session when some instructors started to give hints before three attempts or started to play on behalf of the child. In such cases the researcher had to remind the instructor that they should not provide quick hints or play on the behalf of children with autism. The limit of 3 incorrect attempts was set by considering the maximum of five options available against a question.

In Center A, one instructor was assigned by the centers' director. For gameplay sessions, a separate room was allocated to the research by the director of the center. The study was conducted in the allocated room, where only one child, one instructor and the researcher were present. Beside these 3 people, there were only tangible objects placed in the room for different types of occupational therapies. By contrast, in Center B, there were multiple instructors who took part in the research, and a total of 8 different instructors facilitated the gameplay sessions as part of the research. The director allocated the research a desk in a shared spaced where many other study desks were also placed almost three feet apart from each other. During the gameplay sessions in Center B, multiple academic sessions were being concurrently conducted in the surrounding area within that shared space. Besides the academic setting, there were no noticeable tangible objects placed within the area.

Gameplay sessions were held for a duration of 15 to 25 minutes each. During one session, a child could play between one and three games. In Center A, there was no restriction on the time duration, and a child would leave the gameplay activity when he/she was much distracted, or that he/she did not want to play the games anymore. In Center B, children were also able to end a session if they wanted, however they were not able to continue past a 30 minute mark, which was the time limit set by the administration of the center. Within this timeframe, the researcher first had to set the stage for the gameplay session, which included renewing verbal information and consent, registration, or logging in the child for game session, starting the screen recording of the game, adjusting the camera for video recording of the activities, and maintain the observations sheets.

Table 2: Games played by each participant

Participant	Selection	Sorting	Matching	Adjective	Classification	Association	Emotion
PA1	✓	✓	✓	✓	✓	✓	✓
PA2	✓	✓	✓	✓	✓	✓	✓
PA3	✓	✓	✓	✓	✓	✓	✓
PA4	✓	✓	✓	✓	✓	✓	✓
PA5	✓		✓		✓		
PA6	✓	✓	✓	✓	✓	✓	✓

Participant	Selection	Sorting	Matching	Adjective	Classification	Association	Emotion
PA7	✓	✓	✓		✓	✓	✓
PA8	✓	✓	✓			✓	✓
PA9	✓		✓	✓	✓	✓	✓
PA10	✓		✓	✓		✓	✓
PA11	✓	✓		✓	✓	✓	✓
PA12	✓	✓	✓	✓	✓		✓
PA13	✓	✓				✓	✓
PA14			✓		✓	✓	
PB15						✓	
PB16	✓	✓	✓	✓	✓	✓	✓
PB17	✓				✓	✓	
PB18	✓	✓	✓	✓	✓	✓	✓
PB19	✓	✓	✓	✓	✓	✓	✓
PB20	✓	✓	✓	✓	✓	✓	✓
PB21	✓	✓	✓	✓	✓	✓	✓
PB22	✓	✓	✓	✓	✓	✓	✓
PB23	✓	✓	✓	✓	✓	✓	✓

3.4 Data Collection and Analysis

Multiple methods were used to collect data from the gameplay sessions, including observations written on paper, screen recording, video recording, pictures, and QA sessions. For observations, the researcher took observational notes of each session on paper and maintained a record of each child separately with their username (the actual name of participant was not used to maintain the anonymity) and the name of game(s) played in that session. Childrens' engagement with the game suite was observed based on immersion and flow of playing the games[43]. Along with the observation, data was also collected through video recording the gameplay sessions, screen recording the games running on tablet, taking pictures of participants (each option was selected based on the preference granted by the participants on the consent form). Recordings and pictures were also saved with the same naming conventions used for data recorded on paper (i.e. username and name of the game) to match the recordings with observations later in analysis phase. QA sessions were held with the directors of both centers to know about the demographics and background of children with autism who took part in the research. Questions related to childrens' education and technology usage were asked during the interviews. After gameplay activities, the researchers identified the behavior patterns and attributes by analyzing all the observations noted on A4 sheets and compiled an initial excel spreadsheet with identified behavior patterns as attributes names. These attributes were based on context, support, engagement, and positive (happy, excited, enjoying) and negative reactions (crying, anxiety, frustration) towards the game. After compiling the initial excel sheets, video recording and screen recording captured during sessions were watched and analyzed to fill the missing entries if any. Later the results were analyzed by the team of authors by using principles of iterative inductive approaches to group and present the findings in line with each of the research questions.

4 OBSERVATIONS AND FINDINGS

After conducting the gameplay sessions in both support centers, the research team analyzed the observational notes taken on papers, and screen and video recordings captured during the sessions (as detailed above). The following sub-sections build on the data gathered during the gameplay sessions as we present our findings in relation to i) the influence of

sociocultural and institutional context on the engagement of children with autism and instructors, ii) the nature of support requested or required during the gameplay, and iii) the response of children with autism towards rewards and encouragers and the possibility of using these as a component of additional support.

4.1 Enriched Sociocultural Context is Important for Engagement of Children with Autism

Technology usage was considered as one aspect of the sociocultural context in this investigation. As background technological context for the children, we considered the average daily time spent on a smart device with the permission of their parents. This time could be spent on any educational or recreational games/activities and is not limited to serious game technologies. Centers were not part of this context, as use of any smart device at both centers was completely prohibited(discussed above). In the QA sessions, it was stated that almost all the children use smart devices at home for an average of two hours in a day. This statement implies that all the children with autism would be familiar with how to use the smart device employed in the research. During the observations, it was evident that some children were proficient and positive towards technology usage. They responded to the game dynamics quickly and started to play without any help. However, not all the children were comfortable using the touch screen tablet. Some were not sure how to touch or drag/drop the object; they were shy and seeking help from the instructor to learn how to do touch or drag/drop. They seemed reluctant to touch, hold and use the tablet. They asked instructors to hold their hands while they played the games. This difference might be caused by the type of games and activities children have been doing on smart devices in their homes.

Besides technology usage, the sociocultural context of how the children have learned, and what activities they conduct in their daily routine, also impact the behavior of children during gameplay. In this study, the sociocultural context of center is considered. In Center A, children learn in informal ways: they learn with different musical, dancing, physical and group activities. They play to learn and are coached in teams to enhance their social skills as well. Therefore, it was interesting to note that children in Center A were more expressive and indicating excitation while playing the game. For example, PA2 said *"Hoo"* (a happy hooting sound) when a level was finished, *"Yaay"* and *"way to go"* when an answer was correct, and *"Oh ho"* when an answer was incorrect. She sang *"baby shark"* and *"daddy finger"* throughout the gameplay session and made sad faces when answers were incorrect. Likewise, PA3 also hooted *"Hoo"* when he selected correct answer to a question. PA5 said *"Yay"* and *"Wow"* on a correct answer and *"No"* and *"try again"* on an incorrect answer, she was also singing *"daddy finger"* throughout the gameplay session. PA6 also pointed and said *"this one"* when he identified an answer or said the name of an object if the picture was familiar. PA6 and PA12 also said *"yay"* when a level was finished. PA15 and PA13 were repeating the instructions after the instructor and PA13 was saying *"oh ho"*, *"uh han"* and *"try again"* on incorrect answers.

By contrast, children in Center B learn in a formal way, mirroring the traditional approach used in schools across the country. They have learning sessions of 30 minutes with different instructors to learn different academic concepts; only one of those is dedicated to group or physical activities. The observations in Center B revealed that children were less expressive, and they were silently playing the game. For example, only PB17 pointed to options and said *"this"* with the name of object and PB22 was repeating the instructions after the instructor. PB22 was also saying the name of options he was pointing to confirm from the instructor, and he was also asking about pictures by saying *"what is this?"*.

4.2 Institutional Context can Impact the Gaming Activities of Children with Autism

Furthermore, as described in section 3.2 , participants were recruited from two different support centers located in Lahore, Pakistan and they had different setting for the gameplay sessions. These different settings acted as different institutional contexts for the children while they were engaged with the games. In Center A, the investigations were conducted in a

separate room, with no noise, or other children, or distractions in the surrounding area. It was observed that in Center A, children were engaged with the game more attentively without being distracted or leaning back. They were more focused on playing the games rather than looking around every now and then. They were able to listen to the instructions during the gameplay more clearly and could focus on the words said by the instructor. Meanwhile, it was also convenient for the instructor as well to deliver the instructions in a silent environment with ease, and to repeat them when appropriate. Only younger children (4-6 years old) were less interested in playing the game, as they preferred to play with the tangible objects placed in the room.

On the contrary, in Center B, the investigations were conducted in a shared space where multiple study desks were placed for children. During the investigations, other desks were also being used for several academic activities with other children in parallel. It was observed that the children tended to get distracted and look around, due to the voices and sounds created by other children and instructors in the shared space. To maintain their engagement during the gameplay, the participant instructor had to drive back childrens' attention towards the game more frequently by verbal support, or calling their name again and again, or repeating the instructions more often. Sometimes, instructors also had to speak loudly to deliver the audible instructions.

Additionally, it is important to mention that children who were familiar with the objects and concepts presented in the game screens/questions were less distracted than others who were not familiar with all the objects or concepts. For example, in the game of classification, a child who has knowledge of all the classes was more engaged than another child who knew fewer classes, irrespective of the context and center. Some children also left few games because they were not familiar with the academic concepts of those games. For example, PA4 only played 3 games and PA8 only played 2 games.

4.3 Institutional Context has Substantial Influence over the Instructors Providing Support

The context of the center does not impact only the behaviour of the children, but also the behavior of the instructors, as people who provide support. In Center A, instructor IA1 was assigned to conduct the gameplay session with the researcher and relieved of other duties. Due to this, in addition to not having time constraints on the sessions, he was patient during the activities done by students. He gave children time to think before providing hints or any kind of helpAll sessions ended up lasting less than 30 mins, only because the children started to lose interest and did not play all the games in one session and left, or because they had already completed three of the seven games.

By contrast, in Center B, instructors only had 30 minutes to spend with each child, as per the regulations of the center. Within the time slot of 30 mins, the researcher had to save the data from the previous session, set up the tablet for the new gameplay session, set the camera for video recording, turn on the screen recording, and register or login the child's session. This time varied from 10 to 15 minutes, sometimes due to unexpected reasons such as a malfunctioning tablet, a poor internet connection, some children moving or closing the camera, or opening another application. After making all these arrangements, the child could use the remaining time to play the games. With this time pressure, in some instances when a child was stuck at some point, few instructors (IB3, IB5, IB6) did not give children the time to think and solved the question on his/her behalf to finish the game within the remaining time. This occurred even though instructors were briefed about the support and hints they can provide (section 3.3). In this situation, the researcher reminded the instructors that they cannot give answers on behalf of the children or provide quick hints before three attempts to answer the question. Additionally, few children were playing the game by touching all the options and instructors (IB4, IB5) did not stop them from doing this. They did not ask children to be patient or hold their hands to make them listen to the instructions, potentially in an attempt to save time.

4.4 Varying External Support is Required During Game Session by Children with Autism

All the gameplay sessions were conducted with one child accompanied by one instructor. The role of instructors was to guide children through the game dynamics (touch, drag, and drop), deliver the instructions written on the screen in an understandable way, and provide physical help (hold hands) or verbal help (hints, explanation of games) if required. This role was guided by previous research [16] [40] and instructors were briefed about the role before the sessions were started. Our observations have revealed that children need different type of support during gameplay activities. Some children preferred clicking on the pictures rather than holding a picture to drag from a source location and dropping it at some destination point. This difference in experience might arise from the games children play at home, as discussed in section 4.1. Therefore, in such cases (PA1, PA6, PA7, PA8, PA10, PA13, PB16, PB17, PB20), the instructor had to hold their hand and apply enough pressure so that they can play. However, two children (PA1, PA7) learned drag and drop very quickly and then played the game independently without support after playing a few steps with support. Instructors also had to hold the hands of some children (PA1, PA2, PA4, PA6, PA9, PA10, PA12, PB18, PB20) to prevent them from clicking and touching the tablet screen at random places, accidently close the game, and open some other folder. In addition to help being provided by instructors, some children (PA3, PA5, PA6, PA8, PB19, PB24) explicitly asked instructors to hold their hand while playing. Conversely, PB20 said *"leave my hands"* when the instructor tried to help him and played without any physical help. PB21 and PB24 were irritated when the instructor tried to hold their hands. They did not let the instructor hold their hands and played without any physical support. In addition to guiding hand movements, instructors were also helpful in setting a comfortable environment for the children. For example, PA9 only started to play the game when the instructor changed the table from a wider to a smaller one and brought the child closer to him.

Besides physical help, instructors were also providing verbal support to deliver the written instructions, hints if a child was stuck and encouragements while playing the game. The modus operandi for all the gameplay sessions was the same. The instructors read the instructions written on the screen and children played the game accordingly. None of the children read the instructions by themselves. However, many children (PA1, PA2, PA5, PA6, PA7, PA10, PA11, PB17, PB18, PB19, PB20, PB21, PB22, PB23, PB24) were impatient to touch the screen without waiting for the instructions. In such instances, the instructor also had to prevent the child from touching impatiently. It is also important to mention here that children did not behave impatiently for all the seven games in the suite. They were impatient to start playing the first one or two, and for the rest of the games they were waiting for the instructions and then playing. Furthermore, when a child was stuck at some point, the instructor had to give him/her hints. Hints were of two different types; one was with change of language and the other was with adding some explanation. For example, for PA15, the instructor narrated few instructions in *Urdu (national language of Pakistan)* rather than in *English (international language).* For PA12, the instructor had to explain the class of *Stationery* by adding the phrase, *"with which we write".* Moreover, PA3, PB18, PB22 and PB23 also confirmed the answer before clicking on it by saying *"this"* or just by looking at the instructor for confirmation.

4.5 Rewards and Encouragers can Enhance Engagement of Children with Autism

While children did not notice the game's rewards, they responded well to the encouragers that were introduced in the game suite. The rewards were in the form of stars and scores against a correct answer. The encouragers consisted of an animation of congratulation banner, colorful floating balloons, music for background and correct and incorrect answers visually identified. None of the children noticed stars and scores on the screen and did not give any reaction when a star was increased, or a score was added. However, on congratulations animations, many children gave a response by different gestures. PA1, PA2, PA3, PA7, PA 9, PA10, PB19, PB20, PB22, PB24 got excited when the congratulations screen

appeared. PB21 stood up many times with excitation on applause and balloons. Moreover, during the gameplay activity, PB24 did not know all the answers, but he stayed engaged and played the game until the end on hit and trial, just to see the congratulations screen, and smiled when he finished the game. On the contrary, there were also some children who did not pay any attention to neither rewards nor encouragers. They did not show any emotion or excitement on animations. Additionally, encouragers could have a negative impact as well for some children. For example, PA1, PA8, PA9, PA10 did not play games with the music on, and the instructor had to turn the music off to keep them engaged.

In addition, some children played few games from the game suite or left the games unfinished. PA11 was interested and started to play with focus but at one point the tablet stuck, and he lost interest due to delay in response from the game. Later the tablet was restored but he did not resume and left the game unfinished. PA16 and PA17 withdrew from one gameplay activity because they were not interested in playing even after multiple attempts of verbal encouragement from instructors. They left the session without playing any game that day.

5 DISCUSSION

Observations and findings described in the above section reveal that the sociocultural and institutional context plays an important role. It can impact both the gameplay of the children with autism as well as the behavior of instructors, in different ways. Although previous studies have mentioned that contextual factors including lifestyle, infrastructure, and monetary resources have an impact on the life of children with autism [36, 52], our research has provided more insight regarding the socio-cultural background in relation to gameplay activities of children with autism in learning centers. The sociocultural context, in terms of gameplay activities, includes previous exposure to technology (such as smart devices usage at home) the environment (in which a child with autism learns) and learning activities (he/she has been involved for learning and intervention in his/her daily life). Considering the sociocultural context can help children with autism in adopting technology-based learning methods in support centers in addition to, or in replacement of, some traditional methods. Children who have previous exposure with smart devices learn in an intuitive environment and have more social connections during learning activities; they are explicitly expressive and demonstrate more excitement towards educational game technologies.

With regards to institutional context, to our knowledge no previous studies have yet discussed the direct impact of this context on learning activities children with autism with game technologies or on instructors who are providing the support, despite the fact that this context is considered important for game technologies [38]. The institutional context might involve learning settings such as centers' environment and place of sitting (where child with autism engages in learning activities), duties assigned to instructors in centers and their overall workload. However with our findings, we emphasize that this context has its importance and, children with autism tend to be more engaged in the game technologies within a setting with less extrinsic stimuli and distractions, minimal external sounds, and in the absence of multiple people around them. However this is only a trend, and does not apply to all individuals, due to the fact that each child with autism has a unique behavior and can react to subtle triggers. Our findings also reveal that children with autism are also less distracted when they are familiar with the context of the game technology and the content within it. In such cases, they ignore all the extrinsic stimuli generated by the institutional context and focus on the gameplay. Therefore, to enhance the engagement of children with autism, we suggest to start within an environment which creates less distracting stimuli, and scaffold the use of game technology with basic and simple concepts presented in different mini games (even if these concepts might not be part of the scope of academic criteria for the game). This has potential to minimize distractions in the long term, including when advanced concepts are introduced.

Furthermore, our observations revealed that institutional context also has an impact on the behavior of instructors as people who provide support in general. If an instructor is relieved from multiple duties in the institution and is only assigned the task to provide external support to the children, they can be patient towards the children and can engage the children for a longer time. Instructors in such contexts will be more attuned to when support should be offered to a child to keep him/her engaged with the learning activity, and when support should be held so that they could actively learn by themselves. On the other hand, in contexts where instructors have limited time slots for sessions, their priorities might change, and this can induce a negative impact on the childs' gameplay. In a hurry to finish the session and join the next student, instructors can provide unnecessary hints to finish the activity early. They can play the game themselves on behalf of child with autism to avoid potential delays. In the worst case, they might provide no support at all and let the child play on hit and trial by allowing them clicking on all the options available one by one to avoid the time delays which might be added by physical (holding hands) or verbal support (narrating instructions or providing hints). In such cases, children may not learn anything from the game technology. Ultimately, the behavior of instructors, influenced by the institutional context in terms of duties assigned and in which they support children, can have a direct impact on both physical and verbal support provided for children with autism.

In such situations where there is systemic inability of instructors to dedicate attention and time to children while they learn, learning games themselves can compensate for this to a certain extent by design. One approach is to add Interactive Voice Instructions (IVI) in games alongside visual illustration. IVI with graphics has been reported beneficial for learners with autism [1] for independent learning. Moreover, it has also been observed during this research that children with autism tend to click the screen at random places which results in changing the game screen. This can be reduced by locking the game screen so that the child is unable to minimize or close the game and open other applications. Little animations can be added to teach the children how to play a specific game (click, drag, and drop). Although suggested design improvements will reduce the external support required for children with autism, the need for external support should never be intended to be entirely eliminated.

Lastly, our observations have confirmed the previous findings from the literature [12] that the children with autism start to get distracted after approximately 20 minutes. Therefore, if elements that might help in keeping them engaged for longer would not be part of game design, children might lose interest even before this time span. To keep the children with autism engaged in gameplay activities, we suggest from our finding that dynamic, and immediate rewards and encouragers are more effective than static rewards such as score and stars. Instead, their engagement can be enhanced by adding animations and dynamic encouraging objects which appears frequently; it can act as a positive trigger to maintain their interest in gameplay activities for longer. We suggest that besides the level completion animation, customized animated cartoons with related sounds can be added for indications of correct or incorrect answer, longer pause, and to represent various tasks within the game (e.g. forward, backward, skip etc.). These animations can also act as additional support to keep the children with autism engaged for longer and to reduce the intensity of support provided by instructors. This may consequently also reduce the number of withdrawn or unfinished games by children due to lack of interest during gameplay.

6 CONCLUSION

In the presented research investigation, we raised the importance of investigating the impact of sociocultural and institutional context, which can substantially affect both the activities of children with autism while they are engaged with serious game technologies, and the support provided by instructors who support the children in those activities. We also explored the types of physical and verbal support required by children with autism to play or stay engaged in gameplay sessions. Finally, we discussed the role of rewards and encouragers presented during the gameplay.

Our findings reveal that providing a suitable context to the children with autism can improve their engagement, as well as the behavior of instructors. Such an enriched sociocultural context and institutional context established with less distractions can improve the focus and engagement while playing serious games. Similarly, for instructors, institutional context with flexible timing and provision of facilities to reschedule duties, if not offloading, can improve instructors' attitude towards the children with autism during gameplay activities. Moreover, additional features in game design, such as interactive voice instruction and locking the game screen, can reduce the support required such as hints and preventing children from clicking randomly. Furthermore, adding more diverse concepts, ranging from basic to advanced, has the potential to reduce the unfinished and withdrawn games rate. We also found that animations added for encouragements and dynamic rewards within the game can enhance interest and can keep the children with autism engaged with the game for a longer period, in comparison to static rewards.

Future work should explore how design features within the game can encourage instructors in their role, thus making sure that the learning experience itself remains more prominent than the aim for completion, particularly if timeframes are restricted. This research explored the use of the games within the existing structure of the support centers, however future work could consider co-designing the place of the game technologies in these structures, in ways that may better align with individual children's competencies and preferences.

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ETHICAL CLEARANCE

The study and investigations were approved by the Ethical Committee of the COMSATS University Islamabad, Lahore Campus in Pakistan, and the protocols were developed on the basis of a similar clearance approved by the Queensland University of Technology in Australia.

References

[1] Frith, U. (2003). Autism: Explaining the enigma. Blackwell Publishing.

[2] Zeidan, J., Fombonne, E., Scorah, J., Ibrahim, A., Durkin, M. S., Saxena, S., ... & Elsabbagh, M. (2022). Global prevalence of autism: a systematic review update. *Autism Research*, *15*(5), 778-790.

[3] Marto, A., Almeida, H. A., & Gonçalves, A. (2019, October). Using augmented reality in patients with autism: A systematic review. In ECCOMAS Thematic Conference on Computational Vision and Medical Image Processing (pp. 454-463). Springer, Cham.

[4] S. Parsons, S., & Cobb, S. (2011). State-of-the-art of virtual reality technologies for children on the autism spectrum. European Journal of Special Needs Education, 26(3), 355-366.

[5] Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., & O'Reilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. Developmental neurorehabilitation, 15(2), 119-135.

[6] Ramdoss, S., Lang, R., Mulloy, A., Franco, J., O'Reilly, M., Didden, R., & Lancioni, G. (2011). Use of computer-based interventions to teach communication skills to children with autism spectrum disorders: A systematic review. Journal of Behavioral Education, 20(1), 55-76.

[7] Billard, A., Robins, B., Nadel, J., & Dautenhahn, K. (2007). Building Robota, a mini-humanoid robot for the rehabilitation of children with autism. Assistive Technology, 19(1), 37-49.

[8] Saleh, M. A., Hanapiah, F. A., & Hashim, H. (2021). Robot applications for autism: a comprehensive review. Disability and Rehabilitation: Assistive Technology, 16(6), 580-602.

[9] Zakari, H. M., Ma, M., & Simmons, D. (2014, October). A review of serious games for children with autism spectrum disorders (ASD). In International conference on serious games development and applications (pp. 93-106). Springer, Cham.

[10] Tang, J. S., Chen, N. T., Falkmer, M., Bölte, S., & Girdler, S. (2019). A systematic review and meta-analysis of social emotional computer based interventions for autistic individuals using the serious game framework. Research in Autism Spectrum Disorders, 66, 101412. [11] Hassan, A., Pinkwart, N., & Shafi, M. (2021). Serious games to improve social and emotional intelligence in children with autism. Entertainment computing, 38, 100417.

[12] Eder, M. S., Diaz, J. M. L., Madela, J. R. S., Marife, U., & Sabellano, D. D. M. (2016). Fill Me App: an interactive mobile game application for children with autism. Int. J. Interact. Mob. Technol., 10(3), 59-63.

[13] Whyte, E. M., Smyth, J. M., & Scherf, K. S. (2015). Designing serious game interventions for individuals with autism. Journal of autism and developmental disorders, 45(12), 3820-3831.

[14] Tsikinas, S., & Xinogalos, S. (2020). Towards a serious games design framework for people with intellectual disability or autism spectrum disorder. Education and Information Technologies, 25(4), 3405-3423.

[15] Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. International Journal of Computer Games Technology, 2019.

[16] Khowaja, K., & Salim, S. S. (2019). Serious game for children with autism to learn vocabulary: an experimental evaluation. International journal of human–computer interaction, 35(1), 1-26.

[17] Alves, S., Marques, A., Queirós, C., & Orvalho, V. (2013). LIFEisGAME prototype: A serious game about emotions for children with autism spectrum disorders. PsychNology Journal, 11(3).

[18] Bossavit, B., & Parsons, S. (2016, August). Designing an educational game for and with teenagers with high functioning autism. In Proceedings of the 14th Participatory Design Conference: Full papers-Volume 1 (pp. 11-20).

[19] Hassan, A., Pinkwart, N., & Shafi, M. (2021). Serious games to improve social and emotional intelligence in children with autism. Entertainment computing, 38, 100417

[20] Ahmad, M. I., & Shahid, S. (2015, September). Design and evaluation of mobile learning applications for autistic children in Pakistan. In IFIP Conference on Human-Computer Interaction (pp. 436-444). Springer, Cham.

[21] Reed, C. N., Dunbar, S. B., & Bundy, A. C. (2000). The effects of an inclusive preschool experience on the playfulness of children with and without autism. Physical & Occupational Therapy in Pediatrics, 19(3-4), 73-89.

[22] Tang, J. S., Falkmer, M., Chen, N., Bölte, S., & Girdler, S. (2019). Designing a serious game for youth with ASD: perspectives from end-users and professionals. Journal of Autism and Developmental Disorders, 49(3), 978-995.

[23] American Psychiatric Association. (2010). Diagnostic and statistical manual of mental disorders, text revision (DSM-IV-TR®).

[24] World Health Organization. (30 March 2022). Autism. World Health Organization. . https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders

[25] Furrukh, J., & Anjum, G. (2020). Coping with Autism spectrum disorder (ASD) in Pakistan: A phenomenology of mothers who have children with ASD. Cogent psychology, 7(1), 1728108.

[26] Durkin, K. (2010). Videogames and young people with developmental disorders. Review of General Psychology, 14(2), 122-140.

[27] Tsikinas, S., & Xinogalos, S. (2019). Studying the effects of computer serious games on people with intellectual disabilities or autism spectrum disorder: A systematic literature review. Journal of Computer Assisted Learning, 35(1), 61-73.

[28] Chen, J., Wang, G., Zhang, K., Wang, G., & Liu, L. (2019). A pilot study on evaluating children with autism spectrum disorder using computer games. Computers in Human Behavior, 90, 204-214.

[29] ALTRIRAS: A Computer Game for Training Children with Autism Spectrum Disorder in the Recognition of Basic Emotions

[30] Rouhi, A., Spitale, M., Catania, F., Cosentino, G., Gelsomini, M., & Garzotto, F. (2019, March). Emotify: emotional game for children with autism spectrum disorder based-on machine learning. In Proceedings of the 24th International Conference on Intelligent User Interfaces: Companion (pp. 31-32).

[31] Christinaki, E., Triantafyllidis, G., & Vidakis, N. (2013). A gesture-controlled serious game for teaching emotion recognition skills to preschoolers with autism. In Foundations of Digital Games: The 8th International Conference on the Foundations of Digital Games.

[32] De Urturi, Z. S., Zorrilla, A. M., & Zapirain, B. G. (2011, July). Serious Game based on first aid education for individuals with Autism Spectrum Disorder (ASD) using android mobile devices. In 2011 16th International Conference on Computer Games (CGAMES) (pp. 223-227). IEEE.

[33] Hassan, A. Z., Zahed, B. T., Zohora, F. T., Moosa, J. M., Salam, T., Rahman, M. M., ... & Ahmed, S. I. (2011, December). Developing the concept of money by interactive computer games for autistic children. In 2011 IEEE international symposium on multimedia (pp. 559-564). IEEE. [34] Winoto, P., Tang, T. Y., & Guan, A. (2016, June). I will help you pass the puzzle piece to your partner if this is what you want me to: the design of collaborative puzzle games to train Chinese children with autism spectrum disorder joint attention skills. In Proceedings of the The 15th International Conference on Interaction Design and Children (pp. 601-606).

[35] Carlier, S., Van der Paelt, S., Ongenae, F., De Backere, F., & De Turck, F. (2019, May). Using a serious game to reduce stress and anxiety in children with autism spectrum disorder. In Proceedings of the 13th EAI International Conference on Pervasive Computing Technologies for Healthcare (pp. 452-461).

[36] Craig, F., Tenuta, F., De Giacomo, A., Trabacca, A., & Costabile, A. (2021). A systematic review of problematic video-game use in people with Autism Spectrum Disorders. Research in Autism Spectrum Disorders, 82, 101726.

[37] Guler, J., de Vries, P. J., Seris, N., Shabalala, N., & Franz, L. (2018). The importance of context in early autism intervention: A qualitative South African study. Autism, 22(8), 1005-1017.

[38] Canossa, A., Badler, J. B., El-Nasr, M. S., Tignor, S., & Colvin, R. C. (2015, June). In Your Face (t) Impact of Personality and Context on Gameplay Behavior. In FDG.

[39] Sim, G., Read, J. C., Gregory, P., & Xu, D. (2015). From England to Uganda: children designing and evaluating serious games. Human–Computer Interaction, 30(3-4), 263-293.

[40] Bossavit, B., & Parsons, S. (2018). Outcomes for design and learning when teenagers with autism codesign a serious game: A pilot study. Journal of Computer Assisted Learning, 34(3), 293-305.

[41] Cai, S., Zhu, G., Wu, Y. T., Liu, E., & Hu, X. (2018). A case study of gesture-based games in enhancing the fine motor skills and recognition of children with autism. Interactive Learning Environments, 26(8), 1039-1052.

[42] Bernardini, S., Porayska-Pomsta, K., & Smith, T. J. (2014). ECHOES: An intelligent serious game for fostering social communication in children with autism. Information Sciences, 264, 41-60.

[43] Hookham, G., & Nesbitt, K. (2019, January). A systematic review of the definition and measurement of engagement in serious games. In Proceedings of the australasian computer science week multiconference (pp. 1-10).

[46] Imran, N., Chaudry, M. R., Azeem, M. W., Bhatti, M. R., Choudhary, Z. I., & Cheema, M. A. (2011). A survey of Autism knowledge and attitudes among the healthcare professionals in Lahore, Pakistan. BMC pediatrics, 11(1), 1-6

[47] Anwar, M. S., Tahir, M., Nusrat, K., & Khan, M. R. (2018). Knowledge, awareness, and perceptions regarding autism among parents in Karachi, Pakistan. Cureus, 10(9).

[48] Boujarwah, F. A., Rozga, A., Abowd, G. D., Arriaga, R. I., Oberleitner, R., & Pharkute, S. (2012, May). Towards in-home collection of behavior specimens: Within the cultural context of autism in Pakistan. In 2012 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops (pp. 9-16). IEEE.

[49] Fazil, H., & Sulman, N. (2014). Perceptions of School Administrators about Facilities Available in Schools for Children with Autism in Pakistan. Academic Research International Vol. 5 (4), 348-359.

[50] Boujarwah, F. A., Hong, H., Abowd, G. D., & Arriaga, R. I. (2011, October). Towards a framework to situate assistive technology design in the context of culture. In The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility (pp. 19-26)

[51] Sharma, S., Achary, K., Kaur, H., Linna, J., Turunen, M., Varkey, B., ... & Daeeyya, S. (2018, October). 'Wow! You're Wearing a Fitbit, You're a Young Boy Now!" Socio-Technical Aspirations for Children with Autism in India. In Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility (pp. 174-184).

[52] Sharma, S., Avellan, T., Linna, J., Achary, K., Turunen, M., Hakulinen, J., & Varkey, B. (2020). Socio-Technical Aspirations for Children with Special Needs: A Study in Two Locations–India and Finland. ACM Transactions on Accessible Computing (TACCESS), 13(3), 1-27.

[53] The Express TRIBUNE. (02 April 2021). 400K Pakistani Children Suffer from Autism. The Express TRIBUNE. '400k Pakistani children suffer from autism' (tribune.com.pk)

[54] "Center of Disease Control and Prevention. (2 March 2022). Autism Spectrum Disorder. Data and Statistics on Autism Spectrum Disorder. Data & Statistics on Autism Spectrum Disorder | CDC