Evaluating the Effectiveness of an Enhanced Intervention Model Using Augmented Reality Approach: A Structural Equation Modeling

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***Abstract*—Augmented Reality (AR) is one of the interactive applications that has been acknowledged as a powerful way to improve the user experience. In recent years, research on AR as an educational intervention among children with special needs has significantly increased. Therefore, this quantitative research design aims to evaluate the effectiveness of an enhanced intervention model using Augmented Reality approach among children with special needs in Malaysia. Using a stratified random sampling approach, a set of adapted questionnaires were randomly distributed to 381 respondents among parents and teachers of special needs children in both pre-test and post-test measures. This study was conducted based on Technology Acceptance Model (TAM) as the theoretical framework. Prior to Structural Equation Modeling (SEM), Exploratory Factor Analysis (EFA) was conducted on pilot study data and Confirmatory Factor Analysis (CFA) was conducted on field study data. Through IBM-SPSS Amos version 24.0, the pre-test and post-test of field study data were analyzed using standardized, unstandardized regression analysis, and hypothesis testing of SEM to validate the hypothesized relationships and measure the effectiveness of the enhanced intervention model. The significant direct effect of AR applications with the Picture Exchange Communication System (PECS) and Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) methods on the intention to use construct in post-test measure of unstandardized regression weight indicates the effectiveness of the enhanced intervention model among children with special needs. This study highlights the potential of AR with PECS and TEACCH methods as an educational tool in special education needs interventions and suggesting directions for future research as well as practical applications in enhancing learning outcomes.**

***Keywords*—augmented reality, special needs, educational intervention, structural equation modeling, confirmatory factor analysis, exploratory factor analysis, regression**

I. Introduction

According to a report published by Malaysia's Bahagian Pendidikan Khas [1], there were 116,044 registered special needs children in Malaysia between the ages of 7 and 17. Effective early intervention programs are necessary given the rise in special needs children in Malaysia to enhance these children's quality of life, social participation, skills acquisition, developmental functioning, and potential [2]. Due to the increased number of children with special needs, an effective early intervention programs are required [3]. However, many Malaysian family cannot afford the exorbitant cost of treatment at private facilities. As a result, some children with special needs are therefore vulnerable to being abandoned at home without access to learning opportunities or intervention services [4].

Early intervention programs for children with special needs have been established to optimize their skills and strengthen their development in the areas of nursing, physical therapy, occupational therapy, and family counselling services [5, 6]. Examples of early intervention programs are speech therapy, physical therapy, occupational therapy, and other types of services based on the needs of children with special needs [7]. Picture Exchange Communication System is an augmentative communication tool for special needs children particularly for those with Autism Spectrum Disorder (ASD) [8]. Picture Exchange Communication System (PECS) is an image-driven approach developed for children with social communication impairment [9]. PECS assists non-verbal special needs children or special needs children with limited communication abilities to communicate using images or visual cues in the form of flashcards or Velcro PECS books. These images are shown or delivered to their communication partner during their communication with PECS method [10]. Through PECS program, a child's capacity for expressive communication is developed through the techniques of reinforcement, delay, and generalization in numerous settings following its six recommended phases [11, 12]. Despite the benefits of PECS, parents and teachers of special needs children showed less interest in the conventional PECS methods [13].

Meanwhile, treatment and education of autistic and related communication-handicapped children is a clinical service and professional training program with a structured teaching approach that aims to help children with special needs [14]. The structured teaching in Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) emphasizes the development of learning among special needs children through visual prompts or cues in the environment that capitalize on the visual processing strengths of these children. The four basic elements of the TEACCH method include physical organization, schedules, work systems, and task organization [15]. The TEACCH approach has been implemented in several special education needs schools and therapy centers; however, there are still low numbers of special education needs schools that applied it, even though numerous studies have demonstrated the effectiveness of the TEACCH method [16, 17].

In recent years, the education sector has been impacted by the rapid advancement of technology, particularly with

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regards to innovative teaching and learning approaches [18]. This transformation is necessary to provide an efficient mobile learning platform and lower the cost of sending special needs children to private centers and special needs schools [19, 20]. As part of advanced technologies, Augmented Reality (AR) emerges as a potential interactive application that can integrate the real world and digital content in the forms of pictures, text, audio, and video [21]. AR applications are also implemented in the field of special education needs due to its potential to enhance social interaction and communication [22].

According to Baragash *et al.* [23], the growing research in AR applications is impacted by its huge potential in improving the knowledge and skill acquisition among the individuals with special needs, such as people with intellectual disabilities, autism spectrum disorder, attention deficit hyperactivity disorder, or physical disabilities. AR also provides an interactive experience that enables users to overlay digital content onto the real world. By creating immersive environments that simulate a physical presence in a virtual space, AR has the potential to transform how students learn and engage with their environment [24]. The integration of PECS and TEACCH methods into augmented reality as a digital platform potentially improve users interest and provides many benefits as the AR applications are more affordable, portable, readily available, and flexible approach than the conventional PECS method [25].

In addition, the integration of AR with PECS approach can also create a visually engaging system that enhances the child's ability to understand and use communication symbols [13]. Meanwhile, the selection of TEACCH approach that focuses on structured environments aligns well with AR's ability to create consistent, visually structured learning environments, which helps improve social skills among children with special needs [15]. Therefore, this study is conducted to evaluate the effectiveness of an enhanced intervention model using Augmented Reality with PECS and TEACCH methods among special needs children in Malaysia.

The remainder structure of this paper is organized as follows: Section II provides a relevant literature review. Section III describes the materials and methods applied in this study. Meanwhile, Section IV of this study presents the results and discussion. Finally, Section V concludes the paper with implications and future research directions.

II. Literature Review

Augmented reality applications are defined as technologies that could merge real and virtual objects by superimposing digital data over the real environment to improve users' experiences [26]. The emergence of AR technology, which is regarded as a promising technology in the education sector, is a result of advanced technology and innovative learning strategies [18]. The incorporation of AR applications in the classroom teaching could prepare students, especially those with special needs, for the 21st-century digital world, media literacy, life skills, and the most recent learning techniques [27]. From the perspective of special education needs, the augmented reality applications have great potential to empower special needs children and to comprehend their needs [28].

Based on the research conducted by Zeng *et al.* [29], the outcome of the study demonstrated that a group of special needs children demonstrated some improvements and development after receiving the enhanced rehabilitation method in TEACCH approach. Meanwhile, research on the effectiveness of augmented reality environments on individuals with special education needs was conducted by Cakir & Korkmaz [30]. The findings of the design-based research showed that the AR apps were used as teaching method for a group of study involving four teachers and six students of special needs. The AR apps were very helpful in improving special needs students' real-life experiences, increased their readiness level, increased their interest on the learning subjects and became more active in class [30]. In another study, Lorusso *et al.* [31] developed an augmented reality application namely "Giok the Alien" for special needs children to stimulate their cognitive, problem solving and social skills. The results of the research demonstrated the effectiveness of the AR apps by successfully attracted high participation and improved social interaction levels among the special needs children.

Additionally, a smartphone with augmented reality apps was developed in research conducted by Escobedo *et al.* [32] to explore the social skills development among three children with autism spectrum disorder. Based on the behavioral observations, interviews, and transcript coding analysis, the results of the 7 weeks multiple conditions research design showed the improvement of social engagement among the ASD children and a decrease in social and behavioral problems. In a study by McMahon *et al.* [33], involving three students with Intellectual Disabilities (ID) and one student with autism spectrum disorder, the result showed that the students more frequently performed correctly on vocabulary tests after using iPads equipped with augmented reality apps. Additionally, Keshav *et al.* [34] conducted research with 21 children and adults with ASD using Google smart-glasses and augmented reality applications. This study aimed to assess the acceptability and utility of a new smart-glasses system designed as a social communication tool. The findings revealed that the device was well-tolerated and useful for individuals with ASD across a range of ages and severity levels, suggesting its potential as an assistive technology for those with ASD.

To ensure that autistic children receive better alternative interventions using the PECS technique, Shminan *et al.* [19] developed AutiPECS, a mobile-based learning program for parents of children with autism spectrum disorder in Malaysia. This program helps parents reduce their reliance on therapists and the need for expensive treatments at autism centers. Conversely, Taryadi [13] conducted research in Indonesia to design a new application specifically for autistic children, exploring the capabilities and potentials of using the PECS approach within augmented reality applications for learning, teaching, behavioral stimulation, and monitoring. In another study, Amado *et al.* [35] in Peru developed an augmented reality mobile application aimed at helping autistic children in both online and in-person classrooms to enhance their cognitive skills. The Treatment and Education of Autistic and Related Communication Handicapped Children - program recommends structured teaching methods, which have been proven to be more effective for children with autism when learning is visual and interactive, whether through traditional or digital methods [36].

Researchers from various fields are now exploring the integration of PECS and TEACCH approaches into digital-based mediums like computers and touchscreen mobile technology [37]. Given the potential of integrating PECS and TEACCH approaches into augmented reality applications, this study aims to evaluate the effectiveness of an enhanced intervention model using Augmented Reality with PECS and TEACCH methods among special needs children in Malaysia

III. Materials and Methods

This study employs a quantitative research design with pretest and post-test measures. The present study is conducted to evaluate the effectiveness of an enhanced intervention model using Augmented Reality with PECS and TEACCH methods among special needs children in Malaysia. In this quantitative research, a 5-point Likert scale survey questionnaire was adapted and modified from previous studies to meet the specific objectives of this research. In the 5 Likert-scale, a rating of "1" signifies "strongly disagree", and "5" denotes "strongly agree". The questionnaire was initially evaluated by experts for criterion, content, and face validity during a pretest phase prior to pilot study involving 100 respondents. The pilot data was analyzed using Exploratory Factor Analysis (EFA) with IBM-SPSS version 26.0. The EFA was performed on the pilot study data to investigate and quantify the dimensionality of the items for each construct in the survey questionnaires [38].

The pre-test and post-test survey of field study were administered to 381 respondents among parents and teachers of special needs according to Krejcie & Morgan [39] table. By dividing the states in peninsular Malaysia according to four zones including northern region, west coast region, east coast region and southern region, a total of 381 respondents among teachers and parents of children with special needs were selected through a stratified random sampling to ensure a representative sample across different educational levels and demographics. Informed consent was obtained from all participants before the study commenced. To assess the AR intervention's effectiveness, pretest and post-test surveys of this research were conducted. The pretest survey was administered to participants without prior experience with augmented reality applications, while the post-test survey was given to participants after they had used the augmented reality application. Data for the study was gathered through self-administered paper-based surveys.

Using field study data, Pooled-Confirmatory Factor Analysis (CFA) was performed on the field study data using IBM-SPSS Amos version 24.0 to validate the measurement model of augmented reality applications with PECS and TEACCH methods for special needs children in Malaysia. CFA is a statistical method designed to identify and examine latent constructs as they are reflected in imperfect indicators. CFA models can be seamlessly integrated into Structural Equation Modeling (SEM), which involves directional relationships among latent constructs [40]. The CFA procedure of this study removed two items with low factor loadings (below 0.6) due to their insignificance value.

Structural equation modeling was then applied to the field study data after all fitness indices met the required levels of model fit. Structural equation modeling is a comprehensive analytical method that encompasses a range of statistical techniques aimed at summarizing the interrelationships among variables and testing hypothesized connections between constructs [41]. The pretest and post-test data were analyzed using standardized and unstandardized regression analysis, as well as hypothesis testing of structural equation modeling to validate the hypothesized relationships and measure the intervention model's effectiveness to fulfil the objective of this research in which to evaluate the effectiveness of an enhanced intervention model using Augmented Reality technology approach among special needs children in Malaysia.

IV. Result and Discussion

The following Table 1 showed the internal reliability for AR with PECS and TEACCH approaches, Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Intention to Use (ITU), Perceived Efficacy (PE) and Training (TN) constructs after exploratory factor analysis (EFA) procedure of pilot study involving 100 participants.

Table 1. The internal reliability of the constructs

No.	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

The outcome of the EFA procedure demonstrated that the 33 final items of the constructs were reliable since the internal reliability value of Cronbach Alpha for all constructs were above 0.7. The p-value (p-value < 0.001) for Bartlett's test of Sphericity of the 33 final items were also significant, with the Kaiser-Meyer-Olkin (KMO) readings greater than 0.7 which falls above the minimum requirement of 0.60. All the measurement items with high factor loadings (> 0.60) for the six measured constructs remained because these items were significant to develop a valid and reliable measurement model of the augmented reality application with PECS and TEACCH methods among special needs children.

Based on the EFA results in Table 1, 9 items of AR with PECS and TEACCH constructs were retained for having high factor loading above 0.60. Only one item was deleted as the factor loading of the item 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 of the constructs 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 PECS and

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 [42]. Based on the results of the EFA procedure, the augmented reality with PECS and TEACCH methods, perceived efficacy, training, perceived ease of use, perceived usefulness, and intention-to-use constructs were reliable constructs. 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 & Fachantidis [43] involving Greek Primary School teachers, where their perceptions about the educational use of mobile AR based on TAM model were examined.

Therefore, the survey questionnaire can be used to proceed with fieldwork data collection and validated by performing Confirmatory Factor Analysis (CFA). The results of the Pooled-CFA are demonstrated in Fig. 1.

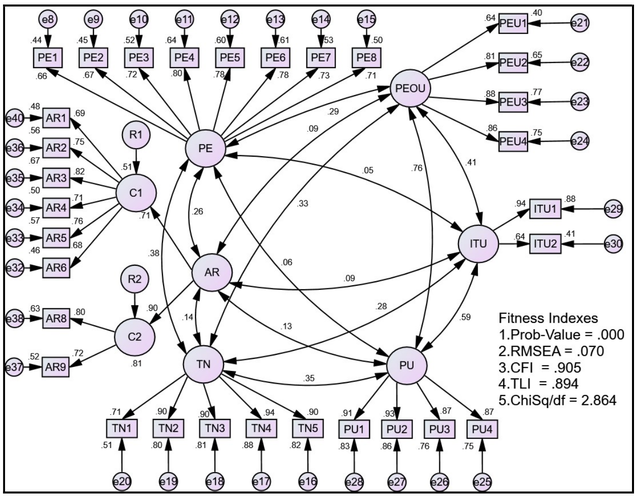

Fig. 1. Result of pooled confirmatory factor analysis. PE: Perceived Efficacy. Note: AR: Augmented Reality. TN: Training. PEOU: Perceived Ease of Use. PU: Perceived Usefulness. ITU: Intention to Use.

Based on Fig. 1 above, the result of pooled confirmatory factor analysis shows the results of fitness indices and factor loading of the 31 measuring items under their respective constructs in the measurement model. The fitness indexes values for Prob-Value, RMSEA, CFI, TLI and Chi-square/df are 0.000, 0.070, 0.905, 0.894 and 2.864 respectively. The fitness indexes values have achieved the required level. The factor loading for each item also achieved the required value which is more than 0.6.

Through the pooled-confirmatory factor analysis as in Fig. 1, the items with low factor loading and do not fit the measurement model were deleted from the measurement model of the enhanced intervention model using augmented reality approach. The fitness indexes of the measurement model were also assessed. The constructs of the measurement model were successfully passed the confirmatory assessment since the total deleted items was less than 20% as per requirements. The constructs of the measurement model of latent constructs were evaluated through the pooled-CFA procedure instead of a separate CFA due to the efficiency of pooled-CFA procedure.

Unidimensionality is achieved for the items with acceptable factor loading, which is above the minimum of 0.6. In terms of validity, the verification of the convergent validity for each construct was computed through Average Variance Extraction (AVE). All the constructs in this measurement model have achieved convergence validity by achieving values above the standard values of 0.5 and 0.45 for a complex model. Low factor loading items were removed prior to the CFA procedure as the items would contribute to low AVE.

As for construct validity, the measurement model of all latent constructs has met the requirement for construct validity as it met the threshold value or level of acceptance as suggested by the literature. The measurement model of all latent constructs achieved the three categories of model fit in construct validity, which are absolute fit, incremental fit, and parsimonious fit. The discriminant validity is also achieved by the measurement model since the construct is free from redundant items and the Modification Indices (MI) are below the value of 15.0. The instrument also attained satisfactory composite reliability. After the CFA procedure, the measurement model retained 31 items of the six constructs: Augmented Reality with Picture Exchange Communication System and Treatment and Education of Autistic and Related Communication Handicapped Children methods, Perceived Efficacy, Training, Perceived Ease of Use, Perceived Usefulness, and Intention-to-use constructs.

In addition, the unidimensionality of the measurement model was also achieved. Unidimensionality is generally applied to describe the items or test scores of the measurement model. An item is considered as unidimensional if the systematic differences within the item variance are caused by only one variance source, or just one latent variable. After the unidimensionality, reliability and validity assessment of the measurement model were achieved, unstandardized and standardized regression weights of structural equation modeling were performed. The unstandardized estimates and regression weight results of the structural model were used to test the research hypotheses for direct effects. A direct effect refers to the impact of one variable on another without any mediation.

The following Figs. 2 and 3 show the unstandardized estimates of the regression path coefficients among the constructs studied: Augmented reality with PECS and TEACCH methods, perceived efficacy, training, perceived ease of use, perceived usefulness and intention to use. These regression path coefficients during pre-test and post-test measures indicate the extent to which the exogenous constructs affect the specific endogenous construct. Meanwhile, the regression path coefficient model can confirm the significance of the constructs in supporting the study's hypotheses. The reports of the regression weight for each of the path analysis of the unstandardized regression weights of structural equation modeling in pre-test measure were shown in the following Fig. 2 and the reports were summarized in the following Table 2.

Table 2 presents the results of hypothesis testing for the causal effect of augmented reality using PECS and TEACCH methods on the intention to use. The regression path coefficient and its significance show that the probability of obtaining a critical ratio as large as 0.098 in absolute value is 0.922. This indicates that the regression weight for augmented reality with PECS and TEACCH methods in predicting the intention to use is not significantly different from zero at the 0.05 level (two-tailed). Additionally, the regression path coefficient (β) value for the augmented reality application with PECS and TEACCH methods on the intention to use is 0.011. This suggests that for each one-unit increase in the augmented reality application with PECS and TEACCH methods, there is a corresponding 0.011 unit increase in the intention to use. The regression weight estimate of 0.011 has a standard error of approximately 0.114.

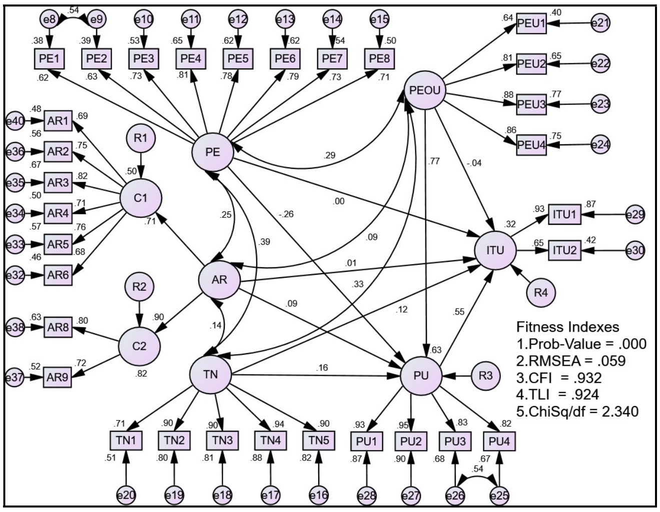

Fig. 2. The Unstandardized regression weights of structural equation note: Modeling (pre-test measure). PE: Perceived Efficacy. AR: Augmented Reality. TN: Training. PEOU: Perceived Ease of Use. PU: Perceived Usefulness. ITU: Intention to Use.

Table 2. The unstandardized regression weights and significant value (pre-test measure)

Construct	Estimate	S.E.	C.R.	P	Result
ITU ← AR	0.011	0.114	0.098	0.922	Not Significant

Note: The arrow symbol "←" is used to represent regression impact relationships. ITU: Intention to Use. AR: Augmented Reality. S.E.: Standard Error. C.R.: Critical Ratio. P: Level of significance (p-value).

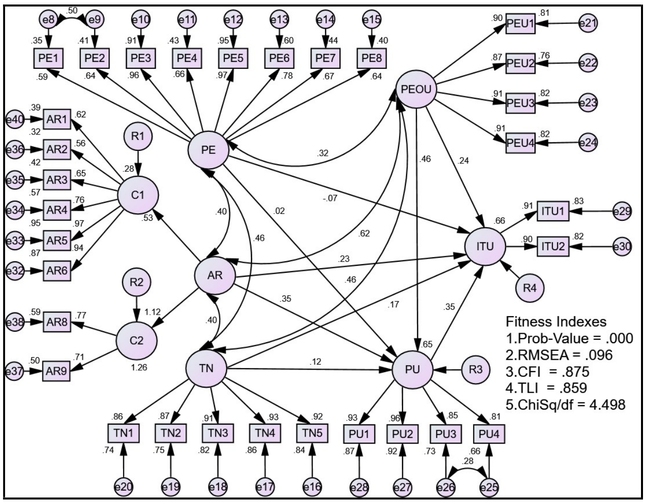

Fig 3. The unstandardized regression weights of structural equation Modeling (post-test measure). PE: Perceived Efficacy. AR: Augmented Reality. TN: Training. PEOU: Perceived Ease of Use. PU: Perceived Usefulness. ITU: Intention to Use.

Table 3. The unstandardized regression weights and significant value (post-test measure)

Construct	Estimate	S.E.	C.R.	P	Result
ITU ← AR	0.340	0.095	3.581	***	Significant

Note: The arrow symbol "←" is used to represent regression impact relationships. ITU: Intention to Use. AR: Augmented Reality. S.E.: Standard Error. C.R.: Critical Ratio. P: Level of significance (p-value). The symbol "***" denotes that the associated regression weight is significant at the $p < 0.001$ level.

The reports of the regression weight for each of the path analysis of the unstandardized regression weights of structural equation modeling in post-test measure in Fig. 2 are summarized in the following Table 3.

Table 3 presents the hypothesis testing results for the causal effect of augmented reality with PECS and TEACCH methods on intention to use. The regression path coefficient and its significance indicate that the probability of obtaining a critical ratio as large as 3.581 in absolute value is 0.001. This means that the regression weight for augmented reality with PECS and TEACCH methods in predicting intention to use is significantly different from zero at the 0.001 level (two-tailed). The regression path coefficient (β) value for the augmented reality application with PECS and TEACCH methods on intention to use is 0.340, implying that each one-unit increase in the augmented reality application with PECS and TEACCH methods results in a 0.340 unit increase in intention to use. The regression weight estimate of 0.340 has a standard error of approximately 0.095. Thus, the regression weight for augmented reality with PECS and TEACCH methods in predicting intention to use is significantly different from zero at the 0.001 level (two-tailed).

Figs. 4 and 5 show the standardized regression weights of structural equation modeling for pre-test and post-test measures. The standardized regression weight provides outputs that include the correlations between constructs, the standardized beta estimates, the R^2 value, and the standard factor loading for all components.

According to the standardized regression weights from the structural equation modeling for the pre-test measure shown in Fig. 4, 63% of the variance in the Perceived Usefulness construct can be predicted using the constructs of Augmented Reality with PECS and TEACCH methods, Perceived Efficacy, Training, and Perceived Ease of Use. Additionally, 32% of the variance in the Intention to Use construct can be predicted using the constructs of Augmented Reality with PECS and TEACCH methods, Perceived Efficacy, Training, Perceived Ease of Use, and Perceived Usefulness. Meanwhile, according to the standardized regression weights from the structural equation modeling for the post-test measure shown in Fig. 5, 65% of the variance in the Perceived Usefulness construct can be predicted using the constructs of Augmented Reality with PECS and TEACCH methods, Perceived Efficacy, Training, and Perceived Ease of Use. Additionally, 66% of the variance in the Intention to Use construct can be predicted using the constructs of Augmented Reality with PECS and TEACCH methods, Perceived Efficacy, Training, Perceived Ease of Use, and Perceived Usefulness. For the pretest measure of unstandardized regression weight in Fig. 2, the regression weight for AR with PECS and TEACCH methods in predicting intention to use was not significant (β = 0.011, standard error = 0.114, critical ratio = 0.098, p =

0.922). Conversely, in the post-test measure in Fig. 3, the regression weight was significant ($\beta = 0.340$, standard error = 0.095, critical ratio = 3.581, $p < 0.001$), indicating a significant direct effect of AR applications on intention to use.

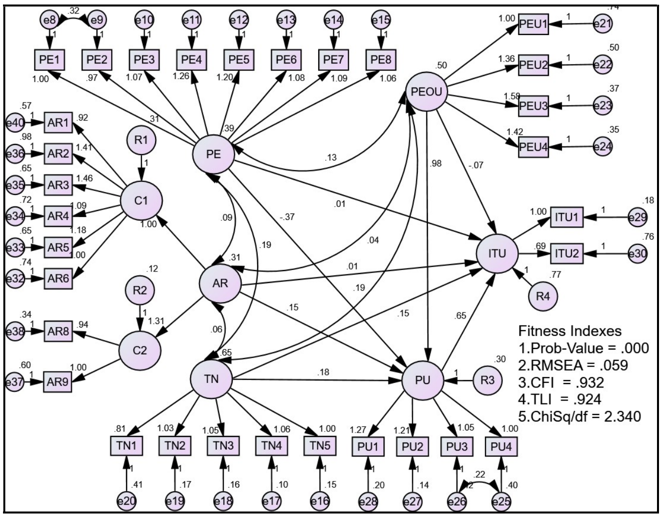

Fig. 4. The Standardized regression weights of structural equation modeling (pre-test measure). PE: Perceived Efficacy. AR: Augmented Reality. TN: Training. PEOU: Perceived Ease of Use. PU: Perceived Usefulness. ITU: Intention to Use.

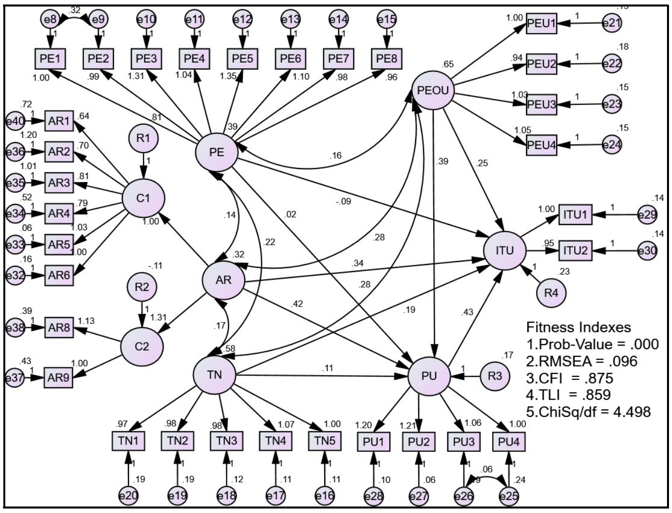

Fig. 5. The Standardized regression weights of structural equation modeling (post-test measure). PE: Perceived Efficacy. AR: Augmented Reality. TN: Training. PEOU: Perceived Ease of Use. PU: Perceived Usefulness. ITU: Intention to Use.

Comparing both groups, there was no causal effect in the pretest group, as they had not experienced the AR intervention. In contrast, the post-test group showed a significant causal effect due to the intervention. The findings are consistent with previous research confirming that AR applications with PECS and TEACCH methods significantly and directly affect the intention to use among special needs children in Malaysia [44–47]. Based on Figs. 4 and 5, the results of post-test measure of standardized regression weight of structural equation modeling demonstrated a higher intention to use the AR application among teachers and parents in the post-test group compared to the pretest group. The study analyzed the R^2 values and the causal effect of the AR applications with PECS and TEACCH methods on the intention to use construct. For the pretest group, 32% of the intention to use could be predicted by AR with PECS and TEACCH, Perceived Efficacy, Training, Perceived Ease of Use, and Perceived Usefulness. Meanwhile, in the post-test measure, the prediction increased to 66%.

V. Conclusion

The findings of this study emphasize the significant of Augmented Reality (AR) applications with Picture Exchange Communication System (PECS) and the Treatment and Education of Autistic and Communication Handicapped Children (TEACCH) methods as an enhanced intervention model for special needs children in Malaysia. Incorporating AR with these approaches can enhance educational experience of children with special needs and generate better educational outcomes. In classroom environments, the use of AR applications with PECS and TEACCH methods provides flexible, effective, and enjoyable learning experiences for special needs children. By shifting from the conventional PECS and TEACCH methods into a new augmented reality applications with PECS and TEACCH methods, as explored in this study, this approach will make social cues, social behavior, and learning more engaging and enjoyable for special needs children. It will also support teachers and parents in delivering more effective educational interventions for these children. To enhance the future research on AR applications for special needs children, particularly in Malaysia, a wide range of AR approaches can be considered alongside PECS and TEACCH methods such as AR Gamified Learning, AR-based Social Skills Training, Speech Therapy using AR, AR-based Behavioral Intervention and Sensory Processing using AR mobile applications.

Appendix

Table A1. Survey items and scale

Constructs	Items	Question	Source
Augmented Reality with PECS and TEACCH methods (AR)	AR1	I have enough experience in the education of children with special needs	[48]
	AR2	I have dealt with children with special needs other than autism before	
	AR3	I have received training to deal with children with special needs	
	AR4	I plan by myself the daily activities of children with special needs	
	AR5	I prepare the daily activities for the children with special needs whether by handwriting, computer software or both	
	AR6	I already knew about TEACCH and PECS methods for children with special needs	
	AR7	There is similarity between augmented reality mobile application with the current methods I use for the children with special needs	
	AR8	I would be able to use the augmented reality mobile app in the daily activities with the children with special needs	
Perceived Efficacy (PE)	PE1	I am knowledgeable about children with special needs	[49]
	PE2	I know what kind of symptoms children with special needs have	

	PE3	I know what happens to children with special needs as they age	
	PF4	I am knowledgeable about what causes a child under autism spectrum disorder	
	PE5	I am aware of treatment option for children with special needs	
	PE6	I understand how common a child to be diagnosed as autism spectrum disorder in the general population	
	PE7	I believe I would know if I met a child who is autism spectrum disorder	
	PE8	I believe I can meet the needs of children with special needs	
Training (TN)	TN1	I need a training on characteristics and nature of children with special needs	[49]
	TN2	I need a training on identification, assessment and diagnosis of children with special needs	
	TN3	I need a training on evidence-based instructional strategies for children with special needs	
	TN4	I need a training on interventions for communication and social development for children with special needs	
	TN5	I need a training on behaviour management and positive behaviour support for children with special needs	
Perceived Usefulness (PU)	PU1	The mobile augmented reality application with PECS and TEACCH methods is easy to use	[43]
	PU2	Learning to use the mobile augmented reality application with PECS and TEACCH methods is not a problem	
	PU3	The operation of mobile augmented reality application with PECS and TEACCH methods is clear and understandable	
	PU4	Generally, I consider that the mobile augmented reality application with PECS and TEACCH methods is easy to use	
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	
	PEOU2	The use of mobile Augmented Reality (AR) application with PECS and TEACCH approaches among children with special needs improves their productivity in learning	
	PEOU3	The use of mobile Augmented Reality (AR) application using PECS and TEACCH approaches among children with special needs improves their learning effectiveness	
	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	
Intention to Use (ITU)	ITU1	I intend to use the mobile Augmented Reality apps with PECS and TEACCH approaches	[43]
	ITU2	I will try to use the mobile Augmented Reality apps with PECS and TEACCH approaches	

Conflict of Interest

The Authors declare no conflict of interest.

Author Contributions

Data collection, N.A.B and M.S.R; research methodology, N.A.B and M.S.R.; instrument, M.S.R.; validation, M.S.R and N.A.B.; data analysis, M.S.R.; supervision, N.A.B; writing template and draft preparation, M.S.R.; writing review and editing, M.S.R., and N.A.B.; all authors had approved the final version.

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