Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

e-ISSN: 2637-0395

Built Environment Journal Vol. 21 (Special Issue) 2024, 168 - 180.

Built Environment Journal

The Environmental Effects of Courtyard Design in Penghulu Demang Abdul Ghani Malay Traditional House, Melaka

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ARTICLE INFO

Article history:
Received 06 May 2024
Revised 13 August 2024
Accepted 30 August 2024
Online first
Published 30 September 2024

Keywords:
Courtyard
Climate change
Environment
Socio-cultural values
Traditional Malay house
Environmental strategies

DOI:
10.24191/bej.v21iSpecial Issue.1487

ABSTRACT

A courtyard in a traditional Malay house is an outdoor space surrounded by buildings or walls. The primary purpose is to provide better environmental effects for the building's indoor design. The study focuses on Melaka's traditional Malay house courtyard style, particularly in Merlimau. The study seeks to comprehend the socio-cultural values of traditional Malay house courtyard design and how the courtyard design affects the surroundings. This study examines how the courtyard establishment affects traditional Malay houses by their environmental design factors. The environmental consequences of courtyard design at Demang Abdul Ghani house, Merlimau, Melaka, were chosen for this study. The questionnaire survey was used to collect the primary data, while the data were analysed by using Statistical Package for the Social Sciences (SPSS). The primary finding revealed that the courtyard is an essential element for the environmental features used for preserving the traditional Malay environment. It also can be used to strategies the integrating between the environmental effects of the courtyards in Melaka's traditional Malay houses and the building's indoor design. The findings of traditional environmental strategies via courtyard design will contribute to the modern housing design. They will generally be the main root of mitigating the effect of climate change.

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https://doi.org/10.24191/bej.v21iSpecial Issue.1487

INTRODUCTION

A courtyard is a constrained area open to the sky and frequently encircled by a structure. Traditional and modern designers have employed courtyards as a characteristic and conventional building feature (Zhai & Previtali, 2010). Courtyards are principal elements in both Western and Eastern construction designs. The courtyards play a role in the structure, whether traditional or modern. For instance, a courtyard is a popular opening architectural design element in tropical buildings or houses due to its social, cultural, and environmental benefits (Taleghani et al., 2012). They add that most buildings or houses have openings for thermal comfort, such as encouraging air circulation/ wind flow and natural lighting. Courtyards create a meaningful social-environmental impact by giving private open space throughout the structure (Alnusairat et al., 2022). According to Edwards et al. (2006), a courtyard is an introverted form defined as an open space surrounded by constructed areas that conceal it from the outside. Consequently, courtyard houses vary from courtyard houses, which might include one or more sides of the areas directly close to the outdoors. The courtyard alternates between private and public spaces, remaining physically restricted yet aesthetically accessible. It can only meet the requirements for safety and privacy by erecting rising walls. Courtyards are enclosed outdoor areas with a roof that is generally open to the weather; another definition of a courtyard is an unroofed area that is open to the elements. Totally or partially surrounded by walls or structures, usually as part of a significant house (Abass et al., 2016).

However, the climate in each country can affected. The design of courtyards is also essential, whether a modern or a traditional house (Ghani et al., 2012). In the context of the local climatic situation in our country, for example, climate conditions in Malaysia are tropical climates with high temperatures and humidity and significant amounts of rainfall throughout the year. Traditional Malay houses are carefully planned through harmonious connections among man, nature, and culture, reflected in the space design and surroundings (Daud, 2016). The preliminary works by researchers have found that many natural places worldwide have lost most of their intrinsic qualities due to humanity's influence (Hasim et al., 2023; Nasir & Teh, 2011b). The Malay culture's tradition of handing down the ways from one generation to the next generation made there some consistency in the architecture of the Malay traditional house. The Malays persisted in their traditions, rituals, and beliefs. Malaysian cultures today are the consequence of what has been transmitted down from generation to generation, incorporating culture from outside too, particularly from the religion of Islam.

LITERATURE REVIEW

Evaluation of Environmental Effect

According to Idris et al. (2018), the courtyard's benefits rely on its awareness of its interior form, which creates a sense of privacy and confinement to the form and owners of the house. Irrespective of how many theories are set up, the courtyard can function as an extension of the kitchen in the morning and as a living area in the evening to entertain visitors, as well as a place for all family members to engage, to encourage the family to function as a unit. Furthermore, courtyards (Zolfagharkhani & Ostwald, 2021) may be used as screening and walled entrances provide visual isolation when the courtyard is visually isolated. When the weather enables outdoor activity, this is an excellent area to sleep at night since the courtyard provides acoustic isolation, and the enclosure features operate as a noise barrier between the courtyard and the rest of the area. In the context of culture, several situations necessitate the usage of more than one courtyard (Lizana et al., 2022). This is typically used to separate a house's public and private portions. The public is primarily made up of visitors and males (especially in Islamic cultures). The inner court is mainly reserved for the family and serves as an outdoor recreation zone for females.

Based on this presumptive belief, we could say that religious and social factors impact the design of architectural components and housing design features, notably the placement of the courtyard design area, which must be related to the house's owner's beliefs and courtyard could provide a comfortable and healthy atmosphere for house users or inhabitants (Agha, 2015).

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Design Method

This research was conducted at Demang Abdul Ghani house, located in Merlimau Melaka. Penghulu Demang Abdul Ghani house is chosen because of the form and characteristic of the house is in a form of Melaka Malay traditional house with an interior courtyard. This study focuses on the environmental effects of courtyard design in traditional houses in Melaka. The environmental impact of courtyard design in Melaka Malay traditional houses may be evaluated using various criteria, including thermal comfort, air quality, and energy efficiency. Courtyards can help to achieve sustainable design by improving thermal and microclimatic conditions, encouraging natural ventilation, and boosting occupant well-being. The primary focus of the environmental impacts of courtyard design in traditional houses in Melaka is to examine how the environment influences the courtyard design of traditional houses. This experience can show the active participation of residents or target groups in traditional Melaka house sites through interactions with their surroundings. This could demonstrate respondent engagement with historic courtyard buildings via interactions with their environment. As a result, environmental indicators in courtyard design include characteristics. They are concerned about air purity, thermal comfort, energy efficiency, and occupant well-being.

The subject of this study is the environmental effects of courtyard design in one of Melaka Malay traditional house in Merlimau, Melaka. This study was conducted by blasting the questionnaire through physical and social media platforms, which took around three weeks to obtain all the data needed. This study aims to analyse the experiences of inhabitants or target groups after visiting that site in Merlimau, Melaka. Melaka Malay traditional house has taken place. The author's method was Partial Least Square Path Modelling (PLS-SEM) (Yahaya et al., 2019), which defined the evaluation of thermal, general knowledge, environmental effects of courtyard design, courtyard design, and strategy to integrate.

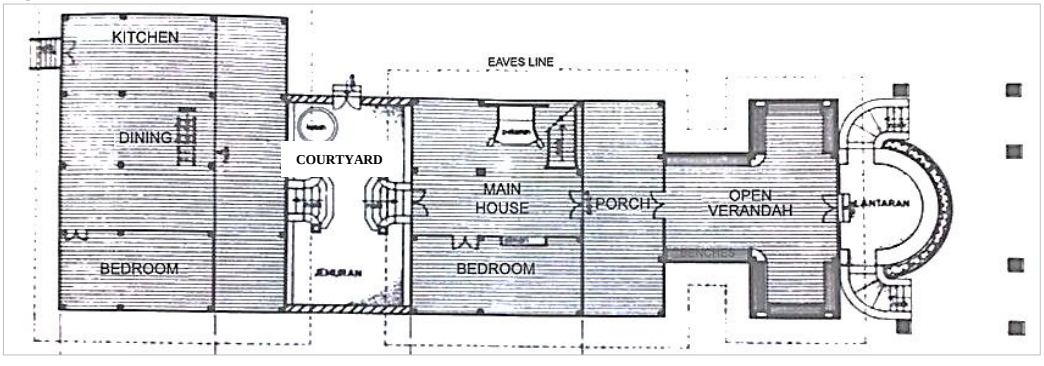

Fig.1. House Floor Plan: Courtyard Located in the Middle of the House

Source: Taufik et al. (2015)

Fig. 2. Front façade (left), and part of side elevations of Melaka Malay traditional house (right)

Source: Author**s (**2024**)**

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Research Structure and Hypothesis

This study explores the relationship between the evaluation of thermal, general knowledge, environmental effects of courtyard design, courtyard design, and strategy to integrate in the context of the environmental effects of courtyard design in Melaka Malay traditional houses. The structure of hypothesis of this study is shown in Figure 3. This approach method can assist in finding out how the dimensions' relationships and influences function of courtyard to the other interior spaces of the house. This study proposes the following hypotheses, Hypothesis 1(H1) -Hypothesis 5 (H5), based on the research intended and framework:

i) The evaluation of differences in the research dimensions of various background variables.

ii) The correlation of influence between research dimensions

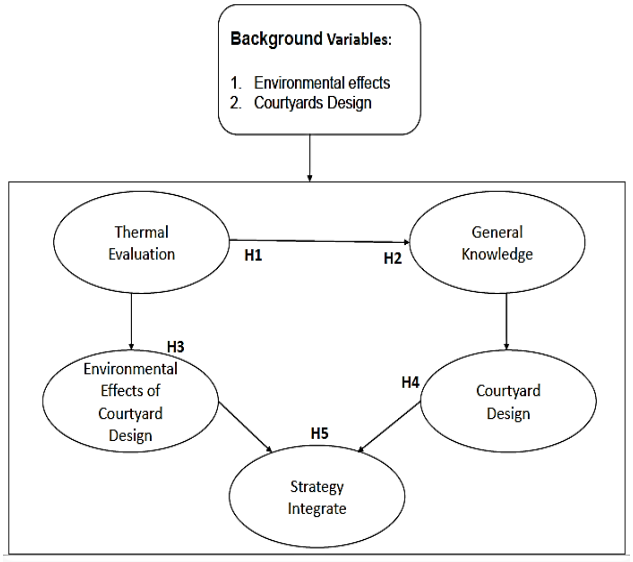

Fig. 3. Hypothesis and Research Model of the environmental effects of courtyard design

Source: Authors (2024)

Definition and Measurement Tables

Table 1. Definition and operation of variables for the environmental effects of courtyard design

No.	Dimension	Operational Definitions
1.	Evaluation of thermal (EVT)	The evaluation of thermal comfort includes determining the amount of comfort experienced by persons in a particular thermal environment.
2.	General knowledge (GK)	General knowledge is a large and diversified variety of information.
3.	Environmental effects of courtyard design (EECD)	Courtyard design has a significant influence on the environment.
4.	Courtyard design of Melaka traditional house (CD)	The courtyard design in Melaka's traditional houses is distinguished by a centre open space that serves as a service entrance space, washing area, and location for numerous activities.
5.	Strategy to integrate the environmental effects of courtyard design in Malay traditional houses (STI)	Courtyard architecture in Malay traditional houses has the potential to improve environmental sustainability and should be investigated and incorporated into the current architecture model.

Source: Authors (2024)

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

The definition and operation of variables in all research aspects of this study were based on the environmental effects of courtyard design in Penghulu Demang Abdul Ghani, Melaka Malay traditional house. Tables 1 and 2 provide definitions for the research dimensions and questionnaire items.

DATA ANALYSIS

This research questionnaire uses Likert's 5-points scale, with options including "strongly disagree," "disagree," "neutral," "agree," and "strongly agree." For the environmental effects of courtyard design in traditional Melaka Malay houses, questionnaires were issued and completed, with 35 valid questionnaires collected after three weeks of distributing the questionnaire online through various social media platforms. All the data from the questionnaire will be analysed to carry out descriptive statistics and independent sample t-test methods to test the difference between the analysis of different background variables and research variables. Next, Smart PLS uses PLS-SEM to measure the correlation between observation and latent variables through a reflective measurement model.

Table 2. Questionnaire items of respondent

No.	Profile	Category
1.	Gender	Female
		Male
2.	Age	18-29 years old
		30-39 years old
		49-59 years old
		60 and above
3.	Race	Malay
		Chinese
		Indian
4.	Occupation	Architects
		Interior Designer
		Conservators
		Student
		Others
5.	State of Origin	Melaka
		Selangor
		Kuala Lumpur
		Kelantan
		Kedah
		Negeri Sembilan
		Terengganu
		Others
6.	Purpose of visits	Holiday
		Educational
		Work

Source: Authors (2024)

PLS-SEM is an analytical tool used to detect or develop prediction models. It surpasses the general linear structural correlation model, ideal for exploratory research, especially model analysis between latent variables. This method is ideal for analysing tiny samples. The PLS sample size should be ten times the most question items in the research dimensions. The dimension of most question items in this study is the environmental effects of courtyard design in Melaka traditional houses (Hair et al., 2020), which has six questions. A higher sample size is recommended under the statistical principle. As a result, the model's effect size often determines the minimum sample size required for an acceptable power level in a PLS-SEM test. This study's sample size is 35, which satisfies the minimum sample size requirement**.** It is more suited for the development of theoretical models. The primary goal of this strategy is to examine if the causal connection has a statistically significant reciprocal linear relationship. PLS-SEM is utilised in this study to look into the relationship between the research variables. It primarily uses the PLS and bootstrapping to repeat sampling 5000 times to obtain route coefficients and significance. It can discuss the link and effect of the research dimensions.

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Table 3. Evaluation Thermal Question

Dimensions	Question
EVT	**EVT 1:** What time do you visit this place? **EVT2:** What is your general thermal sensation? **EVT3**: Using the list below, please check each item of clothing that you are wearing right now. **EVT4**: What is your activity level right now? **EVT5:** How satisfied are you with the temperature in this house's interior space? **EVT6:** If you are dissatisfied with the temperature in your space, which of the following contributes to your dissatisfaction (6a) In warm/hot weather, the temperature in my space is (6b) When is the most often a problem? (6c) How would you best describe the source of this discomfort? (6d) Please describe any other issues related to being too hot or cold in this space.

Source: Authors (2024)

Table 4. General knowledge

Dimensions	Questions
GK	**GK1:** The courtyard is influenced by Melaka Malay architectural features. **GK2**: Courtyards are architectural design elements that can modify the indoor microclimate of the house and increase occupant comfort. **GK3:** The courtyards of this Melaka Malay traditional house are an effective passive architectural design strategy to respond to the tropical microclimate. **GK4:** The courtyard of this house environment may affect the effectiveness of the wind catcher. **GK5**: The courtyard forms of this house are described as an open space hidden from the outside by constructed parts. **GK6:** This Melaka house's courtyard design traditionally provides shading while reducing solar radiation into the interior spaces. **GK7:** In traditional Melaka Malay architecture, the courtyard can function as an intermediate space connecting the *rumah ibu* and kitchen spaces.

Source: Authors (2024)

Table 5. Environmental effects on courtyard design

Dimensions	Questions
EECD	**EECD 1**: Melaka courtyard design may increase the thermal comfort of indoor environments of this house **EECD2:** Window openings around courtyards within the house of this house can strongly affect the wind flow into the interior spaces **EECD3:** The design of courtyards can reduce humidity through wind flow in the courtyard area to the entire interior of this house. EECD4: The courtyard of this house can be used as an enclosed place with noise shields. **EECD5:** Overall courtyard design can encourage wind flow and natural lighting and reduce humidity **EECD6:** Poor environmental conditions can cause discomfort to the inhabitants of this house and have bad effects on human health.

Source: Authors (2024)

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Table 6. Courtyard design

Dimensions	Questions
CD	**CD1**: The courtyard's size is proportionate with the house's size. **CD2:** The courtyard's strategic positioning will benefit the surrounding interior spaces. **CD3:** The courtyard design of this house encourages Melaka cultural elements to influence Baba Nyonya of Melaka. **CD4:** The inside of this Melaka courtyard house also serves as a location for various social activities, especially among housewives. **CD5:** The presence of nature in this courtyard, such as ornamental plants, would provide environmental benefits while serving as an interesting place for housing.

Source: Authors (2024)

Table 7. Strategy to integrate

Dimensions	Question
STI	**STI1:** Concrete can be a good heat insulator material that provides good insulation from heat due to its thermal conductivity. **ST12:** Melaka courtyard house design could affect the quantity of natural light entering the house's interior *rumah ibu and kitchen*. **STI3:** Brick walls and *kekisi* can reduce solar heat gain and improve thermal comfort in the courtyard. **ST14:** Configuration of courtyard orientations towards the north and south of this traditional house can affect the microclimate and thermal performance of the courtyard. **ST15:** The courtyard's design should consider the region's cultural identity, reflect the traditional *Baba & Nyonya Peranakan* architecture of Melaka, and combine with Malay Melaka architecture. **ST16:** The size and scale of the Melaka traditional courtyard house and openings of the interior spaces can have a good impact on the thermal performance of the building and the surrounding microclimate.

Source: Authors (2024)

RESULTS AND DISCUSSION

As shown in Table 8, the questionnaire items in this study show factor loading is more than 0.03, which passes the verification level. All dimension has Cronbach's α and Cronbach alpha values mainly shown >0.5, suggesting strong reliability and internal consistency. For courtyard design, general knowledge and strategy to integrate, their AVE value >0.5, suggesting strong convergent validity also for evaluating thermal comfort and environmental effects of courtyard design, which is >0.5. In this case, when the AVE is <0.5 but the Cronbach alpha is >0.6, the convergent validity remains acceptable.

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Table 8. Measurement model parameter estimation

Dimensions	Items	Factor Loading	Cronbach's a	CR	AVE
EVT	EVT 1	0.526			
	EVT2	0.697			
	EVT3	0.537			
	EVT4	0.524			
	EVT5	0.559	0.528	0.558	0.569
	EVT6	0.584			
	EVT6(b)	0.738			
	EVT6(c)	0.585			
	EVT6(d)	0.507			
Dimensions	Items	Factor Loading	Cronbach's a	CR	AVE
GK	GK1	0.469			
	GK2	0.766			
	GK3	0.901	0.827	0.881	0.537
	GK4	0.815			
	GK5	0.625			
	GK6	0.756			
	GK7	0.852			
Dimensions	Items	Factor Loading	Cronbach's a	CR	AVE
EECD	EECD 1	0.789			
	EECD2	0.652			
	EECD3	0.821	0.768	0.836	0.565
	EECD4	0.526			
	EECD5	0.638			
	EECD6	0.619			
Dimension	Items	Factor Loading	Cronbach's a	CR	AVE
CD	CD1	0.454			
	CD2	0.746	0.768	0.847	0.532
	CD3	0.773			
	CD4	0.826			
	CD5	0.836			
Dimension	Items	Factor Loading	Cronbach's a	CR	AVE
STI	ST1	0.546			
	STI2	0.627			
	STI3	0.891	0.843	0.891	0.569
	STI4	0.869			
	STI5	0.792			
	STI6	0.739			

Source: Authors (2024)

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

Table 9. Discriminant Validity Test (Fornell- Larcker)

Dimensions	AVE	CD	EECD	EVT	GK	STI
CD	0.569	**0.729**				
EECD	0.565	0.589	0.**682**			
EVT	0.169	0.482	0.546	0.511		
GK	0.537	0.418	0.543	0.595	**0.733**	
STI	0.569	0.604	0.693	0.527	0.550	**0.754**

Source: Authors (2024)

Table 10. Heterotrait-Monotrait Ratio of Correlations

Dimension	CD	EECD	EVT	GK	STI
CD					
EECD	0.732				
EVT	0.523	0.693			
GK	0.524	0.547	0.656		
STI	0.674	0.792	0.604	0.635	

Source: Authors (2024)

Table 11. Sample T-test Analysis on the environmental effects of courtyard design

Indicator	Number	Mean	STD	T-Value
Evaluation of thermal comfort	35	0.542	0.508	0.516
General knowledge	35	0.594	0.544	0.516
Environmental effects of courtyard design	35	0.616	0.581	0.001
Courtyard design	35	0.570	0.870	0.058
Strategy to integrate	35	0.558	0.870	0.570

Source: Authors (2024)

Structural Equation model analysis

Table 12. Collinearity Analysis and Model Fit

Dimension Correlation	VIF	Model Fit
CD & STI	1.482	
EECD & CD	1.490	SRMR = 0.138
EECD & STI	1.482	NFI = 0.321
EVT & EECD	1.000	RMS θ = 0.013
EVT & GK	1.000	
GK & CD	1.490	

Source: Authors (2024)

When analysing structural equation modelling, be certain that collinearity has been avoided. When the Variance Inflation Factor (VIF) exceeds 5, it indicates that there may be a collinearity issue between the dimensions. In this study, the VIF value of this model is less than 5, which is between 1 and 1.281, showing no collinearity among the dimensions. To evaluate the adequacy of the entire model, Standardized Root Mean Square Residual (SRMR), Normed Fit Index (NFI), and Root Mean Square (RMS θ) are often used indicators for PLS-SEM. Table 12 shows the VIF, collinearity analysis, and model fit values for each dimension's correlations.

The SRMR value has a range of 0 to 1. Based on the Table above, the SRMR brings out a value ranging from 0 to 1. When the SRMR value is >0.1, which is in this study, the value is 1.490, making the model a fair fit. Next, the NFI produces value ranges between 0 and 1. The higher the value of NFI, such as 0.9, the

better the performance. This study's NFI value is 0.321, which suggests the model fits well. Meanwhile, the RMS θ value should only be used to evaluate reflecting measurement models. A value of RMS θ < 0.12, which this study has produced a value of 0.013, suggests that the model is a good fit. Therefore, this study's SRMR value for model assessment validation is 0.138. Although the NFI value of 0.321 is < 0.9, the differences are insignificant. The value of RMS θ is 0.013 and is highly acceptable. As a result, the model for this study is relatively well-fitted.

The path analysis is used to examine and explain the model verification. The value of t is evaluated in the path analysis to assess whether the hypothesis is accepted. Table 13 shows that H1, H3, and H4 have achieved a significant level with p-values < 0.507. Since the t-value is < 4.278 and the p-value is > 0.05, H3 fails to reject the null hypothesis. A p-value fixed of 0.05 shows that no impact was observed. As a result, all hypotheses in this study are valid. The PLS-SEM path analysis model is shown in Figure 13.

Table 13. Path Analysis Verification

Path Analysis	Path Coefficient	T-Value	P-Value	Hypothesis
CD & STI	6.553	4.585	0.529	H1 valid
EECD & STI	5.672	4.278	0.567	H2 valid
EVT & EECD	4.461	6.664	0.507	H3 valid
EVT & GK	5.907	6.756	0.579	H4 valid
GK & CD	0.481	2.183	0.029	H5 valid

Source: Authors (2024)

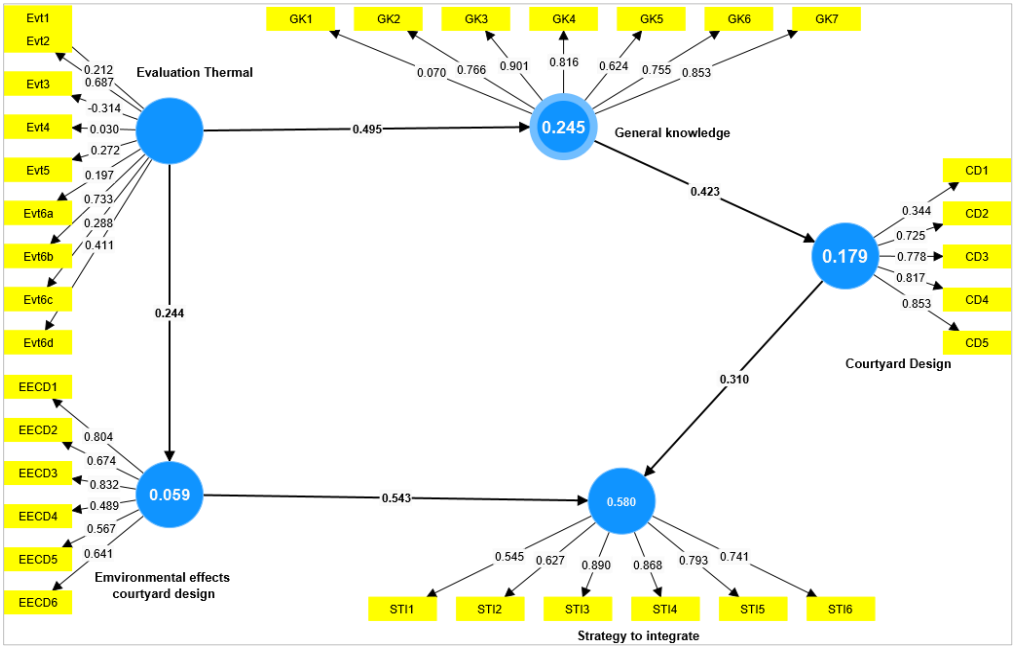

Fig 3. Model PLS-SEM path analysis of the environmental effects of courtyard design

Source: Authors (2024)

The R2 value is used to examine the model's explanatory ability when the R2 value is between 0 and 1. The higher the value, the greater the explanatory ability. The model has a modest explanatory ability when the value equals or exceeds 0.10. Table 14 shows that GK has a 24.5% explanatory ability for EECD. The explanatory ability of GK and EECD to CD is 1.79%. The explanatory ability of STI explains 58.0% of STI. As a result, the model in this study efficiently describes the latent variables and has a high degree.

Table 14. The R2 and f2 Value

Path Analysis	R2	R2 Adjusted	f2
EVT→ GK	0.431	0.395	0.587
EVT→ EECD	0.440	0.423	0.785
EECD→ CD	0.223	0.200	0.138
CD→ STI	0.671	0.650	0.574

Source: Authors (2024)

Effect size is when the explanatory effect value f2 is used to determine the effect of exogenous factors on endogenous variables. Table 14 shows that the explanatory effect value f2 of EVT to GK is 0.587, which demonstrates a medium effect of explanatory ability. Next, the EVT to EECD explanatory ability effect value f2 is 0.785, indicating a small effect explanatory ability. Besides that, EECD to CD has an explanatory effect value f2 of 0.138, which shows a medium effect explanatory ability. Furthermore, the explanatory effect value f2 of CD to STI is 0.574 a medium effect explanatory ability. Except for the explanatory effect value of EECD to CD, which has a negligible effect explanatory ability, the remaining has a medium effect explanatory ability. This suggests that exogenous variables may describe endogenous variables well with a high degree of explanatory effect value.

The path coefficient of the independent variable to the intermediary variable and the path coefficient of the independent variable to the dependent variable must be considerable for the intermediary effect to be established. Next, the intermediate variable's path coefficient to the dependent variable should be significant. Through the intermediate variable, the independent variable indirectly influences the dependent variable. It may be determined that the intermediate variable has an intermediate effect if it is bigger than the direct effect of the independent variable on the dependent variable.

Intermediary Effect Verification

The t-value of the indirect effect may also be used to identify the test of the intermediary effect. A t-value larger than 1.96 suggests the presence of an intermediary effect. The Variance Accounted For (VAF) value can also be used to estimate the extent of the intermediary effect. A VAF of less than 20% indicates a minor intermediary effect. Meanwhile, 20% < VAF < 80% indicates a partly intermediary effect. So, a VAF of more than 80% implies a comprehensive intermediary effect. This study considers GK an intermediary in the relationship between STI and EECD. The indirect effect value is 0.181, and the t-value is 4.278, both statistically significant. Hence, the H3 theory has been proven. So, GK acts as a partial intermediary in the influence of STI on EECD. Table 15 displays the verification data for the intermediary effect.

Table 15. Intermediary Effect Verification

Independent Variables	Intervening Variables	Dependent Variable	Direct Effect	Indirect effect	VAF	Hypothesis
STI	GK	Environmental effects of courtyard design	0.139 (t=1.756)	0.181 (t=4.278)	55%	H3 Valid

Source: Authors (2024)

https://doi.org/10.24191/bej.v21iSpecial Issue.1487

CONCLUSION

This study has produced a structural model to investigate the connection of each variable related to the environmental effects of courtyard design components in this study. PLS-SEM was used to evaluate and develop all the data obtained from the questionnaire into a prediction model. This method can assess the path coefficients and significance using the PLS algorithm and Bootstrapping measurement. In this study, the researcher discovered that the environmental effects of courtyard design, such as the desire to engage in traditional Melaka house experiences, have significantly influenced their environmental effects based on data analysis. The fundamental goal in motivating the environmental effects of courtyard design is for people to embrace their awareness and preserve the courtyard and the Melaka traditional house to keep it as a traditional heritage for future reference. To conclude, the PLS analysis provides important data regarding the significance and efficiency of the suggested model relationship. This study was conducted to understand better the correlation between the evaluation of thermal, general knowledge, and environmental effects of courtyard design, courtyard design, and integration strategy. In the proposed model, the researcher suggests the influence of two factors on the environmental effects of courtyard design: general knowledge and environmental effects. Furthermore, the researcher claims environmental effects can affect the courtyard design and interior of that house's heritage. Through this study, all the hypotheses are proven valid because the environmental effects of courtyard design and strategy to integrate mediated by general knowledge have a positive intermediary effect on the environment of courtyard design in Melaka traditional houses.

ACKNOWLEDGEMENTS

The authors would like to acknowledge to Perbadanan Muzium Melaka (PERZIM) for permitting us to do research in Penghulu Abdul Ghani house. PERZIM also guiding us by giving numerous information and recommendations that helped to accomplish this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nur Najah Mohd Sadri conducted the research and wrote and revised the article. Alamah Misni conceptualized the central research idea, supervised the research progress, anchored the review and revisions, and approved the article submission, while Mohd Basir Abdul Rozak and Nurin Amalia Azmi focusing on reviewing the article and to make sure the results are suitable and sustainable for the environment and interior design industry.

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