



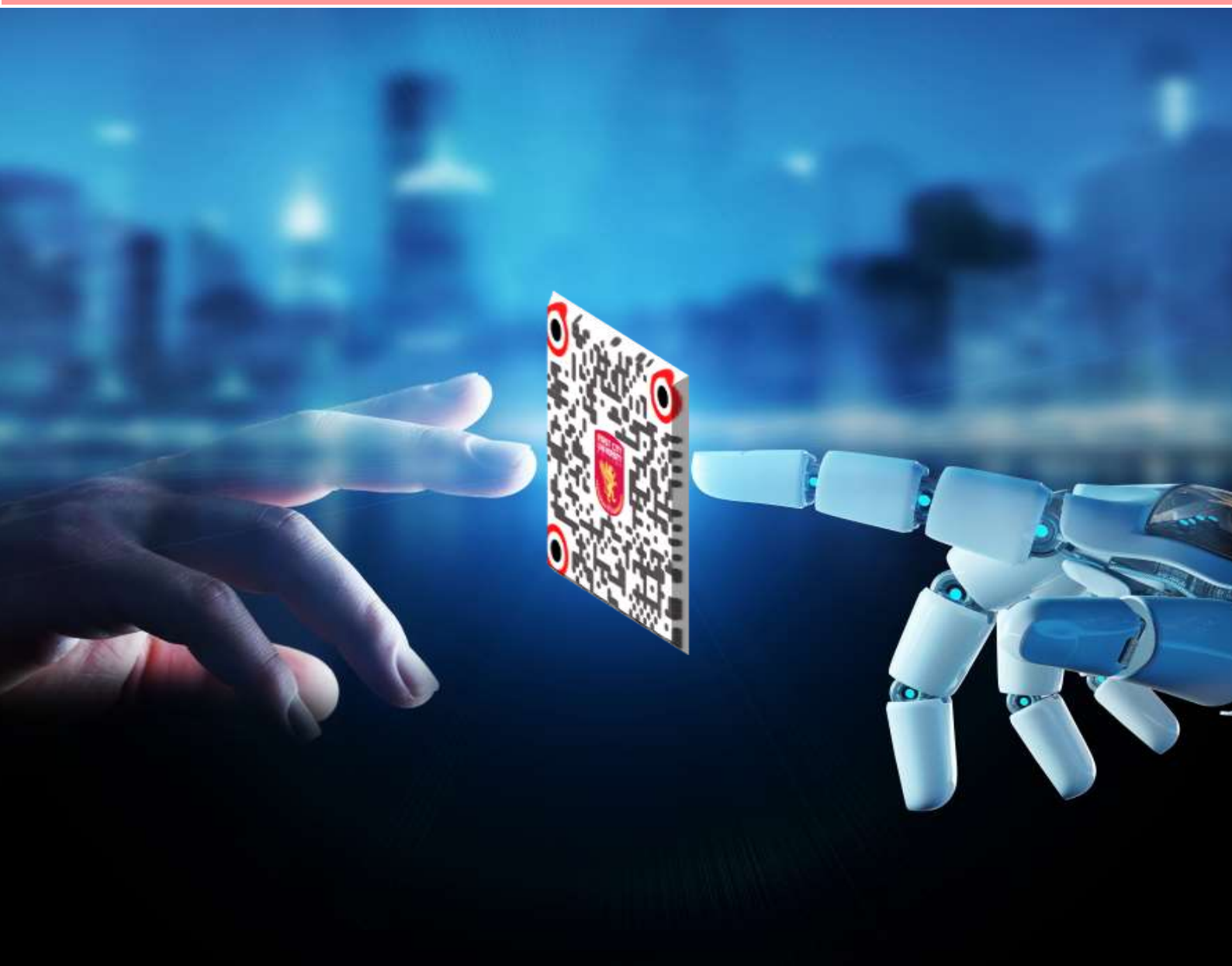
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THE EFFECTIVENESS OF SOCIAL MEDIA IN PROMOTING HIGHER EDUCATION INSTITUTIONS IN MALAYSIA

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ABSTRACT

This study looks into how Higher Education Institutions (HEIs) in Malaysia use social media to promote the institutions. With an emphasis on comprehending how each social media site contributes to the marketing of HEIs, the analysis covers a broad spectrum of platforms, including but not limited to Facebook, Twitter, Instagram, LinkedIn, and YouTube. Additionally, this study assesses how well various material formats including text-based posts, photos, videos, and interactive elements influence current and prospective students, alumni and other stakeholders. A special focus is placed on new developments in technology and trends that are influencing how social media is used to promote the higher education institutions. The researcher's conclusions deepen the understanding of the relationships between social media and the marketing of higher education thus providing guidance to HEIs on maximising their online presence. The results confirmed the validity of the hypothesis, showing a significant positive correlation between content types, platform used, interactive strategies and institution visibility. This study offers a relevant investigation of tactics that can improve social media's ability to promote higher education institutions as the digital landscape changes.

Keywords: *Social Media, Effectiveness, Content types, Engagement, Higher Education Institutions*

INTRODUCTION

The education industry has undergone a significant transformation due to the rapid advancement of technology. Traditional marketing methods are being enriched by digital tools that cater to modern learners' needs and preferences (Akour and Alenezi, 2022). Social media applications have become an important factor in altering the educational landscape, allowing education institutions to engage with target audiences, enhance public recognition, and build brand image. Social media platforms have changed the way people interact and communicate, enabling real-time engagement. Technology has also transformed marketing, allowing institutions to interact directly with their audiences. Social media platforms offer advanced advertising features, enabling institutions to target specific demographic groups and modify content to resonate with their target audience (Pringle and Fritz, 2019).

PROBLEM STATEMENT

There is a need to critically assess the impact and results of such promotional initiatives as there are more and more educational institutions adopting digital communication strategies including social media platforms (Dwivedi et al., 2021). Although social media has the potential to enhance engagement, reach and brand identity, a thorough understanding of how well it accomplishes these goals is still difficult to catch and predict (Lim and Rasul, 2022).

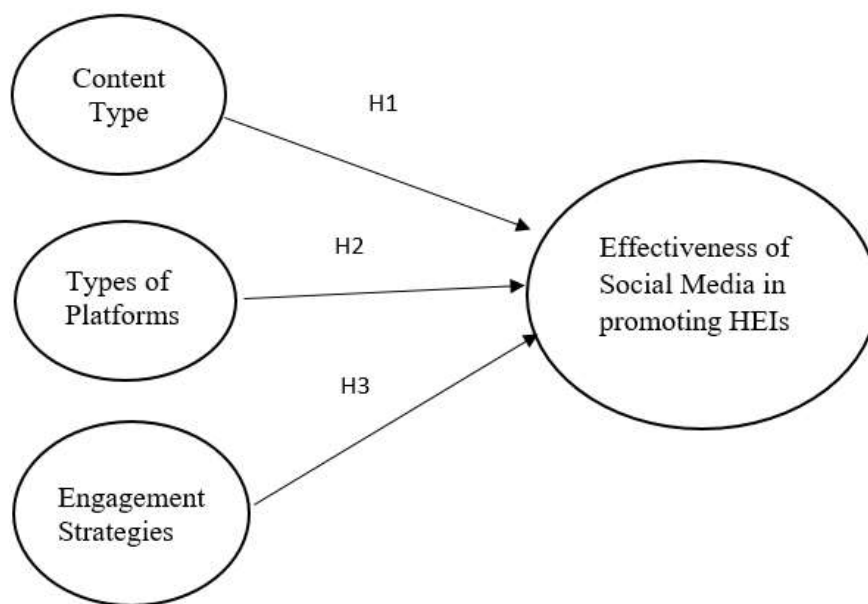
In spite of the increased adoption of social media for promotional and educational purposes, several key questions still exist:

- a) Effectiveness Metrics: Can the effectiveness of social media applications in promoting educational institutions be accurately measured and evaluated? What are the appropriate metrics to assess engagement, reach and the influence of these platforms on the institution's overall visibility? (Rosak et al., 2022)
- b) Audience Engagement: To what extent do social media applications facilitate meaningful engagement with various stakeholders, including prospective students, parents, alumni, and the broader community? (Bennett et al., 2008)
- c) Communication and Collaboration: How effectively do social media applications facilitate communication and collaboration among students, educators, administrators, and other stakeholders within the education institution? (Hui et al., 2022)

CONCEPTUAL FRAMEWORK

The independent variables that are being examined include the kinds of content that are used on social media, the variety of platforms that are used and the interaction strategies that HEIs used. In particular, the selection of material types such as text postings, photos, videos, or interactive elements is expected to impact the degree of engagement and perception of the HEIs, which in turn will impact how well they reach and connect with target audiences as a whole. (Kumar and Nanda, 2020). It is hypothesized that the performance of social media promotional campaigns as a whole is directly impacted by the efficacy of engagement methods including influencer partnerships, live streaming, and virtual campus tours. The study seeks to offer significant perspectives on HEIs' social media strategy optimization, thereby augmenting their promotional efficacy in the digital age.

Figure 1: Research Model



Research Questions

- Which types of social media content, such as campus events, academic achievements, and student testimonials, demonstrate the highest effectiveness in attracting potential students to enroll at an institution of higher education?
- How do different types social media such as Instagram, Twitter, and LinkedIn, enhance the overall effectiveness in promoting higher education institutions?
- What is the significance of employing engagement strategies, such as interactive posts, live Q&A sessions, in fostering a sense of community and creating connections between present students and alumni through social media platforms?

Research Objectives

- To identify the types of content that attract potential students to enroll at an institutions of higher education.
- To examine the effectiveness of different types of social media platforms in promoting higher education institutions.
- To analyse the engagement strategies on social media platform in creating connections among the potential students, current students, and alumni.

LITERATURE REVIEW

Content on Social Media

The content on social media significantly impacts a brand's exposure and effectiveness. Visual stimuli, interactive components, emotional appeal, consistency and brand identity are key factors (Langaro et al., 2018). Visual content, such as photos and videos attracts attention and promotes active engagement. Interactive content, like polls or quizzes extends user interaction and visibility.

Consistency and brand identity are essential for establishing a cohesive brand. Adapting content to specific social media platforms and staying updated with trends are crucial for maintaining visibility. Video content on popular platforms like Instagram, Facebook and TikTok can enhance visibility. In this study, the types of content on social media are expected to have significant influence on the effectiveness in promoting the HEIs (Kujur and Singh, 2017). Therefore, the first hypothesis is as follows:

H1: The types of content on social media significantly influence the effectiveness in promoting the HEIs.

The Usage of Social Media Platforms

Higher education institutions use various social media channels to establish connections, promote campus life, and increase general involvement (Di Tullio, et al., 2021). Facebook promotes events and communities, Twitter allows quick news distribution, Instagram showcases campus culture, LinkedIn increases credibility, YouTube offers dynamic video uploads, Snapchat and TikTok appeal to younger audiences, Pinterest offers creative images, and Reddit provides a forum for real conversations (Sharma et al., 2022). These platforms offer benefits such as better communication, visibility, and customization of content to specific audiences. By using social media strategically, institutions can effectively showcase their services, develop communities, and maintain connections with stakeholders (Icha, 2015). Hence, the second hypothesis formulated is as follows:

H2: The types of social media platforms significantly influence the effectiveness of HEI promotion.

Engagement Strategies Enhancing the Process of Promotion

Social engagement is crucial for a brand's success, and a well-planned strategy can increase audience awareness and promote products or services (Agarwal, 2020). Augmented and virtual reality (AR) and virtual reality (VR) technologies can generate visually captivating content, stimulate user-generated content, and enhance conversions. AI and VR can foster community, provide immersive experiences, and enhance accessibility for those with physical or geographical constraints (Singha, 2023). These technologies can enhance user engagement, create personalized interactions, and promote a vibrant online presence (Gupta, 2021). Hence, the third hypothesis is:

H3: Engagement strategies employed by HEIs positively influence the effectiveness of promotion.

Social Media Effectiveness in Promoting Higher Education Institutions

Social media is a crucial medium for brand information, facilitating knowledge sharing, collaboration, and human interactions. It includes blogs, forums, consumer review sites, Twitter, Blogger, LinkedIn, Facebook, and Wikis. Social media is increasingly used by social networkers, government agencies, and enterprises for marketing and advertising (Richter, 2022).

Singha (2023) highlights the importance of social media in daily life, with Facebook being a powerful digital marketing tool for businesses. Facebook ads use its extensive data to target specific user segments, such as students and higher education enthusiasts. With advanced targeting technology and a growing user base, Facebook is a cost-effective advertising medium. The platform's online communities, including Facebook, Instagram, Facebook Messenger, and WhatsApp, have grown, making it a major commercial lead generator. Marketers focus on cost per click (CPC) rather than advertising spend, aiming to allocate funding based on user behaviors. Ad performance evaluation requires multiple measures, but these cannot indicate campaign success alone (Munsch, 2021).

RESEARCH METHODOLOGY

Research Design

Descriptive research is used in this study to ensure the validity and reliability of findings. It focuses on observing a topic and gathering data without inferring cause-and-effect correlations. Descriptive research helps identify and characterize features of a specific event, such as social media content, platforms, and interaction tactics used by Higher Education Institutions (HEIs). It also provides a baseline for understanding current practices in social media and helps identify trends over time (Mirchandani and Gaur, 2019).

Sampling Design

This research uses a random sampling technique to examine the visibility of Higher Education Institutions (HEIs) on social media. The target audience is 18-55 years old, likely active social media users. Google Forms questionnaires are administered through Google Forms for easy data analysis. Researchers will distribute 200 questionnaires, converting them into QR codes for easy access.

Data Collection Method

Quantitative research approach is used for this study, as it involves the systematic collection and analysis of numerical data. Questionnaires are used to gather data, which is suitable for experiments, observations, and surveys. Aithal and Aithal (2020) believes this approach is most suitable for

hypothesis testing and elucidating the association between variables, making it the most suitable method for this research.

Proposed Data Analysis Tools Used

SPSS is a statistical program used for data analysis in social sciences and marketing research. It provides tools for analyzing and interpreting data, particularly for examining the efficiency of social media promotion techniques in Higher Education Institutions. SPSS allows researchers to produce descriptive statistics, conduct correlation analysis, and evaluate the dependability and accuracy of measurement devices. (Abu-Bader, 2021). This enhances the credibility and rigor of the research, allowing for the identification of correlations among social media engagement measures and the overall efficacy of promotional efforts.

Questionnaire Design

This research uses questionnaires divided into sections A and B, each with 3-4 questions to measure the relationship between variables and their impact on social media effectiveness. Likert scale questions are used for easier interpretation and analysis, ensuring consistency in response options.

Data Analysis

Descriptive Analysis of Respondent (Demographic Characteristics)

This study surveyed 183 social media-active respondents, with a majority of females (58.5%) and males (41.5%). Majority are aged 18-24 (64.5%), 27.3% aged 25-34, 6% aged 35-44, and 1.6% aged 45-55. Only one respondent is above 55 years old. 4.9% are academic staff in higher education institutions, 26.2% are alumni, 47.5% are current students and 21.3% are prospective students.

Table 1: Age

		Age			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	118	64.5	64.5	64.5
	25-34	50	27.3	27.3	91.8
	35-44	11	6.0	6.0	97.8
	45-55	3	1.6	1.6	99.5
	55 and above	1	.5	.5	100.0
	Total	183	100.0	100.0	

Table 2: Gender

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	107	58.5	58.5	58.5
	Male	76	41.5	41.5	100.0
	Total	183	100.0	100.0	

Table 3: Relationship of respondents with Higher Education Institutions (HEIs)

Relationship to HEI					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Academic Staff	9	4.9	4.9	4.9
	Alumni	48	26.2	26.2	31.1
	Current Student	87	47.5	47.5	78.7
	Prospective Students	39	21.3	21.3	100.0
	Total	183	100.0	100.0	

Normality Test

Normality Test of Content Types

The plot shows points clustered around the diagonal line, indicating a normal distribution. The symmetrical, positive-skew histogram curve suggests the quantiles of the sample data closely resemble a theoretical normal distribution.

Normality Test for Platform Preference

The graph shows a normal distribution, with most data points concentrated along the diagonal line, indicating quantiles resemble theoretical normal distribution quantiles. The highly symmetrical and positive-skewed normal curve demonstrates this.

Normality Test of Engagement Strategies

The plot indicates a normal distribution, with points close to the diagonal line, and the quantiles of sample data resemble the quantiles of a theoretical normal distribution, as indicated by an even normal slope.

Normality Test of Social Media Effectiveness (Institutions Visibility)

The plot shows a normal distribution, with points concentrated along the diagonal line, and the quantiles of the data sample resemble a theoretical normal distribution, with a high degree of symmetry.

Reliability Test and Validity Test

The Cronbach's alpha coefficient of 0.926 indicates exceptional internal consistency among the scale's elements, indicating robust reliability. This high value surpasses the standard for outstanding internal consistency, indicating the scale's reliability and internal coherence, allowing researchers and practitioners to trust its accuracy.

Table 4: Reliability Test

Reliability Statistics	
Cronbach's Alpha	N of Items
.926	4

Correlation Tests

Correlations between Content Type and Institution Visibility

The Pearson correlation coefficient of 0.573 shows a moderately strong positive correlation between Institutional Visibility and Content Type. This suggests a positive relationship between both variables. The p-value is less than 0.001, indicating statistical significance at the 0.01 level. Thus, H1 is accepted.

Table 5: Correlations test between Content Type and Institution Visibility

Correlations			
		Content Type 1	Institutional Visibility 1
Content Type 1	Pearson Correlation	1	.573**
	Sig. (2-tailed)		<.001
	N	183	183
Institutional Visibility 1	Pearson Correlation	.573**	1
	Sig. (2-tailed)	<.001	
	N	183	183

** . Correlation is significant at the 0.01 level (2-tailed).

Correlations between Platform Type and Institution Visibility

The Pearson correlation coefficient for Platform Type and Institutional Visibility is 0.625, indicating a moderate and positive relationship. The p-value is below 0.001, indicating statistical significance at a significance level of 0.01, and thus H2 is accepted.

Table 6: Correlations test between Platform Type and Institution Visibility

Correlations		Platform Type 1	Institutional Visibility 1
Platform Type 1	Pearson Correlation	1	.625**
	Sig. (2-tailed)		<.001
	N	183	183
Institutional Visibility 1	Pearson Correlation	.625**	1
	Sig. (2-tailed)	<.001	
	N	183	183

** . Correlation is significant at the 0.01 level (2-tailed).

Correlations between Engagement Strategies and Institution Visibility

The Pearson correlation coefficient between Engagement Strategies and Institutional Visibility 1 is 0.606, indicating a moderate and positive relationship. The p-value is below 0.001, indicating a statistically significant relationship at the 0.01 level. Therefore, H3 is accepted.

Table 7: Correlations test between Engagement Strategies and Institution Visibility

Correlations		Engagement Strategies 1	Institutional Visibility 1
Engagement Strategies 1	Pearson Correlation	1	.606**
	Sig. (2-tailed)		<.001
	N	183	183
Institutional Visibility 1	Pearson Correlation	.606**	1
	Sig. (2-tailed)	<.001	
	N	183	183

** . Correlation is significant at the 0.01 level (2-tailed).

Discussions, Conclusion, and Implications

Discussions of Major Findings

This study aimed to evaluate the impact of Content Type, Platform Type and Engagement Strategies on the effectiveness of social media promotion for Higher Education Institutions (HEIs). The results confirmed the validity of the hypothesis, showing a significant positive correlation between content types and institution visibility. The study also found a significant positive correlation between platform selection and promotional efficacy, indicating that carefully chosen platforms significantly

enhance the overall success of promotional efforts. The study also found a strong positive correlation between interactive strategies and participatory engagement tactics, confirming the importance of effective techniques in augmenting promotional impact. The findings confirm the validity of all three research aims, offering valuable insights for practitioners in creating effective and influential social media campaigns for HEIs.

Implications of the Study

This study offers practical insights for higher education policymakers and practitioners on social media policies, content development, platform usage and engagement tactics. It emphasizes the importance of understanding content types, choosing appropriate platforms and focusing on interactive methods (Adams Becker et al., 2017). The findings can be applied to marketing and communication training and regular inspections and data analytics can boost social media operations. The study also advances educational marketing theory by examining audience engagement tactics and highlighting the potential of intelligent content generation, platform selection, and interaction methods in higher education promotion.

Limitations of the study

The study on social media in promoting Higher Education Institutions faces several limitations. These include the difficulty of extrapolating results to all institutions, potential sampling bias, self-report bias, temporal issues due to ever-evolving trends and difficulty in establishing causality (Haleem et al., 2022). The study's conclusions may not be entirely indicative of the general public interacting with HEIs on social media and the success of social media promotion may be influenced by other factors. Additionally, the researchers' limited knowledge of statistical tools may hinder their ability to conduct more advanced studies or employ new methodologies, potentially affecting the reliability of the analysis.

Recommendations for Future Research

Future research should explore the impact of social media on Higher Education Institutions (HEIs). Longitudinal studies can track advertising performance, explore popular platforms, and customize promotional methods. Advanced analytics can reveal hidden trends and improve promotional effectiveness knowledge (Faizan and Saad, 2022). Real-time monitoring, user experience surveys and multi-method study designs can help adapt promotional plans and understand audience engagement with social media.

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ASSESSING CUSTOMER INTENTIONS AS KEY MEDIATORS IN EVALUATING FACTORS INFLUENCING GREEN RESIDENTIAL BUILDING PURCHASES IN SHANDONG PROVINCE

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ABSTRACT

The construction industry is a typical high-energy, high-resource-consuming, and high-polluting industry. As a building product gradually emerging under the guidance of this concept, promoting the rapid, normalized, and substantial promotion and use of green residential building is an important way to reduce building energy consumption and achieve the goal of emission reduction. The fundamental impetus for the long-term large-scale development of green residential buildings should come from the market. This means that in the future, residents' willingness to pay for green residential buildings and their payment behavior will play an increasingly important role in the promotion of green residential buildings. Therefore, it is more meaningful to accurately explore the driving factors of urban residents' willingness to pay for green residential buildings, their willingness to pay, and the stable path of the evolution of their payment behavior. This study is based on the quantitative analysis of consumers' willingness to pay for green residential buildings, and the target sample population is the tourists' group of forest tourism parks in Shandong Province, China. Descriptive and inferential analyses are conducted based on quantitative data collection methods. The theoretical model of green residential building payment response is explored, and a three-dimensional and evolutionary green residential building promotion path is constructed based on the real situation to provide a reference for the sustainable development of green buildings.

Keywords: *customer intention, green building, purchase decision, purchase decision, social responsibility, green building awareness*

INTRODUCTION

Background of the Study

The building industry plays a major role worldwide and is also one of the main contributors to the environmental crisis. The International Energy Agency (IEA) estimates that buildings account for nearly a quarter of total energy consumption globally and are responsible for about half of Green Building gas emissions (Asah-Kissiedu et al., 2021). Many buildings lack sustainable design, leading to wasted energy and increased environmental burdens (Guarini et al., 2021). Energy inefficiency in buildings increases energy consumption and carbon footprint (Czajkowski et al., 2022). The Research Report on Energy Consumption of Buildings in China (2020) states that the total energy consumption of the whole process of buildings in China accounted for about half of the country's total energy consumption in 2018 (Peng et al., 2021); among them, the energy consumption in the production phase of building materials accounted for the highest proportion; followed by the energy consumption in the operation phase of buildings, which accounted for 21.7% (Blay-Armah et al., 2022). The construction industry occupies a large amount of resources while generating a large amount of pollution (Albaali et al., 2020). According to statistics, China's construction waste accounts for about 40 percent of total urban waste (Tang, 2019). In addition, Atmosphere China 2020: China's Air Pollution Prevention and Control Process point out that more than half of the country's cities still do not fully meet the requirements of air quality standards (Zhu et al., 2023). All of this puts China's energy resources and environment under tremendous pressure (Yang et al., 2022). As the construction industry accounts for about 1/5 of China's total energy consumption, the greening of the construction industry is not only an inevitable trend in the development of the construction industry but also a necessary way to successfully achieve China's carbon emission reduction, carbon peak and carbon neutral, and other important national strategic goals (Zhou et al., 2023).

Competition in the green residential building market is becoming increasingly fierce, developers want to occupy more market share and must be familiar with and understand the behavior of residents, the key factors affecting the willingness of residents to purchase a correct assessment, in order to optimize the performance of green Buildings to meet the needs of residents, prompting more people to choose green residential buildings (Du et al., 2021). The study found that Chinese consumers mainly acquire knowledge about green residential buildings through the publicity by real estate developers and official information from the government. The promotion of green buildings, which are in the initial stage of development, have not yet popularized, depends on the increasing residents' awareness and their willingness to pay (Li et al., 2022).

The Shandong government has taken a number of policy initiatives in recent years in the area of environmental protection and sustainable development, such as increasing energy efficiency improvements and promoting green building standards (Pereira et al., 2021). These policies may influence building buyers' purchasing behavior, as government policy support and incentives can motivate building buyers to be more willing to choose green buildings. Investigating green building market trends will help understand building buyers' perceptions, attitudes, and their purchasing decision (Yang et al., 2022). Data may need to be collected through questionnaires, in-depth

interviews, and other methods to better understand their purchasing behaviors and motivations (Liu et al., 2023).

Therefore, the market promotion of green building needs to be based on the economic feasibility (premium price willing to pay) and non-economic feasibility (green consumption psychology) of both supply and demand (Chen et al., 2022), but there is a lack of incremental theoretical and empirical research that combines these two. In addition, the analysis of driving factors is the "cause" of the market-oriented development of green buildings, and the satisfaction and willingness to pay after occupancy cannot be measured directly, so it is necessary to draw on some scales to measure the psychological activities of residents (Khoshbakht et al., 2018).

Problem Statement

In the context of sustainable development and climate change mitigation, there is a growing consumer interest in green residential buildings. The adoption of these buildings plays a key role in achieving sustainable urban development and reducing the carbon footprint of the built environment (Jia et al., 2019). However, there is a lack of comprehensive research on the factors that influence consumers' decision-making process when purchasing green residential buildings. It is important to identify these factors and assess their effectiveness to better understand consumer preferences, and motivations. Such an assessment can provide valuable insights for policymakers, developers, and marketers to design effective strategies to promote the adoption of green buildings (Buryachenko et al., 2021).

Low-carbon building properties typically have higher construction costs, so understanding whether consumers are willing to pay extra to purchase these properties and their level of willingness to pay can help assess market demand and price sensitivity. The process of obtaining and processing information for the decision to purchase a home can have a significant impact on consumer choice. Understanding the level of consumer interest in information related to low-carbon buildings can help identify effective communication and education strategies that can increase market awareness (Oktiani et al., 2022). In addition, awareness of environmental protection and social responsibility is gradually becoming important factor in home purchase decisions. Exploring the degree of consumers' concern for environmental protection and social responsibility can reveal whether they will consider social and environmental factors in the home-buying process (Afridi et al., 2021). At the same time, understanding the degree of consumers' involvement in green residential buildings and low-carbon living can provide a better understanding of their preferences and motivations for home-buying decisions, and provide guidance for market positioning and promotion strategies (Wang et al., 2022).

Existing literature on green residential buildings focuses on technical aspects, energy efficiency, and environmental benefits (Liu et al., 2022). Limited attention has been given to the specific factors that drive consumer decisions and the effectiveness of these factors in influencing their purchasing behavior (Wei et al., 2021). Therefore, there is a need to fill this research gap by providing a comprehensive assessment of the factors that influence consumers' decisions to purchase green residential buildings.

This research paper aims to fill this gap by evaluating the factors that influence the decision-making process of consumers and assessing the effectiveness of these factors in driving the purchase of green residential buildings. The results of this study will contribute to the existing consumer knowledge of green residential buildings and provide practical implications for policymakers, developers, and marketers to promote consumer adoption of green residential buildings (Higueras-Castillo et al., 2020).

Research Hypotheses

H1 = Environmental knowledge information has a significant positive effect on consumer intention.

H2 = Environmental knowledge information has a significant positive effect on consumer purchase decision.

H3 = Social responsibility has a significant positive effect on consumer intention.

H4 = Social responsibility has a significant positive effect on consumer purchase decision.

H5 = Green building awareness has a significant positive effect on consumer intention.

H6 = Green building awareness has a significant positive effect on consumer purchase decision.

H7 = Consumer intention has a significant positive effect on green tourism purchase behavior.

Significance of the study

The significance of this study is that by gaining a deeper understanding of the factors influencing consumers' propensity to purchase green buildings, it can promote the development and popularization of green buildings (Ofek et al., 2022). In addition, the development of green buildings can reduce carbon emissions in the construction industry, conserve energy and resources, and promote the sustainable development of cities (Chen et al., 2022). Consumers' willingness to buy plays a key role in the market demand for green buildings, and studying the relationship between consumers' willingness to buy and green buildings can reveal the extent of consumers' demand for green building products and services, and understand their preferences, concerns, and motivations for purchasing. This will help building operators and developers to better meet the market demand, provide green building products that meet consumers' expectations, and drive the market in a more sustainable development direction (Zhang et al., 2021).

LITERATURE REVIEW

Environmental knowledge information (Attitude)

Green buildings can address environmental issues like the real estate sector's sloppiness and simplicity as well as the escalation of green Building gas emissions. It is crucial to use sustainable

building materials during both the production and design phases in order to lessen the environmental effects associated with waste disposal (Laurieri et al., 2020). Customers might not be aware of the environmentally friendly facts that green buildings represent (Zeng et al., 2019). There are differences in consumers' perceptions of green buildings, according to Majeed et al. (2022). However, it is the understanding of the green building and the clarity of their environmental benefits that will influence consumers' purchase intentions. The level of consumers' knowledge of product information will help them to make green purchasing decisions. The significance of information on environmental understanding is also evident from similar studies (Setiyarini et al., 2022). Ofek et al. (2018) claim that people's environmental knowledge is what drives them to buy green buildings.

Consumers are more likely to take into account green buildings that contribute to environmental conservation when making purchasing decisions because they have attitudes about the finiteness of natural resources and are aware of ecological crises (Wahyuni et al., 2022). People who are aware of the environment are more likely to pay for green housing. Through a poll of Hong Kong residents, people are prepared to pay a premium for environmental protection (Fabian & Lou, 2019). It has been discovered that environmentally conscious consumers take into account a product's environmental friendliness when choosing what to buy, and some even have a stronger purchase intention because of it. When customers are aware of environmental issues, they are also more likely to have the intention to pay a premium price for green housing, which is an environmentally friendly product (Ansu-Mensah, 2021). However, information about the environmental knowledge of a green Building is primarily concerned with how it has a positive impact on the environment throughout its life cycle, including production, construction, operation, and dismantling, in contrast to the environmental knowledge that consumers already possess, which has been studied in the past. Customers may not be familiar with this information, so it is important for the relevant authorities to make it known to them (Sundaraja et al., 2021). This will affect customers' willingness to pay.

Social Responsibility (Subjective Norm)

Green housing serves as a unique consumer product that highlights the status and identity of customers by highlighting their sense of social responsibility in addition to their consumption preferences (Heqi & Halabi, 2023). Consumers' green buying practices are not only a matter of environmental duty, but also a reflection of the consumer's fashion sense while making purchases, which is a way of upholding social responsibility (Gaffey et al., 2021). Customers who buy green buildings can uphold their social responsibility by reducing their negative environmental impacts to assist sustainable development and improve their social standing, claim Ofek et al. (2018). The main factors influencing customers' decisions to lease green commercial buildings are things like rising social responsibility and stakeholders' increased focus on environmental preservation and social responsibility (Abad-Segura et al., 2020). Thus, information about social responsibility has an increasing impact on consumers' buying intentions (Avotra et al., 2021). The three levels of corporate social responsibility behaviors—giving to charities, protecting the environment, and treating employees well—have a significant impact on consumers' purchase intentions and perceptions of product quality (Han et al., 2020). The developers must meet the related social obligation because the creation and maintenance of green housing places an emphasis on the harmony between people and

nature and also pays attention to the health of the residents.

Green Building Awareness (Perceived Behavioral Control)

According to related studies, consumers' own awareness of green buildings can significantly increase their willingness to pay a premium, and the process of increasing consumers' awareness of green buildings is usually accompanied by an increase in their willingness to pay (Cao et al., 2022). Giving consumers the right marketing tools will therefore raise their perception of the value of green buildings, and a higher perception will increase their willingness to pay (Amin & Tarun, 2019). However, sensible consumers will consider a product's value when making a purchasing decision, and buyers will only be prepared to pay for a product if they believe it to be more important to them (Li & Li, 2022). In addition to resource conservation and environmental protection, green housing enhances tenants' quality of life, particularly in terms of comfort and health. According to the National Association of Builders, 90% of building buyers think that buying a green building will reduce running expenses, and 73% think that green buildings will sell for more money (Rogerson, 2014). Customers make judgments about buying green buildings based on their own perceptions of their fundamental ethical standards, which influence their willingness to spend money (Naz et al., 2020).

Consumer Intention

This study places this variable in the particular context of green tourist consumption and utilizes "willingness to pay" to express it (Sogari et al., 2017). The Theory of Planned Behavior employs "behavioral intention" or "behavioral willingness" to explain it. This study employs "willingness to pay" to express it in the unique context of green tourism consumption (Carfora et al., 2021). In terms of the corresponding "actual behavior" variable, this study also defines "green tourism behavior" in the context of low-carbon tourism through research and data collection: tourists intentionally improve their lifestyle by improving the environment during the tourism process, with the goal of ensuring the tourism experience (Zhang et al., 2021), and without compromising the environment of the tourism destination. The relational hypothesis, which states that behavioral intentions will change into actual actions and that behavioral intentions will have a large beneficial impact on actual behaviors, was put forth by Mr. Fishbein in his book *The Theory of Planned Behavior* (Uddin et al., 2020). The Theory of Planned Behavior was used in later research to validate this course of action (Halim & Setyawan, 2021).

Consumer Purchase Decision

In a study conducted in the UK, most building designers mentioned that the first driver for achieving the promotion of green homes is the needs of home buyers (Hamadneh & Esztergár-Kiss, 2022). Homebuyer demand is closely related to issues of knowledge, values, and cost. Despite the issue of higher acquisition costs, homebuyers may be motivated to

purchase a green home if they are more informed and aware of the 'big picture' benefits of purchasing a green home. In order to more effectively penetrate the green home market, there is a need to increase the knowledge and environmental awareness of all green home stakeholders, and more specifically, to better disseminate information to the demand side, i.e., homebuyers, renters, investment and financial institutions, and others (García-Salirrosas et al., 2023). Individuals make rational decisions based on the information they receive, and the role of that information by stating that the willingness to act is itself a reflection of the information an individual has (Davids et al., 2021). The cognitive process is a prerequisite for consumer purchasing behavior, and there is a significant correlation between the consumer's cognitive level and subjective psychological factors and green home purchasing behavior.

The lack of information, education, and awareness related to green homes also significantly hinders the promotion of green homes because individuals may not have enough knowledge with the right sources of information to guide them in purchasing green homes (García-Salirrosas et al., 2023). For example, a lack of information and education related to green homes is a major barrier for residents, architects, developers, and others to purchase or construct green building projects (Serrano, 2019). Lack of knowledge of advanced energy-saving technologies among relevant architects in Sweden is the biggest challenge in constructing green buildings (Hanapiah et al., 2022).

RESEARCH METHODOLOGY

Target Population

Consumers of green buildings in Jinan, the capital of Shandong Province, China, are the study's defined target group. This is due to two factors: first, Jinan is one of the first green pilot cities in China, where the development of green buildings is relatively advanced; second, the Jinan government has also released a document titled "Implementation Plan for Green Building Action in Jinan" and, at the same time formulated an in-depth green building policy (Kuzmak et al., 2021).

Measures and Data Collection

Scholars found that in order to improve the validity of the statistical results, a larger sample size should be selected, at least more than one hundred, to determine the relevant variables, the reliability of the conclusions of the data analysis, and the number of selected base sample data should have a positive correlation with each other (Fitriani et al., 2021). This study mainly focuses on the residents of typical green residential neighborhoods in the sampling area as the target sample, and the questionnaire is distributed through a combination of online and offline methods.

In the study, five constructs have been used, with three-six items measuring each factor. The study measurement scales were modified and validated from previous studies using a 5-point Likert scale. For instance, items to measure CD were modified from Rafael Bravo (2008). The items to measure the SR and EK were retrieved from Shao & Enes (2019). The Items of GA were modified from Li

et.al. (2019). The items for measuring CI were measured by Rafael Bravo (2008). Details of each item statement are in the supplementary file. A total of 370 (92.5%) of the 400 questionnaires distributed in the initial phase of the survey were returned, which is consistent with the recommended sample size (Hair et al. 1998). Demographic data is presented in Table 3.1. Gender statistics show that 32.4% were male and 67.6% were female. The majority of the respondents (78.1%) were between the ages of 26 and 35.

Table 3.1 Demographic statistics.

		Valid Percent	Cumulative Percent
Gender	Male	67.6	67.6
	Female	32.4	100.0
Age	18-25	21.9	21.9
	26-35	78.1	100.0
Educational	High school	10.5	10.5
	Junior colleges	29.5	40.0
	Bachelor degree	34.0	74.0
	Master above	26.0	100.0
income	2000pmb and below	5.3	5.3
	2001-5000	15.9	21.2
	5001-7000	47.3	68.5
	7001pmb and above	31.5	100.0
	Total	100.0	

Method of Analysis

In this study, a statistical technique called Partial Least Squares Structural Equation Modeling (PLS-SEM) is used to test the research hypothesis (Pan et al., 2021). The data analysis consists of two main steps. First, various aspects such as construct validity, reliability, convergent validity, and discriminant validity are assessed (Wallace et al., 2021). Then, a structural model is constructed to evaluate the hypotheses. PLS-SEM is chosen because it is a non-parametric method that allows for the examination of latent constructs in a path model using multivariate methods (Salehi et al., 2020).

RESULTS

To test the measurement model, internal consistency (CR), factor loadings (indicator loadings), convergent validity (AVE), and discriminant validity HTMT were calculated. To assess the internal consistency of the measurements used, Cronbach's Alpha (CA) and Composite Reliability (CR) were used, which ranged from (0.820 to 0.941) and (0.881 to 0.955), thus exceeding the cut-off value of 0.70. Hair et al. (2014) identified AVE and factor loading as the two main methods for testing the convergent validity of first-order measurement models. All AVE values were shown to exceed 0.5. In summary, all measures are reliable and can be used for further analysis.

Table 4.1 Construct Validity and Reliability.

Constructs	Items	Factor Loadings	CA	CR	AVE
EK	EK1	0.928	0.941	0.955	0.81
	EK2	0.894			
	EK3	0.823			
	EK4	0.89			
	EK5	0.958			
SR	SR1	0.788	0.872	0.92	0.794
	SR2	0.94			
	SR3	0.936			
	SR4	0.815			
GA	GA1	0.764	0.82	0.881	0.65
	GA2	0.848			
	GA3	0.795			
	GA4	0.803			
CI	CI1	0.829	0.837	0.891	0.673
	CI2	0.889			
	CI3	0.754			
	CI4	0.807			
CD	CD1	0.866	0.865	0.909	0.714
	CD2	0.915			
	CD3	0.785			

The HTMT (Heterotrait-Monotrait Ratio of Correlations) and the Vernell-Lack criterion are two statistical methods for detecting inter-conceptual correlations, which are commonly applied in studies such as Structural Equation Modeling (SEM) or Factor Analysis (Factor Analysis). They are used to assess the correlation between different concepts and to test the conceptual validity of the model. HTMT values should be between 0 and 1, which is the ideal situation. If the HTMT value is much higher than 1, it indicates that the correlation between different constructs may be too high and there is a problem of discriminant validity. The data in this study indicated that the HTMT values were all between 0 and 1. Ideally, the correlation between different constructs should be lower than the correlation between the same constructs. In addition, the Vernell-Lacker criterion is a method used to assess the validity of constructs and is usually applied in factor analysis or SEM. This criterion determines the convergent validity of a construct by comparing the correlation between the construct and its counterpart (measurement item) with the correlation between the construct and other constructs. The data indicate that the convergent validity of the constructs for the results of this study meets the criteria.

Table 4.2 HTMT.

HTMT	EK	CD	CI	GA	SR
EK					
CD	0.785				
CI	0.772	0.660			
GA	0.550	0.438	0.760		
SR	0.690	0.639	0.785	0.842	

Table 4.3 Fornell-Larcker Criterion.

	EK	CD	CI	GA	SR
EK	0.837				
CD	0.822	0.712			
CI	0.652	0.557	0.792		
GA	0.441	0.408	0.635	0.807	
SR	0.591	0.554	0.647	0.734	0.724

In Structural Equation Modeling (SEM), F^2 and R^2 are two statistical metrics used to measure model fit and explained variance. R^2 is a statistical metric used to measure the fit of a model, which indicates the degree to which the variance of the dependent variable (the explanatory variable) is explained by the model. F^2 is a statistical metric used to measure the predictive accuracy, which, unlike R^2 , is concerned with the predictive power of the model. Based on the recommendations of Hair et al. (2020), the results of R^2 , effect size F^2 all meet the threshold criteria. In addition, the study further showed that the VIF values for the endogenous variables of the exogenous structure were all less than 3.3, indicating that covariance was not an issue in this study.

Table 4.4 The R^2 in the structural model.

	R^2	Adjusted R^2
CI	0.640	0.601
CD	0.561	0.548

Table 4.5 The F^2 and VIF in the structural model.

F^2	CI	CD
EK	0.350	0.029
GA	0.025	0.044
SI	0.022	0.067
CI		0.048
(Inner VIF)	CI	CD
EK	1.324	2.614

GA	2.590	2.070
SI	1.756	1.828
CI		2.310

Table 4.5 A VIF of less than 3.3 indicates that the linear correlation between the independent variables is relatively low and therefore unlikely to create serious multicollinearity problems for the model estimation.

Table 4.6 Assessment of Path Coefficient

	Original Sample (O)	Sam ple Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values	Significance
EK -> CD	0.521	0.494	0.139	3.754	0	Yes
EK -> GI	0.672	0.643	0.167	4.035	0	Yes
GI -> CD	0.601	0.585	0.174	3.454	0.001	Yes
GA -> CD	0.544	0.532	0.085	6.364	0	Yes
GA -> GI	0.697	0.634	0.162	4.314	0	Yes
SR -> CD	0.259	0.269	0.099	2.613	0.009	Yes
SR -> GI	0.198	0.196	0.058	3.405	0.001	Yes

DISCUSSION

Based on the findings of existing studies, this paper verifies the influence of environmental knowledge information, social responsibility, green building awareness, consumer intention on consumer purchase decisions. The research data show that environmental knowledge information, social responsibility, green building awareness, and consumer intention all positively affect consumer purchase decisions.

The study shows that the more information consumers learn about resource conservation, the stronger their willingness to pay for a green building. This finding further validates the hypothesis that consumers are aware of green issues such as resource conservation and global warming and consider green attributes such as resource conservation when making green purchases. Second, the more information consumers have about environmental knowledge, the stronger their willingness to pay for green buildings. Consumers' environmental knowledge refers to the information they have about environmental protection through external media publicity and information collection. The more information they have about environmental knowledge, the more they can feel the positive impact of the natural environment during the construction and production of green buildings. In this study, the theory of planned behavior is introduced for the first time into the study of consumers' willingness to pay for green homes, and it is found to be useful in examining the factors influencing consumers' behavior in this area. Consumer willingness, as a mediating factor, plays a partially mediating role between environmental knowledge information, social responsibility, and environmental building

awareness and consumers' purchasing decisions, indicating that social responsibility and environmental knowledge information not only directly influence consumers' purchasing decisions, but also indirectly influence consumers' willingness to pay for green homes through consumer willingness. This finding has a greater contribution to the study of consumer willingness and the study of green residential purchase behavior.

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The study has important implications for both academics and practitioners. However, there are some limitations that should be considered in future studies. The results of the study provide compelling evidence on how external environmental factors such as environmental knowledge, social responsibility, awareness of environmentally friendly buildings, and consumer intentions influence consumer purchasing behavior. In order to increase the authenticity of future research, it is recommended that concepts such as action-related environmental knowledge, consumer egoistic values, idealism, relativism and ecological worldviews be introduced into the study. In addition, the research question can be extended to the influential role of concepts such as normative beliefs, perceived validity, and green knowledge as a way to gain a deeper understanding. A longitudinal study can be conducted in order to understand the influencing factors of environmental factors on green building consumer behavior over a period of time. It would be wise to conduct a comparative study between horizontal and vertical cultures. This will enable us to identify the differences that exist between CDs and provide policy makers with effective strategies for success.

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EVALUATING THE FACTORS AFFECTING CUSTOMER SATISFACTION TOWARDS PET-FRIENDLY CAFES IN KLANG VALLEY, MALAYSIA

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ABSTRACT

The idea of pet-friendly cafés is still relatively new in Malaysia, but it has gained popularity after the COVID-19 outbreak. Pets play a vital role in contemporary society as a source of companionship and enjoyment for their owners. Their value also stems from an economic standpoint given the considerable annual maintenance cost that owners spend frequently. The primary goal of this research is to study the factors affecting customer satisfaction in pet-friendly cafés in Klang Valley, Malaysia. This research concentrated on key touchpoints that pet owners encounter when they first visit a pet-friendly café, including the quality of food, the service, quality of service staff, and the café environment. These are the first impressions that can leave a significant impact on customers' experiences and comprise important elements that add to their overall satisfaction during their patronage. This study used the quantitative research method whereby data was gathered through a structured questionnaire. A total of 218 targeted responses were collected from the Klang Valley, Malaysia for this study. IBM Statistical Package for the Social Sciences (SPSS) version 27 is used to conduct data analysis after the data collection. The analysis demonstrated that food quality, service quality, and café environment have a significant and positive impact on customer satisfaction in pet-friendly cafés in Klang Valley, Malaysia. Thus, all the hypotheses are supported. By offering good quality services and environment, the pet-friendly cafes create a comfortable space where pet-owners and their pets may relax and bond.

Keywords: *Pet-friendly Café, Customer Satisfaction, Food Quality, Service Quality, Café Environment*

INTRODUCTION

Malaysia, a country known for its diverse culture and gastronomic delights, is experiencing a notable and evolving trend in the food and beverage industry - the increase of pet-friendly cafés. This trend aligns with the changing dynamics of contemporary society, where pets are increasingly regarded as integral family members (McConnell et al., 2019).

The idea of pet-friendly cafés is still relatively new in Malaysia, but it has gained popularity after the COVID-19 outbreak. Lockdowns and other social distancing measures brought about by COVID-19 pandemic increased demand for indoor recreational activities and opportunities for human-animal interaction (Ng et al., 2021)

According to Consumer Report Malaysia 2023, a study that acquired responses from more than 1,000 participants in Malaysia regarding a variety of industry-related subjects, found that over fifty percent (51.1%) of Malaysians own pets. Out of the same pool, 26.4% have more than one pet, showing that having pets is a big part of their lives and not simply a trend. Remarkably, the survey also revealed that a sizable percentage (26.2%) of the 48.9% of respondents who did not own pets at the moment said they would like to do so in the future. This implies that the number of pet ownership is likely to have continued growth in Malaysia in the coming years. (standard insight, 2023)

Research Problem

Although pet-friendly cafés are becoming more and more popular, there is a visible gap in academic research that comprehensively explores the critical factors influencing their success within the Malaysian context. In particular, not much research has been done on how the food quality, service quality, and café environment at these pet-friendly cafés affect customer satisfaction. Considering these elements is essential for business owners of pet-friendly cafés, who are in high demand, as well as for Malaysia's constantly expanding pet owner community.

Research Questions

The goal of the current study is to examine the factors affecting customer satisfaction towards pet-friendly cafés in Klang Valley, Malaysia. Thus, the research questions are developed as below:

- 1) Does food quality affect customer satisfaction towards pet-friendly cafés?
- 2) Does service quality affect customer satisfaction towards pet-friendly cafés?
- 3) Does café environment affect customer satisfaction towards pet-friendly cafés?

Research Objectives

- 1) To investigate the relationship between food quality and customer satisfaction towards pet-friendly cafés in Klang Valley, Malaysia
- 2) To examine the relationship between service quality and customer satisfaction towards pet-friendly cafés in Klang Valley, Malaysia
- 3) To determine the relationship between café environment and customer satisfaction towards pet-friendly cafés in Klang Valley, Malaysia.

Significance of Research

Firstly, from the aspect of customers, especially pet owners and potential customers that love pets, play a pivotal role in sustaining pet-friendly businesses. The mutual benefits extend not only to the customers but also to the larger community. Understanding the demands and preferences of customers enables businesses to customize their offerings—whether goods or services—to effortlessly align with customer expectations. According to Manuel and Herron (2020), strategic business planning adds to a perception of value for customers, increasing happiness and contentment with their purchases that ultimately results in increased revenue for the establishment.

Through this approach, businesses can elevate the overall pet-friendly café experience, creating a space that resonates with customers and strengthens their connection to the brand. Rakuten Insight conducted a pet ownership survey in Malaysia in January 2022, and found out that 53% of individuals are pet owners. 36% of respondents reported that they do not have any pets. Pet owners who typically have the financial capacity to own a pet might be eligible to patronize a pet-friendly café; the 53% Figureure already accounts for a substantial portion of potential café customers (Malaysia: Pet Ownership Rate 2022, n.d.). Therefore, establishing and running a pet-friendly café is not only viable but also highly feasible within this pet-friendly food industry line.

In addition, this research aims to offer significant perspectives that can guide the growth and improvement of pet-friendly café culture in Malaysia by identifying the factors that may enhance the well-being and satisfaction of both pet owners and their beloved animals. Moreover, it has the potential to elevate the local food and entertainment industry, fostering a more robust and engaging community experience.

LITERATURE REVIEW

Pet-friendly

According to Rodriguez et al., (2021), there is a growing trend in the humanization of pets, as more pet owners look for places where they may socialize with their pets. These locations of interest may include, but are not limited to, malls, grocery stores, eateries, cafés, parks, beaches, workplace and airports. Pet-friendly places can accommodate customers who have pets as well as those who do not. The increasing number of pet owners who treat their pets as family members is driving the growing trend of pet-friendly businesses, notably in the hospitality industry (Buhalis & Chan, 2023). However, Hoffman et al., (2021) argued that pet ownership did not rise during the COVID-19 pandemic and pets were rehomed in increasing numbers, often with friends, family and neighbors.

Customer Satisfaction

The rule is that if the service delivery meets or exceeds the customer's expectations, the customer will be satisfied. Failure to satisfy expectations will result in frustration and the loss of a customer for future purchases (Eid et al., 2019). To attract more customers, competitors would leverage customer dissatisfaction experiences as a selling factor (Rokhman & Abduh, 2019). Businesses are always looking for the best approach to satisfy customers as their preferences, trends and purchasing habits change (Sharma & Jhamb, 2020).

Food Quality

Food quality is the key determinant of customer satisfaction (Zhong & Moon, 2020). It is also the compliance to specific standards or regulations that are managed by a country's food safety regulatory authorities (Guo et al., 2019). According to Kavakli (2021) research, there is an increased need for food quality transparency from customers. They want to know the detailed food content specifics that they are going to consume. Food quality may be attributed to a variety of aspects of the cuisine, such as appearance, menu variety, flavor, and freshness (Luong & Hussey, 2022). According to Uddin (2019), food quality was rated as the most essential component in restaurants. Essentially, customers will only go for high-quality food (Mohd-Any et al., 2019). Hence, customers wanted high-quality products and asked the business to label the food's ingredients.

The following hypothesis is established in this study based on the above literature.

H1: There is a positive relationship between food quality and customer satisfaction.

Service Quality

Shrestha (2021) concludes that the key element influencing customers' satisfaction and loyalty is service quality. To reach the satisfaction and retention of customers in the food and beverage industry, service quality plays an important role (Ahmed et al., 2022). In a study by Ge et al. (2021), they discovered that service quality is a subjective evaluation that reflects the customer's opinion of consistency, certainty, promptness, compassion, and tangibility. Providing excellent service quality has grown in popularity as a way to gain a competitive advantage (Ali et al., 2021). Shafiq et al. (2019) concluded that service quality is a subjective matter because it focuses more on the employee's involvement in supporting the effort in providing services. However, according to the research by Shamsudin et al. (2020), the findings indicate that service quality has no significant impact on customer satisfaction, whereas food quality does. Customer satisfaction and the quality of service provided by food and beverage businesses are used to evaluate effectiveness of services (Serhan & Serhan, 2019).

The following hypothesis is established in this study based on the above literature.

H2: There is a positive relationship between service quality and customer satisfaction.

Café Environment

A pet-friendly café can be more appealing and engaging than a regular café, by providing recreational opportunities, an enjoyable social setting, and pet therapy. Furthermore, research was conducted on café environments that involve furniture and interior design to encourage potential customers and pet owners for motivation to visit (Shu Meng, 2019). The first-time customers to a cafe were not coffee enthusiasts, but rather physical environment explorers or social media influencers. The facility aesthetic, lighting, atmosphere, layout, service product and social elements are all components of the physical environment (Muhammad & Lee, 2019). According to Shaare & Muhammad (2020), the restaurant environment is the most important aspect determining young adults' happiness with hipster cafés. According to AbuThahir and Krishnapillai (2018), due to the increasing number of new entrants offering creative products and services, the food industry is extremely competitive. To stand out in such a competitive industry, merchants nowadays have to prioritize their store environment. In addition to that, an inviting restaurant theme that incorporates a distinctive concept gives a competitive edge that other restaurants are unable to replicate easily (Erkmen & Hancer, 2019). According to research by Shahid et al., (2022), favorable features of a store, such as its location, layout, and engaging stimuli have an impact on customer brand loyalty since they make customers more likely to purchase there again in the future.

The following hypothesis is established in this study based on the above literature.

H3: There is a positive relationship between café environment and customer satisfaction.

Conceptual Framework

The researcher has employed another researcher's framework as the foundational conceptual framework for their study. In the prior researcher's investigation, factors influencing customer satisfaction were identified, with a focus on food quality, service quality, the physical environment of food outlets, hygiene and cleanliness, and customer satisfaction (Kumar & Bhatnagar, 2017).

The current researcher has chosen to adopt and apply certain independent variables from Kumar & Bhatnagar's (2017) framework, including food quality, service quality, and the café environment to analyze and evaluate customer satisfaction towards pet-friendly cafés in the research.

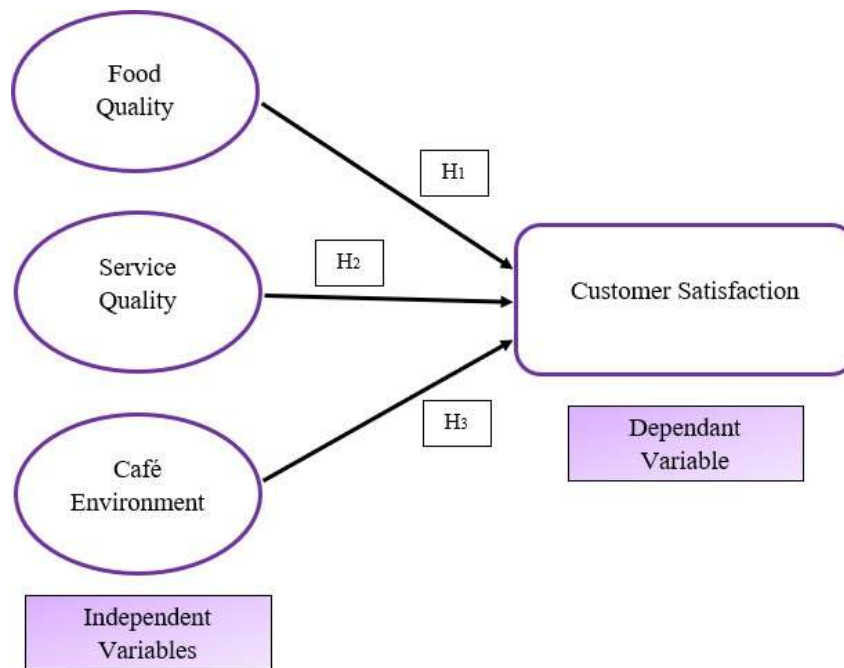


Figure 1 Conceptual Framework

METHODOLOGY

This research survey adopted a quantitative method that is useful for achieving the research's goals and objectives. In order to perform a full quantitative analysis, the responses of the target group were gathered via a sample survey with prepared questions. Therefore, the collected data would then undergo rigorous analysis and utilise statistical techniques to identify significant patterns and draw insightful conclusions about individuals' preferences and experiences affecting customer satisfaction in pet-friendly cafés in Klang Valley, Malaysia.

Sample Unit

The targeted respondents would be individuals that are 18 years old and above, with different age groups including from 18-20 years old, 21-30 years old, 31-40 years old, 41-50 years old and 51 years old and above. Individuals aged 18 and above are generally believed to have greater autonomy and decision-making competence than minors. Furthermore, the respondents will be those who have interest in contributing to the pet-friendly practices in Malaysia. The research's respondents can be either those who are pet owners, pet lovers that do not have pets, and potential customers who are interested to visit the pet-friendly establishments.

Sampling Method

The convenience method was used by the researcher, which is the most popular sampling method. Convenience sampling can be used to create objectives and hypotheses for use in more in-depth research endeavors when no other sample approach is feasible. Furthermore, convenience sampling is less expensive, faster, and simpler than other sample methods.

Sample Size

Overall, 218 targeted responses have been collected in Klang Valley, Malaysia for this study. The researcher exceeded the required sample size of 134 respondents to establish a 95% confidence level for a population of 200. The study not only meets but exceeds the stated criteria of 218 respondents, enhancing the robustness and reliability of the findings of the study (Malhotra, 2019).

Survey Location

Surveys were sent and gathered electronically using Google Forms. Participants receive a short invitation message to complete the survey. Before taking part in the survey, the participant must agree that the results will only be used for academic purposes. The responses will then be collected and recorded to enable future analysis.

Collection Method

Questionnaires were developed using Google Forms and delivered in the form of an online questionnaire survey. The full data is collected via Google Forms and then made accessible for download in an analysis-friendly format. The collected data will be downloaded into an editable spreadsheet file, which can then be used to construct a variety of chart illustrations for clearer understanding.

In this study, questions are asked in a consistent way in a structured questionnaire. The questionnaire consists of two main sections which are demographic profile in Section A; and items to measure the four constructs in Section B. The questionnaire has a total of 22 questions in Likert scale format regarding factors of demographic information, food quality, service quality, café environment, and customer satisfaction that influences the customer satisfaction towards pet-friendly cafés in Klang Valley, Malaysia. By providing a range of options rather than a binary yes or no, Likert scales can assist in decreasing bias and ambiguity.

Data Analysis Tool

To acquire a greater understanding of the research parameters, a detailed analysis was performed in this study using a series of six tests. The research begins with an examination at demographic characteristics, focusing on the most important demographic variables relevant to the study's participants. A descriptive analysis is then done to offer a complete summary of the acquired data.

Following that, the dataset is subjected to a normality test to analyze variable distribution and the suitability of statistical procedures. The reliability test was used to determine the consistency and dependability of the research tools. Pearson correlation was used to investigate the relationship between independent variables and dependent variables.

Finally, multiple linear regression was used to interpret the complex interplay of numerous independent variables on the dependent variable, providing a full and detailed view of the research findings. The study's multifaceted methodology attempts to yield relevant insights and contribute to a better understanding of the research topic.

The Literature Matrix consisting of the survey questions are shown below.

Table 1 Literature Matrix

Construct		Items	Operationalization of Variables	Measurement Scale and Related References
Demographics		Gender		Nominal
		Age		Ordinal
		Do you have a pet?		Nominal
		Have you patronized Pet-friendly Cafés before?		Nominal
		Will you be interested in visiting Pet-friendly cafes?		Nominal
		How often do you visit Pet-friendly Cafés?		Ordinal
IV1: Food quality	FQ1	I am more likely to visit Pet-friendly Cafés if the food is delicious.	(Kumar & Bhatnagar, 2017)	Five-point Likert Scale (1 for Strongly Disagree to 5 for Strongly Agree) 1- Strongly Disagree 2- Disagree 3- Neutral 4- Agree 5- Strongly Agree
	FQ2	I would prefer it if the food of Pet- friendly Cafés is fresh and of good quality.		
	FQ3	I would prefer it if Pet-friendly Cafés offered a variety of food on the menu.		

	FQ4	I am more satisfied when the food served is visually appealing in Pet-friendly Cafés.		
IV2: Service Quality	SQ1	I am more satisfied when the customer service of Pet-friendly cafes is friendly.		
	SQ2	I am more satisfied when the service staff of Pet-friendly Cafés are attentive.		
	SQ3	I would prefer food ordered to be served in a timely manner in Pet-friendly Cafés.		
	SQ4	I would prefer the service staff to be responsible for cleaning up any pet waste in Pet- friendly Cafés.		
IV3: Café Environment	CE1	I believe comfortable seating arrangement is important in Pet- friendly Cafés.		
	CE2	I would prefer it if Pet-friendly Cafés had designated pet zones.		
	CE3	I am more satisfied when there are high standards of cleanliness and hygiene in Pet-friendly Cafés.		
	CE4	I would frequently visit when the decoration of Pet-friendly Cafés follows the current occasion.		
DV: Customer Satisfaction	CS1	I am happy to visit Pet-friendly Café when I feel satisfied.		

	CS2	I would recommend the Pet-friendly Café to my friends and relatives when I feel satisfied.		
	CS3	I would revisit Pet-friendly Cafés when I feel satisfied.		
	CS4	I feel satisfied when the overall performance of the Pet-friendly Café is good.		

Data Analysis

Demographic Variables	Frequency n = 218	Percentage %
Gender		
<i>Female</i>	151	69.3
<i>Male</i>	67	30.7
Age		
<i>18-20</i>	25	11.5
<i>21-30</i>	121	55.5
<i>31-40</i>	42	19.3
<i>41-50</i>	15	6.9
<i>51 and above</i>	15	6.9
Do you have a pet?		
<i>No</i>	20	9.2
<i>Yes</i>	198	90.8
Have you patronized Pet-friendly Cafés before?		
<i>No</i>	15	6.9
<i>Yes</i>	203	93.1
Will you be interested to visit Pet-friendly Cafés in future?		
<i>No</i>		
<i>Maybe</i>	0	0
<i>Yes</i>	18	8.3
	200	91.7
How often do you visit Pet-friendly Cafés?		
<i>Never Visited</i>	15	6.9
<i>Regular Visitor (More than 3 times a year)</i>	102	46.8
<i>Visit Occasionally (1 to 3 times a year)</i>	60	27.5
<i>Visited Once</i>	41	18.8

Table 2 Descriptive Analysis of Respondent Profile

The table summarizes survey responses from a total of 218 participants, categorizing their demographic variables and preferences related to pet-friendly cafés. Majority of respondents were female, comprising 69.3%, while 30.7% were male. The age distribution shows that the largest group falls within the 21-30 age range, constituting 55.5% of the participants, followed by the 31-40 age group at 19.3%. When it comes to owning pets, a significant majority, 90.8%, indicated that they have pets. Furthermore, 93.1% of the participants have previously patronized pet-friendly cafés. Looking ahead, 91.7% expressed interest in visiting pet-friendly cafés in the future, with none outright declining. The frequency of visits to pet-friendly cafés varied, with 46.8% being regular visitors (more than three times a year) and 27.5% visiting occasionally (1 to 3 times a year). The table 2 provides a comprehensive overview of the participants' demographics and their attitudes and behaviors towards pet-friendly cafés.

Pearson Correlation		
		Customer Satisfaction
Food Quality	Pearson Correlation	.349
	Sig. (2-tailed)	.000
Service Quality	Pearson Correlation	.376
	Sig. (2-tailed)	.000
Café Environment	Pearson Correlation	.365
	Sig. (2-tailed)	.000

Table 3 Pearson Correlation

The correlation coefficients are 0.349, 0.376, and 0.365 for food quality, service quality, and café environment, respectively. A positive correlation implies that as the values of these variables increase, customer satisfaction tends to increase as well. Moreover, all correlation coefficients are statistically significant with a two-tailed significance level of 0.000, indicating that the observed relationships are unlikely to have occurred by chance. These findings suggest a robust and positive association between the identified variables and customer satisfaction, emphasizing their potential impact on overall customer contentment.

Reliability Statistics			
Cronbach's Alpha	Cronbach's Alpha Based on		N of
	Standardised Items	Items	
.763		.817	12

Table 4 Reliability Statistics

The reliability statistics demonstrate the internal consistency of a group of items measured in a survey. Cronbach's Alpha, a measure of reliability, is recorded in this case as 0.763. Cronbach's Alpha rises to 0.817 when standardised items are used, which account for the variability of item ratings. Both results indicate a moderate to high level of internal consistency among the 12 items in the survey. A higher Cronbach's Alpha suggests that the items in the survey consistently measure the same underlying construct. In this context, the reported values imply a credible and internally consistent set of survey items.

Discussion, Conclusion and Implications

Hypotheses	Significant Level (P-Value)	Results
H1: There is a positive relationship between food quality and customer satisfaction.	<0.001	Supported
H2: There is a positive relationship between service quality and customer satisfaction.	<0.001	Supported
H3: There is a positive relationship between café environment and customer satisfaction.	<0.001	Supported

Table 5 Summary of Hypotheses Findings

In conclusion, the research's findings indicate that there are favorable correlations between food quality, service quality, café environment, and customer satisfaction. All the three hypotheses are supported. These findings provide useful insights for food and beverage businesses, particularly pet-friendly cafes to emphasize the importance of food quality, service quality, and café environment in improving customer satisfaction.

In addition, the delicious choices tempt customers taste senses, promoting a unique and exclusive dining experience (Hong & Hsu, 2020). By providing attentive services, along with a pet-friendly environment, businesses create a pleasant space where customers and their beloved pets can unwind and connect. It is of the utmost importance for researchers to conduct study on pet-friendly establishments since pets are like humans. They experience a variety of emotions. Understanding and acknowledging our animal companions' emotional well-being is vital when crafting surroundings that cater to their requirements, so they, too, are able to experience enjoyment, comfort and a sense of belonging in the spaces we share with them (Gorman, 2019).

Furthermore, the findings from the study show the importance of procedures for maintaining hygiene and safety standards in pet-friendly cafes (Buhalis & Chan, 2023). Policymakers and health officials

may need to work with business owners to develop clear protocols that enable harmonious shared space between customers and their pets. This required educating café owners and employees to handle various sorts of animals as well as implementing pet-friendly infrastructure and amenities. As a result, a well-regulated and standardized approach to pet-friendly facilities could help to improve the quality of life for both pet owners and those without pets (Joo et al., 2023).

Implications of the Study

The rise of pet-friendly cafes in Malaysia may help to foster a more inclusive and compassionate community. These cafes may serve as drivers for establishing a more pet-friendly culture by encouraging ethical pet ownership and fostering pleasant relationships between pet owners, pets, and the general public. This cultural transformation has the potential to benefit both humans and animals by fostering a sense of community and social unity (Chen & Schänzel, 2019) Generally, the study reveals that the establishment of pet-friendly cafés in Malaysia has the potential to change the social landscape and contribute to the overall improvement of the nation's social and economic fabric.

Limitations of the Study

There are certain limitations to this study on pet-friendly cafes in Malaysia that should be considered. Due to the study's concentration on specific places, the findings may lack generalizability, potentially neglecting the diverse geography of the entire country. The use of self-reported data raises the likelihood of bias and inaccuracy. In addition, the study may miss evolving patterns, and the lack of viewpoints from non-pet owners, local governments, and regulators restricts the research's comprehensiveness. These constraints highlight the importance of cautious interpretation and suggest future research to address these limitations and improve the study's robustness.

Recommendations of Future Research

Future study on pet-friendly cafes in Malaysia should concentrate on several key areas to improve on the understanding and contribution to the growth of this rising trend. For example, an in-depth examination into the socio-cultural aspects impacting the acceptance and implementation of pet-friendly cafes in various Malaysian regions is required.

Understanding customer's various perspectives and tastes, along with the obstacle's café operators experience in catering to both human and pet requirements, will provide useful insights for the business. Additionally, investigating the economic impact and potential benefits of pet-friendly cafés on local communities and tourism might help policymakers and entrepreneurs create a more inviting atmosphere for such establishments.

More importantly, a longitudinal study that tracks the growth of pet-friendly café trends over time would help predict future market demands and alter business tactics accordingly. Ultimately, by studying the design and management characteristics such as safety, hygiene, and comfort for both

customers and pets of these cafes will give practical guidance for the sustained expansion of pet-friendly cafes in Malaysia (Chun-Lin & Toso, 2022)

In conclusion, there is a strong and positive correlation between customer satisfaction, café atmosphere, food quality, and service quality. The mouth-watering options entice patrons' palates and foster an exceptional and intimate eating encounter. By offering good quality services and environment, the pet-friendly cafes create a comfortable space where pets-owners and their cherished pets may relax and bond.

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EXPLORING TEACHERS' PERSPECTIVES ON THE EFFECTIVENESS OF KINDERGARTEN MUSIC EDUCATION AND DEVELOPMENT OF MULTIPLE INTELLIGENCES IN GUANGDONG, CHINA

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ABSTRACT

The role of music education in early childhood development has been a topic of significant interest among educators and researchers. In China, where the education system places a strong emphasis on academic performance, the implementation and perceived effectiveness of kindergarten music education programs warrant investigation. This study explores teachers' perspectives on the effectiveness of kindergarten music education in promoting the development of multiple intelligences in Guangdong, China. A mixed-methods approach was employed, involving the distribution of a survey to 150 kindergarten teachers and in-depth interviews with 20 of them. The findings indicate that teachers generally believe music education positively impacts the development of children's musical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal intelligences. However, challenges such as limited instructional time, insufficient teacher training, and parental focus on academic achievement were identified as barriers to the full realization of music education's potential. The study highlights the need for a more holistic approach to early childhood education that recognizes the importance of music in fostering the diverse talents and abilities of young learners.

Keywords: *kindergarten, music education, multiple intelligences, teacher perspectives, Guangdong, China*

INTRODUCTION

Introduce the Problem

The importance of music education in early childhood development has been well-documented in the literature. Music has been found to positively influence the development of various cognitive, social, and emotional skills in young children (Hallam, 2010; Schellenberg, 2004). One of the prominent theories that underscores the multifaceted benefits of music education is Howard Gardner's theory of multiple intelligences (Gardner, 1983, 2006). This theory posits that individuals possess diverse abilities, including musical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal intelligences, among others.

In China, where the education system has traditionally emphasized academic performance and test scores, the implementation and perceived effectiveness of kindergarten music education programmes are worthy of investigation. Guangdong province, located in southern China, is known for its economic development and progressive educational reforms. Understanding the perspectives of kindergarten teachers in this region can provide valuable insights into the challenges and opportunities surrounding the integration of music education and the cultivation of multiple intelligences.

Previous studies have explored the impact of music education on children's development in China (Li & Xie, 2018; Shen, 2015), but fewer have specifically focused on teachers' perspectives in the context of Guangdong. This study aims to fill this gap by investigating kindergarten teachers' perceptions of the effectiveness of music education in promoting the development of multiple intelligences among young learners in Guangdong, China.

METHOD

The Method section describes in detail how the study was conducted, including conceptual and operational definitions of the variables used in the study. Different types of studies will rely on different methodologies; however, a complete description of the methods used enables the reader to evaluate the appropriateness of your methods and the reliability and the validity of your results. It also permits experienced investigators to replicate the study. If your manuscript is an update of an ongoing or earlier study and the method has been published in detail elsewhere, you may refer the reader to that source and simply give a brief synopsis of the method in this section.

This study employed a mixed-methods approach, combining a survey and in-depth interviews to explore kindergarten teachers' perspectives on the effectiveness of music education and the development of multiple intelligences.

Participants

The survey participants were 150 kindergarten teachers from various public and private kindergartens in Guangdong, China. The teachers were selected using a stratified random sampling method to

ensure representation from different regions within the province. In addition, 20 of the survey participants were invited to participate in follow-up interviews to provide more detailed and contextual insights.

Instruments

The survey instrument consisted of three main sections: (1) demographic information, (2) teachers' perceptions of the effectiveness of music education in developing multiple intelligences, and (3) open-ended questions about the perceived challenges and opportunities in implementing music education programmes. The items were adapted from previous studies on music education and multiple intelligences (Gardner, 2006; Hallam, 2010).

The semi-structured interviews focused on exploring teachers' experiences, beliefs, and insights regarding the role of music education in nurturing children's diverse abilities, as well as the perceived barriers and facilitators to effective music education programmes in kindergartens.

Data Collection Analysis

The survey was distributed to the 150 kindergarten teachers, who were asked to complete it anonymously. The 20 teachers selected for the interviews were contacted individually and invited to participate in the follow-up discussions, which were conducted either in person or via video conference.

The survey data were analyzed using descriptive statistics and inferential analyses, such as one-way ANOVA and Pearson's correlation, to examine the relationships between teachers' perceptions and their demographic characteristics. The interview transcripts were analyzed using thematic analysis to identify key themes and patterns in the teachers' perspectives.

RESULTS

The survey results revealed that the majority of the kindergarten teachers (82%) believed that music education was effective in promoting the development of multiple intelligences among their students. Specifically, they perceived music education to be most effective in developing children's musical ($M = 4.23$, $SD = 0.81$), bodily-kinesthetic, ($M = 4.11$, $SD = 0.74$), and spatial ($M = 4.05$, $SD = 0.82$) intelligences. The teachers also reported that music education positively influenced the development of interpersonal ($M = 3.92$, $SD = 0.88$) and intrapersonal ($M = 3.87$, $SD = 0.91$) intelligences.

Further analyses showed that teachers with more years of experience ($r = 0.27$, $p < 0.01$) and those who had received specialized music education training ($F(2, 147) = 8.54$, $p < 0.001$) were more likely to perceive music education as effective in developing multiple intelligences.

Interview Findings

The in-depth interviews provided a deeper understanding of the teachers' perspectives and the contextual factors influencing the implementation of music education programmes.

Positive Impacts of Music Education

The teachers unanimously expressed the belief that music education played a crucial role in developing children's multiple intelligences. They emphasized the benefits of music education in fostering children's musical abilities, as well as its positive impact on their spatial, bodily-kinesthetic, interpersonal, and intrapersonal skills.

One teacher explained, "Music education allows children to express themselves creatively, improve their coordination and motor skills, and develop a better understanding of themselves and their peers."

Challenges in Implementing Music Education

Despite the perceived benefits, the teachers also highlighted several challenges in effectively integrating music education into the kindergarten curriculum. These included limited instructional time, inadequate teacher training, and parental focus on academic achievement.

As one teacher stated, "The school administration often prioritizes academic subjects, leaving little time for music education. Many teachers also lack the necessary training and expertise to deliver effective music lessons."

Strategies for Enhancing Music Education

The teachers suggested several strategies to address the challenges and improve the implementation of music education programmes. These included increasing the allocated time for music lessons, providing comprehensive teacher training, and engaging parents to recognize the importance of music education in child development.

A teacher commented, "If we could allocate more time for music lessons and ensure that all teachers receive specialized training, we could better harness the potential of music education to develop children's diverse talents and abilities."

DISCUSSION

The findings of this study suggest that kindergarten teachers in Guangdong, China, generally perceive music education as an effective tool for promoting the development of multiple intelligences among young learners. The teachers recognized the positive impact of music education on children's musical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal skills.

These results align with previous research highlighting the multifaceted benefits of music education in early childhood development (Hallam, 2010; Schellenberg, 2004). The teachers' perspectives underscore the important role of music in nurturing the diverse talents and abilities of young children, as conceptualized in Gardner's theory of multiple intelligences (Gardner, 1983, 2006).

However, the study also identified several challenges that hinder the effective implementation of music education programmes in Guangdong kindergartens. The limited instructional time, insufficient teacher training, and parental focus on academic achievement were perceived as significant barriers to fully realizing the potential of music education.

These findings suggest the need for a more holistic approach to early childhood education in China, one that recognizes the importance of music and other creative arts in fostering the all-around development of young learners. Policymakers and school administrators should consider increasing the allocated time for music education, providing comprehensive teacher training, and engaging with parents to raise awareness about the broader benefits of music education beyond academic performance.

By addressing these challenges and embracing a more inclusive and balanced approach to early childhood education, kindergartens in Guangdong can better leverage the power of music to cultivate the diverse talents and abilities of their students, ultimately contributing to their overall growth and well-being.

Limitations and Future Research

This study provides valuable insights into kindergarten teachers' perspectives on the effectiveness of music education in Guangdong, China. However, it is not without limitations. The sample size, though representative, may not capture the full diversity of experiences and perceptions across the province. Additionally, the study focused on teachers' views and did not directly assess the impact of music education on children's development.

Future Research

Future research could explore the perspectives of parents, school administrators, and policymakers to gain a more comprehensive understanding of the opportunities and challenges surrounding music education in early childhood settings in China. Additionally, conducting longitudinal studies to directly measure the impact of music education on the development of multiple intelligences would provide empirical evidence to support the teachers' perceptions.

Conclusion

This study provides valuable insights into kindergarten teachers' perspectives on the effectiveness of music education in promoting the development of multiple intelligences among young learners in

Guangdong, China. The findings suggest that teachers generally believe music education positively impacts the development of children's musical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal intelligences. However, the teachers also identified challenges, such as limited instructional time, insufficient teacher training, and parental focus on academic achievement, as barriers to the full realization of music education's potential.

To address these challenges and further harness the benefits of music education, a more holistic approach to early childhood education is needed. This would involve increasing the allocated time for music lessons, providing comprehensive teacher training, and engaging parents to recognize the importance of music education in fostering the diverse talents and abilities of young learners.

By embracing a balanced and inclusive approach to early childhood education, kindergartens in Guangdong can better leverage the power of music to cultivate the multifaceted development of their students, ultimately contributing to their overall growth and well-being. The findings of this study contribute to the ongoing dialogue on the role of music education in early childhood settings and have implications for educational policies and practices in China and beyond.

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VALIDITY AND RELIABILITY OF THE RESEARCH INSTRUMENT TO MEASURE AESTHETIC VALUES INTO THE PRODUCT DESIGN SKILL FRAMEWORK BASED ON COMPUTER AIDED DESIGN COURSE MODULE

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ABSTRACT

This study explores and measures aesthetic content framework skills in the CAD module and recommends its application to the Industrial Machining Technology course conducted under the TVET programme. Computer-Aided Design (CAD) is an important module in the Technical and Vocational Education and Training (TVET) programme especially for product design. The constructs of aesthetic values within the product design skill framework, based on literature are relevant to the Product Design Requirements (PDR), Product Design Concept (PDC), Product Design Detailing (PDD), and Product Design Evaluation (PDE). Face and content validity and reliability analysis (pilot study) on research instrument were conducted. The results of the interrater analysis are $\kappa = .629$ (95% CI, -0.02, 1.00), $p < .015$. It shows the expertise agree the research instruments. Meanwhile, reliability analysis shows Cronbach's Alpha for Product Design Requirement (PDR) .765, Product Design Concept (PDC) .880, Product Design Detailing (PDD) .733 and Product Design Evaluation (PDE) .793. Overall, the research instruments can be applied to explore and develop the framework.

Keywords: CAD, Aesthetic, TVET, Validity, Reliability

INTRODUCTION

In the past few decades, CAD has been the key to successful product development, as it helps companies analyze the design, identify deficiencies, and optimize the manufacturing of products. The early stage of product development is the most critical. When all product requirements are agreed upon, a strategy is determined, and an initial idea develops into a functional prototype. Therefore, CAD can play a pivotal role in ensuring the new product designs proceeds smoothly and encounter minor problems in the future.

The designer should understand consumers' problems, even the manufacturer's needs (Brunner et al., 2016; Tsegaw et al., 2017). Apart from that, designers or students need to think creatively and go through a structured methodology. 58.8% of designers cannot empower the structured method on the design process (Tsegaw et al., 2017). In the early stages of idea generation, research and technical aspects must be conducted to include aesthetic value in design (Efer, 2017). However, there are missing significant aesthetic values (Ibrahim et al., 2019). Aesthetic value is part of creativity outcome, which should be documented in the form of sketches (Kwon et al., 2018). It can develop into the final idea before proceeding to CAD and prototype process (Ranscombe & Bissett-Johnson, 2016). That documentation will reflect the designer's or student's critical thinking in problem-solving. Therefore, a study to develop aesthetic content in the product design and analysis module is needed to improve the learning process in the Industrial Machinery programme in vocational education.

Vocational colleges provide Technical and Vocational Education and Training (TVET) to the students. TVET areas of study include engineering, design, food and beverages, and management. In industrial machinery at a vocational college, the programme is considered as part of the engineering field. For the fulfillment of the study, the students are required to design products for their final projects. However, the technical students' performance analysis has shown moderate and low-level performance where the students are relatively weak and lack exposure to aesthetic values in product design (Doran & Ryan, 2017). In general, designing a product is a human-centered approach in terms of strategies, processes, and methodologies in which new product development occurs, business advances, and integration with human needs is achieved (Dyer, 2019). Therefore, the product's production must focus on quality, including aesthetics, ergonomics, materials, function, and safety. However, there are weaknesses related to creating a quality design that still occurs, especially on aesthetic values (Yehua et al., 2018).

Besides the vocational colleges, there are the similar problems reported in other higher education institutions. According to B. Saleh (2020), many product designs produced by design technology students in Institute of Teacher Education (IPG) do not show maturity in terms of the appearance and packaging of the final product. Meanwhile, Syukri et al., (2017) states that engineering students do not have concrete design concepts that meet aesthetic, ergonomic, and creative characteristics. On the other hand, creative thinking is a free burst of free and out of bounds (Chua, Y.L., Balakrishnan, B., Choong, P.Y., & Koh, 2020). But it is also connected with critical thinking to filter ideas because there are technical limitations (Becker & Mentzer, 2015). Therefore, a systematic study needs to be done to combine the creative and the technical aspects. Thus, the designer should also look to the aesthetic value to ensure consumer attraction.

LITERATURE REVIEW

The constructs for aesthetic values into the product design skill framework based on literature are relevant to the Product Design Requirements (PDR), Product Design Concept (PDC), Product Design Detailing (PDD), and Product Design Evaluation (PDE). These include design information, specifications, sketches, product design evaluation, product detail design, three-dimensional modelling, prototype, and product testing. Furthermore, the literature on the quality product design process includes aesthetics, ergonomics, colour, safety, and consumer behaviour.

The literature also explains the product design innovations using computer-aided design (CAD) software in two-dimensional and three-dimensional product design engineering drawings. At the same time, the study explores the research methodology techniques such as face and content validity and reliability analysis. Aesthetic value in design art is essential in ensuring that every art product produced is of high quality. The concept of aesthetics or beauty of a product usually depends on several complementary elements such as finesse, skill, design, function, and appearance. The idea of beauty in the aesthetic sense is satisfaction through appreciation or evaluation of art.

Aesthetics refers to a term used in various art forms and is associated with the theory of beauty. Some opinions associate it with the smoothness of a logical system of axiom argument. The word aesthetics comes from the Greek word that reads 'Aesthetikos' or Aisthesis. In science, aesthetics is a field of the philosophical study of 'The Science of Beauty' (beauty). It involves the sensitivity of the senses of observation in art. The concept of aesthetics is commonly associated with two approaches to art appreciation. The first is the desire to examine the element of beauty found in an object or image in work. Some writers describe the beauty of art objects seen based on formalistic aspects. Second, it involves expressing feelings or emotions that arise because of the experience of beauty through the appreciation of art. Feelings or emotions affect an art admirer's interpretation of what is called the meaning of iconography.

In the end, the product user or consumer will always expose and demand on aesthetics in the market. Therefore, aesthetics become an essential requirement (Y. L. Lee et al., 2016). Customers will look at aesthetics (parts and component shapes), product colors (tones, contrast, and reflection), and materials (product texture, surface, and weight) needed in the product design development process (Efer, 2017). Therefore, the involvement of consumers in determining the marketability of products in the market becomes essential. It shows that the role of consumers in deciding product design needs and properties is necessary. The survey questionnaire is one of the best methods to know the consumer's needs and demands.

Again, consumers play an essential role in determining the quality of product design, in line with the study conducted by Page, (2014) on the impact of product design sustainability. The study, using the qualitative methods, involved interviews with 36 participants. From the findings, four factors influence the consumer's additional installation of the product: functionality, effectiveness, durability, and longevity. Meanwhile, the design appearance, such as aesthetics, use of the latest technology, patents, exploration of new materials, intelligent solutions, and aspects related to culture and local features, are also considered to ensure product quality (Umentani et al., 2015). According to Mourtzis et al. (2015), acquiring this information further can also contribute to the cost-efficiency of new products in today's highly competitive market.

METHOD

This study explores and measures aesthetic content framework skills in the CAD module and recommends its application to the Industrial Machining Technology course conducted under the TVET programme. Before conducting the actual survey, research instruments should be validated and tested to ensure the reliability of the instruments. Validity and reliability are two important factors to consider when developing and testing any instrument.

Questionnaires design

There are 2 sections in the questionnaire designed. Section A aims to get the demographic data and descriptive statistic. Section A includes the user's job positions, salary, age, and educational background. Meanwhile, Section B will focus on the inference statistic. Table 3.5 shows the selected Likert scale type. Important keywords were used to measure product users' aesthetic perception of the

new product design. See table 1 for selected Likert scale.

Table 1 Selected Likert scale

Agreement level				
1	2	3	4	5
Not important	Slightly important	Moderately Important	Important	Very Important

Below is the questionnaire design for Section B. with a total of 22 items. Items number 1, 2 and 3 consist of the functional value of the product design (FV). Items number 4 to 5 consist of the social value of the product design (SV). See table 2.

Table 2 Product Design Requirement (PDR). Adapted from Toufani et al, 2017), (Maheshwari et al., 2018), (Ulrich & Eppinger, 2016), Pahl & Beitz (2013)

1.	FV1	The designed product must work properly.
2.	FV2	The designed product is easy to use (user- friendly).
3.	FV3	The designed product is durable.
4.	SV3	The designed product can address problems faced by the community.
5.	SV4	The designed product can elavate self esteem/social status.

Items number 6 to 8 consist of the form design (FO). Items 9 to 11 consist of the product's colour (CO). See table 3.

Table 3 Product Design Concept (PDC). Adapted from (Saleh, 2020), (Johan et al., 2019), (Efer, 2017),; Pahl & Beitz (2013).

6.	FO5	The form of the designed product should be in geometrical shape.
7.	FO6	The form of the designed product should be in organic shape.
8.	FO7	The form of the designed product must combine BOTH elements of geometric and organic shapes.
9.	CO8	The designed product should apply bright colours.
10.	CO9	The designed product should apply dark colours.
11.	CO10	The designed product should apply a range of tones/ colours.

Items number 12 to 14 consist of the product texture (TE). Items 15 to 17 are consist of the material selection on the product design (MA). See table 4.

Table 4 Product Design Detailing (PDD). Adapted from (Lakemond, 2016), (Giesecke et al., 2016), (Weiss & Hari, 2015), French (1971).

12.	TE12	The designed product should have an embossed texture (tactile element).
13.	TE13	The designed product should have a visual textured element (none embossed).
14.	TE14	The designed product should apply BOTH embossed and visual textures.
15.	MA15	The product should be well-designed and use affordable materials.
16.	MA16	The product should be well-designed and use high quality materials.
17.	MA17	The product should be well-designed and use durable materials.

Items 18 and 20 consist of and focus on product design safety (SA). Meanwhile, items number 21 to 22 focus on ergonomics (ER). See table 5.

Table 5. Product Design Evaluation (PDE). Adapted from (Fauzi, 2017), (Shahriman, 2020), (Eppinger, Ulrich & Young, 2020), (Mohammad et al., 2016), (Lo, 2018), French (1971);, Pahl & Beitz (2013).

18.	SA18	The designed product should be safe to use/ handle.
19.	SA19	The designed product should use non-hazardous materials.
20.	ER20	The designed product size is suitable for human form and scale.
21.	ER21	The designed product must comply with health standards.
22.	ER22	The designed product should be appropriately weighted and comfortable to use.

In this stage, the face and content validity processes will be conducted and verified with two experts panels. During the procedure, Cohen's Kappa was used to validate and evaluate the instruments. The expertise involved is one senior lecturer from the Institution of Teachers Education (IPG), and one from the industry panel. The selected panel of experts consists of individuals with teaching experience who have applied CAD in the product design process. There are two experts who will be involved in the study.

Validity refers to the extent to which a measurement accurately assesses what it is intended to measure. The instrument used must be capable of precisely measuring what is to be measured. It includes content validity, face validity, and construct validity.

Content validity involves evaluating test content to ensure and determine the domain being measured represents the entire content of the study (Bujang & Baharum, 2017). All fields or constructs reviewed to be appropriate, reasonable, and accurate is that the content of the tested item has high validity.

The selected panel of experts will check and validate the face and content of the questionnaire before the reliability analysis and actual survey. The Cohen Kappa is helpful to measure the inter-rater reliability and further determine the usability of the suitability of Aesthetic on product design skills framework for CAD courses. Cohen's Kappa statistics can be analysed when two inter-rate (Carpentier et al., 2017). Each evaluates one test per sample, or one inter-rater evaluates two tests in one sampling.

Besides, Cohen's Kappa has the assumption that inter-rater selection is pre-selected. If the inter-rater is randomly selected with more than two people, Fliess' Kappa statistics can be applied (Carpentier et

al., 2017). But due to time constraints and costs, the researchers chose 2 experts and applied Cohen's Kappa. The advantage of using Cohen's Kappa statistics is because of its procedure which has more than one independent evaluator who categorise unit samples and determine the level, importance, and stability of inter-rater agreements or agreements (Cohen, 1960). Besides, the statistical power of Cohen's Kappa can produce descriptive measurements to summarise the agreement between the two inter-rater across some issues (Warren & Bunga Pratiwi, 2016).

The experts will rate their agreement using a dichotomous assessment scale: very inappropriate, inappropriate, appropriate, and very appropriate. Stage 1 of the analysis uses the Cohen's Kappa Coefficient Valuation interpretation scale to determine whether the model developed is appropriate to each aspect of suitability presented, including elements of learning, terminology, efficiency, aesthetics, and overall usability of the model. The calculation of the value of the Cohen's Kappa Coefficient Index is done using the following formula:

$$K = (F_a - F_c) / (N - F_c)$$

Where:

K - Coefficient Value

F_a - Unit of approval

F_c - 50% expected agreement

N - Number of units tested for agreement value

Source: Asnul Dahar (2012)

Table 6 shows the Cohen's Kappa Coefficient Valuation interpretation scale. According to Landis and Koch (1977), as cited by Aya A. Mtani, (2017) stated, the Kappa value of 0.6 and above is a good index value to indicate that the model's elements have high usability.

Table 6 Scale of Kappa value interpretation

Kappa Efficiency Coefficient Value	Agreement
0.81 – 0.99	Perfect
0.61 – 0.80	Substantial
0.41 – 0.60	Moderate
0.21 – 0.40	Fair
0.01 – 0.20	Slight
< 0	No agreement

Reliability analysis

Reliability refers to the extent to which a scale produces consistent results when repeated measurements are designed (Goyal et al., 2017). When a research instrument adheres to the reliability, one can ensure that temporary factors and circumstances do not interfere. Reliability is standardizing the conditions under which measurements occur, i.e., the source from which variations occur should be removed or minimized (Tsegaw et al., 2017).

The validity of a construct aims to see to what extent an instrument accurately measures what it is supposed to measure accurately, ensuring that the test is considered valid (Yusoff, 2019). Construct validity is the most complicated because it is assessed using statistics and practical procedures (Albers et al., 2020). So before the questionnaires were administered to the study sample for the pilot study, the items first acquired face validity and validity content, followed by construct validity. Pilot studies need to be conducted, and the outcome of data obtained should be in quantitative form to determine the

value of Cronbach's Alpha coefficient.

Cronbach's Alpha coefficient (α), developed by Lee Cronbach in 1951, is used to measure reliability or internal consistency (Lee Saat & Shukri Zain, 2016). "Reliability" is the extent to which a test measures a construct. The Cronbach's Alpha test was performed to see if the survey questions measured through the Likert scale were reliable (Abdullah & Wei, 2017; Tavakol & Dennick, 2011).

In general, a value of reliability coefficient > 0.6 is accepted in the study and indicates the items in the questionnaire are reliable. Pallant (2001) states that a Cronbach's Alpha value above 0.6 is considered high reliability and acceptable index. Whereas, the value A Cronbach's Alpha less than 0.6 is considered low. Cronbach's Alpha values in the range of 0.60 - 0.80 are considered moderate, but acceptable. While Alpha Cronbach in the ranges of 0.8 and up to 1.00 is considered very good. Therefore, through this article the determination of Cronbach's Alpha values for the instruments developed is used to determine the degree of reliability of the instruments. It is also possible that the small number of items can be a contributing factor (Creswell, 2014; Sekaran & Bougie, 2016). But if the Cronbach's Alpha value is too high, the items may have a high correlation with each other (Etefi & Eniekenemi, 2016). This determination is as in Table 7 below.

Table 7 Cronbach's Alpha Value Indicator Reliability Index Classification

Cronbach's Alpha Value	
<0.80 – 1.00	Very Reliable
<0.60-.80	Reliable
>0.40 – 0.60	Quite Reliable
>0.20 – 0.40	Rather Reliable
0.0-.0.2	Less Reliable

Samplings

The criteria for validity sampling involve selecting experts who have experience related to the issues discussed, contribute views, evaluate, and reach a consensus (Pill, 1971; Stewart et al., 2017). The expert panel should have working experience from industries and a minimum of 5 years teaching experience in their areas (Jon Richard Jones, 2018). At the same time, the board of experts should voluntarily participate in the study, have enough time to participate in the research, and have the most significant knowledge in related fields (Srivastava et al., 2019; Woodcock et al., 2020).

Sampling aims refer to a sampling procedure involving a group of subjects with specific characteristics (Kim & Yeo, 2018). The number of samples for the Cohen's Kappa method must have 2 respondents (Powers, 2012) as cited (Abdul Mutalib et al., 2019). All respondents have extensive working experience relevant to the research purposes (DuBois et al., 2018). The researcher selects a total of 2 respondents in meeting the criteria of a study consisting of IPG, lecturers, and industries who are experienced and qualified in the field of product design. Table 8 shows the detailed summary of the selected expert panels.

Table 8 Selected expert panels

No	Position	Expertise area	Year (experience)
1	Senior lecturer (IPG)	Manufacturing technology and CAD	10
2	Designer	Product Design and CAD	10

For the reliability analysis, a sample of 32 participants will be selected using simple random sampling. The participants are the product users from the Klang Valley area. The sampling method follows a cluster sampling approach and is conducted as simple random sampling.

If the sample measurements are less than 30, the reliability analysis should not be attempted (Samuels, 2015). Whereas for sample sizes between 30 and 50, it is recommended that each item with a component loading less than 0.4 be removed from the scale and then rerun the Main Component Analysis (Zapf et al., 2016). If the value generated is less than 0.6, then reliability analysis cannot be attempted. If less than four items have a component indicating 0.8, the researcher should discuss this to make an accurate decision on whether a reliability analysis should be attempted (Goyal et al., 2017). The most common value is a coefficient value above 0.7 (Kline, 1999) as cited (Samuels, 2015).

FINDINGS

However, both raters agreed and gave positive feedback. Rater 1 mentioned that aesthetic values are an important element in making decisions for the user and the maker of the product. Through the visual aspects of colours and forms, consumers know that the product they are buying will align with their preferences. Work in progress such as in CAID/CAD/CAM that offers aesthetic related functions such as material visuals and product 3D rendering, are essential in determining the criteria in a product presentation. Therefore, it shows that materials can visually represent the texture of the product. Meanwhile, Rater 2 mentioned that the product design elements applied in the product design skills framework through CAD are very suitable and can enhance the design skills of students at an early stage. Additionally, instructors can apply these elements into the teaching and learning process.

The validated questionnaires were given to 32 respondents for the pilot study, of which 43.8 percent was male and 56.3% female. They are from urban areas. All completed questionnaires will be analyzed by including the associated data into the SPSS software version 20.0. Based on the questionnaires, 25 items were created. If the Cronbach's Alpha value is at 0.60 and below, it would mean that the instrument is quite reliable. If the value is more than 0.60-0.80, it would be considered reliable and acceptable (Creswell, 2014; Julie Pallant, 2020; Uma Sekaran & Roger Bougie, 2016).

The following is an analysis of the findings to determine the validity and reliability of the questionnaire for measuring the level of skills needed for product design skills. Table 11 shows the values of correlation and Cronbach's Alpha for all constructs in the instrument. The validity of each item in the questionnaire was assessed using the Corrected Item - Total Correlation and Cronbach's Alpha if Item Deleted. Whereas the value of Cronbach's Alpha is used to obtain the reliability index for each aspect or related construct

Table 6 shows the constructs of awareness regarding the importance of product design requirements into the functional and social value in product design skills. The correlation value of item score,

measured using Corrected Item - Total Correlation, ranges from 0.377 to 0.723, while the overall value of Cronbach's Alpha value is 0.765.

Table 11 shows the values of correlation and Cronbach's Alpha for the constructs of awareness regarding the importance of product design requirements in relation to functional and social value in product design skills

Construct	Item	Corrected Item – Total Correlation	Cronbach Alpha's if item Deleted	Cronbach Alpha's
Product Design Requirement (PDR)	1. Functional value 1	0.561	0.725	0.765
	2. Functional value 2	0.723	0.657	
	3. Functional value 3	0.561	0.725	
	4.Social value 1	0.618	0.690	
	5 Social value 2	0.377	0.812	

Table 12 shows the constructs of awareness regarding the importance of product design concepts in relation to colour and form in product design skills. The correlation value of the item score, measured using Corrected Item - Total Correlation, ranges from 0.571 to 0.788, while the overall value of Cronbach's Alpha is 0.880.

Table 12 shows the values of correlation and Cronbach's Alpha for the constructs of awareness regarding the importance of product design concepts in relation to the form and colour in product design skills.

Construct	Item	Corrected Item – Total Correlation	Cronbach Alpha's if item Deleted	Cronbach Alpha's
Product Design Concept (PDC)	6.Form 1	0.747	0.850	0.880
	7.Form 2	0.708	0.856	
	8.Form 3	0.571	0.882	
	9.Colour 1	0.650	0.867	
	10.Colour 2	0.788	0.844	
	11.Colour 3	0.700	0.858	

Table 13 shows the constructs of awareness regarding the importance of product design in relation to the texture and material in product design skills. The correlation value of the item score, measured using Corrected Item - Total Correlation, ranges from 0.277 to 0.744. While, the overall value of Cronbach Alpha is 0.773.

Table 13 shows the values of correlation and Cronbach's Alpha for the constructs of awareness regarding the importance of product design concepts in relation to the form and colour in product design skills.

Construct	Item	Corrected Item – Total Correlation	Cronbach Alpha's if item Deleted	Cronbach Alpha's
Product Design Detailing (PDD)	12. Texture 1	0.518	0.681	0.733
	13. Texture 2	0.744	0.615	
	14. Texture 3	0.719	0.608	
	15. Material 1	0.468	0.697	
	16. Material 2	0.277	0.757	
	17. Material 3	0.129	0.769	

Table 14 shows the constructs of awareness regarding the importance of product design evaluation in relation to the safety, ergonomic and emotional value in product design skills. The correlation value of the item score, measured using Corrected Item - Total Correlation, ranges from 0.244 to 0.724, while the overall value of Cronbach Alpha is 0.793.

Table 14 shows the values of correlation and Cronbach's Alpha for the construct of awareness regarding the importance of product design concepts in relation to the safety, ergonomic, and emotional value in the product design skills.

Construct	Item	Corrected Item – Total Correlation	Cronbach Alpha's if item Deleted	Cronbach Alpha's
Product Design Detailing (PDD)	18. Safety 1	0.724	0.746	0.793
	19. Safety 2	0.591	0.758	
	20. Ergonomic 1	0.707	0.748	
	21. Ergonomic 2	0.547	0.767	
	22. Ergonomic 3	0.681	0.754	

CONCLUSION

All experts or raters agree on the research instruments. Based on kappa value, the result shows a value greater than 0.6, indicating a good level of agreement. Kappa values from 0.40 to 0.59 are considered moderate, 0.60 to 0.79 substantial, and 0.80 outstanding (Landis & Koch, 1977). Both raters agree that the PDR items can include functional values and social values which are relevant to consumer behaviour. For PDC, they agree to include forms and colours to start the ideation. For PDD, texture and materials should be incorporated to start out detailing on the products. Lastly, PDE can include ergonomic, safety and emotional values. The three items can be applied to evaluate the finished products. From the findings, it is evident that all constructs in the research instruments can be applied.

The pilot study shows results on reliability analysis. The PDR,PDC,PDD and PDE reliability analysis show Cronbach's Alpha values greater than 0,7, According to Julie Pallant (2001) & Sekaran (1992) as cited (Khidzir et al., 2018), a value of reliability coefficient > 0.6 is accepted in the study, indicating that the items in the question are reliable. The total correlation values and Cronbach's Alpha demonstrate a very high value of validity and reliability of the instrument. Therefore, it shows that all 25 items in the questionnaires can be applied.

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RAIN PATH LOSS SIMULATION FOR SUSTAINABLE 5G SIGNAL PROPAGATION

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ABSTRACT

5G stands for the fifth generation of mobile communication standards, superseding 4G technologies. 5G technology creates new possibilities, allowing fast internet, reliable connectivity and communication among many devices. The 700 MHz, 3.5 GHz and 26/28 GHz bands have been identified for the initial deployment of 5G in Malaysia. The challenges of high frequency 5G signal transmission are high path attenuation, short transmission distance and high rain attenuation. 5G signal path loss in mobile environment is simulated using MATLAB. The simulation result is verified through theoretical calculations using rain path loss model based on ITU-R recommendations. 5G signal propagation at 700 MHz has larger coverage area than 3.5 GHz and 28 GHz due to low attenuation. 5G signal at 28 GHz is strongly attenuated by rain; therefore, alternative 5G signals at 700 MHz and 3.5 GHz are recommended for less rain attenuation. The study is significant to recommend 5G signal frequency to mitigate the effect of rain path loss for sustainable telecommunication services.

Keywords: *rain path loss, rain rate, rain attenuation, mitigation technique, 5G, signal propagation, frequency, and ITU-R recommendation.*

INTRODUCTION

Mobile communication generations have evolved rapidly over the last few decades to fulfil the demands of the Internet in the Industrial Revolution 4.0 era. There is a need to develop sustainable telecommunication infrastructure for smart cities, as advocated in United Nations Sustainable Development Goal 11, Sustainable Cities and Communities. Target 11.3 focuses on enhancing inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries. In other words, responsible smart city solutions and technologies could contribute to SDGs (Ayyoob Sharifi, et al., 2024). Smart cities could catalyze the transition to sustainable development. Therefore, this study is important to recommend 5G signal frequency to mitigate the effect of rain path loss for sustainable telecommunication services.

Based on the review of existing models to measure path loss, it is observed that not all models consider the rain correction factor in predicting path loss. Short distance is required between antenna and user for high frequency communication, especially in 5G. Environmental factors pose challenges to 5G transmission, especially heavy rain in tropical countries like Malaysia. Therefore, the objective of this study is to investigate the effect of signal attenuation at different frequencies under rainy conditions, through MATLAB simulation and theoretical calculation of rain path loss model, in order to recommend a suitable frequency to mitigate the rain effect for sustainable 5G signal propagation.

LITERATURE REVIEW

A. *Evolution of mobile technology standard*

The need for the evolution of mobile technology standards is well documented in the literature (Chowdury M. and Biswas A., 2017). First generation cellular telephone standard uses analogue technology and provides only voice service using frequency modulation (FM). The analogue communication technology is prone to interference and security threats and has a large component size. In the 2G standard, digital technology is introduced. Voice service and short messaging service are offered. 2G has low data rate, which restricts mobile computing. To include data service, enhancement of 2G was introduced. GSM introduced high-speed circuit switched data service by allowing users to use multiple time slots. In circuit switching, the resource is dedicated to a user. The circuit switching technique is not efficient for data service compared to packet switching technique. The packet-switching data service solution is known as the General Packet Radio Service (GPRS) or 2.5G. Next, new coding and modulation techniques were incorporated into the GPRS system to develop 2.75G or EDGE (Enhanced Data Rates for GSM Evolution). The third-generation (3G) system, named IMT2000, was developed to enable global roaming and multimedia support for the Internet. The 3G system provides voice services, data, and video services with much higher speed and efficiency than the 2G system. 4G or LTE was developed for mobile broadband connectivity to access the Internet with high efficiency and fast speeds.

B. *5G system use cases*

Simulation of 5G systems using MATLAB was done in previous work using the MATLAB 5G Toolbox (Houman, Z., 2018). The 5G Toolbox enables simulation, analysis, and testing of 5G wireless communications systems. There are three main IMT-2020 or 5G mobile telecommunication standard use cases (Sacha K., 2022). The first use case is eMBB (Enhanced Mobile Broadband). There are data-driven use cases requiring high data rates across a wide coverage area. There is need for high capacity for use in densely populated areas, such as stadiums. There is a need for signal availability for mobile users in cars and high-speed trains. The second use case is mMTC (massive Machine Type Communications). There is a need to support a very large number of devices in a small area, which may only send data sporadically, such as Internet of Things (IoT) use cases. The third use case is uRLLC (UltraReliable and Low Latency Communications). This is for strict requirements on latency and reliability for mission critical communications, such as remote surgery, autonomous vehicles or the Tactile Internet. In short, 5G technology creates new possibilities, allowing fast internet, reliable connectivity and communication among many devices.

C. *Review of models for path loss measurement*

Path loss measurement is reviewed using several established models. The modelling for path loss includes the analytical model for free space path loss, and the two-ray model. Free space path loss is typically used for path loss measurement between a satellite and a base station, where there are no obstacles in the transmission path. The higher the frequency, the greater the attenuation. The longer the distance of transmission, the greater the path loss. The two-ray model assumes there is a line-of-sight ray and a ground reflection. The higher the antenna height, the lower the path loss. This explains why antennas are typically installed on top of mountain or building for line-of-sight and benefit from the gain provided by ground reflection. The two-ray model gives an accurate prediction at longer distances compared to the free space model. However, both analytical models do not include correction factors. Therefore, there is a need to include correction factors in calculations. The Hata model and Okumura model are empirical models that include correction factors for terrains, such as suburban areas or rural areas. However, both Okumura and Hata models do not incorporate rain in calculation of path loss. A tropical country like Malaysia can experience rainfall of up to 164.6 mm/h in Perai, Penang, as recorded on 14 August 2017 (Malaysian Meteorological Department, 2024). Therefore, there is a need

to include the rain factor in calculating path loss. In this study, the rain path loss is analysed based on International Telecommunication Union Radiocommunication Sector (ITU-R) recommendation for the rain path loss model (Geneva, 2005).

D. 5G signal frequency

The 700 MHz, 3.5 GHz and 26/28 GHz bands have been identified for the initial deployment of 5G in Malaysia (MCMC, 2019a). The analogue switch-off (ASO) for the digital terrestrial TV switchover occurred in the third quarter of 2019 to allow the use of 700 MHz frequency for mobile broadband service (MCMC, 2019b). A comparison of the signal band is conducted. The 700 MHz signal is mainly used for rural areas or interstate highways because the 700 MHz signal can travel far, up to 10 km (Wong, 2020). The 3.5 GHz signal is mainly used in high capacity and high density areas because the 3.5 GHz signal coverage is limited. Line-of-sight propagation for the 3.5 GHz signal allows 700 Mbps transmission speeds up to 700 m distance; whereas, non-line-of-sight propagation for 3.5 GHz signal allows transmission speeds of 100 Mbps up to 1 km distance (Halvarsson B., 2018). The 28 GHz signal is used for extremely high bandwidth application. However, the 28 GHz signal coverage area is very limited up to 200 m (Azar, 2013) and easily affected by rain (Qingling and Li, 2006). The 28 GHz signal cannot penetrate walls, and requires in-building cellular aids (Hongtao Z., 2019). The 28 GHz signal is scattered by objects such as cars (Al-Samman, 2018), and interferes with fixed satellite services from 27.0GHz to 29.5GHz (MCMC, 2019a). In short, frequency selection is important to suit the type of application and requirement, especially in rainy condition.

METHODOLOGY

A. MATLAB simulation

The rain path loss model is simulated using MATLAB `rainpl` and `loglog` commands, based on International Telecommunication Union Radiocommunication Sector (ITU-R) recommendation, for wave propagation from 1 GHz to 1000 GHz for 1 mm/h light rain, 3 mm/h moderate rain, and 10 mm/h heavy rain and 30 mm/h extreme rain. The range between the transmitter and receiver is 1 km. The results are compared to theoretical calculations from the ITU-R rain path loss model.

B. Theoretical calculations

The ITU-R rain path loss model (Geneva, 2005) has the following parameters:

- Rain rate, R is measured in mm/h. Usually long term statistical rain rate, $R_{0.01}$ exceeded for 0.01% of the time is used. The rain rate can be categorized as follows:

Very light rain: precipitation rate is < 0.25 mm/hour

Light rain: precipitation rate is between 0.25mm/hour and 1.0mm/hour

Moderate rain: precipitation rate is between 1.0 mm/hour and 4.0 mm/hour

Heavy rain: precipitation rate is between 4.0 mm/hour and 16.0 mm/hour

Extreme rain precipitation rate is between 16.0 mm/hour and 50 mm/hour

- Geometric distance between transmitter and receiver, d is measured in km.
- Frequency of signal, f is measured in GHz.
- Scale factor for rain path loss model

$$r = \frac{1}{0.477 d^{0.623} R_{0.01}^{0.073} f^{0.123} - 10.579(1 - e^{-0.024d})}$$

- Coefficients k and α are determined as functions of frequency, f (GHz), in the range from 1 to 1000 GHz, and is dependent on polarization.

For horizontal polarization

$$k = k_H$$

$$\alpha = \alpha_H$$

For vertical polarization

$$k = k_V$$

$$\alpha = \alpha_V$$

- Effective propagation distance is measured in km

$$d_{eff} = dr$$

- Specific attenuation in dB/km

$$\gamma_R = kR^\alpha$$

- Total signal attenuation due to rain in dB is

$$L = \gamma_R d_{eff}$$

RESULTS AND DISCUSSIONS

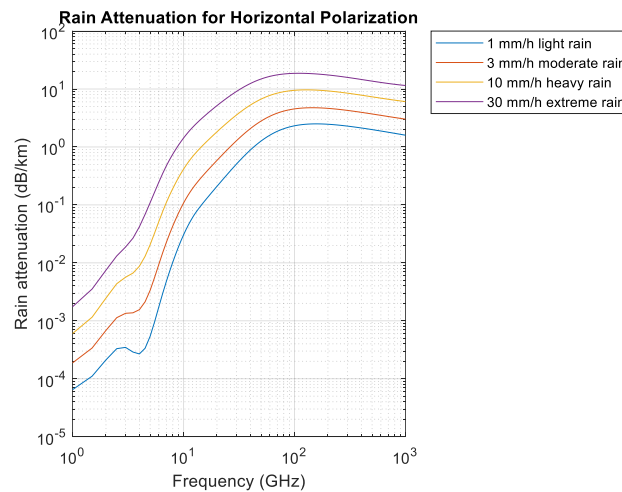


Figure 1. Rain Attenuation for Horizontal Polarization

The rain path loss model simulation using MATLAB `rainpl` and `loglog` commands, for wave propagation from 1 GHz to 1000 GHz for 1 mm/h light rain, 3 mm/h moderate rain, 10 mm/h heavy rain, and 30 mm/h extreme rain. The range between the transmitter and receiver is 1 km.

Figure 1 shows the higher the rain rate, the larger the signal attenuation. This shows that signal transmission is best performed during sunny weather. Droplets in the air reduce signal strength, with different-sized droplets affecting specific frequencies in the signal.

Figure 1 shows that the higher the frequency of signal, the greater the signal attenuation due to rain. For example, a 5G signal at 28 GHz (3.203 dB/km) experiences significantly greater signal attenuation than a 5G signal at 3.5 GHz (0.006653 dB/km) under heavy rain of 10 mm/h. This suggests that the performance of a 5G signal at 28 GHz is strongly affected by rain. Alternative 5G signals at 700 MHz and 3.5 GHz are recommended for less rain attenuation. Space diversity or antenna diversity should be adopted to incorporate more receiving paths, to mitigate rain.

The rain attenuation for MATLAB simulation (3.203 dB/km at 28 GHz and 0.006653 dB/km at 700 MHz) and theoretical calculations (3.202 dB/km at 28 GHz and 0.006654 dB/km at 700 MHz) from ITU-R rain path loss models are in good agreement as shown in Table I

Table I: Comparison of Rain Attenuation Between Theoretical Calculation and MATLAB Simulation for 5g Signal Propagation in Mobile Environment Under Rainy Conditions

Parameter	MATLAB Simulation		Theoretical Calculation	
Polarization	Horizontal	Horizontal	Horizontal	Horizontal
Rain rate (mm/h)	10	10	10	10
Frequency (GHz)	28	3.5	28	3.5
Rain attenuation (dB/km)	3.203	0.006653	3.202	0.006654

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, there is a need to investigate rain path loss for 5G signals in a tropical country that experiences rain, such as Malaysia. Existing free space, two-ray, Okumura and Hata models are insufficient as they do not include the rain correction factor for accurate prediction. Therefore, the rain path loss of 5G signal propagation is investigated. MATLAB simulations are performed using the `rainpl` command and validated using theoretical calculations from the ITU-R rain path loss model. Simulation results show that the higher the rain rate, the greater the signal attenuation. This shows that signal transmission is best performed during sunny weather. The higher the frequency of signal, the greater the signal attenuation due to rain. This shows that short distances are required between antenna and user for high frequency communication. Alternative 5G signals at 700 MHz and 3.5 GHz are recommended for less rain attenuation compared to 28 Hz, ensuring sustainable 5G signal propagation under rainy conditions.

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DVB -T2 AND DVB-S2 SIMULINK: GREEN MODELS FOR ASEAN ENGINEERS

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ABSTRACT

Digital Video Broadcast is delivered in ASEAN using satellite and terrestrial platform. The 1st generation DVB-Terrestrial (DVB-T) and DVB-Satellite (DVB-S) systems have been replaced by 2nd generation DVB-T2 and DVB-S2 which carry more payload and are more energy efficient. 1st generation DVB-T used 16-QAM whilst DVB-S used QPSK to transmit Standard Definition TV. However, DVB-T2 and DVB-S2 utilises advanced forward error correction technique with Low Density Parity Check (LDPC) coding that enables the transmission of modulated data over noisy channel. DVB-T2 uses 256 QAM whilst DVB-S 2 uses 8PSK resulting in the attainment of High Definition TV delivery over channels requiring high bit rates. Hence, transmitters are consuming less energy with reduced carbon footprint and can be considered as part of green technology. This paper uses Matlab/Simulink software to analyse the performance of DVB-T2 and DVB-S2 under different configuration modes. Both practitioner and academician can conduct research in the laboratory in order to improve field performance. The DVB-T2 and DVB-S2 Simulink software can be regarded as Green models as the laboratory tests reduces manpower and energy consumption compared to testing at the transmitter sites.

Keywords: DVB-T2, DVB-S2, LDPC , 8PSK , 256 QAM

INTRODUCTION

Analogue Switch Off (ASO) of terrestrial TV signals have occurred internationally and a number of ASEAN member nations namely Brunei, Singapore, Malaysia, Vietnam and Thailand have stopped transmission before 2020, which was in accordance to the timeline agreed by ASEAN (GSMA,2018). On 2 November 2022, Indonesia ceased transmission of analogue PAL Colour TV and implemented Digital Switch Over (DSO) of Digital Terrestrial TV (Sjuchro et al., 2023). It must be noted that terrestrial transmission cannot provide full coverage in countries such as Indonesia, Philippines or Malaysia. Indonesia and Philippines consist of many islands whilst Malaysia is geographically separated by the South China Sea, into Peninsula Malaysia and East Malaysia. The Digital Video Broadcast- Terrestrial-2 (DVB-T2) network is linked with Digital Video Broadcast-Satellite-2 (DVB-S2) network to overcome the barriers of providing cost efficient and full coverage of DTV even in remote areas (Fischer,2020). In Malaysia, DVB-T2 transmitters have been installed in Peninsula Malaysia, Sabah and Sarawak but Digital TV signals are relayed from Kuala Lumpur to Kota Kinabalu (Sabah) and Kuching (Sarawak) utilising DVB-S2 signals via MEASAT 3d space satellite with C band transponders.

1st generation DVB-T used a Forward Error Correction (FEC) subsystem consisting of Reed Solomon concatenated with Convolutional codes, 64 QAM modulation and 8K OFDM carriers (DVB, 2015). DVB-S used the same FEC subsystem but with QPSK modulation (DVB, 1997). However, 1st generation systems had limited payload and could only deliver Standard Definition TV (SDTV) and

have been replaced by 2nd generation systems which carry more TV channels and are more energy efficient.

DVB-T2 uses FEC subsystem consisting of Bose Chaudhuri Hocquenghem (BCH) code concatenated with Low Density Parity Check Code (LDPC) enabling the extension of modulation order from 64-QAM to 256-QAM and increase from 2K to 32K OFDM carriers (Richardson et al., 2008)(Johnson et al., 2008)(DVB, 2023). DVB-S2 also incorporates similar Forward Error Correction (FEC) subsystem enabling almost error free operation of higher level Multi Phase Shift Keying (MPSK) constellation such as 8PSK 16 Amplitude PSK (APSK) and 32 APSK (DVB, 2014). The improvements have enabled the transmission of High-Definition TV (HDTV) and UHDTV (Ultra High-Definition TV).

The recent Digital Switch Over in ASEAN has created a demand for engineers who have the technical knowledge in implementing DVB systems with the various configuration modes. It is a daunting task for ASEAN engineers, who have to analyse the signal flow process and thus specify the correct mode of operation in the field. Therefore, it is indeed timely to introduce training courses using Matlab/Simulink models to enhance the learning process of new engineers more effectively.

The green advantages of DVB-T2 and DVB-S2 are electrical power savings, more efficient audio and video compression techniques using High Efficiency Video Coding (HEVC)/H265, and smaller carbon footprint. Additional savings are realised from reduction in facility space, cooling, construction, and maintenance costs.

LITERATURE REVIEW

The performance of 2nd generation DVB systems has been a subject of research by several engineers. In 2013, an Egyptian study was conducted with DVB-T2 Simulink, but the research was confined to 16K OFDM subcarriers and 64 QAM (Amin et al., 2013). In 2022, research was conducted in Indonesia using DVB-T2 Simulink designed with 32K subcarriers and 64 QAM (Salam, 2022). The project also examined transmission over Rayleigh and AWGN channel with various LDPC code rates. The main limitation of this project was that 64 QAM could only be used for SDTV and hence the study should have been extended to 256 QAM which is necessary for HDTV transmission.

In 2012, a Malaysian study was conducted with DVB-S2 Simulink using constellation modes of QPSK, 8PSK, 16 Amplitude PSK and 32 APSK (Azarbad, 2012). It is noteworthy to mention that 16 APSK and 32 APSK constellation modes are to be used in Digital Satellite News Gathering (DSNG) and conforms to ITU Recommendations BO 1784-1 (DVB, 2016). 16 APSK and 32 APSK were found to be more susceptible to noise and should not be used for direct broadcasting. In 2019, a study in Pakistan was conducted with DVB-S2 Simulink using 8 PSK and the number of LDPC iterations was counted. The limitation was that comparison of QPSK and 8PSK was not undertaken.

There haven't been any papers published on the joint research of both systems which is necessary as they share common FEC subsystem. It is more effective for ASEAN engineers to learn both the terrestrial and satellite system as part of a combined training course, reducing the number of learning hours and leading to the engineers' better understanding of the concept of the FEC subsystem.

Till now, there has been no Simulink analysis of DVB-T2 performance with 32 K carriers and 256 QAM over various propagation channels. A proper analysis is needed as there is fixed as well as mobile reception of DVB-T2 signals. In addition, there are hardly any papers published on the High Power Amplifier (HPA) performance based on Saleh or Rapp model.

Hitherto, there has been no comparative analysis of DVB-S2 performance between QPSK 8PSK and 16 PSK using Matlab simulation. Although the previous Malaysian project studied various constellation modes, it did not include 16 PSK, which is more suitable for direct broadcasting instead of 16 Amplitude PSK.

PROBLEM STATEMENT

Economical methods of analysing the performance of the various configuration of DVB systems are needed. In addition, testing of DVB signals must not cause interference to viewers, adjacent satellites and to other ASEAN member countries as there is overlap of terrestrial TV coverage at each country's border.

Simulink models can provide less complex method of analysing the performance of DVB. Separate Simulink models have been designed to record the response of the DVB-T2 and DVB-S2 under different code rates and constellation modes. Past research on DVB-T2 was mostly confined to 2K, 8K, 16 K subcarriers, 64 QAM and simplified propagation channel. Designing a model with 32 K subcarriers, 256 QAM and propagation channels, which better represent multipath behaviour is more complicated because the parameters must be tuned for optimum performance. In the case of DVB-S2, research was mostly confined to QPSK and 8 PSK constellation. Thus, the DVB-S2 model has been modified to simulate system behaviour to include 16 PSK.

METHODOLOGY

The research strategy undertaken is based on the simulation of DVB system under various configuration modes and measuring performance with various tools such as Spectrum Analyzer and Constellation Diagram.

The DVB-T2 Simulink programme consists of an end-to-end transmitter receiver chain with a switchable HPA representing either the Saleh or Rapp model. The technical parameters measured are Signal to Noise Ratio (SNR) and Bit Error Rate (BER). The DVB-S2 Simulink model was modified to allow for the extension of constellation modes to 16 PSK. The technical parameters measured are Bit Error Rate (BER), Packet Error Ratio (PER) and Number of Iterations needed by the LDPC decoder. If $PER < 10^{-7}$, the target of Quasi Error Free (QEF) performance is achieved. The number of iterations indicates the performance of the LDPC decoder under an increasing noise level and DVB-S2 standard specifies maximum iterations to be 50.

DVB Simulink Models

Simulink models were designed based on DVB-T2 and DVB-S2 technical specifications and run under various configuration modes as discussed in the next two subsections.

DVB-T2 Simulink Model

The Simulink model capable of simulating the various configurations is illustrated by Figure 1. For clarity, the transmitter chain is shaded in cyan and receiver chain is shaded in yellow. The data from the transmitter and receiver are compared for Bit Error Rate (BER) calculation.

At the transmitting front end, a Random Integer Generator acting as video/audio data source delivers 1504 integers which can be regarded as an MPEG-2 Transport Stream. The 1504 integers are converted into 31584 bits and padded to 32220 bits which act as the data field for the formation of Baseband Frame. The samples per frame = 50000 samples and the sample time = $2 \times 1.385 \times 10^{-8}$ s setting the spectrum at 5MHz, which is the video transmission bandwidth of the DVB-T2 signal in Malaysia.

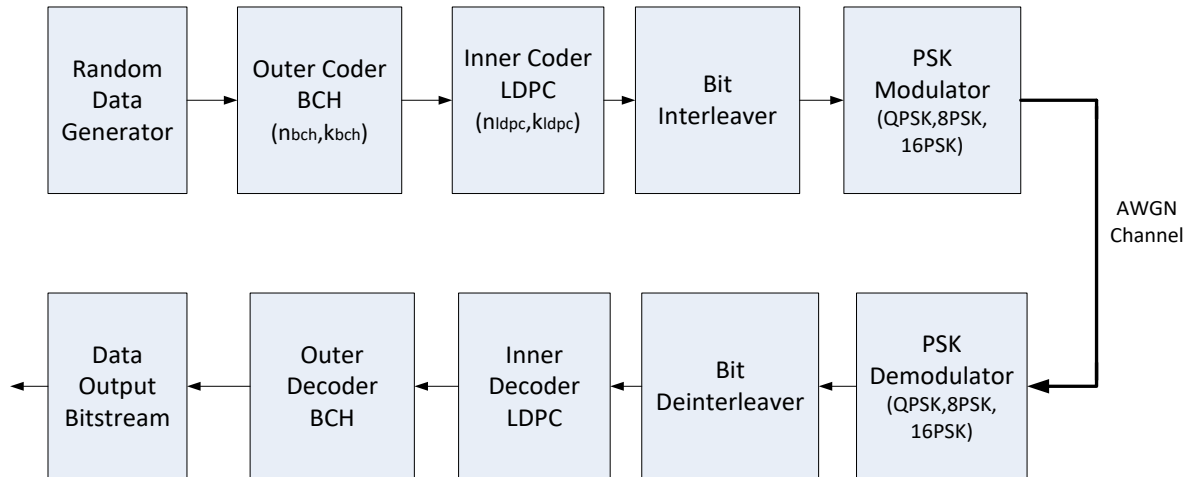


Figure 2: Functional block diagram of the Matlab DVB-S2 System Simulation

If a code rate $= 1/2$ is chosen, a Baseband Frame of $K_{BCH} = 32208$ bits is formed and processed by the Forward Error Correction (FEC) subsystem consisting of an Outer Coder which is a BCH ($N_{bch} = 32400$, $K_{bch} = 32208$) encoder concatenated with an Inner Coder comprising a LDPC ($N_{ldpc} = 64800$, $K_{ldpc} = 32400$) encoder. The frames are interleaved and modulated with a QPSK/8PSK/16PSK constellation and transmitted over an Additive White Gaussian Noise (AWGN) channel. The AWGN channel represents the uplink path from the earth station to the space satellite and the downlink path to the small parabolic antenna at the home.

SIMULATION RESULTS & DISCUSSION

The comparative performance of each DVB System is analysed separately and discussed in two subsections.

DVB-T2 Model

The selection of AWGN, Rician and Rayleigh propagation channels as well choice of Saleh or Rapp HPA model affects overall performance. Table 1 shows the results obtained using the 3 different propagation channels and both HPA models.

Table 1: Performance of 32 K DVB-T2 256 QAM Code Rate:1/2 with High Power Amplifier based on Saleh and Rapp model over AWGN, Rician and Rayleigh channels

Signal to Noise Ratio SNR (dB)	High Power Amplifier - Saleh model			High Power Amplifier -Rapp model		
	Rayleigh Channel	Rician Channel	AWGN Channel	Rayleigh Channel	Rician Channel	AWGN Channel
	Bit Error Rate (BER)	Bit Error Rate (BER)	Bit Error Rate(BER)	Bit Error Rate (BER)	Bit Error Rate (BER)	Bit Error Rate (BER)
0	1.9832e-01	1.9831e-01	1.9832e-01	1.9832e-01	1.9833e-01	1.9833e-01
10	1.9827e-01	1.9825e-01	1.9825e-01	1.9831e-01	1.9830e-01	1.9821e-01
20	1.9814e-01	1.9805e-01	1.9802e-01	1.9826e-01	1.9822e-01	1.9821e-01
30	1.9769e-01	1.9736e-01	1.9730e-01	1.9808e-01	1.9795e-01	1.9792e-01
40	1.9629e-01	1.9543e-01	1.9522e-01	1.9748e-01	1.9705e-01	1.9696e-01
50	1.9437e-01	1.9407e-01	1.9403e-01	1.9583e-01	1.9499e-01	1.9477e-01

Figure 3 below illustrates the graph plotted from the data obtained from Table 1. DVB-T2 performance over the three different propagation channels decreases in the following order from AWGN, Ricean to Rayleigh. The decrease in performance over the Rayleigh channel shows mobile TV reception is not as good as fixed reception. The Rapp class of HPA model considers only AM/AM distortion whilst the Saleh class considers AM/AM as well as AM/PM distortion. It should be noted that slight distortion occurred, and pre-distortion techniques were introduced to correct the signal. It can also be deduced that HPA based on the Saleh model performs better than the Rapp model because the Saleh model represents the non-linearity of the Solid State HPA more accurately.

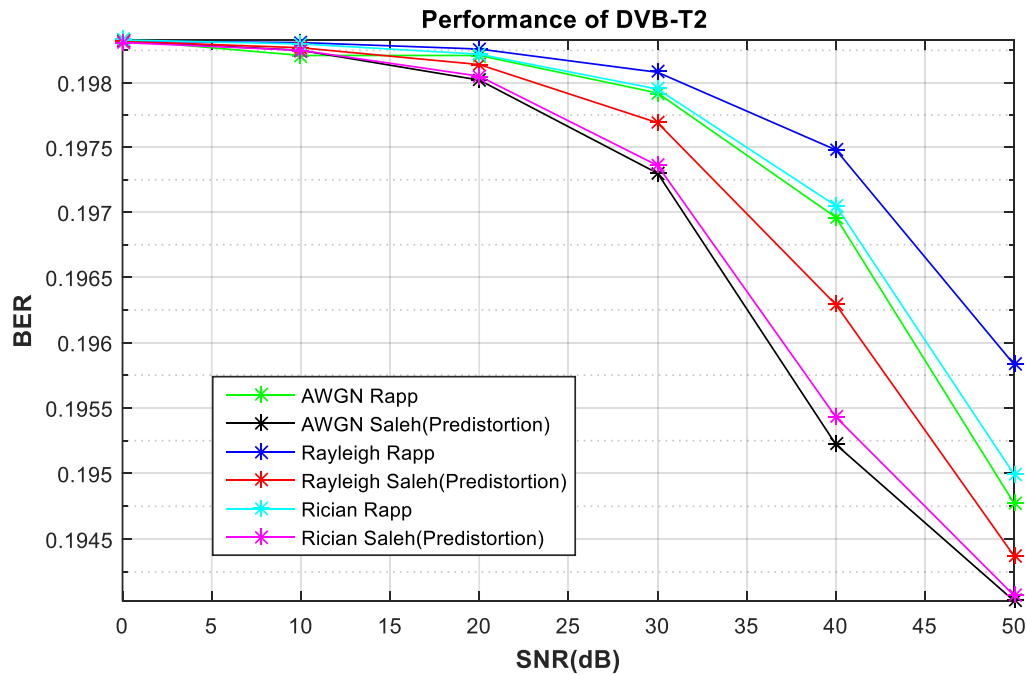


Figure 3: Performance of DVB-T2 over various propagation channels

Figure 4 below shows the 256 QAM constellation taken at the transmitter and whilst Figure 5 shows the display taken at the receiver. Although slight distortion is evident, the FEC subsystem has corrected most errors.

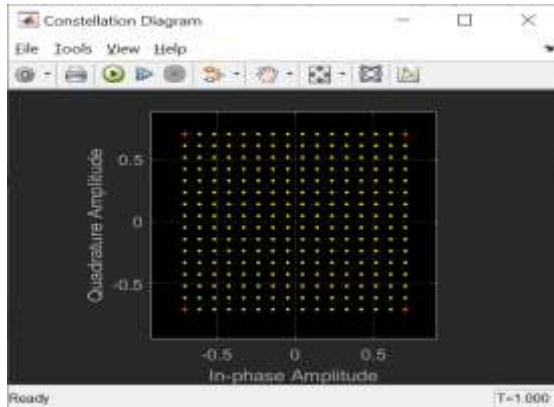


Figure 4: 256 QAM display at Transmitter

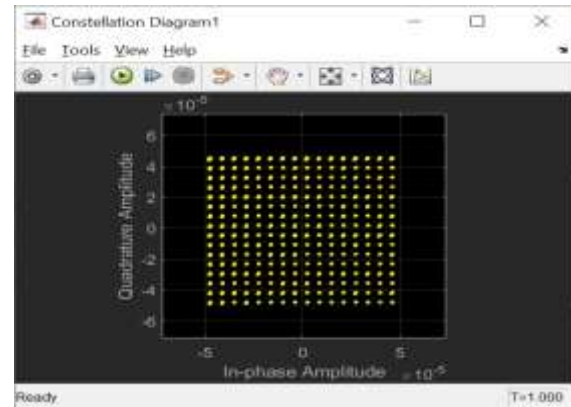


Figure 5: 256 QAM display at Receiver

The OFDM spectrum with a bandwidth of 5 MHz is shown by Figure 6 for the transmitter output and by Figure 7 for the receiver input. Results from AWGN and Rician channels are not shown as space is limited. As expected, there is a loss of amplitude of the OFDM signal as it propagates along the Rayleigh channel.

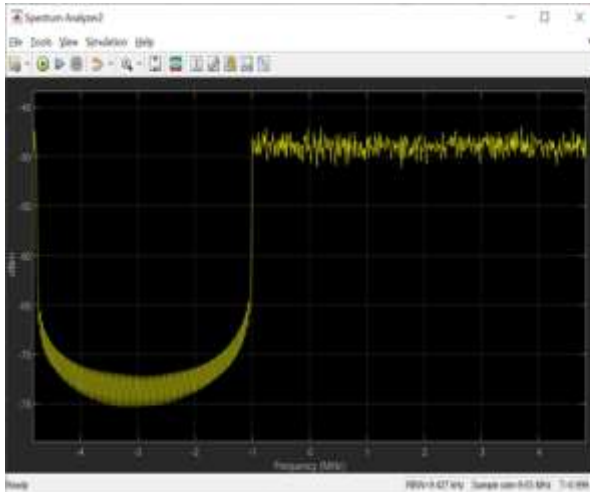


Figure 6: OFDM spectrum at Transmitter

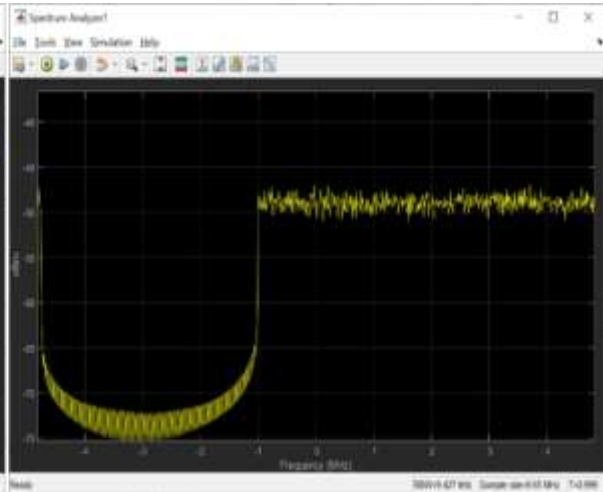


Figure 7: OFDM spectrum at Receiver

DVB-S2 Model

As space is limited, only simulation results of certain configurations such as QPSK 9/10 and 3/4, 8 PSK 1/2 and 16 PSK 1/2 are shown in the following pages. Changes in the code rates are met by adjusting the N_{bch} , K_{bch} and K_{ldpc} parameters and are reflected in the output of the respective Outer and Inner Coders. These parameter changes provide easily understood explanation for the operation of the Baseband Frame stage and FEC subsystem. The selection of QPSK, 8PSK or 16 PSK affects overall performance and is easily visualised through the constellation display. Data shown are the BER at the demodulator output, the BER at the LDPC decoder output, and the PER of the end-to-end system together with the measured Signal to Noise Ratio (SNR) at the receiver input.

Table 2a: DVB-S2 Configuration Mode: QPSK, Code Rate: 9/10,
 $K_{bch} = 58192$, $N_{bch} = 58320$, $K_{ldpc} = 58320$, $N_{ldpc} = 64800$

Es/No dB	Demodulator Output BER	LDPC Decoder Output BER	Number of Iteration	Packet Error Ratio (PER)	Signal to Noise Ratio (SNR) dB
0.0	1.58e-01	1.58e-01	50	1.00e+00	0.01
0.5	1.45e-01	1.45e-01	50	1.00e+00	0.51
1.0	1.31e-01	1.31e-01	50	1.00e+00	1.00
1.5	1.17e-01	1.17e-01	50	1.00e+00	1.50
2.0	1.04e-01	1.03e-01	50	1.00e+00	2.00
2.5	9.09e-02	9.09e-02	50	1.00e+00	2.51
3.0	7.89e-02	7.87e-02	50	1.00e+00	3.00
3.5	6.73e-02	6.72e-02	50	1.00e+00	3.49
4.0	5.63e-02	5.58e-02	50	1.00e+00	4.00

Table 2b: DVB-S2 Configuration Mode : QPSK , Code Rate : 3/4 ,
 $K_{bch} = 48408$, $N_{bch} = 48600$, $K_{ldpc} = 48600$, $N_{ldpc} = 64800$

Es/No dB	Demodulator Output BER	LDPC Decoder Output BER	Number of Iteration	Packet Error Ratio (PER)	Signal to Noise Ratio (SNR) dB
0.0	1.59e-01	1.30e-01	50	1.00e+00	0.00
0.2	1.53e-01	1.18e-01	50	1.00e+00	0.20

0.4	1.48e-01	1.05e-01	50	1.00e+00	0.40
0.5	1.45e-01	9.55e-02	50	1.00e+00	0.49
0.6	1.42e-01	7.87e-02	50	1.00e+00	0.60
0.8	1.37e-01	2.61e-04	35	3.57e-02	0.80
1.0	1.31e-01	0.00e+00	31	0.00e+00	1.0

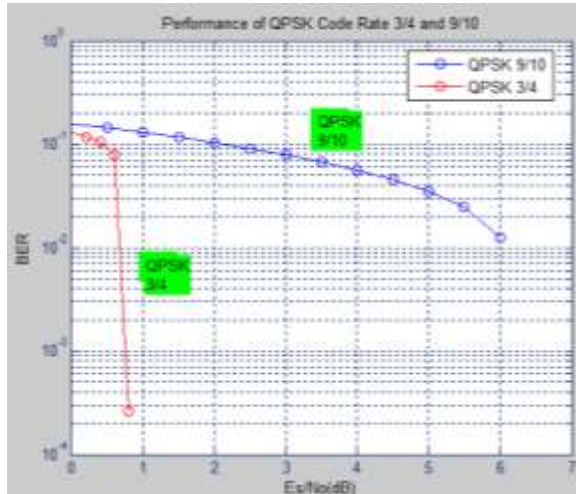


Figure 8a: DVB-S2 QPSK BER Performance

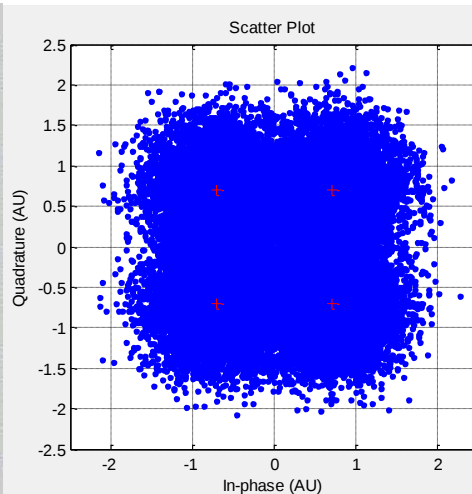


Figure 8b: QPSK Scatterplot

Data analysis from Table 2a & b indicates that QPSK performs better with a lower code rate ratio (CR) as BER reaches zero value faster if CR= 3/4 instead of CR=9/10. The results conform to theory as QPSK 3/4 is a stronger signal with more error correction capability although it can carry lesser payload. The BER plot of Figure 8a indicates that the LDPC has a waterfall region where the error curves drop steeply. The LDPC Inner Decoder does most of the error correction, leaving the BCH Outer Decoder to operate in the error floor region where the LDPC code cannot reach. Figure 8b shows the QPSK signal with its 4 constellation points which can still operate in such a noisy environment.

Table 3a: DVB-S2 Configuration Mode: 8PSK, Code Rate: 9/10

$$K_{bch} = 58192, N_{bch} = 58320, K_{ldpc} = 58320, N_{ldpc} = 64800$$

Es/No dB	Demodulator Output BER	LDPC Decoder Output BER	Number of Iteration	Packet Error Ratio (PER)	Signal to Noise Ratio (SNR) dB
0.0	2.41e-01	2.46e-01	50	1.00e+00	0.00
0.5	2.28e-01	2.34e-01	50	1.00e+00	0.50
1.0	2.16e-01	2.21e-01	50	1.00e+00	1.00
1.5	2.03e-01	2.08e-01	50	1.00e+00	1.50
2.0	1.90e-01	1.95e-01	50	1.00e+00	2.00
2.5	1.77e-01	1.82e-01	50	1.00e+00	2.51
3.0	1.65e-01	1.69e-01	50	1.00e+00	3.01
3.5	1.52e-01	1.56e-01	50	1.00e+00	3.50
4.0	1.41e-01	1.44e-01	50	1.00e+00	4.00
4.5	1.28e-01	1.32e-01	50	1.00e+00	4.51

5.0	1.17e-01	1.20e-01	50	1.00e+00	5.00
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Table 3b : DVB-S2 Configuration Mode : 8PSK , Code Rate : 3/4 ,
 $K_{bch} = 48408$, $N_{bch} = 48600$, $K_{ldpc} = 48600$, $N_{ldpc} = 64800$

Es/No dB	Demodulator Output BER	LDPC Decoder Output BER	Number of Iteration	Packet Error Ratio (PER)	Signal to Noise Ratio (SNR) dB
0.0	2.41e-01	2.57e-01	50	1.00e+00	0.00
0.5	2.29e-01	2.44e-01	50	1.00e+00	0.50
1.0	2.16e-01	2.30e-01	50	1.00e+00	1.01
1.5	2.03e-01	2.17e-01	50	1.00e+00	1.51
2.0	1.91e-01	2.04e-01	50	1.00e+00	2.00
2.5	1.77e-01	1.90e-01	50	1.00e+00	2.51
3.0	1.66e-01	1.78e-01	50	1.00e+00	3.00
3.5	1.53e-01	1.64e-01	50	1.00e+00	3.51
4.0	1.41e-01	1.52e-01	50	1.00e+00	4.01
4.5	1.29e-01	1.39e-01	50	1.00e+00	4.50
5.0	1.17e-01	1.26e-01	50	1.00e+00	5.00

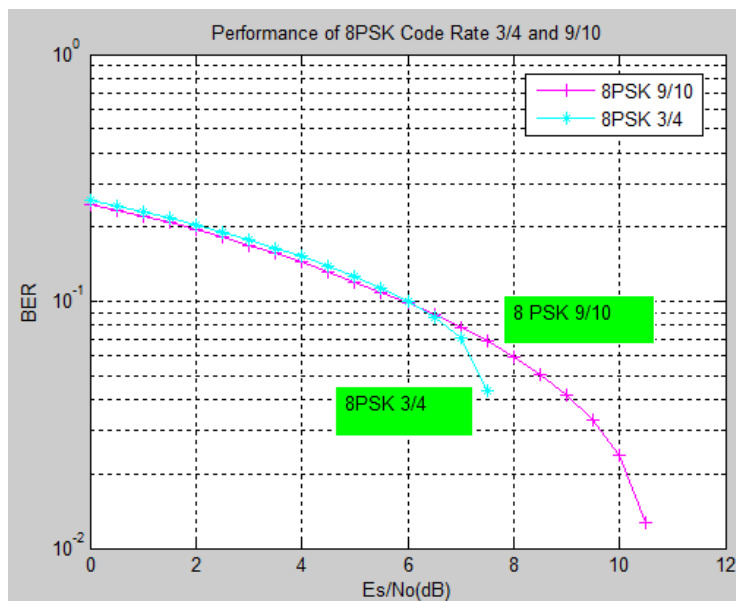


Figure 9a: DVB-S2 8PSK BER Performance Scatterplot

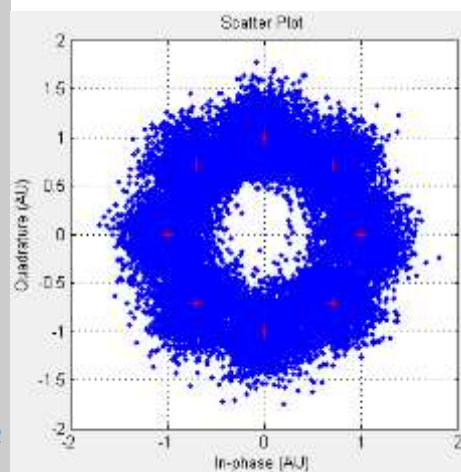


Figure 9b: 8PSK

From Table 3a & b, 8 PSK does not perform as well as QPSK as it requires higher Es/No for better BER performance. In spite of this, 8 PSK can be used as the LDPC decoder is capable of correcting errors, even at low signal power. Figure 9a indicates that both 8 PSK 3/4 and 9/10 give almost similar performance at low Es/No but at higher signal energy, 8PSK 3/4 gives better improvement. Figure 9b shows the 8PSK constellation points indicating that the signal is delivering the data transmitted to the receiver without significant errors.

Table 4 : DVB-S2 Configuration Mode : 16 PSK , Code Rate : 3/4 ,
 $K_{bch} = 48408$, $N_{bch} = 48600$, $K_{ldpc} = 48600$, $N_{ldpc} = 64800$

Es/No dB	Demodulator Output BER	LDPC Decoder Output BER	Number of Iteration	Packet Error Ratio (PER)	Signal to Noise Ratio (SNR) dB
0.0	3.41e-01	3.41e-01	50	1.00e+00	0.00
0.5	3.30e-01	3.30e-01	50	1.00e+00	0.49
1.0	3.19e-01	3.19e-01	50	1.00e+00	1.00
1.5	3.08e-01	3.08e-01	50	1.00e+00	1.51
2.0	2.96e-01	2.96e-01	50	1.00e+00	1.99
2.5	2.85e-01	2.85e-01	50	1.00e+00	2.49
3.0	2.72e-01	2.72e-01	50	1.00e+00	3.00
3.5	2.60e-01	2.60e-01	50	1.00e+00	3.51
4.0	2.48e-01	2.48e-01	50	1.00e+00	3.99
4.5	2.34e-01	2.34e-01	50	1.00e+00	4.51
5.0	2.21e-01	2.21e-01	50	1.00e+00	5.00

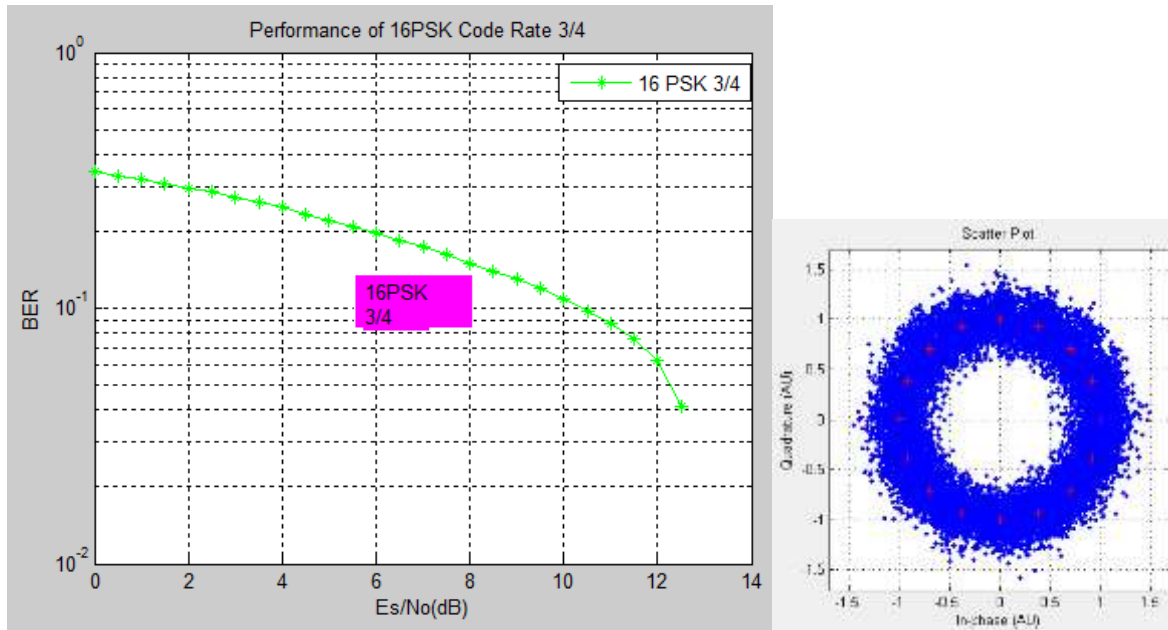


Figure 10a: DVB-S2 16 PSK BER Performance

Figure 10b: 16PSK Scatterplot

As expected, data from Table 4 confirms that higher signal strength is needed for 16 PSK mode to achieve a BER of zero value. 16 PSK requires $E_s/N_0 = 13$ dB to achieve error free operation when compared to 8 PSK which only needs 8 dB. Figure 10a shows the steady decline in BER as signal strength gathers whilst Figure 10b indicates that 16 PSK operation can be sustained at reasonable field strength. Only 16 PSK with code rate 3/4 is shown so as to reduce publication space.

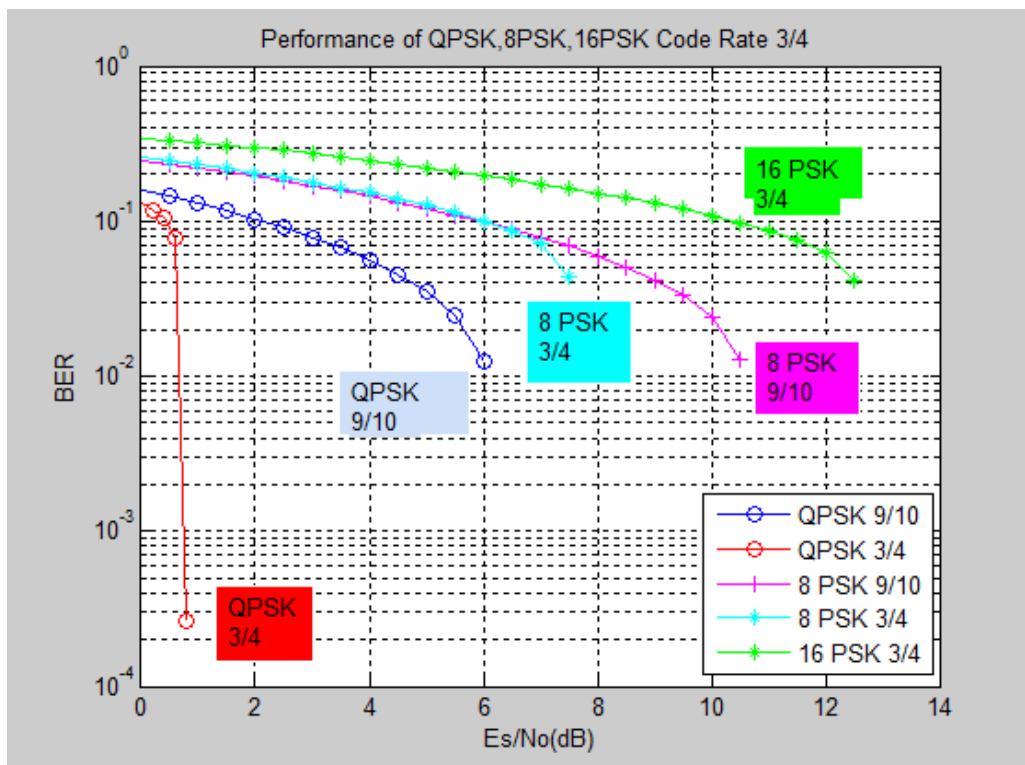


Figure 11: Comparison of QPSK, 8PSK and 16 PSK BER Performance

Comparative analysis of all the configuration modes is laid out in Figure 11 for the sake of convenience. Simply put, the progress from a lower constellation mode to a higher constellation mode requires higher signal power. This is caused by the shrinking in distance of the constellation points from each other, which would result in the points not being detected accurately especially when noise is becoming troublesome. The change in code rate also substantially influences the BER as a received MPSK signal with $CR = 3/4$ has more robust error correction capability compared to a signal with $CR = 9/10$.

The main limitation of this paper is that not all ASEAN countries have chosen DVB-T2 as the digital terrestrial TV standard. Brunei, Singapore, Indonesia, Malaysia, Vietnam, Thailand Cambodia and Myanmar have selected DVB-T2. Philippines have selected the Brazilian standard Integrated Services Digital Broadcasting (ISDB-Tb) whilst Laos have selected the Chinese standard Digital Terrestrial Multimedia Broadcast (DTMB). Hence, engineers in Laos and Philippines may not be able to utilise the DVB-T2 Simulink model. However, ASEAN countries including Philippines and Laos can utilise the DVB-S2 Simulink, as all ASEAN members use the same Satellite standard. Nevertheless, the majority of ASEAN countries use DVB-T2 and hence this paper should provide a valuable resource for the region's engineers.

Future work should be conducted on the utilisation of Amplitude Phase Shift Keying (APSK) for DVB-S2X which is an extension to the DVB-S2 standard. Although DVB-S2X is to be utilised for Digital Satellite News Gathering only, the ASEAN engineer can gain additional skills in using a suitable DVB-S2X Simulink model. The recommended configuration by the DVB organisation are 32APSK, 64APSK, 128 APSK and 256APSK.

CONCLUSION

The Simulink model programme can be used during training sessions in the field of Digital Broadcasting. It is essential that engineers comprehend the advanced FEC subsystem and the theory behind Shannon's Theorem, relating the maximum capacity that can be achieved over a given channel with certain noise characteristics and bandwidth. Since DVB-T2 can cater for both fixed and mobile reception, engineers should comprehend the different performance of DVB-T2 over AWGN, Rician and Rayleigh channels. High Power Amplifiers also introduce non-linearities into the signal and hence suitable classes of models such as Rapp or Saleh should be studied. The performance of DVB-T2 is remarkable, as low BER is achieved even at low signal to noise ratio making the use of 256 QAM a feasible choice. HDTV services require much higher bitrates compared to SDTV and cannot be met by using the present 64 QAM mode.

Overall, the performance of DVB-S2 is remarkable, as low BER is achieved even at low signal strength making the use of 16 PSK a feasible choice. UHD TV services require much higher bitrates compared to HDTV and cannot be met by using the present 8PSK mode. Therefore, communication engineers have to incorporate higher constellation modes in their design.

It is essential that ASEAN engineers acquire skills in both DVB-T2 and DVB-S2 as it is rather risky for a country to rely on a single platform to deliver TV signals to the public. It must be also noted that DVB-S2 using Ku band cannot provide reliable reception to homes during cloudy weather. The public also has to pay to subscribe to satellite TV channels whereas terrestrial TV channels are free. Satellite transmission cannot provide mobile reception whereas DVB-T2 can reach car receivers and mobile

phones. The advantages of DVB-S2 are that the signals can reach distant regions and UHDTV is a practical proposition.

Both DVB-T2 and DVB-S2 networks are linked to each other to provide cost effective and disruption free service to the public. Both are green technology as they consume less energy and have lower carbon footprint than analogue transmitters. Higher Signal/Noise ratio is required at the receiver as there is no error correction of signals from the analogue transmitters resulting in the transmitters having much higher power ratings. The smaller Digital Terrestrial TV infrastructure emits lesser carbon, and renewable energy can be used for low power transposers in remote regions. Hence, ASEAN can benefit from both digital systems in terms of cost and green technology.

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“If we knew what it was we were doing, it would not be called research, would it?”

– Albert Einstein
