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Exploratory Factor Analysis on the Measurement Model of the Augmented Reality Applications with PECS and TEACCH Methods for Special Needs Children

Mohamad Suhaimi Ramli and Norsuhaily Abu Bakar
Faculty of Applied Social Science, University Sultan Zainal Abidin, 21300 Kuala Nerus, Terengganu, Malaysia
Corresponding Author Email: norsuhaily@unisza.edu.my

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Abstract
Utilising multimedia and computer-assisted instruction models is now common practice in the special needs education. Augmented reality (AR) is one of the interactive multimedia applications that has been acknowledged as a powerful way to improve the user experience. Research on the use of augmented reality (AR) as an educational intervention among children with special needs has significantly increased in the last few years. However, there is limited study on the application of AR that integrates both TEACCH and PECS for children with special needs. Therefore, the purpose of this study is to develop a valid and reliable measurement model of the augmented reality applications with PECS and TEACCH methods among special needs children. Prior to the distribution of the survey questionnaire among 100 teachers and parents of children with special needs, the survey questionnaire was assessed by the experts of the criteria, substance, and face validity. The five-point Likert scale structured survey questionnaire was developed to measure respondents' levels of agreement or disagreement with the item statements or questions given. The collected data were subjected to an exploratory factor analysis (EFA) utilizing IBM-SPSS version 26.0. Based on the outcomes of the EFA procedure, one item with low factor loading and below the 0.6 cut-off threshold were removed. The actual 34 items representing the six constructs were reduced to 33 items. The 33 items with high factor loading from the EFA procedure were retained to be used in the real fieldwork data collection before performing confirmatory factor analysis (CFA) procedure.
Keywords: Exploratory Factor Analysis, Special needs, Augmented Reality, PECS, TEACCH

Introduction

Special needs children have unique requirements that must be addressed in a particular way, require specific attention, and have different demands than other children (Bakar et al., 2020). These children also require a special education curriculum designed to meet their individual learning needs (Bryant, Bryant, 2019). All special needs children also have the right to receive education on par with other typical children. Inclusion strategies by including them in mainstream education in regular learning settings are one of the strategies to ensure that they can interact with their peers, feel included in society, and subsequently develop their self-confidence and daily living skills (Dogan et al., 2017; Uzunboylu & Özcan, 2019). In Malaysia, there are around 105,785 special education students registered in accredited special education schools and institutes, ranging from preschool to high school level (Buku Data Pendidikan Khas, 2022). To address social, cognitive, and communicative issues among the large number of children with special needs, effective intervention programmes are required (Baragash et al., 2020).

Early intervention programmes are a variety of programmes designed specifically to assist and support the special needs children by proving them with therapy, knowledge, support, love, and encouragement (Tan & Mohamad, 2019). Special needs children such as children with autism spectrum disorder (ASD) who undergo focused intervention practice achieve specific area of behavioural or developmental results within a short period of time compared to comprehensive treatment models (CTM) which is a multi-component interventions used over a long time to have a broader developmental impact (Sanz-Cervera et al., 2018). Comprehensive treatment models include the Denver model, the LEAP model, the pivotal response treatment model, ABA (Applied Behaviour Analysis), and TEACCH (Treatment and Education of Autistic and Related Communication Handicapped Children). (Odom et al., 2014; Sanz-Cervera et al., 2018). TEACCH is an educational intervention approach that helps ASD children to overcome their communication difficulties by considering a variety of elements, such as different items, locations, and weather, and employing activities to promote social behaviour, cognitive skills, and psychological capabilities (Oliveira et al., 2019). To meet the unique learning needs of people with ASD, such as those who have strengths in visual information processing but difficulties with social communication, attention, and executive function, TEACCH intervention places a strong emphasis on the use of visual cues, environmental organisation, and individualised evaluation (Shminan et al., 2020).

The TEACCH approach also assigns specific workstations to children with special needs, such as those with ASD, in a designated area so they can complete tasks and activities given to them by their therapists, thereby creating an organised teaching and learning environment. (Oliveira et al., 2019). Meanwhile, as an evidence-based, low-tech, portable, and easily-used tool, the Picture Exchange Communication System was created for children with special needs who were either non-verbal or had delayed speech to develop the communication skills of these children so that they can express their emotions and convey their messages, whether at home or in the classroom (Bondy, & Frost, 2011). The PECS approach has six steps that assist children with ASD in starting a conversation with their communication partner (Ivy et al., 2020). PECS is regarded as one of the best educational interventions for kids with ASD, according to prior research (Shminan et al., 2017). Therefore, the purpose of this study is to develop a valid and reliable measurement model of the Augmented Reality application with PECS And TEACCH methods for special needs children.

Literature Review

Children with special needs are frequently linked to behavioural issues and struggle to learn life's fundamental skills, which has led to the development of a curriculum that places a strong emphasis on practical and real-life experiences (Cakir & Korkmaz, 2019). For children with special needs, particularly those with autism, the PECS and TEACCH programmes are among the most successful intervention strategies for enhancing social communication, visual information processing, and inclusive educational support (Shminan et al., 2017, 2020). Additionally, the PECS approach is widely used in special education centres and special needs children's schools as an efficient communication training tool during the teaching and learning process (Flippin et al., 2010). TEACCH, on the other hand, is a structured intervention programme created especially for kids with autism. It addresses all the characteristics of autism as well as the unique challenges faced by each autistic child to reduce the challenges faced by ASD children through alternative communication techniques, changes to the environment, and systematic intervention. (Panerai et al., 2002).

To date, various methods have been developed and introduced to measure the effectiveness of mobile AR applications based on the Technology Acceptance Model (TAM) to evaluate the effectiveness of technology and the user's perception of its usefulness and acceptance of its use (Asiri & El Aasar, 2022). Based on a study conducted by Pasalidou and Fachantidis (2021), aimed at assessing the perceptions of a group of Greek primary school teachers about the education use of augmented reality, the result demonstrated a high factor loading for all three main variables examined: perceived usefulness, perceived ease of use, and behavioural intention. In another major study, Mikropoulos et al (2020), investigated the acceptance and user experience of an augmented reality system for the stimulation of sensory overload in children with autism. This study adapted and modified the questionnaire based on technology acceptance model (TAM) that consists of six variables: Interface Style (IS), Perceived Usefulness (PU), Perceived Ease of Use (PEU), Perceived Situation Awareness (PSA), Attitude Toward Using (ATU), and Intention to Use (ITU). The findings from the TAM showed in their majority high internal consistency (> .70) and high mean scores. Meanwhile, Kung-Teck et al. (2019) conducted a quasi-experimental research design aimed to identify the e-courseware effectiveness and Special Education (SpeEdu.) Teacher perception in using Basic Living Skills (BLS) E-courseware prototypes, namely BLS (Augmented Reality Animation) and BLS (Static graphic). The effectiveness of the proposed prototypes was measured based on the academic performance from the three tests that were carried out.

Meanwhile, to ensure that autistic children can receive better alternative interventions using the PECS technique, Shminan et al (2017), developed a mobile-based learning programme called AutiPECS for parents of children with autism spectrum disorder (ASD) in Malaysia. This programme helps parents of autistic children reduce their reliance on therapists and the need for costly treatment at autism centres. In contrast, Taryadi (2018), conducted a research in Indonesia to design a new application specifically made for autistic children to investigate the capabilities and potentials of using PECS approach within augmented reality applications for learning and teaching, behavioural stimulation, and monitoring. Meanwhile, Amado et al (2021), conducted a research in Peru to create an augmented reality mobile application that will help autistic kids in both online and in-person classrooms to boost their cognitive skills. The Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) programme has offered structured teaching methods as a recommendation and it has been proven that children with autism learn more effectively when learning is visual and interactive, whether through conventional methods or digital methods (Rao, Shaila & Gagie, 2006). PECS and TEACCH approaches are now being studied by researchers from a variety of sectors to be integrated into digital-based mediums like computers and touchscreen mobile technology (Kamaruzaman et al., 2016). Thus, the application of AR effectively assists in the acquisition of these skills, while providing a platform for individuals with special needs to increase their motivation and understanding of certain information AR-related studies (Cakir & Korkmaz, 2019). Due to the potential of PECS and TEACCH approaches to be integrated in mobile application, therefore, the purpose of this study is to develop a valid and reliable measurement model of the augmented reality applications with PECS and TEACCH methods among special needs children.

Methodology

This study employed a survey research design to obtain the pilot study data. The approach of this pilot study is quantitative and the self-administered survey was adapted from previous literatures (Oliveira et al., 2019; Pasalidou & Fachantidis, 2021; Rakap et al., 2018). The questions and statement of items in the questionnaire were modified in accordance with the research's objectives and the statement of items were divided into seven parts. The first part of the survey questionnaire consisted of demographic questions meanwhile part 2 until part 7 represented the constructs of this research including AR with PECS and TEACCH Approaches, Perceived Usefulness, Perceived Ease of Use, Intention to Use, Perceived Efficacy, and Training. The AR with PECS and TEACCH Approaches construct consisted of ten items. There were four items under perceived usefulness and perceived ease of use constructs, three items for intention to use construct, eight items for the perceived efficacy construct and five items for the training construct. In total, there were 34 items from part 2 until part 7. Each item statement was designed as a closed-ended question with five Likert-scales to measure the agreement and disagreement of the respondents. The Likert scale range from 1 to 5 to represent "strongly disagree" and "strongly agree". Pre-test of the survey questionnaire was conducted by the researcher before the pilot study survey distribution to ensure the questions developed were understood by the intended respondent. During pre-test, the questionnaire is examined by the experts to ensure that all the questions were appropriate and fulfil criteria, face, and content validity. The respondents of the pilot study were among special needs teachers and parents of special needs children in Malaysia. The sampling frame was obtained from the Special Needs Data Book Year 2021 released by the Ministry of Education Malaysia (MOE). Simple random sampling method was adopted to randomly select a sample of 100 respondents for the pilot study. The selected respondents were given a self-administered questionnaire by the special needs centre, or the special needs school administration and they were given enough time to answer the given survey questionnaire.

Results

The Exploratory Factor Analysis (EFA) procedure

The designed questionnaire was distributed to 100 selected respondents comprising teachers and parents of the special needs children for the purpose of pilot study data collection. The EFA was conducted on the pilot study data to explore and measure the dimensionality of the items for each construct used to develop a valid and reliable measurement model of the Augmented Reality application with PECS And TEACCH methods for special needs children. This study was likely to create new dimensions since it was conducted in a new environment and was concerned with a different subject (Hoque et al., 2018). Table 1 demonstrated the results of mean and standard deviation for every item under its construct. The interval scale ranging from 1 (strongly disagree) to 5 (strongly agree) was employed to provide a wide range of options as recommended by Allen and Seaman (2007). The results of standard deviation for each item show how much variation there is from the mean.

Table 1
The Mean and Standard Deviation for the Items of Each Construct

Item statement		Mean	Std. Deviation
Augmented Reality with PECS & TEACCH methods (AUG)			
AUG1	I have enough experience in the special needs education	2.820	1.158
AUG2	I have dealt with children with special needs other than autism before	2.620	1.516
AUG3	I have received training to deal with children with special needs	2.770	1.462
AUG4	I plan by myself the daily activities of children with special needs	3.110	1.188
AUG5	I prepare the daily activities for the children with special needs whether by hand writing, computer software or both	3.160	1.229
AUG6	Communication failure is the difficulty I face in dealing with children with special needs	3.680	1.091
AUG7	I already knew about TEACCH and PECS methods for children with special needs	2.550	1.226
AUG8	I agree with the development of a mobile application that integrates both PECS and TEACCH methods using augmented reality method	3.730	1.072
AUG9	There is similarity between augmented reality mobile application with the current methods I use for the children with special needs	3.150	0.880
AUG10	I would be able to use the augmented reality mobile app in the daily activities with the children with special needs	3.060	0.993
Perceived Usefulness (PCU)			
PCU1	The mobile augmented reality application with PECS and TEACCH methods is easy to use	2.270	0.983
PCU2	Learning to use the mobile augmented reality application with PECS and TEACCH methods is not a problem	2.650	1.048
PCU3	The operation of mobile augmented reality application with PECS and TEACCH methods is clear and understandable	2.350	1.351

PCU4	Generally, I consider that the mobile augmented reality application with PECS and TEACCH methods is easy to use	2.350	1.258
Perceived Ease of Use (PEOU)			
PEOU1	The use of mobile Augmented Reality (AR) application with PECS and TEACCH approaches among children with special needs increases their performance in learning	2.590	1.280
PEOU2	The use of mobile Augmented Reality (AR) application with PECS and TEACCH approaches among children with special needs improves their productivity in learning	2.810	1.107
PEOU3	The use of mobile Augmented Reality (AR) application using PECS and TEACCH approaches among children with special needs improves their learning effectiveness	2.910	1.190
PEOU4	Generally, I consider that the mobile Augmented Reality (AR) application with PECS and TEACCH approaches can be useful in the learning process of children with special needs	2.810	1.285
Intention to Use (INTU)			
INTU1	I intend to use the mobile Augmented Reality apps with PECS and TEACCH approaches	3.590	1.055
INTU2	I will try to use the mobile Augmented Reality apps with PECS and TEACCH approaches	3.590	1.045
INTU3	I plan to use the mobile Augmented Reality apps with PECS and TEACCH approaches	3.430	0.956
Perceived Efficacy (PEF)			
PEF1	I am knowledgeable about children with special needs	3.590	1.055
PEF2	I know types of symptoms children with special needs have	3.590	1.045
PEF3	I know what happens to children with special needs as they get older	3.430	0.956
PEF4	I am knowledgeable about what causes a child to be under special needs category	3.230	0.952
PEF5	I am aware of treatment option for children with special needs	3.560	0.988
PEF6	I understand how common a child to be diagnosed as children with special needs in the general population	3.560	0.935

PEF7	I believe I would know if I met a child with special needs	3.320	0.984
PEF8	I believe I can meet the needs of special needs children	3.360	1.030
Training (TRN)			
TRN1	I need a training on characteristics and nature of children with special needs	3.850	1.149
TRN2	I need a training on identification, assessment and diagnosis of children with special needs	3.750	1.077
TRN3	I need a training on evidence-based instructional strategies for children with special needs	3.630	1.134
TRN4	I need a training on interventions for communication and social development	3.850	1.114
TRN5	I need a training on behavior management and positive behavior support	3.840	1.070

The table 2 below shows the Bartletts' test of sphericity for AR with PECS and TEACCH approaches, Perceived Usefulness, Perceived Ease of Use, and Intention to Use constructs, Perceived Efficacy and Training were significant (p-value < 0.001). The value of Kaiser–Meyer–Olkin (KMO) for all six constructs were also greater than 0.6 (KMO>0.6) indicating that the number of samples was adequate to proceed with data reduction procedure and further analysis (Alias et al., 2020).

Table 2
The value of Kaiser–Meyer–Olkin (KMO) and Bartlett's Test Score

Constructs	**KMO (>0.6)**	**Bartlett's Test Score (<0.001)**
Augmented Reality with PECS and TEACCH approaches	0.794	0.000
Perceived Usefulness	0.798	0.000
Perceived Ease of Use	0.766	0.000
Intention to Use	0.725	0.000
Perceived Efficacy	0.896	0.000
Training Needed	0.836	0.000

Table 3 displayed the two components and their respective items for Augmented Reality with PECS and TEACCH constructs. The value of the factor loading for each item was higher than 0.6, except for AUG6. Therefore, the AUG6 item with factor loading of less than 0.6 was deleted (Ehido et al., 2020). The nine items with high factor loading were retained to assess the AR with PECS and TEACCH constructs.

Table 3
The 2 Components and their respective Items for Augmented Reality with PECS and TEACCH Constructs

Rotated Component Matrix[a]		
	Component	
	1	2
AUG1	0.826	
AUG2	0.849	
AUG3	0.846	
AUG4	0.699	
AUG5	0.829	
AUG6 ITEM DELETED		
AUG7	0.668	
AUG8		0.741
AUG9		0.797
AUG10		0.735

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

The Table 4 showed that all four items of Perceived Usefulness construct with high factor loading of greater than 0.6 were retained in one component only. There is no new component created and no deleted item needed, therefore the four items with high factor loading can proceed to be used to assess the Perceived Usefulness construct.

Table 4
The 1 Component and the Respective Items for Perceived Usefulness Construct

Component Matrix[a]	
	Component
	1
PCU1	0.934
PCU2	0.952
PCU3	0.948
PCU4	0.943

Table 5 showed that all four items to assess Perceived Ease of Use construct displayed high factor loading greater than 0.6 and also that they were retained in one component only. Since there is no new component created and no deleted item needed, therefore the four items with high factor loading can proceed to be used to assess the Perceived Ease of Use construct.

Table 5
Component and the Respective Items for Perceived Ease of Use construct

Component Matrix[a]	
	Component
	1
PEOU1	0.768
PEOU2	0.893
PEOU3	0.923
PEOU4	0.906

Table 6 also showed that all three items to assess Intention to Use construct displayed high factor loading above the recommended value of 0.6 and all items were retained in one component only. Since there is no new component created and no deleted item required, therefore the three items with high factor loading can proceed to be used to assess the Intention to Use construct.

Table 6
The 1 Component and the Respective Items for Intention to Use Construct

Component Matrix[a]	
	Component
	1
INTU1	0.904
INTU2	0.915
INTU3	0.861

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Table 7 showed that all eight items to assess Perceived Efficacy construct displayed high factor loading greater than 0.6 and retained in one component only. Since there is no new component created and no deleted item needed, therefore the eight items with high factor loading can proceed to be used to assess the Perceived Usefulness construct.

Table 7
The 1 Component and the Respective Items for Perceived Efficacy Construc

Component Matrix[a]	
	Component
	1
PEF1	0.832
PEF2	0.831
PEF3	0.875
PEF4	0.824
PEF5	0.841
PEF6	0.834
PEF7	0.870
PEF8	0.848

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Table 8 showed that all five items to assess Training construct displayed high factor loading above the recommended value of 0.6 and all items were retained in one component only. Since there is no new component created and no deleted item required, therefore the five items with high factor loading can proceed to be used to assess the Training construct.

Table 8
The 1 Component and the Respective Items for Training Construct

Component Matrix[a]	
	Component
	1
TRN1	0.689
TRN2	0.952
TRN3	0.929
TRN4	0.950
TRN5	0.955

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

The table 9 displayed the internal reliability for AR with PECS and TEACCH approaches, Perceived Usefulness, Perceived Ease of Use, and Intention to Use constructs, Perceived Efficacy and Training constructs.

Table 9
The Internal Reliability for the Constructs

	Constructs	No of items	Cronbach's Alpha
1	Augmented Reality with PECS and TEACCH approaches	9	0.832
2	Perceived Usefulness	4	0.895
3	Perceived Ease of Use	4	0.958
4	Intention to Use	3	0.874
5	Perceived Efficacy	8	0.942
6	Training	5	0.937

Discussion

This study was conducted to develop a valid and reliable measurement model of the Augmented Reality application with PECS And TEACCH methods among special needs children by performing a detailed validation of four constructs and their respective items through exploratory factor analysis (EFA) procedure. Based on the EFA results, 9 items of AR with PECS and TEACCH constructs were retained for having high factor loading above 0.60. One item was deleted as the factor loading was below 0.60. Meanwhile, all the items under perceived efficacy, training, perceived ease of use, perceived usefulness, and intention-to-use constructs were retained and not deleted as the items displayed high factor loading under a single component respectively. Only the construct of AR with PECS and TEACCH approaches created two new dimensions while the other constructs remained as one component. in total, 33 reliable items from augmented reality with picture exchange communication system (PECS) and treatment and education of autistic and related communication handicapped children (TEACCH) methods, perceived efficacy, training, perceived ease of use, perceived usefulness, and intention-to-use constructs were established in this study. The established data were reliable and significant for conducting a valid EFA based on descriptive statistical analysis. Based on the KMO results, the sample size of 100 parents and teachers as respondents were adequate for conducting the EFA (Shkeer & Awang, 2019). Based on the results of the EFA procedure, augmented reality with picture exchange communication system (PECS) and treatment and education of autistic and related communication handicapped children (TEACCH) methods, perceived efficacy, training, perceived ease of use, perceived usefulness, and intention-to-use constructs were reliable constructs, therefore the survey questionnaire can be used to proceed with fieldwork data collection. High factor loading for Perceived Usefulness, Perceived Ease of Use, and Intention to Use were supported by the outcome of a recent study by Pasalidou and Fachantidis (2021) involving Greek Primary School teachers, where their perceptions about the educational use of mobile AR based on TAM model were examined.

Conclusion

This study has contributed to the measurement items of the Augmented Reality application with PECS and TEACCH methods among children with special needs. The outcome of the EFA procedure demonstrated that the 33 final items under Augmented Reality with Picture Exchange Communication System (PECS) and Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) methods, Perceived Efficacy, Training, Perceived Ease of Use, Perceived Usefulness, and Intention-to-Use constructs were reliable measurement model of the augmented reality applications with PECS and TEACCH methods among special needs children since the internal reliability value of Cronbach Alpha for all constructs were above 0.7, p-value (p-value <0.001) for Bartlett's test of Sphericity were highly significant, and KMO readings were greater than 0.7 which falls above the minimum requirement of 0.60. It can be concluded that the extracted components for each construct and their corresponding items were also reliable. By eliminating the non-reliable and low-factor loading items during the EFA procedure, this study has contributed towards increasing the validity of the instrument. All the measurement items with high factor loadings (> 0.60) for the six constructs examined remained because these items were significant to developing a valid and reliable measurement model of the augmented reality application with PECS and TEACCH methods among special needs children. Thus, the established survey questionnaire can be used for fieldwork data collection and validated by performing confirmatory factor analysis (CFA).

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