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Developing a Framework of Sensory Environment for Autism Centre

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Abstract
The learning environment is critical in developing the skill and mental of children with autism. However, designers are often unaware of the sensory issues and designing a unique environment that would affect learning process. The paper's objective is to identify the main factor in creating the physical learning environment for autism. Partial Least Square Structural Equation Modelling (PLS-SEM) was conducted to develop a framework of the sensory environment. It is hoped that this paper could be an impressive contribution to technical agencies and designers during their design stage, thus creating a better physical learning environment supported with sensory design features.

Keywords: Sensory environment; autism; physical learning environment;

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1.0 Introduction
Children with autism could develop independent living skills during the learning environment process. Cikili, Sari, and Deniz (2015) mentioned that no matter which learning environment they are in, education is defined as the process of behaviour change. They suggested that children with autism are encouraged to continue their education in suitable learning environments due to their difficulty with social, communication, and behavioural skills (Cikili et al., 2015; Shaari and Ahmad, 2016). Children with autism develop skills, social interaction, and their fullest potential while in school. Designing spaces for them need to consider how they will experience and utilise the space since they have particular sensory needs and experience the world differently than those without autism who have trouble understanding how people with ASD's brain processes stimulation (Raar, 2012). Children with autism exhibit inattention and distractibility more than typically developing children (Matin et al., 2017). Every child with autism has different academic problems, such as difficulties in class participation, low attention span, and inappropriate behaviours that hinder their ability to participate in educational activities. According to Amirul et al. (2013), the learning environment is the social context, psychological and pedagogical, which can affect the students' learning,

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achievement, and attitudes. The physical learning environment refers to the space allocated for classrooms, science labs, open spaces and offices (Amirul et al., 2013). Matin et al. (2017) also mentioned that children with autism are distracted easily from education by their own repetitive, restless, and disruptive classroom behaviours. Hence, they usually experience disappointment in educational progress, as usual, intervention strategies, since they do not deal with the sensory issues that may reduce the distressing behaviour. Matin et al. (2017) stressed that ignoring proper changes in the environment may have severe negative impacts on the learning processes of children with autism. The learning environment has become significant because research has proven that the quality of educational facilities affects learning outcomes and the individuals within the building (Nazri and Ismail, 2016). It is essential to enhance the development of children with autism to ensure that the building is practical, convenient, fit, and feasible for all children, especially for children with autism (Martin, 2016). Designers are often unaware of the sensory issues that would affect their learning process. Problems were highlighted and only focused on sensory sensitivity, stimulation, and design toward the physical learning environment. However, none of them is looking at the research concurrently and developing a framework. Hence, this paper's objective is to identify the main factor in creating the physical learning environment for autism. It is hypothesized that there is a significant relationship between sensory design towards the physical learning environment in the Autism Centre. This paper aims to establish a framework for the sensory environment towards the physical learning environment for autism centres. This paper is part of PhD research and not fully comprehensive; however, it is hoped that this paper could contribute to technical agencies and designers during their design stage, thus creating a better physical learning environment supported by sensory design features.

2.0 Literature Review

2.1 The Theory of Environmental Psychology

The theory of Environmental psychology investigates the interrelationship between the environment and human behaviour (DeYoung, 2012). This approach aimed to improve human relations with the natural environment and make the built environment more humane (Gifford, 2014). The earliest study recognized the environment-behaviour relationship have also been systematically studied by psychologists producing a rapidly growing discipline in environmental psychology (Donovan and Rossiter, 1982). Psychologists have studied store environments, work environments, residential environments, entertainment environments, and institutional environments such as schools, hospitals and prisons (Donovan and Rossiter, 1982). The study found well documented the theory of environmental psychology. It acknowledges that human psychology develops from the interaction the brain and nervous system in a body within a social and physical world (Montello, 2007). As Montello (2007) explained, psychology shows that behaviours, thoughts, and emotions must look inward at the mind and outward at the world. Hence, psychology depends partly on the characteristics of the built and natural environments in which people live (Montello, 2007).

In the past, environmental psychology focused on the effects of environmental conditions on behaviour and how the individual perceives and acts on the environment (Moser and Uzzell, 2003). The conducive physical learning environment is the ultimate objective of environmental psychology and developing a body of innovative research into how people of all ages with severe neurological impairment navigate and experience the built environment (Tuckett et al., 2004). Montello (2007) described the six elements of physical environment mechanisms as helpful approaches that influence human experience and behaviour through various psychological mechanisms. The six environmental psychology elements highlighted: sensory access (what can be seen and heard); attention (what is looked at and listened to); memorability (what is remembered and what is forgotten); behavioural affordance (where one can walk, eat); affect (mood, comfort, stress, fear, aesthetics), and finally sociality (pedestrian flows, noise, eye contact, social distance) (Montello, 2007). The whole set of environmental, psychological mechanisms remains briefly addressed in the literature. Several theories have been proposed for environmental psychology, some focusing on the environmental, others on behaviour. Likewise, the environment for autism is unique, and people with cognitive impairments find specific spaces extremely difficult (Tackx, 2020).

2.2 Conceptual Framework

The conceptual framework consists of four key concepts, namely Sensory Sensitivity (SSy), Sensory Stimulation (SSn), Sensory Design (SD) and Physical Learning Environment (PLE). The concept has developed to accomplish more than one sensory element to access the needs of autism. Studies of sensory sensitivity (Gaines et al., 2016; Gray, 2018) and sensory stimulation (Beaver, 2006; Liss Radunovich and Kochert, 2014) are well documented. The sensory design model (Mostafa, 2014) is also well acknowledged that an Autism ASPECTSS™ Design Index illustrated the seven design principles. The Autism ASPECTSS™ Design Index comprises acoustics, spatial sequencing, escape space, compartmentalization, transition spaces, sensory zoning and safety (Mostafa, 2015b). These principles are summarized in the Autism ASPECTSS™ Index impact the architectural environment on sensory environment issues for students with autism.

Applying sensory sensitivity, stimulation, and design to the physical learning environment involves a great challenge. Those elements are essential to be considered as early as the design stage by an architect or designers. Thus, the literature indicated the need for research on sensory sensitivity, sensory stimulation, sensory design toward the physical learning environment. The sensory sensitivity is preferably identified by Montello (2007) that 'sensory access' as what can be seen and heard, such as sound, sight, smell, taste, touch, proprioception and vestibular. At the same time, sensory stimulation is recognized as 'affect' that would impact mood, comfort, stress, fear, and aesthetics (Montello, 2007).

The study addresses several elements in sensory stimulation such as acoustic, colour, smell, lighting and visual. Montello (2007) described the sensory design known as 'sociality' identified by Montello (2007), which is essential to consider the pedestrian flows, noise, eye contact, social distance and others. The sensory design includes acoustic, spatial sequencing, escape space, compartmentation, transition zone, sensory zoning, and safety. Consequently, the physical learning environment is characterized by 'memorability' by Montello (2007) as what is remembered, and what is forgotten refers to building scale, accessibility, wayfinding, toilet provision, window, ventilation and heating, threshold, legibility, and furniture. The researcher has proposed a conceptual framework based on the theories. The epistemological research for this study shows in Figure 1.

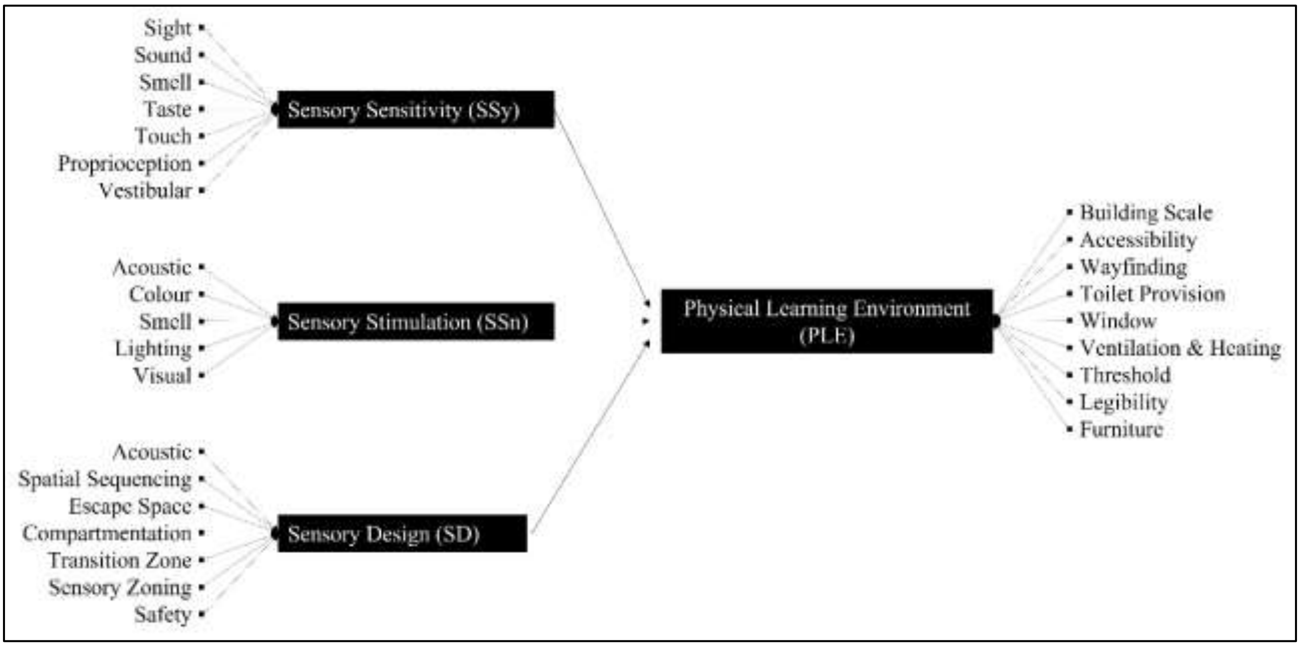

Fig. 1: The conceptual framework
(Source: author)

3.0 Methodology

The study involved a quantitative methodology design. This study generally involved a questionnaire survey. To achieve the research objectives, the survey was conducted to understand the design issues behind sensory sensitivity, sensory stimulation, sensory design towards the physical learning environment experienced by the respondent. The researcher contacted three hundred eighty-four (384) respondents to responses the questionnaire. A total of three hundred fifty-four (354) respondents from the technical agency. They are architects working throughout Malaysia. Designated architects are involved in the planning, designing, and constructing of various buildings such as schools, mosques, office buildings, building renovations and many more. As an architect, they are knowledgeable in universal design. Therefore, the respondent indirectly will be involved in the design of the autism centre. The thirty (30) respondent attached to Autism Centre who involves directly in the learning space throughout the learning session with these autistic children. They have included the interventionist, occupational therapies, and speech therapies.

3.2 Limitation

Due to pandemic covid-19, the participants will be given a set of questionnaires by email and informed consent to briefly explain the study's nature to enable the participants to decide on taking part in the survey. Data will be collected through a self-administer questionnaire to the architects and interventionists. The participant must respond to all questions, and finally, all the information about the participant is kept confidential.

3.3 Data analysis

The study used the Partial Least Squares (PLS) technique using the Smart-PLS software. The following recommended process is the two-stage analytical procedure. The researcher tested the measurement model (validity and reliability of the measures) and examined the structural model (testing the hypothesized relationship). Besides, a bootstrapping method was used to test the significance of the path coefficients and the loadings (Ramayah et al., 2018).

4.0 Findings

The statistical analysis used the Structure Equation Modelling (SEM) software package that applies the Partial Least Square (PLS) method to assess the fitness of the conceptual framework. During the statistical analysis, the key concept constructs from Sensory Sensitivity (SSy), Sensory Stimulation (SSn), Sensory Design (SD) towards the Physical Learning Environment (PLE) were analysed. The study recommended two-stage analytical procedures by testing the measurement model and examining the structural model, whereas each component applies different fitness cut-off points (Ramayah et al., 2017; Hair et al., 2019; Kushairi Rashid, 2013).

4.1 Measurement Model Analysis

The measurement model fitness was gauged based on variable reliability and the latent variable quality criteria of convergent and discriminant validity (Hair et al., 2019; Samani, 2016). There are two types of assessing the validity of the measurement model: convergent validity and discriminant validity.

4.1.1 Convergent Validity

The measuring of convergent validity is usually ascertained by examining the loadings, average variance extracted (AVE), and composite reliability (Ramayah et al., 2017). Determine the variables' reliability, and each variable factor loading should exceed 0.5 (Hair et al., 2019). While the convergent validity of each latent variable is determined by assessing the Average Variance Extracted (AVE) with a cut-off point of 0.5 and the Composite Reliability cut-off point is 0.7 (Ramayah et al., 2017; Munir, 2018). Therefore, the loadings were all higher than 0.5 (the lowest is 0.688), the composite reliabilities were all higher than 0.7 (the highest is SD – 0.938), and the AVE of all constructs were also higher than 0.5, as shown in Table 1 and Figure 2.

Table 1. The result of convergent validity

Variables	Components	Items	Loadings	Cronbach's Alpha	rhoA	Composite Reliability	Average Variance Extracted (AVE)
Sensory Sensitivity (SSy)	Sound	SSy4	0.696	0.723	0.727	0.827	0.545
	Taste	SSy12	0.741				
	Proprioception	SSy20	0.753				
	Vestibular	SSy26	0.761				
Sensory Stimulation (SSn)	Smell	SSn11	0.811	0.86	0.861	0.896	0.59
		SSn12	0.819				
		SSn13	0.761				
	Lighting	SSn17	0.778				
	Visual	SSn20	0.745				
	Colour	SSn6	0.688				
Sensory Design (SD)	Safety	SD30	0.86	0.918	0.919	0.938	0.752
		SD31	0.874				
	Spatial Sequencing	SD7	0.874				
		SD8	0.876				
		SD9	0.853				
Physical Learning Environment (PLE)	Wayfinding	PLE11	0.825	0.907	0.909	0.931	0.73
		PLE12	0.851				
	Threshold	PLE34	0.814				
	Legibility	PLE37	0.886				
		PLE38	0.893				

(Source: author)

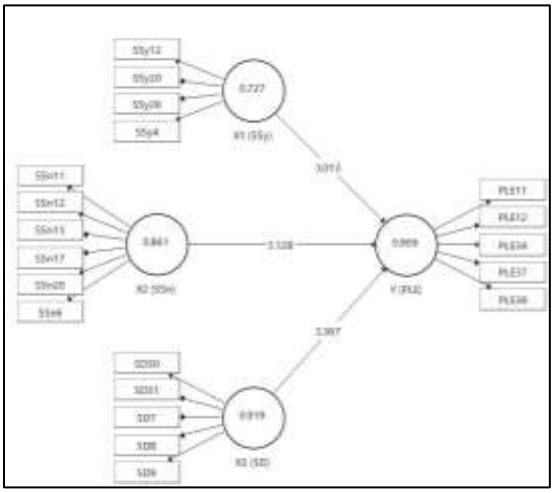

Fig. 2: The measurement model result
(Source: author)

4.1.2 Discriminant validity

Discriminant validity involves two latent variables representing two different theoretical concepts that are statistically sufficiently different. To obtain empirical evidence for discriminant validity, the study should consider the HTMT value lower than 0.85 (Benitez et al., 2020). In this study, the HTMT of SSy to PLE is 0.790, SSn to PLE is 0.778 and SD to PLE is 8.37, thus below the recommended threshold of 0.85. As all the values passed the HTMT below 0.85, Table 2 indicates that discriminant validity was ascertained.

4.2 Structural Model Analysis

In evaluating the structural model, the analysis examines the estimated model's overall fit, the path coefficient estimates, their significance, the effect sizes (f^2), and the coefficient of determination (R^2). Analysis focus precisely and primarily on overall model fit in confirmatory research and primarily on R^2, the path coefficient estimates, and the effect sizes in explanatory research (Benitez et al., 2020).

Table 2. Heterotrait- Monotrait Ratio (HTMT) Result

	X1 (SSy)	X2 (SSn)	X3 (SD)	Y (PLE)
X1 (SSy)				
X2 (SSn)	0.839			
X3 (SD)	0.832	0.722		
Y (PLE)	0.79	0.778	0.837	

(Source: author)

4.2.1 The coefficient of determination (R^2)

R^2 is used to assess goodness of fit in regression analysis and is also referred to as in-sample predictive power. In the case of models estimated, the R^2 value gives the share of variance explained in a dependent construct (Hair et al., 2019b; Benitez et al., 2020). Hence, it provides an understanding of a model's in-sample predictive power (Benitez et al., 2020). In a study done by Benitez et al. (2020), the expected magnitude of R^2 depends on the phenomenon investigated. They elaborated that some phenomena are already quite well understood to expect a relatively high R^2. For phenomena that are less well understood, a lower R^2 is acceptable. The R^2 values should be judged relative to studies investigating the same dependent variable. Hair et al. (2019b) suggested that the R^2 values of 0.75, 0.50 and 0.25 are considered substantial, moderate, and weak. According to Hair et al. (2019b), R^2 values of 0.90 and higher typically indicate overfitting. Therefore, the coefficient of determination R^2 of the model is 0.663 for the PLE endogenous latent variable. This means that the three latent variables (SSy, SSn, and SD) moderately explain 66.3% of the variance in PLE as shown in Table 3.

Table 3. The Result of Structural Model Analysis

Hypothesis	Relationship	Std. Beta	Std. Error	T-Value	Decision	f^2	R^2	Q^2	q^2
H1	SSy --> PLE	0.1	0.077	1.305	Not supported	0.013			
H2	SSn --> PLE	0.297	0.068	4.342	Supported	0.128			
H3	SD --> PLE	0.51	0.078	6.583	Supported	0.367			
	PLE						0.663	0.47	0.731

(Source: author)

4.2.2 Effect size (f^2)

The purpose of calculating the effect size (f^2) is to estimate the extent of the influence of an independent latent variable on the dependent variable.

Table 4. Effect of size on Physical learning Environment (PLE)

	Effect size (f 2)	Rating
Sensory Sensitivity (Ssy)	0.013	Small effect
Sensory Stimulation (SSn)	0.128	Small effect
Sensory Design (SD)	0.367	Large effect

(Source: author)

The effect size is based on the coefficient of determination (R^2) (Hedayati Marzbali, Abdullah, and Maghsoodi Tilaki, 2016). Indeed, the rank order of the predictor constructs' relevance in explaining a dependent construct in the structural model is often the same when comparing the size of the path coefficients and the f^2 effect sizes (Hair et al., 2019). The interpretation of the f^2 is by following the guidelines values of 0.02, 0.15 and 0.35 represent small, medium and large effect size, respectively (Hedayati Marzbali, Abdullah, and Maghsoodi

Tilaki, 2016; Hair et al., 2019b). As shown in Table 4, the effect size of SSy, SSn and SD on PLE was 0.013, 0.128 and 0.367, respectively. Therefore, it can be concluded that SD has a large influence on PLE, whereas SSy and SSn on PLE are small.

4.2.3 Predictive relevance

Using a bootstrapping method, the following procedure generates T-statistics for significance testing of both the inner and outer model. In this procedure, a large number of subsamples (e.g., 5000) are taken from the original sample with replacement to give standard bootstrapping errors, which in turn gives approximate T-values for significance testing of the structural path (Hedayati Marzbali, Abdullah, and Maghsoodi Tilaki, 2016; Ramayah et al., 2017; Ramayah et al., 2018). The structure model was assessed to determine the path significance between latent variables (Ramayah et al., 2017; Ramayah et al., 2018). Using a two-tailed t-test with a significance level of 5%, the path coefficient will be significant if the T-statistics is larger than 1.96 (Wong, 2013). The structural model result is shown in Figure 3. In addition to estimating the magnitude of R^2, researchers have recently included predictive relevance as an additional assessment of model fit. This technique represents how well the model reproduced the manifest indicators and parameter estimates (Hedayati Marzbali, Abdullah, and Maghsoodi Tilaki, 2016; Ramayah et al., 2017). As suggested by Hedayati Marzbali, Abdullah, and Maghsoodi Tilaki (2016), predictive relevance was also performed to assess the validity of the formative construct. According to Hair et al. (2019b), Q^2 (cross-validated redundancy) was computed to examine the predictive relevance using a blindfolding procedure in PLS. Following the guidelines suggested by Hair et al. (2019b), values larger than zero are meaningful, meaning values higher than 0 - 0.25 and 0.50 depict the PLS path model's small, medium and large predictive accuracy. For calculating Q^2, a blindfold analysis was performed, and the cross-validated redundancy Q^2 for SSy, SSn and SD was 0.47, which are more significant than zero. This indicates that the model exhibits medium predictive relevance. Since this is a saturated model with no free paths, the saturated model (measurement) fit values and the estimated model (structural model) fit values were 0.731 (73.1%), indicating the data fit the model well, as shown in Table 3.

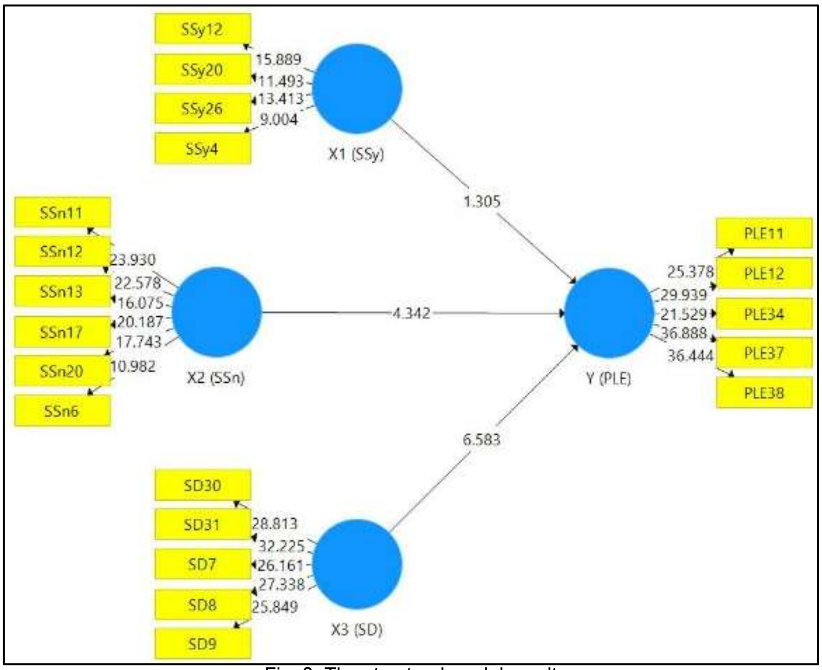

Fig. 3: The structural model result
(Source: author)

5.0 Discussion

This paper aims to establish a framework for the sensory environment towards the physical learning environment for autism centres. The interpretation's findings provide the necessary evidence to claim the achievement of the research aim to develop a framework. Based on the proposed model measurement analysis findings, the model can be summarized that all the three constructs - Physical Learning Environment, sensory sensitivity, sensory stimulation, and sensory design are valid. Measures of their constructs based on their factor estimations statistical significance. Figure 2 illustrates the interaction between SSy, SSn and SD variables in PLE. The results suggest that the sensory sensitivity, sensory stimulation, sensory design variables of the physical learning environment positively contribute to a conducive environment. Although the influence of SSy (f^2=0.013) is a small effect and SSn (f^2=0.128) is a moderate effect on PLE, the SD (f^2=0.367) has a large effect on PLE. However, based on the result of the structural model analysis was found that the sensory sensitivity (t=1.334) did not support the physical learning environment, even though the sensory stimulation (t=4.408) and sensory design (t=6.621) supported the physical learning environment. Figure 2 illustrates the coefficient significance between SSy, SSn and SD towards the PLE.

6.0 Conclusion

The study shows the influence of sensory sensitivity, sensory stimulation, and sensory design on the physical learning environment. The findings revealed that the sensory design significantly affects the physical learning environment. However, based on the result of the structural model analysis, the sensory sensitivity did not support the physical learning environment. In contrast, the sensory stimulation and sensory design supported the physical learning environment. There is a significant relationship between sensory design towards the physical learning environment in the Autism Centre. The study developed a framework of sensory stimulation and sensory design for the physical learning environment. The study findings show that sensory stimulation and sensory design expect a conducive physical learning environment. Earlier studies like Arnaiz et al. (2011), Mostafa (2015), Block (2018) and Love (2019) confirms the study prediction that designing the environment by considering sensory stimulation and sensory design would create a conducive learning environment for autism. This research recommended that experimental studies can be done to observe autistic children in the learning environment for future research. There are not many studies on autistic children in the Malaysian context. Perhaps, this could highlight new knowledge or ideas that could help to improve the learning environment of autistic children.

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Paper Contribution to Related Field of Study

The practical contribution is to provide a guideline during the design stage and improve the autism learning environment; hence the essential features are attributed to a conducive learning environment. This research would help specialised agencies and related government agencies used as a benchmark to improve the autism learning environment in Malaysia.

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