

A smartphone application for enhancing educational skills to support and improve the safety of autistic individuals

Adeed Ishaq (✉ adeed.cs@gmail.com)

The University of Lahore - New Campus

Muhammad Shoaib

Kean University - Wenzhou Campus

Long research paper

Keywords: Autism, Learning, Safety Skills, Video Modelling, Application

Posted Date: January 29th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-169682/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

This paper presents a smartphone application that provides learning and communication support to children with autism spectrum disorder (ASD), especially in emergency situations. This application provides learning with video modeling in case of disaster i.e., fire and rain to instruct the ASD children about safety skills. In addition, the application eases collaboration support between caregivers and ASD children. The single-subject design is used to measure the usefulness of the application and the analysis is performed for two males and one female ASD children. The results show that the proposed application enhances the satisfaction level of all the participants with significant improvement in learning skills.

1. Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder that produces difficulties in thinking, social contact, verbal/non-verbal communication, tough attitudes like hyperactivity, and an increase in anger. It affects how somebody observes and meets other people [1–2]. The intensity of Autism Spectrum Disorder (ASD) can be high or low as it differs on the basis of cognitive functioning and observed shortage levels that disturb an individual. Computerized technologies have provided a huge advantage to researchers and also clinicians over the last ten years in the form of remedial and educational tools for people with ASD [3]. These days smartphone apps are being used for individuals with ASD which help in various aspects of their lives (e.g., communication, social interaction, daily living, and vocational independence) [4]. Video modeling has been useful in teaching different skills that include behavioral, social, and functional skills to people with ASD. Moreover, it gives the learners a chance to watch the model depicting target skills and asked to perform them [5]. People with ASD try to enhance their freedom and they also endeavor to learn how to respond if unpleasant situations occur. Parents of individuals who are diagnosed with ASD are concerned about their safety because in certain situations they could be in danger, for instance, they may not be able to make a correct decision whether they are lost or not, or even if they are in an emergency situation or they might fail to talk for getting help in order to be reunited with their caregivers [6]. It is one of those areas where location detection is very helpful for caregivers to keep track of their autistic children [7]. Few studies have inspected the genuine usage of GPS technology in Autism Spectrum Disability, dementia, or development disability [8]. In this study, a smartphone application is introduced for enhancing educational skills to support and improve the safety of ASD children.

The proposed application mainly divided into two segments, the first segment designed for autistic individuals which is further divided into two subparts (e.g., Learning and emergency). The first part uses video modeling for teaching safety skills (e.g., Fire and Rain). The second part provides a one-touch interface to autistic individuals so they contact their caregivers in emergency situations. The second segment is purely designed for caregivers. They can easily track the location of their autistic individuals and also, they can set a safe zone to ensure the safety of their children.

In the remaining of the paper, section two covers the related work that describes the technological work done for people with autism. In section three, the proposed methodology is described. Section four presents the experimental details along with the data collection and analysis techniques. In section five the experimental results are described. Section six describes the discussion performed in the current study. Finally, section seven presents the conclusion and future directions.

2. Related Work

Increasing independence and interaction with society is an important objective of people with disabilities. However, lack of support by the community could raise some major safety issues. In [9], a mobile application developed to indicate the level of panic to the autism person in the panic state is presented. Once the level of a panic attack is selected, the device then detects the context automatically and helps the person by calling a caregiver. Another study [10] evaluated the benefits of using the iPhone 4 by adults who have a slight intellectual disability so that they could be able to send their location using video captions whenever they get lost in public. Goel et al. [11] used smart bands as a source of communication between children and their parents so that parents could keep track of their kids. The training of safety skills is often neglected for people with autism spectrum disorder (ASD). However, the importance of safety skills cannot be ignored as they could prove life-saving when needed, for example skills for emergency situations like in a fire or rainfall [12]. According to the United States Fire Administration [13], children of young ages are at higher risk of being injured than older children due to a lack of cognitive ability. The importance of smoke alarms to alert children about the danger is also described. Different studies were conducted to teach these skills to children with autism spectrum disorder ignoring whether they were needed or not. Another study [14], evaluated the fire safety skills taught to five people with autism spectrum disorder (ASD). They used a virtual reality computer program that includes the detection of fire-related disasters and evacuating in such situations. Results show that four participants did very well on a fire drill. Morrongiello et al. [15] designed a computer game for young children with autism to teach them fire safety skills. The children have to get the animated character out of the fire hazard situation as a task. It was concluded that the game effectively improved the knowledge of children about fire safety skills. A recent number of studies show the importance of video modeling to teach safety skills to young people with autism by using portable digital devices. These devices included laptop computers, handheld personal digital assistant (PDA) devices, iPods, portable augmentative, and alternative communication (AAC) devices used to display video models [16–22]. Taylor et al. [23] teach children with autism to seek help when lost using behavioral training. They were taught target skills with the help of video modeling and physical guidance in the school and community settings. Another study evaluated the use of spherical video-based virtual reality (SVVR) intervention smartphone app to teach adaptive skills for adults with autism spectrum disorder. The evaluation process consisted of the content experts' reviews and the actual testing with adults with ASD. Results indicated the usefulness of the proposed application as all the participants found SVVR easy to use [24]. In this study [25] the impact of embodied Digital Technology (DT) on the four adults with autism spectrum disorder for improving daily living skills such as doing the laundry and washing dishes, was assessed. Reversal single-subject design

(RSSD) used for the evaluation process and the collected data shows that the participants complete the task activities without taking educators' help. Ying et al. [43] used a storytelling application for smartphones to affect five kids having ASD so that consciousness about road safety could be enhanced in them. Class teachers were asked to assess the behavior of the participating children with autism spectrum disorder. In the study, two types of storytelling techniques were used i.e., social stories storytelling technique and digital storytelling technique. Both of these techniques were used to learn about awareness level of children and later assist them or support them about road safety. Engaging children with ASD to road safety awareness is difficult and by the obtained results, this study was proved to be beneficial for raising awareness. Both of these techniques were equally important in this regard.

3. Purposed Methodology

In Fig. 1 the core components of the application along with the communication procedure between both users are shown. The proposed smartphone application is divided into two segments. The first segment is purely designed for autistic individuals while the second segment is designed for their caregivers. The first segment is further divided into two parts (e.g., Learning support and Emergency support). In Learning support, video modeling is used to teach safety skills (e.g., Fire and Rain) to autistic individuals. In Emergency support, ASD children send the location to caregivers if they face emergency situations related to fire and rain using a one-touch interface. In the second segment (e.g., Additional support) caregivers can easily track the location of the autistic individuals. They can set a safe zone to ensure the safety of their children. Once the child moves outside from the safe zone then the application notifies the caregivers by sending the current location of the child.

4. Participants And Data Analysis

Three participants, two males and one female ASD children aged between 14 and 18 years took part in this study. The Childhood Autism Rating Scale (CARS) is a behavior rating scale developed by Schopler et al. [27], used to diagnose autism in children. The main purpose of the scale was to differentiate the autistic children from those with other developmental disabilities. All the participants were recruited from a non-profit organization for children with special disabilities. The main aims are to provide them with free public education as well as to teach them life skills (e.g., positive social skills and etiquette, verbal/nonverbal communication, self-confidence, overcome stage fear, work ethics, and so on). All participants had their vision within normal range and due to this reason, they were considered good candidates for learning from video modeling. Moreover, not a single child had previously received video-based instructions for learning. It was seen by informal observations that all participants had imitation skills but no official assessment was conducted.

The proposed study was concisely assessed and ethically accepted by the university ethical committee. Before the study conducted, an informed consent form was filled in and received by the caregivers of autistic individuals. As the participants are unable to read and understand the consent form, therefore, approval was received by their caregivers. Demographic information is provided in Table 1 for each

participant. It includes the name, age, gender, and diagnoses. Selection criteria of participants included a few things i.e., the participant should have some knowledge of using smartphone, satisfactory vision and hearing as revealed by the school system's hearing and vision test, IEP goals connected to self-help and vocational skills, the capability to attend a short video segment and generalized motor imitation.

Table 1
Participants characteristics

Participant	Name	Age	Gender	CARS Scale
A	Annus Sajid	16	Male	MILD
B	Sumama Shafiq	14	Male	Moderate
C	Muskan Ahmed	18	Female	Moderate

4.1 Safety Skill Task and Equipment

The focus of the intervention was mainly on instructing the participants to finish safety skill tasks related to both (a) fire and (b) rain (see Table 2). These tasks were considered important for each participant to enhance safety skills. The participants' teacher also identified these tasks as vital and described that they had not taken any instruction on fire and rain safety skills before. Participants have to perform the task with help of our proposed application. A few user interfaces are shown in Fig. 2.

Video modeling: Rain and fire safety skills were taught using video modeling shown on a mobile phone. Two videos were recorded with the help of an adult model and shot from the performer's perspective [28] to teach target behaviors about safety skills (e.g., Fire and Rain) for ASD children. Each video consists of eight sequential steps depicting target behaviors for fire and rain safety skills. The digital video camera was used for recording videos and those videos were uploaded onto a computer for editing. Before starting a step, a number of that step was displayed on the screen. After that, a video clip of that particular step was played (e.g., video of a hand touching the Fire Picture Thumbnail to send current location"). The duration of both videos was almost 2 min long. Participants watched a video and learned how to perform the task by looking at the performer going through the sequential steps to achieve target behaviors linked with fire and rain safety skills.

Setting: All the participants were presented in the classroom devoted to children with moderate ASD equipped with a table and chairs. Two mobile phones. a Motorola G4 plus (running Android 7.0) and a Huawei Y6 (running Android 5.0) were used. All the participants used the first phone i.e., Motorola G4 plus to perform the tasks. The other device, Huawei Y6 was used by the caregiver for receiving the current state and location of the autistic children. Moreover, the participants were taught to touch the thumbnail of fire or rain to alert the caregivers with their current situation.

Table 2
Task Analysis for Target Behaviors

Fire Safety Skills	Rain Safety Skills
1. The child remains calm on fire alarm sounds	1. The child remains calm on thunder sound
2. The child walks to exiting the door	2. The child locates the nearest shelter
3. The child exits through the door and walks to the playground area	3. The child walks to the shelter
4. The child opens the smartphone	4. The child opens the smartphone
5. The child touches the application thumbnail	5. The child touches the application thumbnail
6. The child touches the " Fire Picture" Thumbnail	6. The child touches the " Rain Picture" Thumbnail
7. The child waits for the confirmation dialog	7. The child waits for the confirmation dialog
8. The child remains there until the caregiver approach	8. The child remains there until the caregiver approach

4.2 Outcome Measures and Data Collection

The main dependent measure was the percentage of correct responses for both tasks performed by the participant every time he/she heard the fire alarm sound (to perform the fire safety task) or thunder sound (to perform the rain safety task). The first author of this manuscript and a female educator from acted as observers during the sessions. The role of observers was to maintain the checklist and evaluate the target behaviors of all the participants. Every participant was evaluated on each target behavior (e.g., fire and rain) after the sound of a fire alarm/thunderstorm. If the target behavior was correct then it was marked with a check [✓] sign. Similarly, if the target behavior was wrong then it was marked with an [x] sign. Each target behavior was counted as a chance for a child to make a free-response. A behavior is regarded as correct if the next step is initiated within 10 seconds and completed within 20 seconds. Incorrect behavior was defined in different ways: if the student could not finish the step within 10 seconds, if the student did not initiate a target behavior within 10 seconds, or if the student completed a step out of order according to the task sequence. To get the percentage of right answers, a total number of right answers were divided by the total number of steps in the given task analysis. Training sessions happened twice or three times a week and during these one-to-one training sessions, data was collected. Every session was almost 15 minutes long and after each session, the participants were appreciated for participating using verbal praises.

4.3 Data Analysis

A Single Subject Design (SSD) [29], precisely A-B design was used in this study along with maintenance after the intervention. In the design, the “A” corresponds to the baseline phase and “B” corresponds to the intervention phase. At the baseline phase, the participants were not taught by video modeling about fire and rain safety skills and it was supposed that all the participants are weak in displaying safety skills. In the intervention phase, safety skills were taught to participants having ASD with the help of video modeling using a mobile phone. After they had mastered the set of safety skills in the intervention phase, the maintenance phase was conducted in the next two weeks for safety skills. In the maintenance phase, the skills of a child were evaluated by providing the sound of fire alarm and thunder. No video model was shown to the children in the maintenance phase. To find the amount of intervention effect on the performance of those children, the PND (Percentage of Non-Overlapping Data) approach was used. This approach is labeled as a “meaningful index of treatment effectiveness” [30]. The non-overlap calculation provides the percentage of treatment or intervention phase data that surpasses the maximum values in the pre-treatment or baseline phase [31]. Visual analysis has many tasks and one important task is to detect the amount of difference or non-overlap in the data points through successive conditions; that is why visual analysis settles nicely with non-overlap methods and these methods deliver important information about treatment effects [32]. If the non-overlap score is above 90% then it is considered very effective, if it is in the range of 70–90% is considered effective, 50–70% questionable and below 50% suggests that the treatment was not effective. Moreover, the aggregated analysis was conducted for all phases, by finding the average percentage of skill proficiency by subject and overall skill proficiency in general.

4.4 Procedure

Prior to baseline: Two training sessions were held before the baseline phase. Session one included instructions on fire safety skills and session two included instructions on rain safety skills. Training sessions were conducted two times per week and the maximum duration of each session was almost 15 minutes.

Baseline: During the baseline phase, participants had to perform the desired tasks for both safety skills. In the fire safety skill session, the participant was brought to the classroom. He/she sat on a chair and was told to perform required tasks related to fire safety after hearing the sound of a fire alarm. For the rain safety skill session, the participant was brought to the ground and he/she was asked to perform the desired tasks related to rain safety after hearing the sound of thunder. Evaluation of each task was carried out within three sessions or until the stabilization of baseline data. If any participant performs the task inaccurately or cannot give a response, the observer intervened to help the participant and completed the task himself/herself, and then the student was again provided with the opportunity to complete the next step in the list. Throughout these sessions, the observer recorded the amount of correctly performed tasks. The session was finished if the participant could not initiate the first step within 10 seconds or failed to finish the previous task within 20 seconds.

Intervention: During the intervention phase, the participants were provided the smartphone having the installed application with module two already opened, and set to play the video for the targeted task.

Video modeling was used for training. They were directed to carry out a task through an instruction like “Watch this.” The participant then touched the screen and watched the video on how to do the task. They were then asked to perform that task after the observer said, “Now you do it” and then the participants tried to copy the relative behavior shown in the video clip about fire and rain safety skills once they hear the sound of fire alarm and thunder. Participants also receive verbal praise, i.e., “Nice job”, on performing the task correctly after every third step. They were given 10 seconds to initiate the task and 2 minutes to finish it. If the participant failed to finish the task within 2 minutes or failed to initiate a task within 10 seconds then the session was dismissed. Unsuccessful tasks were left incomplete because the tasks had to be completed in the specified order of respective task analysis. No other prompts, responses, or instructions were delivered. Throughout the intervention phase, the safety skills of participants were assessed two times a week for a total of nine data points.

Maintenance: In the maintenance phase, participants were not shown any video clip for training through video modeling about fire and rain safety skills. They were brought to the classroom and ground of the school for fire and rain safety skill tasks respectively. In the fire safety skill task, they heard the sound of fire alarm, in the rain safety skill task they heard the sound of thunder and then they were told to perform according to the desired behaviors taught throughout the intervention session. A maximum of two sessions was required for the evaluation of each task. If the performance declined below the accepted level then students were allowed to watch the videos again to see whether their performance recovers.

5. Results

The percentage of steps for fire safety skill tasks performed correctly by each participant is presented in Fig. 2. Child A finished 14 intervention sessions that were distributed in three phases. At baseline, he was found to have very low proficiency (25%) on one of the three data points in the fire safety drill. He improved his skill proficiency throughout the training phase throughout weeks 1–4. He finished all the steps in the last session of the intervention phase attaining 100% proficiency. He performed all the fire safety skill steps with 100% proficiency in the maintenance phase of the intervention. PND of child A in fire safety skill was equal to 78% and 100% in case of maintenance. On the basis of these results, the PNDs at the maintenance and intervention phases propose that video modeling was effective in improving the fire safety skills of the child. At baseline phase, Child B was assessed with having very low proficiency (25%) in the fire safety skill. He significantly increased proficiency from session four (25%) to session six (75%) during the intervention stage. Child B achieved 100% proficiency in showing the fire safety skills at the tenth session. However, this was not true for the eleventh session as the child reverted back to 88% proficiency. He was successful in completing all fire safety skill steps by twelfth session and displayed a very high skill proficiency (100%). In the maintenance phase, Child B showed 88% proficiency in fire safety skills as depicted in Fig. 2. PND of child B in fire safety skill was equal to 89% and 100% in intervention and maintenance phase respectively. On the basis of these results, the PNDs at maintenance and intervention phases propose that video modeling was very helpful and effective in improving the fire safety skill of Child B. During baseline, Child C obtained 13% proficiency in the fire safety skill which gradually increased to 100% in the intervention phase. In the maintenance phase, Child C exhibited 100%

proficiency in the fire safety skill as shown in Fig. 2. This result was obtained without the use of a video model and all steps were retained during this two-session follow up. PND of child C in fire safety skill was equal to 100% during the intervention phase and also 100% in the maintenance phase. On the basis of these results, the PNDs at maintenance and intervention phases propose that video modeling was very helpful and effective in improving the fire safety skill of Child C.

The percentage of steps for rain safety skill task performed correctly by each participant is shown in Fig. 3. When child A was evaluated at baseline phase, he had very low rain safety skill proficiency (13%). At that point he only showed the ability for the first step of rain safety, "Child remains calm on thunder sound." Child A significantly increased his proficiency during the intervention stage from the fourth session (13%) to the end of the intervention session (100%). In the maintenance phase, Child A maintained 100% proficiency in a demonstration of the rain safety skill. PND for child A in the rain safety skill was equal to 89% and 100% in intervention and maintenance phase respectively. These results suggest that video modeling was effective in improving the rain safety skill of Child A. Figure 3 illustrates 14 intervention sessions attended by Child B which were divided into three phases i.e., baseline, intervention, and maintenance phase. At the baseline phase, he had very low proficiency (13%) across the three data points. He gradually improved his proficiency from 13% at the beginning to 100% by the end of the intervention phase. At the end of the tenth and eleven sessions, Child B gained 75% proficiency during the intervention phase, and in the last session of the intervention phase i.e., the twelfth session, he completed all the steps and showed 100% proficiency. PND for child B in the rain safety skill was equal to 100% during the intervention phase and also 100% in the maintenance phase. Based on the results, the PNDs at intervention and maintenance phases suggest that video modeling was effective in improving the rain safety skill of Child B. Child C finished 14 intervention sessions that were distributed into three phases. At baseline, she was found to have very low proficiency (13%). At the beginning of the intervention session, she initiated the first three rain safety skill steps. At the end of the seventh session, Child C showed a relatively higher proficiency of 75% in the rain safety skill. However, at session eight, Child C regressed to 63% proficiency. Then she improved her proficiency throughout the remaining sessions and reached 100% proficiency by the twelfth session as shown in Fig. 3. Moreover, she maintained her rain safety skill proficiency during the maintenance phase as well. The resulting PND's equivalent to 100% during the intervention phase and 100% in the maintenance phase. Hence this shows that learning with the help of video modeling was very effective for improving safety skills than learning with old traditional techniques.

5.1 Aggregated Scores

At the baseline phase, all three children had very low proficiency in a demonstration of fire safety skills, averaging at 19%. This proficiency improved in the intervention phase. During the intervention phase, all three children showed relatively better proficiency in a demonstration of fire safety skills averaging at 75%. This rate increased in the maintenance phase as the children showed higher proficiency than the other two phases averaging at 96% in fire safety skills.

Table 3
Mean of Percent Fire Skill Proficiency of Participants across Intervention Phases

Participant	Intervention Phase		
	Baseline	Intervention	Maintenance
A	17	60	100
B	25	74	88
C	13	89	100
Overall Mean	19	75	96

At the baseline phase, all three children had very low proficiency in a demonstration of rain safety skills averaging at 13%. This proficiency improved in the intervention phase. During the intervention phase, all three children showed relatively better proficiency in a demonstration of rain safety skills averaging at 64%. This rate increased in the maintenance phase as the children showed higher proficiency than the other two phases averaging at 96% in rain safety skills.

Table 4
Mean of Percent Rain Skill Proficiency of Participants across Intervention Phases

Participant	Intervention Phase		
	Baseline	Intervention	Maintenance
A	13	59	100
B	13	53	88
C	13	75	100
Overall Mean	13	64	96

6. Discussion

Safety is a major problem for young people with autism thus it is a concern for caregivers because these people are at a higher risk of being hurt. Safety skills education is important for children with ASD as it promotes changes in behavior. There are different types of safety skills and the paper has focused on two of them, (1) Fire safety and (2) Rain safety skills. The current study adds to the literature on fire and rain safety skills for children with ASD by developing a smartphone application. It assists ASD children in an unpleasant situation and instructs them on how to deal with these situations. To measure the

effectiveness of the application in assisting children with ASD, Percentage Non-overlapping Data (PND) technique was used. The PND score of all the participants was more than 70%, which shows that the proposed application is quite useful for providing assistance related to fire and rain safety skills. Additionally, video modeling is an effective approach for teaching children with ASD. The means of baseline, intervention and maintenance phases in case of fire safety skills are 19, 75, and 96 percent respectively. On the other hand, the means of baseline, intervention, and maintenance phases in case of rain safety skills are 13, 64, and 96 percent, which clearly shows that the proposed application effectively improves the learning skills of autistic children. Furthermore, the satisfaction level of autistic individuals was measured with the help of questionnaires, filled by their teachers and caregivers. Results obtained from the questionnaire depict that they feel satisfied with the use of the proposed application. Moreover, they describe that children were not annoyed and do not show any hyperactivity while using the application.

7. Conclusion And Future Guidelines

Developmental disabilities such as autism spectrum disorder (ASD) induce numerous challenges to autistic individuals in definite areas of life, especially in communication, social interaction, imagination, learning, self-help, and independent living. At the same time, safety is also a major issue for these individuals, and lacking safety skills could be harmful. Therefore, individuals with ASD need to be aware of potential dangers in the environment and get familiar with the proper safety skills to stay safe. With the help of video modeling, different types of skills can be taught to individual with Autism Spectrum Disorder. It is an effective way of teaching in which numerous learners can benefit at a single time. This study provides assistance regarding safety skills (e.g., Fire and Rain) to individuals with ASD. It also reports that the learning skills of autistic individuals were gradually enhanced with the help of video modeling. Moreover, results show that autistic individuals feel satisfied and remain active while using proposed smartphone application. There are certain lines of future work related to the current study. In the future, the generalization phase will be considered and evaluation be made using several different sounds (alarms or thunder), which can deliver different auditory stimuli that can stimulate the fire or rain safety behaviors. Also, it would be valuable to generalize these skills to different environments (e.g., home and work settings). Future research should consider increasing the number of participants which will reinforce validity. At last, extending the range of age groups can make the intervention procedures stronger.

Declarations

Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Skillen, K.L., Donnelly, M.P., Nugent, C.D., Booth, N.: (2016). LifePal: A Mobile Self-Management Tool for Supporting Young People with Autism. In XIV Mediterranean Conference on Medical and Biological Engineering and Computing 2016 (pp. 1174–1179). Springer, Cham
2. Hoch, H., Taylor, B.A., Rodriguez, A.: Teaching teenagers with autism to answer cell phones and seek assistance when lost. *Behavior Analysis in Practice* **2**(1), 14–20 (2009)
3. Grynspan, O., Weiss, P.L., Perez-Diaz, F., Gal, E.: Innovative technology-based interventions for autism spectrum disorders: a meta-analysis. *Autism* **18**(4), 346–361 (2014)
4. Mintz, J.: Can smartphones support inclusion for autism in mainstream? *J. Assist. Technol.* **7**(4), 235–242 (2013)
5. Allen, K.D., Wallace, D.P., Renes, D., Bowen, S.L., Burke, R.V.: Use of video modeling to teach vocational skills to adolescents and young adults with autism spectrum disorders. *Education and Treatment of Children* **33**(3), 339–349 (2010)
6. Bergstrom, R., Najdowski, A.C., Tarbox, J.: Teaching children with autism to seek help when lost in public. *J. Appl. Behav. Anal.* **45**(1), 191–195 (2012)
7. Vuković, M., Car, Ž, Feralj, M., Penezić, I., Miklaušić, V., Ivšac, J., ... Mandić, L.: (2016). Location-based smartwatch application for people with complex communication needs. In *Computer and Energy Science (SpliTech), International Multidisciplinary Conference on* (pp. 1–7). IEEE
8. Hayward, B., Ransley, F., Memery, R.: GPS Devices for Elopement of People With Autism and Other Developmental Disabilities: A Review of the Published Literature. *Journal of Policy and Practice in Intellectual Disabilities* **13**(1), 69–74 (2016)
9. Mohammedali, M., Phung, D., Adams, B., Venkatesh, S.: (2011). A context-sensitive device to help people with autism cope with anxiety. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 1201–1206). ACM
10. Purrazzella, K., Mechling, L.C.: Use of an iPhone 4 with video features to assist location of students with moderate intellectual disability when lost in community settings. *Education and Training in Autism and Developmental Disabilities* **48**(2), 179–189 (2013)
11. Goel, I., Kumar, D.: (2015). Design and implementation of android based wearable smart locator band for people with autism, dementia, and Alzheimer. *Advances in Electronics*, 2015, 8–14
12. Dixon, D.R., Bergstrom, R., Smith, M.N., Tarbox, J.: A review of research on procedures for teaching safety skills to persons with developmental disabilities. *Res. Dev. Disabil.* **31**(5), 985–994 (2010)
13. United States Fire Administration: Fire risk in 2014. *Topical Fire Report Series* **17**(7), 1–14 (2013)
14. Padgett, L.S., Strickland, D., Coles, C.D.: Case study: using a virtual reality computer game to teach fire safety skills to children diagnosed with fetal alcohol syndrome. *J. Pediatr. Psychol.* **31**(1), 65–70 (2005)
15. Morrongiello, B.A., Schwebel, D.C., Bell, M., Stewart, J., Davis, A.L.: (2012). An evaluation of The Great Escape: can an interactive computer game improve young children's fire safety knowledge and behaviors? *Health psychology*, **31**(4), 496

16. Spivey, C.E., Mechling, L.C.: Video Modeling to Teach Social Safety Skills to Young Adults with Intellectual Disability. *Education and Training in Autism and Developmental Disabilities* **51**(1), 79–92 (2016)
17. Mechling, L.C., Gast, D.L., Gustafson, M.R.: Use of video modeling to teach extinguishing of cooking related fires to individuals with moderate intellectual disabilities. *Education and Training in Developmental Disabilities* **44**(1), 67–79 (2009)
18. Bidwell, M.A., Rehfeldt, R.A.: Using video modeling to teach a domestic skill with an embedded social skill to adults with severe mental retardation. *Behav. Interv.* **19**(4), 263–274 (2004)
19. Kagohara, D.M.: Three students with developmental disabilities learn to operate an iPod to access age-appropriate entertainment videos. *Journal of Behavioral Education* **20**(1), 33–43 (2011)
20. Mechling, L.C., Gast, D.L., Seid, N.H.: Using a personal digital assistant to increase independent task completion by students with autism spectrum disorder. *J. Autism Dev. Disord.* **39**(10), 1420–1434 (2009)
21. Park, J., Bouck, E.C., Duenas, A.: Using video modeling to teach social skills for employment to youth with intellectual disability. *Career Development and Transition for Exceptional Individuals* **43**(1), 40–52 (2020)
22. Bassette, L.A., Taber-Doughty, T., Gama, R.I., Alberto, P., Yakubova, G., Cihak, D.: The use of cell phones to address safety skills for students with a moderate ID in community-based settings. *Focus on Autism and Other Developmental Disabilities* **33**(2), 100–110 (2018)
23. Taylor, B.A., Hughes, C.E., Richard, E., Hoch, H., Coello, A.R.: Teaching teenagers with autism to seek assistance when lost. *J. Appl. Behav. Anal.* **37**(1), 79–82 (2004)
24. Schmidt, M., Schmidt, C., Glaser, N., Beck, D., Lim, M., Palmer, H.: (2019). Evaluation of a spherical video-based virtual reality intervention designed to teach adaptive skills for adults with autism: a preliminary report. *Interactive Learning Environments*, 1–20
25. Pérez-Fuster, P., Sevilla, J., Herrera, G.: Enhancing daily living skills in four adults with autism spectrum disorder through an embodied digital technology-mediated intervention. *Research in Autism Spectrum Disorders* **58**, 54–67 (2019)
26. Ying, K.T., Sah, S.B.M., Abdullah, M.H.L.: (2016). Personalised avatar on social stories and digital storytelling: Fostering positive behavioural skills for children with autism spectrum disorder. In *User Science and Engineering (i-USEr)*, 2016 4th International Conference on (pp. 253–258). IEEE
27. Schopler, E., Reichler, R.J., DeVellis, R.F., Daly, K.: Toward objective classification of childhood autism: Childhood Autism Rating Scale (CARS). *J. Autism Dev. Disord.* **10**(1), 91–103 (1980)
28. Scruggs, T.E., Mastropieri, M.A.: Summarizing single-subject research: Issues and applications. *Behav. Modif.* **22**(3), 221–242 (1998)
29. Horner, R.H., Carr, E.G., Halle, J., McGee, G., Odom, S., Wolery, M.: The use of single-subject research to identify evidence-based practice in special education. *Exceptional children* **71**(2), 165–179 (2005)
30. Olive, M.L., Franco, J.H.: Effect) size matters: And so does the calculation. *The Behavior Analyst Today* **9**(1), 5–10 (2008)

31. Lenz, A.S.: Calculating effect size in single-case research: A comparison of nonoverlap methods. *Measurement and Evaluation in Counseling and Development* **46**(1), 64–73 (2013)

32. Dallery, J., Cassidy, R.N., Raiff, B.R.: Single-case experimental designs to evaluate novel technology-based health interventions. *J. Med. Internet. Res.* **15**(2), e22 (2013)

Figures

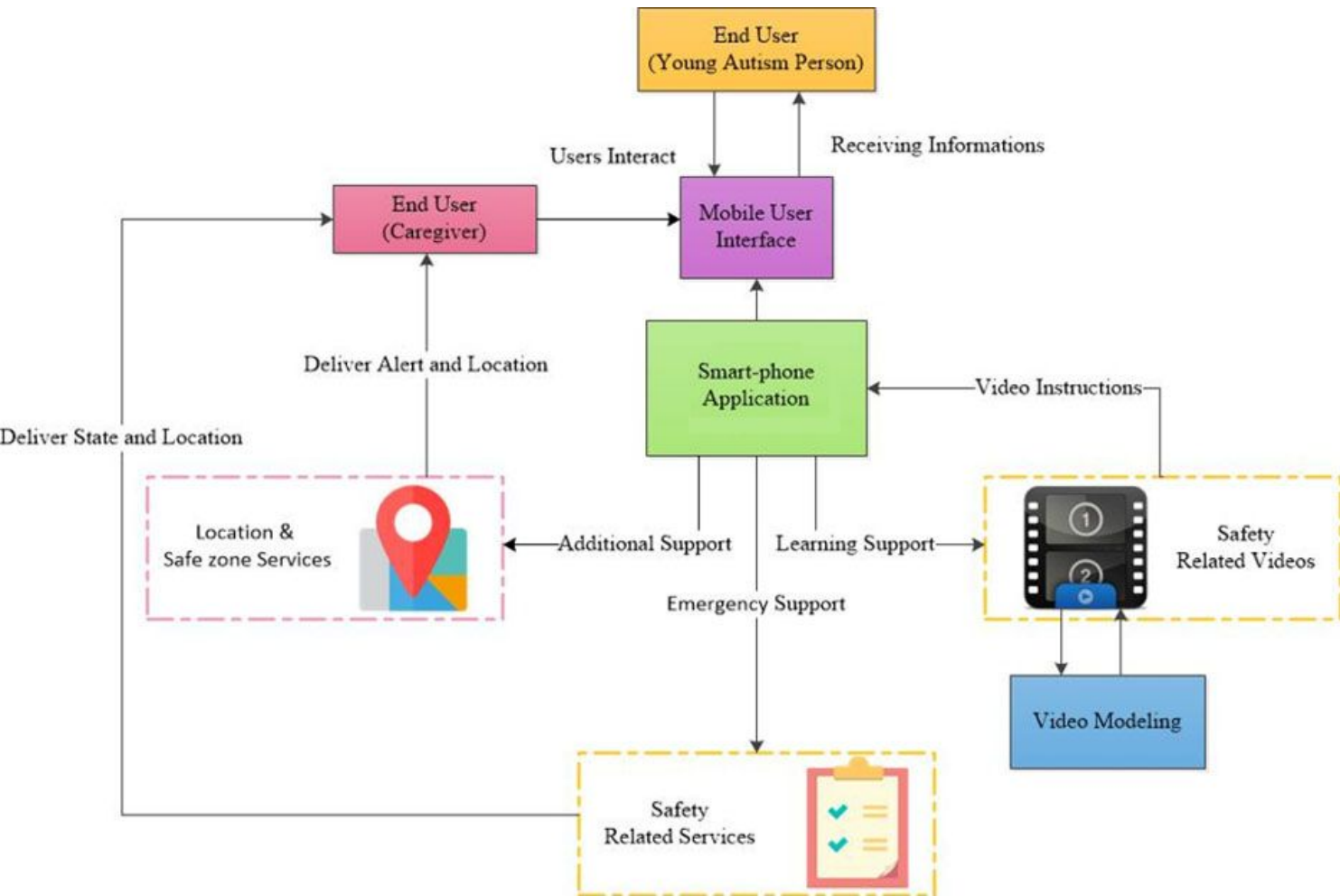


Figure 1

Core components of the proposed application

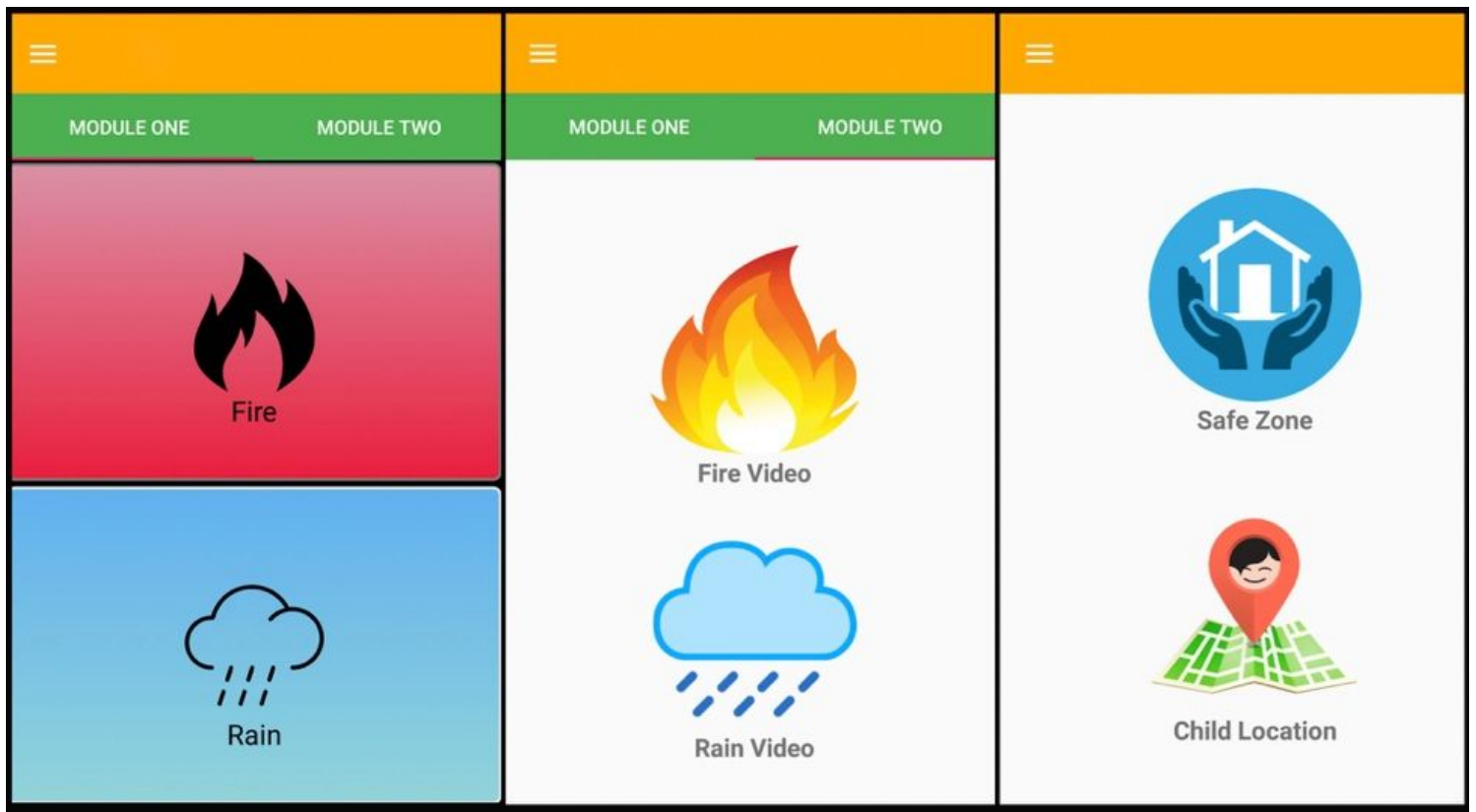


Figure 2

User interfaces of the proposed application

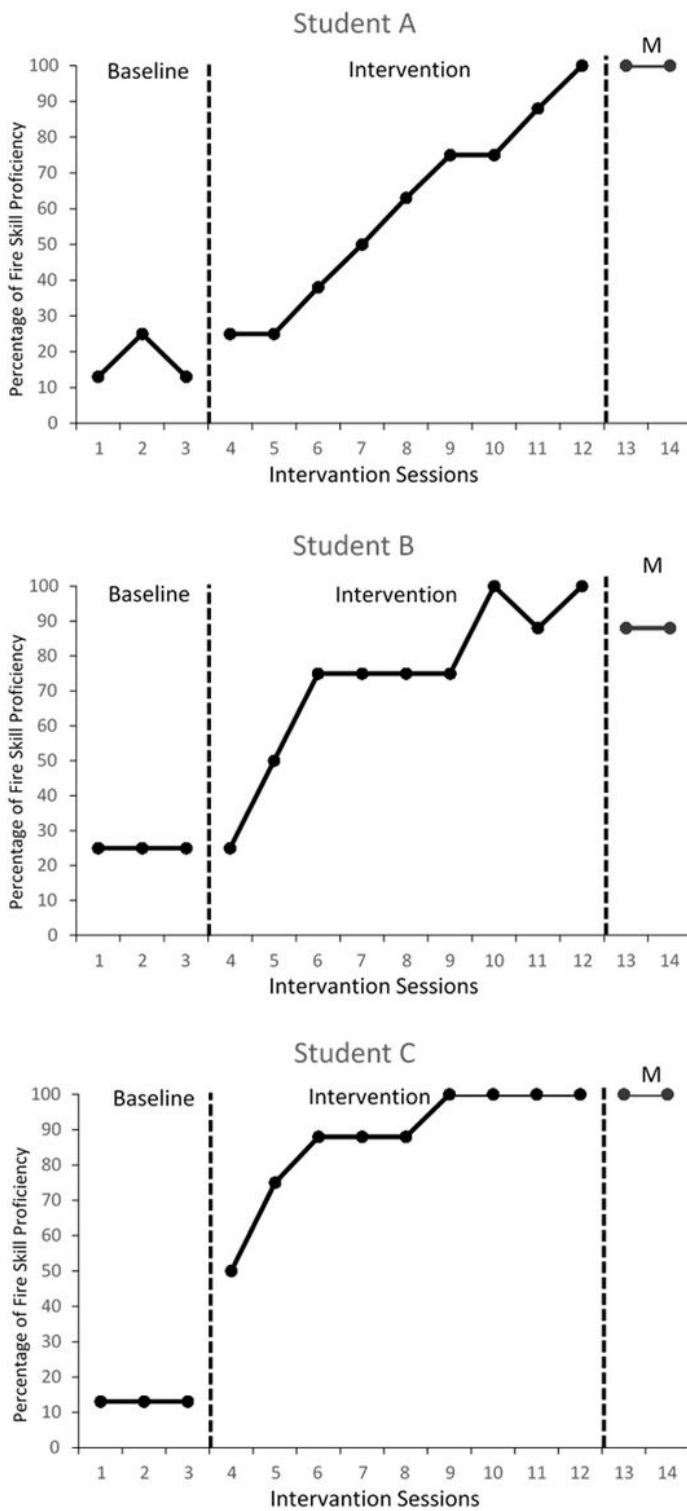


Figure 3

Graph describing the percent of steps performed correctly by all three participants during baseline, intervention, and maintenance in Fire Safety Skill

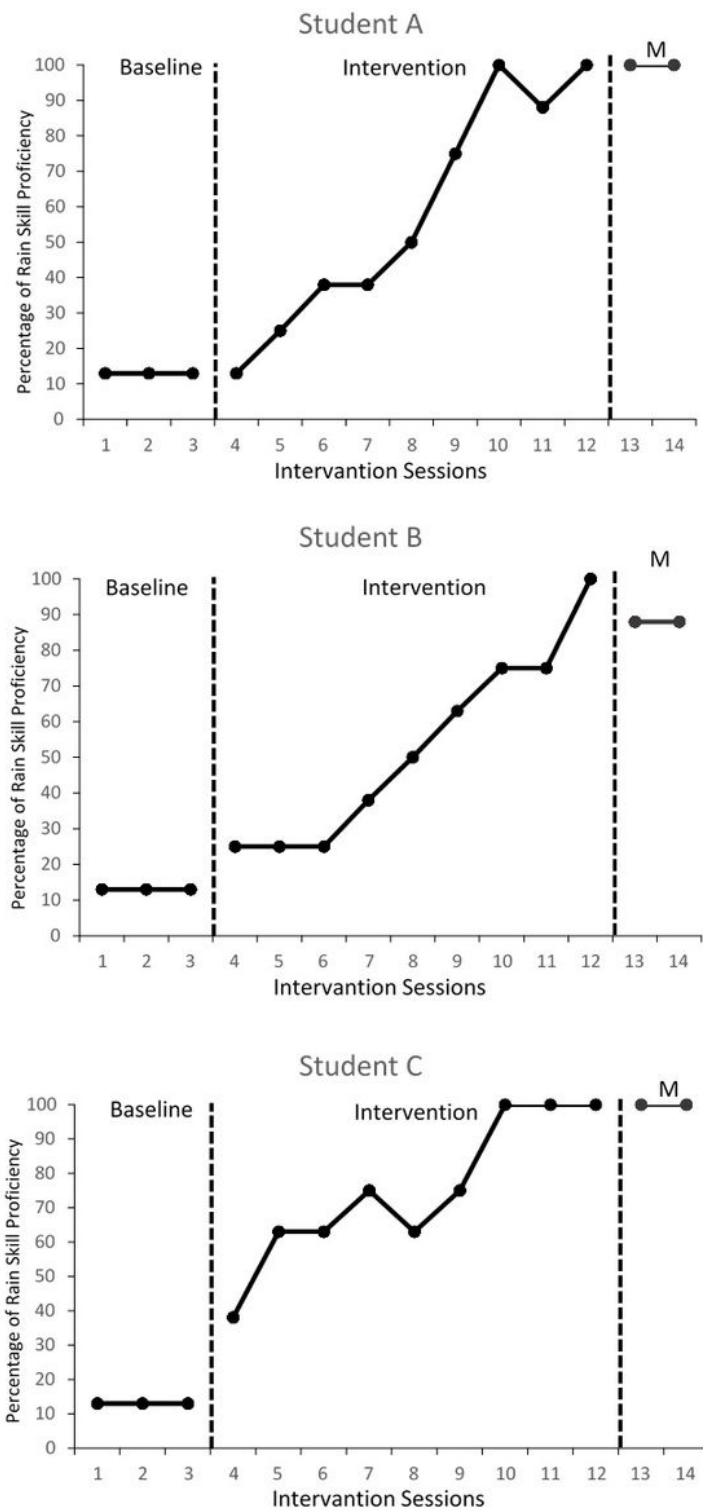


Figure 4

Graph depicting the percentage of steps performed correctly by all three participants during baseline, intervention, and maintenance in Rain Safety Skill