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LONG PAPER

Usability investigation of an educational mobile application for individuals with intellectual disabilities

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Abstract

This research examined the usability of an interactive mobile application (tablet application) designed to teach daily living skills to individuals with intellectual disabilities (ID). Effectiveness, efficiency, and satisfaction aspects were investigated. The persistence of a newly learned skill, operating a vacuum cleaner, was assessed following training sessions. The study also examined how well participants generalized the skill to a different tool and setting after learning via the interactive tablet application. In addition, to determine the social validity of the study, five special education teachers' views (satisfaction levels) about the tablet application were examined. To determine the efficiency of the tablet application, differences in time of intervention sessions between the pilot study and the main study were investigated. A single-case research methodology was employed with a multiple baseline design. Furthermore, to identify the usability issues of educational tablet applications, heuristic evaluation and user test methods were used together. One male and four females with a diagnosis of intellectual disability took part in the study. All participants improved their ability to use the vacuum cleaner and performed the skill correctly following the intervention sessions. Performance during generalization and maintenance sessions also met defined success criteria. Efficiency data show that changes in the tablet application decrease the significant amount of time spent for intervention. It is an important result for individuals with ID who might not be able to focus attention over a longer period of time. The results of this study show that using the interactive tablet applications in the education of individuals with ID is an effective method for improving their daily living skills.

Keywords Intellectual disabilities · Tablet application (mobile application) · Daily living skills · Tablets · Mobile devices · Usability test · Heuristic evaluation

1 Introduction

Daily living skills are particularly crucial for children with learning impairments because they directly affect the development of capabilities such as autonomy and self-determination [4, 43]. One daily living skill tied to better life outcomes for individuals with intellectual disabilities (ID) is house cleaning. Performing tasks such as laundry and tidying spaces improves self-regulation and may expand choices for future living environments [43]. In addition, being able to complete daily living skills can lead to greater independence and increased initiative, encouraging development of further abilities [12]. Several researchers have applied technological interventions to improve the daily living skills of individuals with ID [10, 43].

Technology is already known to be effective for designing new learning approaches [7] and for providing opportunities to engage in basic drills and practices, simulations,

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and exploratory or communication activities matched to individual needs and abilities [17, 18]. The successful and appropriate integration of technology into learning environments has incredible potential for students in special education [34]. For example, computers are technological tools that attract the attention of individuals with special needs and motivate them to concentrate on performance, a common problem in education [13, 18]. Başoğlu [6] compared traditional teaching and computer-assisted teaching methods with students in special education and found the computer-based lessons to be more interesting, simpler, and faster. Dalgin-Eyyip [16], Tanju [39], Aruk [3], Kanpolat [28], Özak [38], Armutçu [2], Çatak [13], and Uçar [41] investigated the effects of computers in special education, generally reporting advantages for improving students' pretend play skills, reading skills, writing skills with word processors, academic achievement, and knowledge about mathematical concepts. As a more recent technology, virtual reality technology-based method is proven to be effective in the cognitive and motor skills development of people with intellectual disabilities [15]. Korozi et al. [31] developed an interactive educational game that combines tangible interaction with a virtual environment, so as to facilitate independent living training for children with cognitive disabilities. Some studies about mobile technology-supported special education have also been conducted. Acungil [1] investigated the effects of an application teaching students how to use a tablet, and all participants met the predetermined criteria for success. Meanwhile, Kuzu et al. [32] conducted a study to develop mobile software for parents to teach daily living skills to children with ID.

Mobile devices, an emerging choice in instructional technology, offer people with special education needs different types of help [42] aids for carrying out functions in everyday activities such as communication tools or an assistant for learning process [18]. Unique features of mobile devices allow users to carry out tasks anywhere and at anytime. Interaction through motion is another important feature of mobile devices, which can detect when an individual rotates or shakes them. In addition, touch screens are attractive and easy to use. Children with cognitive disabilities may not have the skills to work with a pencil or stylus, making a tablet an ideal learning tool [46]. Interaction with mobile devices is easier than with computers because of their portability and touch screens [24]. As multifunctional devices, tablets can be used to surf the web, read books, play games, and interact with friends—all activities that can aid in the development of individuals with special education needs [23]. In addition, tablets seem to be placing in education and rehabilitation programs that involve individuals with developmental disabilities [27]. A tablet was selected as the preferred mobile device in this study because its screen size is larger, improving the likelihood of attracting the attention of participants. As a result, at the heart of good teaching with technology are three core components, content, pedagogy, and technology, plus the relationships among and between them [30]. Teaching with technology is a difficult thing to do well. Content, pedagogy, technology, and teaching/learning contexts have different roles to play individually and together. Teaching successfully with technology requires continually creating, maintaining, and re-establishing a dynamic equilibrium among all components [30].

Another important issue regarding usability, designing, and making usable multimedia gives special individuals a real sense of achievement. Well-designed, usable materials can support the improvement in student learning. Brown et al. [9] made a usability study with a panel of experts to evaluate a product for individuals with learning difficulties. William and Nicholas [44] examined the usability of a multimedia learning environment designed for people with special educational needs, and they made suggestions for designing to match learner needs to learning materials according to cognitive and accessibility profiles of individuals. In the literature, there are not enough empirical usability studies related to the integration of mobile technology in the education of people with special needs.

Students with special needs will accept or utilize technology easily, if special education teachers use the technology in their lessons [36]. Current research on technology use in education suggests that for it to be used effectively and successfully, teachers need to have the understanding of how to apply it appropriately with individuals with disabilities [19]. Due to their key role in technology integration, the views of special education teachers were also investigated in this study.

1.1 Purpose of study

The purpose of this study was to examine the usability of an educational tablet application designed to teach individuals with ID how to use the vacuum cleaner, a daily living skill in terms of effectiveness, efficiency, and satisfaction (social validity). Being able to learn a new skill from the tablet application and sweep the carpet independently might help an individual with ID become more self-sufficient. This study explored the performance levels of participants during the intervention and the following 1, 3, and 4 weeks. Generalization to a different vacuum and setting was also examined.

1.2 Research questions

This study addressed the following research questions and sub-questions: First, can educational tablet applications contribute to the learning of daily living skills for individuals with ID (Effectiveness)? More specifically, (a) does the new skill persist at 1, 3, and 4 weeks after training, and (b) can the new skill be generalized across different vacuum cleaners and settings? Second, what is the efficiency of educational tablet applications in terms of time spent? Third, what are the views of special education teachers about the utilization of tablets and educational tablet applications (satisfaction)?

2 Methodology

2.1 Participants

Three female students aged 11–17 with a diagnosis of intellectual disability participated in this study. Also, a pilot study was carried out with two different students with a diagnosis of ID. Their demographic information is reported in Table 1. In addition to attending a public high school full time, all five participants received one-on-one special education services at the rehabilitation center twice a week. All participants also met the following pre-specified criteria for inclusion in the study: (a) ability to follow simple verbal instructions (sentences consist of minimum five words), (b) ability to direct attention to an event for at least 10 min, (c) ability to imitate motor skills, (d) ability to use hands and fingers, (e) regular school attendance, (f) ability to point to an answer using a finger or to answer verbally, and (g) lack of knowledge of the skill to be taught. The participants were recommended by their teachers, who were consulted by the researcher to determine whether subjects met the requirements. Another variable considered during the selection procedure was whether participants needed to learn daily living skills in order to become more independent at home.

Participants were assigned the pseudonyms OA, KE, BG, DS, and IG. OA was 11 years old. Her IQ was reported to be 65. She had been attending the rehabilitation center for 2 years. Her 44-year-old mother was a housewife, and her 45-year-old father was a waiter. Her parents' highest completed education was primary school. She had three siblings, aged 9, 20, and 25. KE was 17 years old. Her IQ was reported to be 40. She had been attending the rehabilitation center for 2 years. Her 40-year-old mother was a housewife, and her 45-year-old father was a painter. Her mother had finished secondary school; her father had finished high school. She had one 15-year-old sister. BG was 12 years old. Her IQ was reported to be 60. She had been attending the rehabilitation center for 1 year. Her 37-year-old mother was a housewife, and her 40-year-old father was a tailor. Her mother had finished primary school; her father had finished high school. She had two siblings, aged 10 and 15. DS and IG participated in the pilot study. DS was a 37 years old female with a diagnosis of ID and epilepsy. Her IQ was reported to be 55. She had been attending the present rehabilitation center for 3 years. At the time of this study, she was not attending any other institution. The other participant, IG, was an 8 years old male with diagnosis of autism and pervasive developmental disorders. His IQ was reported to be 60. He had been attending the present rehabilitation center for 2 years. At the time of this study, he was attending to special class in another state school. Both individuals were receiving individual special education services twice a week in the rehabilitation center.

Table 1 Participant characteristics

Code	Gender	Age	Diagnosis	IQ
OA	Female	11	Intellectual disability	65
KE	Female	17	Intellectual disability	40
BG	Female	12	Intellectual disability	60
DS (pilot study)	Female	37	Intellectual disability and epilepsy	55
IG (pilot study)	Male	8	Autism and pervasive developmental disorders	60

2.2 Experimental design

A multiple baseline across subject design was applied as single-case research to examine the effectiveness of an educational tablet application in teaching a daily living skill to individuals with ID [5]. This design practices baseline sessions for interpreting threats to internal validity and exhibiting experimental control. To achieve maximum efficiency according to this design, individuals with similar learning backgrounds who exhibited similar behaviors under similar environmental conditions were consecutively exposed to the same independent variable [22]. Single-subject research involves studying in detail the behavior of each of a small number of participants; single-subject research designs are sometimes called small-n designs [25]. Furthermore, to identify the usability issues of educational tablet applications, "expert approach—heuristic evaluation" and "experimental approach—user test" methods were used together. Experts carry out heuristic evaluation by analyzing interface carefully and suggesting advices about the interface's good and bad attributes [37]. During the user test, performance measures can be collected from a user while they are performing certain tasks. Nielsen and Rubin determined 18 measurable performance measurements, including the ratio between successful interactions and errors, task completion time, number of directions or features used by user, number of user errors, and number of times user contacts help desk [37]. In the special education field, user testing alone is not enough without experts' view, since people with ID may have some difficulties to reflect their thoughts and may behave differently than before in the different tests. Therefore, when experts (usability experts and special education experts) use heuristic evaluation to identify usability issues, the data from user tests data may be helpful.

2.3 Setting and materials

Baseline, intervention, generalization, and maintenance sessions were conducted in a classroom. Each session was recorded by a teacher with a digital camera. The researcher directed the process according to predetermined instructions. To avoid distraction, students were allowed to touch the camera before the intervention began. Sessions included the researcher, a special education teacher, and the participant. A tablet with an Android 4.2 version and a multi-touch 10.1-inch screen size was used for the SCV (sweeping carpet with vacuum) tablet application delivery. Two different vacuum cleaners were used to examine whether sweeping ability can be generalized to different machines.

The dependent variable of the study was the skill of sweeping the carpet using a vacuum, a skill with a high probability for future use. The independent variable of the study was the instruction provided by the educational tablet application.

The SCV (sweeping carpet with vacuum) tablet application was developed with the supervision of special education experts and instructional technologists under the scope of a research project to improve the daily living skills of students in special education. Thorough task analysis of sweeping the carpet with a vacuum was conducted by the research team. Individuals were observed while performing the task in order to determine common steps. After analysis, the team carried out the steps to determine whether they defined the skill properly (see Table 2). The tablet application is mainly created as educational software. The tablet application was updated according to the results of usability tests with the target group and heuristic evaluation, improving it in terms of efficiency and satisfaction. With the help of the application, students can gain carpet sweeping skills by listening, observing, and imitating the avatar. In the SCV tablet application, the avatar (a digital representation of a person) performed each task step on the separate screen (as shown in Fig. 1). For each task step, students watched and observed the avatar first, after the command of the avatar, and tried to repeat the same step by themselves. All steps continued in the same way until they were successfully completed. If students did not complete one step, they watched the same step

Table 2 Task analysis steps: sweeping carpet with vacuum cleaner

Step no	Task
1	Pull the power cord by the plug
2	Find the socket in the room
3	Plug in the power cord
4	Press the power button on
5	Hold the tube
6	Sweep the carpet by moving the tube back and forth
7	Press the power button off
8	Unplug the power cord
9	Press the button to rewind the cord
10	Store the vacuum cleaner in its designated place

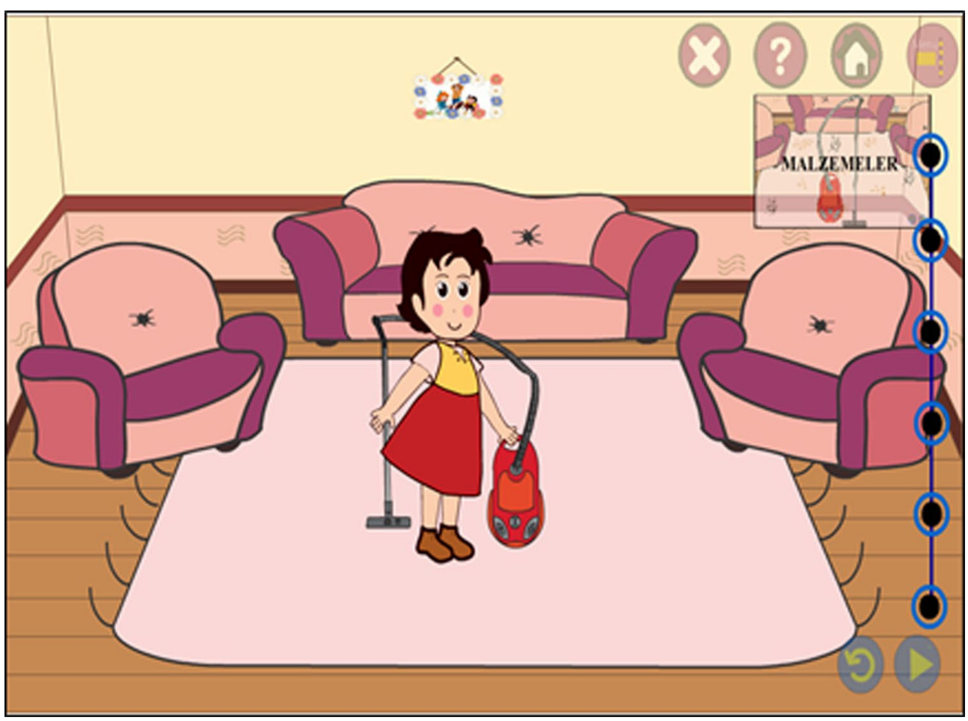


Fig. 1 Avatar and menu options

again. The SCV tablet application is available for Android and Windows on the Google Play Store for free. The applications related to other daily living skills (soup preparation, sandwich preparation, fruit juice preparation, floor cleaning, etc.) are also accessible from the same web site. There are in total ten steps for sweeping the carpet with a vacuum; if the participants successfully complete all ten steps, they will meet the 100% criterion.

2.4 Experimental conditions

In the experimental process of the study, the following sessions were conducted: baseline, probe, intervention, generalization, and follow-up (as shown in Fig. 2). Prior to baseline data collection, the parents of the students were informed regarding the recording of the experiment, and teachers collected signed consent forms from the parents. In addition, participation was reinforced with preferred rewards at the conclusion of each session. Specific rewards such as a cookie or small toy were identified for each student by teachers at the beginning of the study.

During baseline sessions, at least three baseline sessions were conducted with each participant to determine the starting skill levels. During this process, the researcher acted according to pre-arranged instructions, which were also given to an observer who collected procedural fidelity data. The researcher instructed participants to sweep the carpet with the vacuum cleaner, and correct responses were reinforced verbally, while wrong answers terminated the session. A single-opportunity method was used in baseline and probe sessions, as it reduces the possibility of student learning during the evaluation and to reveal the effectiveness of the intervention more clearly. Once a stable baseline was established, the participant who exhibited the greatest need for instruction was introduced to the intervention first. After the first intervention session, *probe sessions* were organized before each intervention session and began with the same instructions as the baseline sessions (as shown in Fig. 2).

In probe sessions, positive verbal reinforcement was provided for correct answers, and wrong responses terminated the session. Each intervention and probe session continued until three consecutive probe sessions met the 100% criteria. *In intervention sessions*, the researcher showed the participants activity steps via the tablet application and asked them to attempt each step with a real vacuum cleaner after watching. Until the end of all tasks, participants watched each step

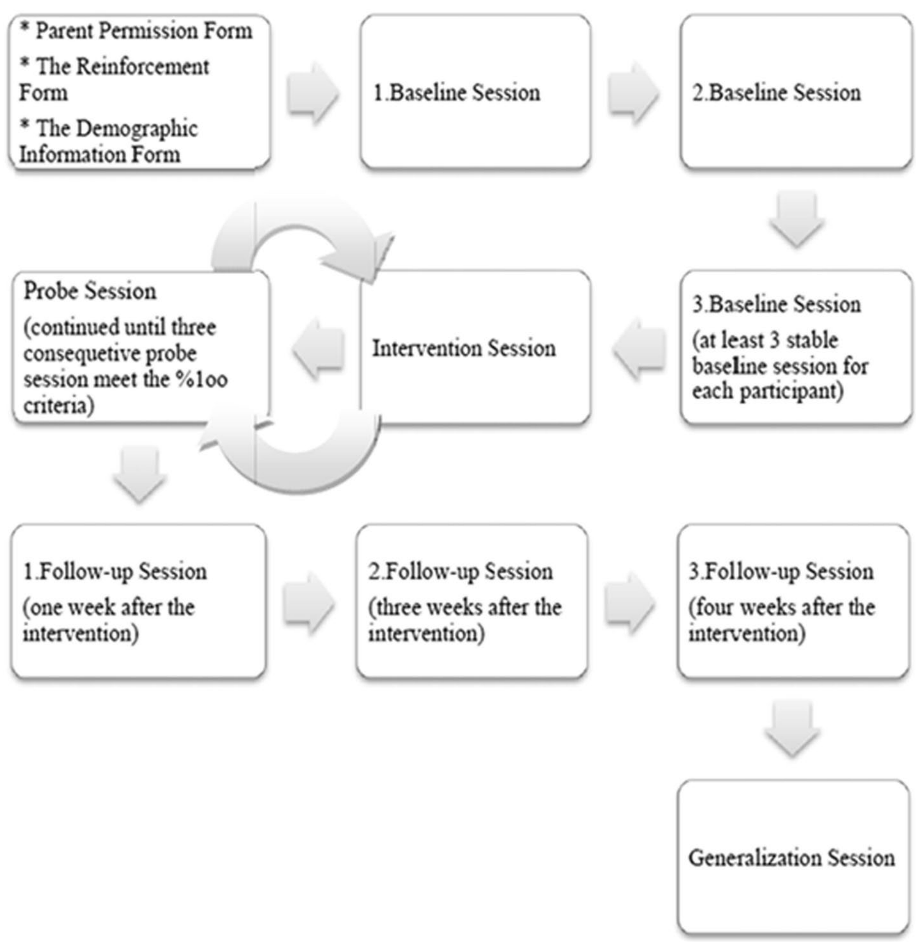


Fig. 2 Flowchart of the implementation process

via the tablet application; they attempted each related step by using a real vacuum cleaner. Correct responses were again reinforced verbally by the researcher; after wrong responses, students were asked to review the application and try again. This process was repeated for each student until all tasks were completed correctly. The only error correction procedure was showing the prompt, since participants did not persist in giving incorrect responses. The participants did not observe during sweeping the floor with a real vacuum in any of the experiment sessions. They attempted sweeping the floor themselves with a real vacuum in all of the experiment sessions. In the intervention session, for each task step, students watched and observed the avatar first, and following the command of the avatar the students tried to do the same step with real vacuum. All steps continued in the same way until they were successfully completed. *Follow-up data* were collected to examine the persistence of the new skill 1, 3, and 4 weeks later. In addition, to evaluate if the skill was transferred between different tools and settings, *generalization sessions* took place 1 week after all individuals fulfilled the 100% criteria for three consecutive follow-up sessions.

2.5 Data collection and analysis procedures

In this research, effectiveness, efficiency, reliability, and satisfaction (social validity) data were collected. To determine effectiveness data about the target skill, correct and incorrect reactions of participants were recorded, and percentages of correct behavior were calculated. For every step of the task, behaviors were classified as one of two types: (a) The student could not demonstrate the skill, or (b) the student could demonstrate the skill at an acceptable rate. Efficiency data were analyzed by comparing differences in time of intervention sessions between pilot study and main study.

Reliability data included inter-observer reliability and procedural fidelity data. Inter-observer reliability analysis was conducted by comparing data obtained by the practitioner and observer. The researcher was the primary coder for all sessions. The second coder was a special education teacher with a psychology degree and 3 years of experience in teaching. She was informed about the data gathering process via an observer notification sheet. For a randomly selected 30% of each participant different type of sessions (baseline, probe, follow-up and generalization), inter-observer reliability data were coded to assess inter-observer agreement. Finally, the formula consensus/[consensus + dissensus × 100] was applied to calculate inter-observer reliability [40]. Procedural fidelity reveals the suitability of actual practice versus intended practice. For this reason, practitioner behavior was determined, and a procedural fidelity checklist was designed. The intervention was carried out by the researcher, and the procedural fidelity data were coded by the special education teacher (second coder). In total, a random 30% selection of each different session type (baseline, probe, intervention, follow-up, and generalization) was coded for fidelity of intervention, and procedural fidelity was calculated using the formula of observed practitioner behavior/planned practitioner behavior × 100 [8].

Finally, social validity data were collected and analyzed. Subjective evaluation and normative comparison approaches have been suggested for the evaluation of social validity by Kazdin [29] and Wolf [45]. Wolf [45] focused on subjective evaluation as a social validation method to evaluate social acceptability and the significance of goals, methods, and results, arguing that this method produces more objective evaluation [21]. In this research, subjective evaluation was selected for analyzing social validity. The teaching methods and tools used in the study were examined according to their social aspects, and interviews were conducted with special education teachers to evaluate the results. Five special education teachers who joined the study as video recorders were interviewed. To assess the reliability of the interview coding, two researchers coded the same body of content.

Tables 3 and 4 reveal findings regarding the effectiveness of the tablet application. The x-axis shows the number of sessions, while the y-axis shows the percentage of correct responses. Qualitative data analysis was conducted on the interviews following Yıldırım and Şimşek [47]. Data were coded, themes were determined, data were organized and defined according to the codes and themes, and interpretations were made.

3 Results

3.1 Effectiveness data of participants

In terms of effectiveness, the participants' achievement level according to skill steps of the pilot version and new version of the SCV application were analyzed. Percentages of correct responses for pilot study participants during baseline, intervention—probe, and generalization sessions are shown in Table 3. The percentages of the main study for correct responses during baseline, intervention—probe, follow-up, and generalization sessions are also shown in Table 4. For Tables 3 and 4, *y*-axis shows the percentage of correct actions, and *x*-axis shows the probe session number in which the participant took part.

According to baseline sessions of the pilot study, participant DS performed 6%, 33%, and 22% correct responses in three consecutive sessions. After the first intervention session, the participant had a 44% correct response rate in the first probe session. After the third intervention session, she reached the predetermined criterion correctly as shown in Table 3. In addition, IG performed 28%, 33%, and 28% correct responses in three consecutive sessions. After the first

Table 3 Two participants' percentage of correct actions (Pilot study)

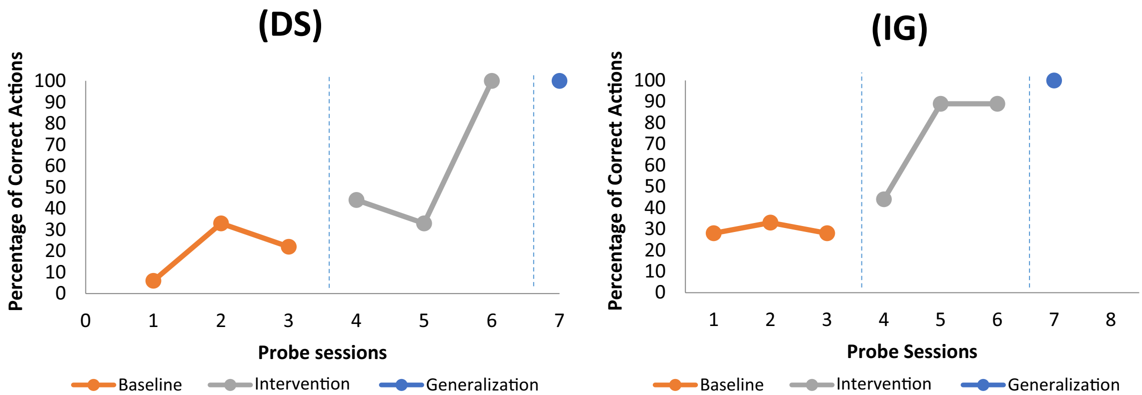
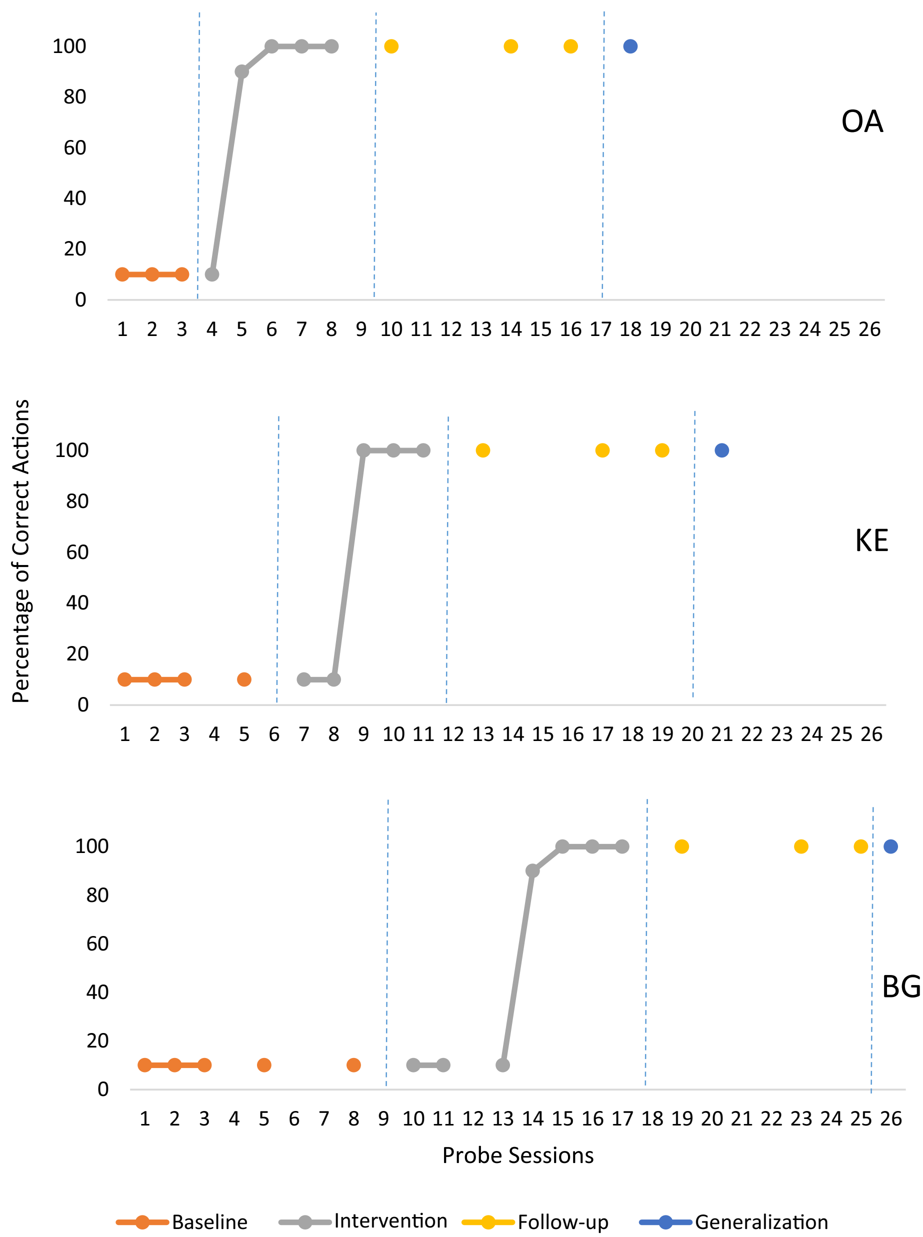


Table 4 Three participants' percentage of correct actions for the baseline, intervention, follow-up, and generalization sessions (main study)



intervention session, IG produced 44% correct responses in the first probe session in a similar manner. After the last two intervention sessions, he improved to 89% as shown in Table 3.

According to baseline data of the main study, the mean score was 10%; in other words, participants performed an average of 10% correct responses during baseline sessions. More explicitly, they only performed one step of vacuuming correctly—holding the tube and moving it back and forth—and did not perform other steps (see Table 4).

After the first intervention session, participant OA produced a 10% correct response in the first probe session. In the second probe session, which took place after the second intervention session, she produced a 90% correct response, a dramatic improvement. After the third intervention session, participant OA improved to 100% in the third probe session. She also performed at 100% in the last two probe sessions. Thus, she performed all steps of sweeping the carpet with a vacuum cleaner correctly in three consecutive sessions, and intervention sessions were terminated (see Table 4).

After the first intervention session, participant KE produced a 10% correct response in the first probe session. In the second probe session, which took place after the second intervention session, she again produced a 10% correct response. After the third intervention session, she produced a 100% correct response in the third probe session as well as in the last two probe sessions. She successfully performed the skill in three consecutive sessions, so intervention sessions were terminated (see Table 4).

Similarly, after the first and second intervention sessions, participant BG produced a 10% correct response during the first and second probe sessions. After the second intervention session, she missed a session at the rehabilitation center. In the third probe session, she produced another 10% correct response. After the fourth intervention session, she improved to 90% in the fourth probe session. Finally, after the fifth intervention session, she performed all steps correctly in the fifth probe session and the following two probe sessions. The desired extent (100%) was reached for three consecutive sessions, so intervention sessions were terminated (see Table 4).

The general success rates for all participants (pilot study and main study) in baseline and probe sessions are shown in Table 5. The probe sessions' mean for the pilot study (66.5%) is higher than the general mean of the main study (49.1%); participants are already more successful in baseline sessions of the pilot study (25%) than the main study (10%) as shown in Table 5. Although participants' intellectual disability levels are similar between the pilot study and the main study, the main reason of this difference is that in the pilot version of the application, there are two main sections which "parts of vacuum cleaner" and "sweeping carpet". The "Parts of vacuum cleaner" section was removed in the new version of the tablet application. Moreover, some unnecessary steps from the sweeping section were removed. Hence, the pilot study data indicate that although participants learned the sweeping skill, they had difficulties to show the parts of the vacuum cleaner. Participants in the pilot study could not match the names and real parts of the vacuum cleaner. However, when they studied with the tablet application, they could match the picture shown in the tablet and the real object (part of the vacuum cleaner). For

Table 5 Differences in success rate between pilot study and main study (effectiveness)

Before changes in application (Pilot study)					After changes in application (Main study)				
Code of part.	Number of baseline sessions	Percentage of correct responses	Number of probe sessions after intervention	Percentage of correct responses	Code of part.	Number of baseline sessions	Percentage of correct responses	Number of probe sessions after intervention	Percentage of correct responses
DS	1. B	6	1. P	44	OA	1. B	10	1. P	10
DS	2. B	33	2. P	33	OA	2. B	10	2. P	90
DS	3. B	22	3. P	100	OA	3. B	10	3. P	100
IG	1. B	28	1. P	44	KE	1. B	10	1. P	10
IG	2. B	33	2. P	89	KE	2. B	10	2. P	10
IG	3. B	28	3. P	89	KE	3. B	10	3. P	100
					KE	4. B	10		
					BG	1. B	10	1. P	10
					BG	2. B	10	2. P	10
					BG	3. B	10	3. P	10
					BG	4. B	10	4. P	90
					BG	5. B	10	5. P	100
	Mean	25		66.5		Mean	10		49.1

example, participants could not show the floor brush or pipe when their names were said, but they were able to use the floor brush or pipe properly.

3.2 Maintenance and generalization data

In order to answer the research question related to skill maintenance, the researcher examined whether the ability to sweep the carpet with a vacuum was sustained 1, 3, and 4 weeks after the last probe in the main study. All three participants (OA, KE, and BG) completed all tasks 100% correctly in all three follow-up sessions, demonstrating that they maintained the new skill (see Table 4). In terms of generalization, all participants of the pilot study and the main study (DS, IG, OA, KE, and BG) performed the sweeping task with 100% accuracy using a different vacuum cleaner and on a different carpet, as shown in Tables 3 and 4.

3.3 Efficiency data

As indicated in Table 6, there is a significant advance in the mean time spent for intervention sessions after the pilot study. While participants in the pilot study completed intervention sessions in 10 min on average, after changes in the application most of the participants in the main study completed the intervention sessions in 5–6 min on average. In the main study, only one participant (BG) completed the first intervention session in 10 min. It took time for her to get used to the application because she had shy and timid characteristic features. After BG got used to the process, she completed the intervention sessions in 5–6 min like the other two participants. In addition, the amount of time spent for the intervention sessions decreased for each student. For example, the duration of the first intervention session of DS was 11.30 min, for the second was 10 min, and for the last intervention session the duration was 6.13 min. Similarly, the time spent by other participants for the intervention sessions decreased as well. Therefore, this is an important efficiency result, since after the participants got used to the tablet application, the time spent for intervention sessions decreased. This achievement can be beneficial for participants with limited attention time. Finally, efficiency data show that changes in the tablet application decreased for a significant amount of time spent for intervention. This is important for individuals with ID who are able to focus attention for a limited time, also for teachers who need to spend less time for one student's training. Although there was a decrease in the duration of each session, no decrease in the number of sessions needed to achieve a 100% level was observed.

3.4 Inter-observer reliability data

In order to assess the reliability of the coding, two researchers coded the same body of content. Inter-observer reliability data in single-subject research are expected to be at least 80% [40]. The consensus between the two observers in the current study was 100% for all participants and all session types (baseline, probe, follow-up, and generalization sessions).

3.5 Procedural fidelity data

Procedural fidelity data were calculated for all session types. In total, there were 29 baseline sessions, 11 intervention sessions, 9 follow-up sessions, and 3 generalization sessions. The number of evaluated sessions was calculated as 30% of the total number of sessions. These findings showed that the practitioner performed the probe, follow-up, and generalization sessions with 100% accuracy, while intervention

Table 6 Differences in time of intervention sessions between pilot study and main study (efficiency)

Before changes in application (Pilot study)			After changes in application (Main study)		
Code of participant	Number of intervention sessions	Time of intervention sessions (min)	Code of participant	Number of intervention sessions	Time of intervention sessions (min)
DS	1. Intervention	11.30	OA	1. Intervention	6
DS	2. Intervention	10	OA	2. Intervention	6.23
DS	3. Intervention	6.13	OA	3. Intervention	4.55
IG	1. Intervention	13.41	KE	1. Intervention	5.40
IG	2. Intervention	8.15	KE	2. Intervention	5.36
IG	3. Intervention	8.20	KE	3. Intervention	5.40
			BG	1. Intervention	10
			BG	2. Intervention	6.19
			BG	3. Intervention	6.08
			BG	4. Intervention	5.05
			BG	5. Intervention	5
	Mean	10		Mean	6.42

sessions were performed with 98% accuracy. Procedural fidelity results show that the actual practice was suitable to the intended practice for all sessions.

3.6 Social validity (satisfaction) data

Two researchers coded all interview transcripts for social validity data. Themes and sub-themes were compared, and reliability coefficients were calculated. The agreement rates between coders were 100% for themes and 91% for sub-themes. Teachers' views about the SCV tablet application were categorized under six themes: effectiveness, usefulness, enjoyment, ease of use, attitudes about future use, and improvements (see Table 7).

In terms of effectiveness, most of the interviewed special education teachers stated that the SCV tablet application was effective since it presented visual and audio content together, such as with cartoons, drawing the students' attention. Also, participants can move while watching the tablet application, as the portability of tablets provides freedom of movement for students. They added that it was helpful to practice with real materials. Using the SCV application proved to be a valuable method for teaching this daily living skill.

The special education teachers also described the SCV tablet application as useful because students gained new technological skills and the tablets increased the students' ability to focus. Some teachers further indicated that the application could help to develop motor skills. In addition, to complete such a task independently could increase self-confidence. The participants' parents had not previously offered them the opportunity to sweep the carpet at home; by performing this task like their family members, they recognized themselves as capable individuals. Another useful aspect of the SCV application is that it saves time for the teachers.

Next, the special education teachers found the SCV tablet application to be enjoyable because the method was new and interesting. Plus, it increased the sense of curiosity in students with special needs, and the students were happy to perform the task independently.

The special education teachers also stated that learning to use the SCV tablet application was easy, and the difficulty level of the application was suitable for children who exhibit prerequisite behaviors. One teacher who participated in the pilot study added that it was difficult for students to gather up items from the floor prior to vacuuming, a step that was removed from the process before implementation.

Table 7 Teachers' views about the SCV tablet application

Theme	Sub-theme
Effectiveness	*The SCV tablet application is effective because…*
	Visual and audio content are presented together It is practice based (real materials used) It trains daily living skills It is ideal for female students It is portable
Usefulness	*The SCV tablet application is useful because it…*
	Increases technological skills Increases focus duration Develops motor skills Supports self-confidence Saves time for the teacher Helps to transfer and generalize knowledge
Enjoyment	*The SCV tablet application is enjoyable because…*
	It is a new and different method It increases student concentration and sense of wonder It made students happy to complete tasks independently
Ease of use	*The SCV tablet application is easy/difficult to use because…*
	It was simple to learn the use of the interface Students grew comfortable after a few practice sessions It was difficult to gather items from the floor prior to vacuuming (task in pilot study)
Attitude (Future use)	*I would like to use the SCV application in the future because…*
	It is enjoyable, useful, and/or interesting Data transfers quickly to students It provides visual and audio support It saves the teacher time
Improvements	*Properties of the SCV tablet application that should be changed include…*
	Teaching parts of the vacuum cleaner one by one (in pilot study) Not gathering up items from the floor prior to vacuuming (in pilot study)

In terms of attitude, all teachers expressed a desire to use the SCV application in the future. They found the application enjoyable, interesting, and useful. The teachers explained that some skills could be gained more quickly with the tablet than with other methods, especially given how visual and audio components work together to facilitate the learning process of students with special needs.

Finally, the special education teachers identified properties to change; however, both items were drawn from the pilot study. First, teaching the names of the vacuum cleaner parts was deemed irrelevant because participants could sweep successfully without that knowledge. In addition, as mentioned above, one teacher said that the screen instructing students to gather items from the floor prior to vacuuming should be removed. These two elements were changed after the pilot study. Otherwise, the teachers offered no suggested improvements to the application.

3.7 Limitations

A single-opportunity method was used in the baseline and probe sessions. In the single-opportunity method, an accurate evaluation of all steps may not be made because the evaluation is stopped at the first wrong step, although there may be a step that the individual can exhibit correctly in the skill analysis. The multiple-opportunity method was not preferred, since learning can take place while the practitioner performs behaviors that the individual cannot exhibit correctly during assessment sessions. This may prevent the effectiveness of the application from to be seen clearly.

This research is limited to the experiences of only three females with a diagnosis of intellectual disability. In future studies, it is considered that the study could be realized with more individuals with different types of diagnosis, as it can be useful to obtain more detailed information. The study is also limited to the Educational Tablet Application—the sweeping carpet with vacuum (SCV) Application. It is advisable to repeat a similar study with different educational tablet applications in order to increase the reliability of the findings presented regarding the effectiveness of tablet applications in the field of special education.

4 Discussion

The usability of two versions of the SCV application (pilot and main version) was examined in terms of effectiveness, efficiency, and satisfaction. Effectiveness data show that after the intervention sessions, the general mean of the pilot study (66.5%) is higher than the general mean of the main study (49.1%). Participants are already more successful in the baseline sessions of the pilot study (25%) than the baseline sessions of the main study (10%). For both versions, general difference between the baseline and intervention sessions is almost 40%. Thus, there is no significant increase in terms of effectiveness. However, efficiency data show that changes in the tablet application decrease the significant amount of time spent for intervention (it decreases from 10 min to 5–6 min). In addition, the amount of time spent for intervention sessions decreases for each participant. After participants got used to the tablet application, the amount of time spent for intervention sessions decreases and it can be beneficial for participants with limited attention time. Removing the "parts of the vacuum cleaner" section in the main study might affect the time spent for the intervention sessions. Trying to teach the names of the vacuum cleaner's parts is not necessary for the ultimate goal and leads to a loss of time as shown in the efficiency data section. Another factor of usability is satisfaction. Satisfaction data were presented as a social validity data. Special education teachers explain positive views about tablet usage and application.

The results of this study extend the literature on (a) technology usage strategies for teaching daily living skills to individuals with intellectual disabilities and (b) the effectiveness of such a strategy toward improving a specific daily living skill. Three participants (OA, KE, and BG) with similar disability type and rate, IQ, age, gender, and socioeconomic status exhibited similar correct responses and effectiveness data. Participants performed 10% of the steps correctly in all baseline sessions before the intervention. They each performed only one step correctly, moving the tube back and forth; they could not perform any other steps of the skill. Their previous experiences with vacuum cleaners, such as watching their parents using a vacuum at home, might have had a significant effect on this result. They had no knowledge about how the vacuum cleaner started to work.

Probe and intervention sessions continued until three consecutive probe sessions met the 100% criteria of the skill. OA and KE learned to sweep the carpet with the vacuum after three intervention sessions, while BG learned after five intervention sessions. Two factors may explain the extended intervention sessions of BG: (a) after the second probe session, BG did not return to the rehabilitation center for one session and may have forgotten the newly learned information, and (b) BG lacked initiative, so familiarizing herself with the tablet took a bit longer.

These findings support previous studies by suggesting the effectiveness of educational mobile technology usage in improving the academic, communication, employment, leisure, and transitioning skills of individuals with special educational needs [10, 14, 18, 20, 26, 43]. Van Laarhoven et al. [43] used iPods to develop the daily living skills (cleaning the bathroom, mopping the floor, emptying garbage, and cleaning kennels) of a 17-year-old male with 1p36 deletion syndrome and an intellectual disability. The results suggested that the iPod's video and audio prompting tools were effective for increasing task completion. Similarly, Burke et al. [10] gave fire safety training to six participants with ASD and found that the cueing system presented on the iPhone and iPod Touch was an effective form of prompting in an employment setting.

In follow-up sessions, all three participants completed all skill tasks 100% correctly, demonstrating their knowledge retention of the new skill. All three participants also completed all tasks correctly using a different vacuum cleaner and different carpet, showing the generalizability of the new skill. Thus, the skill is expected to transfer to their own vacuum cleaners and carpets at home. Similarly, the follow-up session on week 10, Van Laarhoven et al. [43] found that students with deletion syndrome and ID maintained new daily living skills learned using an iPod with performances remaining at 89% correct. Burke et al. [10] also found that responses to fire safety training learned via iPod remained high during follow-up and generalization sessions.

To determine the social validity of the study, five special education teachers' views about the SCV application were examined. They described the SCV application as effective since it combines audio and visual stimuli like cartoons, capturing the attention of participants. According to Microsoft external research [35] about the visualization properties of mobile devices, picture-based communication helps many children with moderate or severe autism to compensate for their limited verbal skills. In this study, interviewees found the application to be very useful for helping to increase the students' technological skills and length of focus. Similarly, in a different research study it was found that the tablet captured the attention of students with special needs [11]. Moreover, they indicated that the application could help to develop motor skills and support self-confidence. To be able to complete tasks independently increases one's self-confidence and independence. The interviewed teachers also stated that the SCV application could save time in lessons and students enjoyed it because it was different and interesting. Correspondingly, Lopez et al. [33] pointed out that the use of mobile devices and multimedia-assisted learning increases focus time and interest of students, helping them to learn while they are entertained. The interviewed teachers felt that learning to use the application was easy for the students with ID, though they added that in the case of students with special needs, learning exercises should be individualized [33]. The attitudes of the special education teachers were very positive about using the SCV application in the future.

One advantage revealed by this study lies in the portability of tablets. Sweeping the carpet with a vacuum cleaner is a daily living skill that requires active movement. Due to the flexible features of the tablet, students were able to stand up and continue training without interruption. Individuals with ID who have problems moving quickly and holding focus can especially benefit from training with tablet applications. The portability of tablets can gain further value in the context of daily living skills requiring even more movements, such as floor cleaning, which requires additional steps of traveling to the sink and returning.

Another advantage for this study was that the tablet application used was developed according to the needs of special individuals under the supervision of special education experts and instructional technologists. The tablet application was updated according to the results of usability tests with the target group and heuristic evaluation, improving it in terms of efficiency and satisfaction. This study has revealed a true need for tablet applications that are well designed and meet the needs of students with disabilities.

Usable interactive mobile applications have the capability to decrease the workload of special education teachers and allow students to study independently of their location and time. In traditional education methods, sweeping the carpet with a vacuum cleaner would be taught to a student through demonstration, demanding both time and effort. The mobile application in the study increased the time available to teachers for additional education, an important advantage for students who have limited time available at the rehabilitation center. Furthermore, parents could access the tablet application to continue education outside of school and in any location.

5 Suggestions and implications for future research

Mobile devices are becoming more powerful, less expensive, and ubiquitous. However, the literature lacks studies about the effectiveness of mobile devices in special education. Studies exploring the effectiveness of mobile devices (tablets, smart phones, etc.), producing new applications for individuals with special needs, and developing innovative instructional methods should be among the priority topics for research. Success in learning by using technological devices largely depends on the use of well-established instructional procedures and applications. Due to a limited number of studies addressing the user interface design of tablet applications for students with ID, several relevant features could not be specified in this study. Therefore, more studies about tablet usability for students with special needs are necessary. End user satisfaction and parents' view related to the app can be investigated in further studies.

The results of this study show that using interactive tablet applications in the education of individuals with ID is an effective method for improving their daily living skills. For this reason, new educational environments for students with ID should be designed with the support of these innovative devices. Rehabilitation centers and special education schools should also educate their teachers and students about the use of these and other new technological devices.

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