Scandinavian Journal of Occupational Therapy

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/iocc20

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To cite this article: Lin-Ju Kang, Pei-Yi Lin, Mats Granlund, Chia-Ling Chen, Wen-Hsu Sung & Ya-Lan Chiu (2023) Development and usability of an app-based instrument of participation in children with disabilities, Scandinavian Journal of Occupational Therapy, 30:3, 322-333, DOI: 10.1080/11038128.2022.2083014

To link to this article: https://doi.org/10.1080/11038128.2022.2083014

Published online: 14 Jun 2022.

SCANDINAVIAN JOURNAL OF OCCUPATIONAL THERAPY
2023, VOL. 30, NO. 3, 322–333
https://doi.org/10.1080/11038128.2022.2083014

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ORIGINAL ARTICLE

Development and usability of an app-based instrument of participation in children with disabilities

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ABSTRACT

Background: Picture My Participation (PmP) is a picture-supported child-report instrument of participation of children with disabilities.

Aims: This study described the development of a mobile application of the PmP Traditional Chinese version (PmP-C) and evaluated its usability.

Methods: The PmP-C App includes features that allow the input of a child's demographics, identification of frequency and involvement of 22 culturally appropriate activities, selection of the three most important activities and the specification of the environmental facilitators and barriers. The usability test was conducted with 10 healthcare workers, who interviewed 10 children with disabilities aged 6–12 years. The healthcare workers completed a usability questionnaire and were asked to provide feedback on the ease of use, learning, satisfaction and perceived usefulness.

Results: The mean score for the usability questionnaire ranged from 2.7 to 4.6 out of 5.0. The feedback indicated that the interface was simple to operate by the healthcare workers and was attractive and motivating to children. Improvements of layout design, operation instructions and technical problems were recommended, which contributed to the app program optimization.

Conclusions: The PmP-C App provides a practical tool with initial support for usability to enable active engagement and communication of children with disabilities with healthcare providers.

ARTICLE HISTORY
Received 27 October 2021
Revised 5 May 2022
Accepted 24 May 2022

KEYWORDS
Children with disabilities; design; environment; mobile application; participation; usability

Introduction

Participation refers to the child's involvement in daily lives and is affected by their surrounding environment [1]. Children have the rights to access living environment and social contexts that are meaningful to them. However, school-aged children with disabilities (in this study, 6–12 years) have been shown to experience greater participation restrictions and fewer environmental supports than their peers without disabilities [2–4]. They tend to be involved with less complex, quiet or sedentary activities at home [3]. Children with disabilities are more restricted outside the home as they participate less frequently in school and community activities, such as school clubs, socializing with peers, physical activities and community events [2,4]. Current research has focussed on parental reports. In this respect, children's opinions in their own life experiences have been under investigated [5]. Emerging research suggests that children with disabilities and their caregivers value different things [6–9], supporting the need to hear children's voices. An appropriate instrument with a structured procedure may help engage children with disabilities in expressing their life experiences.

Understanding children's participation and the influence of the environment on participation provides a holistic view of the life experiences of children with disabilities. As described in a framework of the Family of Participation-Related Constructs, participation involves *attendance* and *involvement* [10]. The attendance aspect can be quantified on the basis of the frequency of actual attendance in an activity in a daily situation. The involvement aspect can be measured based on the perceived involvement while attending the activity that may include the sense of

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engagement and belonging, motivation, persistence and social relationship. It is also important to measure how the children perceive the impacts of contextual and environmental factors on participation (regarding the people, place, activity, objects and time) through their involvement in specific activities [10]. Perceived involvement and environmental impacts of children are subjective experiences that may be difficult to answer reliably by proxy respondents (parents, caregivers or service providers), and there is a lack of self-reporting or self-rating measures for children with disabilities [11].

In light of the need for assessing a child's self-reported participation and environmental factors, the Picture My Participation (PmP) was designed for children with disabilities in the age range of 5–21 years [12]. The PmP was a picture-supported instrument that included 20 activities in an everyday setting, which were mostly related to home (nine items) and community (10 items) activities, with one school-related activity. The Talking Mats™ approach [13] was used with the original version of the PmP, where the child identified the frequency of attendance and level of involvement for each activity, selected three important activities among all activities and then identified related environmental facilitators and barriers of the three important activities. Content and structural validity was established for children with and without intellectual disability in low and middle-income settings (e.g. South Africa and Mainland China) and high-income settings (e.g. Sweden and Taiwan) [14–16]. The visual scales were shown to be useful for children to respond to the frequency of attendance and level of involvement [14].

The PmP was translated and cross-culturally adapted into Traditional Chinese version (PmP-C) following the development of culturally sensitive pictures for the Taiwan context [17,18]. Linguistic and cultural equivalence was examined via cognitive interviews with three children with intellectual and developmental disabilities and two children with typical development in the age range of 6–13 years and their parents. The cognitive interview aimed to provide clarification and refinement of the PmP-C. Children and parents were asked to verbalize their interpretation of items and pictures, comment on the item wordings, pictures and response process. The conceptual, item, semantic and operational equivalence were established [17]. The results indicated that the children and parents were able to identify the purpose of this instrument and considered it appropriate to understand children's life experiences (conceptual equivalence). They were able to understand the meanings of the items and also provided suggestions to improve the clarity of the item wordings and pictures (item and semantic equivalence). Two additional items (i.e. school leisure and physical recreation) were considered important and thus added to the original 20 items. The children and parents showed understanding for most of the instructions during the interview process, and parents also provided recommendations to facilitate children's responses to identify environmental facilitators and barriers (operational equivalence) [17]. Findings from our previous study resulted in the 22-item version of the PmP-C that was used in this study.

The use of everyday technology, e.g. mobile application (app) to further develop the PmP-C can provide a promising alternative to the original Talking Mats™ format. Talking Mats™ uses symbols and a structured procedure to visualize topics, options and scales in a conversation, and the contents of the conversation are usually preserved to provide a visual summary [19]. The PmP-C involved multiple steps that required at least 22 picture cards to present items for participation and environmental factors and three different visual scales for frequency, involvement and barriers/supports. Additionally, recording forms were suggested to record the children's ratings and qualitative information [17]. We found that the child's responses might be affected by their previous choices as they tended to fill in every blank under the visual scale symbol. In this situation we needed to remove their previous choices, which increased demands for data recording. App technology enables integration of the multiple steps and allows instant saving and exportation of data. Developing the PmP-C into an app can facilitate data collection and management, as well as its feasibility and accessibility to families and healthcare providers in our digital society. Importantly, the app's features can be designed to make it fun and easy to sort the pictures and actively engage children in the interview process.

Mobile health technology is beginning to be used for the assessment of client-centered outcomes and healthcare planning [20–23]. Taking advantage of interactive, touch-based and animated features, mobile app technology has been used to create self-report instruments for the assessment of children's psychological health [20] and physiological health conditions [24]. Use of pictures or videos, culturally appropriate materials, simple language and easy-to-understand instructions facilitates a child-friendly design of an app-based instrument [25]. Children considered the

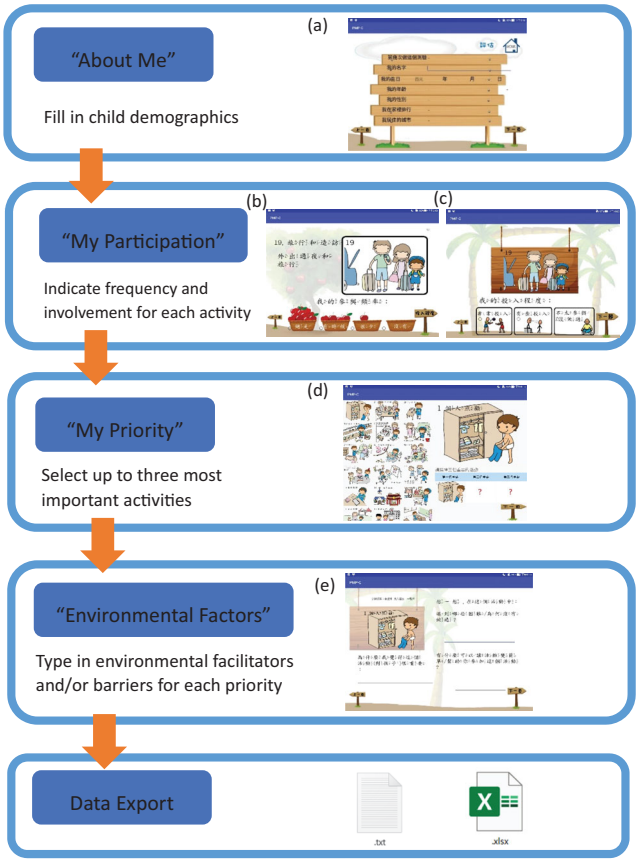

Figure 1. Overview of the PmP-C App. Images show screen shots for: (a) demographic information page; (b) frequency of attendance page; (c) involvement page; (d) scroll-down menu to select important activities; and (e) environmental factors page.

use of an application to answer questions more fun than using a paper questionnaire or verbal questions [24]. At the time of this study, we could not find an app-based instrument designed for children with disabilities to express their participation patterns, priorities and associated environmental factors together.

Given the potential of an app to facilitate self-reporting in the cases of children with disabilities, the objectives of this study included the development of the PmP-C in an app (PmP-C App) and the evaluation of the usability via interviews of healthcare workers with children with disabilities. Usability refers to the extent to which a product can be used by specified users with effectiveness, efficiency and satisfaction in a specified context of use [26]. Measures of usability usually cover perceived usefulness, ease of learning, ease of use and user satisfaction in previous usability studies [22,27,28]. Usability testing is a critical step in identifying user experiences and areas for improvement to inform program modification before further testing of preliminary effects [22,28].

Materials and methods

Development of the PmP-C app

The PmP-C App was intended to be used with children with disabilities to express their participation experiences through interviews by adult caregivers. The digital images in the app facilitated visualization of the interview questions. With adult support, children can respond in variable ways depending on their abilities, including clicking, talking or pointing out their selections, followed by the input of the entries by the adults. The development of the app program mainly involved content design, interface design and programming, as described in the following.

Content design

The PmP manual [12] and our work on the culturally adapted items (in the form of text and depicted with culturally appropriate pictures) and visual scale symbols [17,18] collectively informed the content of the application program. Text was presented with both Chinese character and phonetic notation that are known to literate children in Taiwan. Digital images related to the content were created by *Adobe Illustrator* (Adobe Inc.). The app involved five steps. First, the child's demographic information was completed (e.g. name, birthday, sex, birth order and city), and three trial items were used to investigate if the child understood the format (the questions were 'do you like ice cream?' 'do you like watching television?' and 'do you play with a snake at home?'). Second, frequencies of attendance and involvement for each of the 22 activities on the PmP-C were rated. Third, the three most important activities were prioritized on the basis of the selection of appropriate options from the list that comprised 22 activities, and their importance was described. Fourth, supports and/or barriers within the environment for each of the three important activities were identified. Last, the child's responses were confirmed, and the information was saved. Instructions were developed for healthcare workers to guide the child through these steps.

Interface design

The app was intended to offer an interactive and touch-based interface between the users (i.e. healthcare workers and children) and the app program (Figure 1(a–e)). The design focussed on the production of a child-friendly interface to facilitate the navigation of the application. The graphical layout was simply structured with brief instructions to facilitate children's understanding of the process. For the rating

Table 1. Basic demographic information of the health care workers and results of the usability questionnaire.

Number of testers (T)	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10	
Age range, year	30–39	30–39	20–29	20–29	20–29	30–39	20–29	30–39	30–39	20–29	
Sex	F	F	F	F	F	F	F	F	M	F	
Professional background	ECCE	Nurse	PT	PT	OT	ECCE	SW	SE	ECCE	PT	
Usability Questionnaire											Mean (SD)
1. I feel it's easy to operate.	2	4	4	5	4	5	3	5	4	4	4.0 (0.9)
2. I feel confident about using it.	2	3	3	5	4	4	3	5	4	4	3.7 (0.9)
3. I am willing to use it.	3	5	4	5	4	5	2	5	4	4	4.1 (1.3)
4. I can mamange to use it without others' assistance.	2	4	2	4	4	4	3	4	2	4	3.3 (0.9)
5. Its function is clearly shown.	4	4	2	5	4	5	2	5	4	2	3.7 (0.9)
6. Figures match item descriptions.	4	3	4	4	5	5	3	4	4	4	4.0 (1.0)
7. I feel others should be able to learn quickly.	2	3	4	4	2	4	4	5	4	4	3.6 (0.7)
8. I can minimize mistakes when using it.	2	4	2	3	4	4	3	3	2	2	2.9 (1.3)
9. I understand the instruction from the user manual.	2	3	2	5	3	5	4	5	4	2	3.5 (1.0)
10. It is attractive to a child.	4	5	5	4	4	5	3	5	4	5	4.0 (0.7)
11. It is easy to understand for a child.	3	4	3	5	2	5	4	5	2	4	3.7 (1.2)

ECCE: early childhood care and education; PT: physical therapy; OT: occupational therapy; SW: social worker; SE: special education. Scoring for the usability questionnaire: 1 = strongly disagree; 2 = disagree; 3 = neither; 4 = agree; 5 = strongly agree.

of frequencies of attendance and involvement, the required information for one item was intuitively displayed on the same screen (Figure 1(b,c) for illustration). The rating of frequencies of attendance and involvement was presented in separate pages to prevent overburdening the children's cognition and recall memory. Visual notifications were used to provide feedback once a response was selected or when an interview phase had been completed. For the prioritization of activities, we designed a scroll-down menu to list all the pictures for all 22 activities on a single page (Figure 1(d) for illustration). The child can click to enlarge any picture they want to see in more detail to select the most important activities. After they select the important activities, the program will direct them to evaluate the importance of the environmental factors for each selected activity. To allow children to talk freely on how the selected environmental factors act as supports and barriers, spaces for text messages were provided for the interviewer to type in children's responses (Figure 1(e) for illustration). We attempted to minimize motor demands to involve children as much as possible, most of the app functions can be operated by single-clicking, spaces for text messages can also be entered by voice inputs with subsequent conversion of speech to electronic text.

Programming

The application was developed by *Android Studio* (Google Inc.). The programming process focussed on the layout configuration and the data storage. The goals were to ensure that the content was displayed properly on the screen as designed and the data were instantly stored and could be further outputted in a proper format for data processing. An ongoing correction and system testing are conducted until the completion of the PmP-C App prototype.

Usability test

Participants

In this usability study, the interviewers were healthcare workers who currently worked with school-aged children with disabilities either in research or in practice. Following the PmP manual, the interviewers can be from any professional background. Therefore, we attempted to engage a diverse disciplinary group of healthcare workers. The interviewees were children with disabilities who met the following inclusion criteria: (i) aged 6–12 years who had an identified disability based on the Disability Evaluation System in Taiwan [29], (ii) had a cognitive level of at least five-years of developmental age, and were able to make choices between four options (tested by three trial questions), (iii) were able to understand verbal instructions and express their thoughts verbally, in writing/typing, or with Augmentative and Alternative Communication (AAC). Children with uncorrected visual or hearing impairments and thus were unable to see or hear were excluded.

Ten healthcare workers and 10 children with disabilities were recruited from Northern Taiwan through convenience sampling (Tables 1 and 2). The participating children had sufficient vision to see the text, pictures and symbols, and sufficient hearing to receive the interviewer's verbal instructions. They had cognitive skills to understand the pictures and symbols, assisted by reading the text and the interviewer's explanation. They were able to communicate (verbally) and indicate a response (out of three or four options). All children demonstrated motor skills to

Table 2. Basic demographic information of the children with disabilities and the results of the PmP-C interview.

Number	Child 01	Child 02	Child 03	Child 04	Child 05	Child 06	Child 07	Child 08	Child 09	Child 10
Age	6	6	11	9	12	11	9	11	8	7
Sex	Girl	Boy	Boy	Boy	Boy	Boy	Boy	Girl	Boy	Girl
Birth order	2	1	1	1	1	1	1	2	2	3
Diagnosis	PD	LI	ASD	PD	ASD	DD	ASD	ID	ID	DD
Frequency	2.1 (1.2)	30. (1.3)	2.5 (0.9)	3.9 (0.4)	3.3 (0.9)	2.3 (1.1)	2.2 (1.1)	2.0 (1.2)	3.8 (0.7)	3.0 (1.3)
Involvment	1.7 (0.8)	2.6 (0.7)	2.2 (0.7)	2.8 (0.6)	2.7 (0.5)	2.0 (0.7)	1.6 (0.8)	1.6 (0.7)	2.6 (0.8)	2.4 (0.9)
1st Priority	Personal care	Physical recreation (mountain climbing)	Overnight visits and trips	Learning at school	Overnight visits and trips (to relatives' houses)	Quiet recreation	Overnight visits and trips	Quiet recreation (drawing)	Health visits	Family/community celebrations
1st Priority-environmental factors	Parent's physical assistance (+)	Family accompany (+) long mountain load (−)	Not specified	Not specified	Holiday time (+) friendly relatives (+)	Not specified	Family accompany (+) limited time (−)	Parent's guiding and assistance (+)	Not specified	Family arrangement (+)
2nd Priority	learning at school	Religious and spiritual activities	Family/community celebrations	Shopping and errands	Physical recreation	Overnight visits and trips	Quiet recreation	Taking care of animals (cat)	Social and community activities	Religious and spiritual activities
2nd Priority-environmental factors	Being with classmates (+)	Fun activities (+) church members are welcoming (+)	Family arrangement (+)	Heavy cart is hard to push (−)	Limited time due to homework (−)	Not specified	Smartphone available (+) no private space at home (−)	Help from sibling (+)	Not specified	Not specified
3rd Priority	Family/community celebrations	Learning at school	Family mealtime	Quiet recreation (reading papers)	Quiet recreation (reading, music)	Religious and & spiritual activities	Organized leisure	Getting together with other children in the community	Learning at school	Overnight visits and trips
3rd Priority-environmental factors	Not specified	Not specified	Busy family schedule (−)	Font too small (−)	Limited time (−)	Not specified	No friends to go with (−)	Playground available and fun (+) parent's guiding and assistance (+)	Not specified	Not specified

PmP-C: picture my participation traditional Chinese version; PD: physical disability; LI: language impairment; ASD: autism spectrum disorder; DD: developmental delay; ID: intellectual disability.
Scoring for Frequency: 1 = Never; 2 = Seldom; 3 = Sometimes; 4 = Always; Scoring for Involvement: 1 = No or minimally involved; 2 = Somewhat involved; 3 = Very involved. '+': environmental facilitators; '-': environmental barriers.

click the icons by using the touch screen with minimal or no assistance. Ethical approval was granted by the Centre for Research Ethics at the National Taiwan Normal University (201812ES010). All participants provided written consent. The parents of children with disabilities signed the parent-version consent forms, while children aged ≥7 years signed the child-version consent forms. The child-version used simple language with both Chinese character and phonetic notation to facilitate children's understanding of the written information about the study.

Usability questionnaire

A usability questionnaire was designed for this study to assess various aspects of the app program, including ease of use, ease of learning and satisfaction with operation. The questionnaire contained 11 survey questions (Table 1) based on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The items were constructed based on the System Usability Scale (SUS) [30], which can be used with small sample sizes (<12) to evaluate a wide variety of products and systems, including mobile applications. The items on the SUS cover a variety of aspects of usability such as the user's ability to use, need for support or training, product functionality and subjective experiences. As the app was intended to be used with children, we added two items (items #10 and #11) to explore the healthcare worker's views from interacting with the child. Additionally, the usability questionnaire also included three open-ended questions to gather narrative responses regarding the following questions: (1) What do you think about the use and operation of the app? (2) What do you think about its appearance? (3) What are your perceptions on this app (i.e. any positive or negative views, or any suggestions for improvement)?

Procedures

In the usability test, the healthcare workers were the usability testers (the persons who provided feedback regarding usability), and the children's responses during the testing process were observed by one researcher from our team. The healthcare workers and children had not used the PmP before the study, but they were informed that the purpose of this interview was to test the app version of the PmP derived from a paper-based version. The healthcare workers first learned to use the app and then each interviewed one child. The researcher was responsible for the conduct of training for healthcare workers before testing and conducted interviews with the healthcare workers using the usability questionnaire after testing. The training was mainly for the healthcare workers to understand the testing items and procedures, and the app operation. The healthcare workers first read the operation manual, and the researcher then demonstrated how to operate the app and gave the healthcare workers a chance to practice. The researcher attempted to ensure that the healthcare workers understood the testing process to prevent testing errors due to their unfamiliarity with the app program. After training, the healthcare workers and the researcher set up a time and location that was convenient and comfortable for the children's families for the testing.

During the testing, the healthcare workers sat close to the child in a position that allowed them to face the child. The tablet was placed on the table so both of them could see the screen. The healthcare workers controlled the pace of the interview by asking interview questions while they operated the app. When it was the turn for the child to respond, they answered by clicking icons or by typing in text. The healthcare workers may ask follow-up questions to allow the children to be more expressive on the answers they provided. The testing procedure took around 30–40 min. The researcher maintained an observation note log on their interactions and app operating process.

After testing, the researcher interviewed the healthcare workers to gather both quantitative and qualitative data on usability. The researcher read the survey items and asked the healthcare workers to provide ratings and thoughts for each item. For the open-ended questions, the healthcare workers provided additional comments related to usage and operation, aesthetics, and any positive or negative aspects they had about the PmP-C App. Both the healthcare workers and children were given a voucher that was worth 16 USD after the completion of this study. The audio of the interview was recorded to ensure the existence of a complete collection of feedback and opinions. The testing results informed modification and refinement of the app program.

Data analysis

For quantitative data, the scores for the 11 survey questions were reported as the means and standard deviations for each item and each individual. For qualitative data, content analyses were used to analyse the transcripts and observation notes. An inductive approach was used to form categories that fitted the

Table 3. Positive feedback and perceived benefits to the PMP-C App.

Categories	Responses*
Layout and icon design	User interface is simple. (3)
	Text with phonetic notation is easy for a child to read. (1)
Pictures and symbols	Pictures are lovely with appropriate size. (5)
	Pictures and symbols are easy to understand (e.g. using the quantity of apples to symbolize the level of frequency). (3)
Operating procedures	Easy to use and to involve a child in using it. (4)
	Entering responses has good flexibility and easy to modify answers if needed. (1)
	Self-learning to operate this program is feasible by reading the operation manual. (4)
	Children learn how to operate after trying a few times. (4)
Aesthetics	Interface is colourful and attractive. (2)
	Overall design is user-friendly. (2)
Use of technology	The device is a motivator to the child. (4)
	The app appears to attract the child and make them concentrate on the interview. (3)
	A effective communication tool with minimal demands which allows children to make choices. (4)
	The app is efficient in collecting and saving data, the device is easy to carry and save space for interview. (1)

*The number of respondents reporting each comment are noted in the parentheses.

content of the qualitative data [31]. The transcripts and observation notes were reviewed and then coded by category. The number of healthcare workers who had the same or similar responses in every category was calculated. Two researchers in our research team reviewed the transcripts and notes and cross-checked the coded categories and responses. The summary of findings was reviewed by other research team members to ensure the trustworthiness of the analysis [32].

Results

Description of the PmP-C app

The PmP-C App prototype had four key features (Figure 1): 'About Me,' 'My Participation,' 'My Priority' and 'Environmental Factor.' In 'About Me,' the child provided their demographic information including names, age, gender, living areas and family members living with the child. This information could be entered by the adult interviewers. Having a good understanding of the child's knowledge about their own basic information may facilitate consequent interviews with the child. In 'My participation,' the child first answered three trial questions to become familiar with the response options. The child then went through the 22 activities, and each activity (presented by both text and picture) appeared repeatedly in two separate pages, one for frequency of attendance (presented by both text and symbol for 'Never', 'Seldom', 'Sometimes' and 'Always') and one for involvement (presented by both text and symbol for 'No or minimally involved', 'Somewhat involved' and 'Very involved'). A child needed to understand each activity and the scales, and responded by clicking the symbol that corresponded to their selections. The adult interviewer could provide verbal explaination to support the child's understanding or physical assistance when responding. In 'My Priority,' a child was guided to select up to three most important activities from a scroll-down menu that comprised all the 22 items. The child could click to enlarge any specific picture to facilitate his/her recollection or discussion about the activity and then specified which were the first, second and third important activities. In the 'Environmental Factor,' for each selected priority, the child was encouraged to express why this was important and identified environmental facilitators and/or barriers. The adult interviewer typed in the responses using the child's own words. Upon the completion of the interview, the data were retrieved and then downloaded and imported to statistical software such as *Microsoft Excel or SPSS* for data management.

Results of the usability questionnaire

The 10 healthcare workers reported an overall mean score of 3.7 (on a scale from 1 to 5) for the 11-item usability questionnaire. Individual scores for each item are listed in Table 1. The item with the highest mean score is 'It is attractive to a child' (Mean = 4.4), and the item with the lowest mean score is 'I can minimize mistakes when using it' (Mean = 2.9).

The qualitative results identified some positive aspects of the PmP-C App in terms of the design, operation, aesthetics and use of technology (Table 3). Overall, the participants considered the interface as simple and child-friendly and facilitated involving a child in a responding process. They thought that the colourful pictures helped visualize the interview items and were attractive to children. Additional advantages related to the use of mobile technology were reported, such as the flexibility of entering or correcting the responses, simplicity of operation with all testing materials contained in one device and efficiency of data management. The device itself could be a motivator for a child to stay engaged throughout the process.

Table 4. Professional's critical feedback and our program modification in response to the feedback.

Categories	Feedback*	Modification
Layout and icon design	• The visual feedback (a red dot) after clicking at the response icon is not obvious (7) • Not every click has feedback. (2) • Need to reduce number of icons, some icons (such as 'home') are rarely used. (2)	• Enlarge the visual feedback to improve visibility. • Add clicking sound and vibration. • Simplify icons appearing on the screen and re-arrange the layout.
Pictures and symbols	• Need more instructions when selecting 3 important activities from the list of all items. (1)	• Design a preview mode to show the picture with short title for each item.
Operating procedures	• Need a reminder when skipping any item unintentionally.(1) • Allow the child to skip an item if they don't want to answer. (1) • The items may be covered when the keyboard appears on the screen. (5) • The instructions are too brief to understand, especially for the questions for environmental facilitators and barriers. (5)	• Add a dialog to indicate an missing response. The user can go back to answer or press 'confirm' to skip the item. • Relocate the screen keyboard. • Modify the instructions on the App. • Add more descriptions and examples in the user manual to improve the interviewers' understanding to guide the child.
Aesthetics	• In some pages, background colour is too dark to interfere the visibility of the pictures, suggest changing to lighter colour or change transparency. (2)	• Modify the background colour and transparency.
Technical problems	• The app sometimes shut down unexpectedly. (2) • Need a way to ensure the data is saved. (2)	• Optimize the program to remove error and solve problems. • Add a dialog box to indicate the data is autosaved.

*The number of respondents reporting each comment are noted in the parentheses.

There was critical feedback on layout and icon design, pictures, and symbols, operating procedures, aesthetics and technical problems (Table 4). The major suggestions included the enhancement of visual or audio feedback after the input of responses, the input of operation instructions (especially for the identification of environmental factors), the modification of pictures to facilitate prioritization of activities and the need for a reminder when an item was skipped either intentionally or unintentionally. Other suggestions included the need for the improvement of background colour, icon location and technical problems. These suggestions informed specific modifications of the program that have been done by the research team, as listed in Table 4. The PmP-C App has been optimized on the basis of the refinement of the programming and amendments to the user manual.

Discussion

In the effort to achieve a client-centered care in rehabilitation, both children and family members play active roles in identifying needs and planning care [33]. Involving children in care planning is a continuous process that requires techniques to facilitate children's expression, such as interaction skills appropriate for children's age and abilities, as well as creative visual methods [9]. The PmP-C App provides visualization of interview questions using culturally appropriate pictures/symbols, structures of the responding process into small steps, which may facilitate children's understanding and expression. Use of the PmP-C has potential to empower children by enabling them to tell lived experiences, make activity choices, and reflect on the supports and barriers they perceive. It provides healthcare workers a medium to actively engage children with disabilities within their own care, and to facilitate families and care providers to develop collective support plans to promote participation.

The PmP-C App is a promising electronic health instrument to gather data on the self-perceived attendance and involvement in activities, as well as environmental supports or barriers for children with disabilities. Although the app is intended to be used for children with various types of disabilities, children need to have basic skills for using it, including seeing and hearing, understanding the pictures and symbols, making choices and responding via communication (verbal or non-verbal) or motor actions (clicking). The child's use of the app relies greatly on the support of healthcare workers. For instance, the child's understanding and decision making can be facilitated by verbal guidance and prompting skills of the interviewer. Children who cannot manipulate the app due to motor impairments or other difficulties can respond with the interviewer's physical assistance or assistive technology, or manipulating by the interviewer. This study, therefore, presented the

interviewers' valuable feedback based on their observation and interaction with the child when using the app.

Feedback from the interviewers suggested the app design as an attractive and user-friendly interface that facilitated the child's involvement during the interview. When introducing the interview purpose and the use of the device (i.e. tablet), children expressed interest immediately. Although the interviewers sought to gather opinions from the child, the colourful pictures helped them visualize the questions and also increased children's motivation and attention span. The children had chances to learn to respond by themselves through navigating the interface, and they learned quickly after a few trials. The children were observed to actively engage in the interview, and they were able to interact with the interviewers through conversation as well as manipulation of the app during the responding process.

The results of usability tests revealed several benefits associated with the use of app technology. The app was considered easy to operate and its functions were clearly shown to guide the interview steps. Like all electronic products, it requires learning before its use for the first time. In this study, the researcher provided training to ensure that all healthcare workers have the same level of familiarity with the app before usability testing. However, self-learning with the operational manual was considered possible by some participants, which might enhance its applicability. One participant suggested the potential of using app technology to save time and space for interview, and facilitate data collection. Further exploration is needed to better understand the app's efficiency in data collection and management.

Despite the positive aspects of using the PmP-C App for interviews, the results of the usability test revealed several issues that informed program optimizations. It is important to simplify the program and remove errors so the interviewers can focus on direct interaction with the child without worrying about technical issues. The participants' feedback corresponds to the literature, thus indicating that adult caregivers desire a simple and easy mobile health application as part of their care planning [25]. The healthcare workers tend to think that it is easy to make a mistake when they manipulate the program, such as pressing the wrong icon or skipping an item unintentionally. This was improved by simplifying and rearranging the icons, adding a 'dialog' to a missing response, and providing more clear instructions for navigating the app functions. Additionally, we found that variability existed regarding the healthcare workers' need for personal assistance to become familiar with the operation procedures and enhanced their abilities to learn to use the program from the operational manual. Thus, we have added more descriptions on each icon function and supplied it with tips to prevent technical errors in the operational manual.

Guiding the children to self-analyze their environmental factors in relation to their prioritized activities is an important final step of the interview process. The healthcare workers exhibited variable abilities in prompting the children to identify relevant supports or barriers. Consequently, eight children specified environmental factors in relation to all or some of their prioritized activities, while two children did not specify any environmental factors. Therefore, simple wording to inquire about environmental factors is essential, such as the use of 'things that make the activity easier to perform' to indicate environmental facilitators and 'things that make the activity harder or unable to perform' to indicate environmental barriers. According to the feedback received from healthcare workers, examples of environmental factors were then supplied in the user manual to support the healthcare workers in guiding the child. These examples may help the interviewers provide prompts to enable the child's responses that reflect their real-life situations.

Limitations and needs for further study

There are several limitations of the current app version that warrant further development and adaptions. This version is designed for *Android* devices but is not yet compatible with the iOS system. To show the pictures properly, the app is functioning well with tablets but not with smartphones, which limits its availability. The test procedure involved children with various types of disabilities and demonstrated initial feasibility to these children. Because of the limited numbers, however, we were unable to examine the possible influence of children's characteristics (such as age, sex and type of disability) on their user experiences [34]. The app will need to be adapted to be used with children with sensory (vision or hearing) impairments, such as magnification of text and pictures or conversion of text to speech to offer voice outputs for children with low vision [35]. Children with hearing impairments may require the interviewer's supports using appropriate communication methods in addition to verbal guidance. Children who have difficulty

using a touch screen were not included in this study, though we did not intend to exclude children due to motor impairments. Further adaptions can be considered to link with the use of other user interfaces to accommodate motor control limitations, such as trackball, joystick or headmouse [36]. Additionally, considering the response burden to children, we did not ask children questions about the usability. The results of the usability test mainly reflected the interviewer's perspectives, which might not accurately reflect children's understanding and thoughts to the app. Children's perspectives could be gathered by designing questions and response scales appropriate to be used with children with disabilities. It will be of interest to investigate children's thoughts to the app for further feasibility testing.

Implication for research

The development of electronic instruments is a novel research priority in the fields of rehabilitation sciences and information technology [37]. The PmP-C App is developed through a multidisciplinary collaboration among rehabilitation sciences, information technology and special education. Validation of the PmP-C App to a larger sample of children with and without disabilities is ongoing and aims to provide an innovative and valid electronic tool to assess the child-perceived needs for participation in their daily environments. The relevance of the items to Taiwanese children with disabilities is planned to be examined. Future research will focus on providing support to the reliability, validity and utility of the instrument in children who have various levels of abilities, including those with intellectual or communicative disabilities. Given that mobile devices are widely used in everyday life, this app-based instrument will enable data collection in various settings, even for remote or resource-poor areas.

Implications for practice

This study contributes to the implementation of best practices pertaining to healthcare professionals who seek to empower clients to take a lead in the adopted healthcare process [38]. The PmP-C App offers an electronic administration instrument that has potential to empower the child and family in their care processes. Along with the use of the app to visualize interview questions, healthcare workers need to use responsive interaction skills to encourage the child in expressing their opinions. Healthcare providers need to have supportive attitudes and employ appropriate techniques for effective communication with children [8,9]. To provide relevant information for children's healthcare and educational planning, the caregivers are encouraged to provide their perspectives considering the child's best interests.

Acknowledgement

We are grateful to have the active participation of children and healthcare workers in the study. We appreciate our esteemed colleague, Ai-Wen Hwang, for her great supports during the time of this study, and appreciate the authors of the PmP for their inputs in the process of cross-cultural adaptation and app development.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Ministry of Sciences and Technology, Taiwan under [Grants MOST 107-2314-B-182-048 and 108-2314-B-182 – 041 -MY2].

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