

The impact of digital comics as a teaching and learning tool in economics education on future-ready talent development: the mediating role of attitude

Hainnuraqma Rahim¹, Abd Hadi Mustaffa², Norashida Othman³, Putri Aliah Mohd Hidzir⁴

¹Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Rembau, Rembau, Malaysia

²Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Melaka, Melaka, Malaysia

³Faculty of Business and Management, University Teknologi MARA, Puncak Alam, Malaysia

⁴Faculty of Business and Communication, Universiti Malaysia Perlis, Kampus Uniciti Sg. Chuchuh, Padang Besar, Malaysia

Article Info

Article history:

Received Nov 10, 2025

Revised Jun 10, 2026

Accepted Aug 5, 2026

Keywords:

Attitude

Digital comics

Economics

Readiness

Subjective norms

ABSTRACT

Economics education at the tertiary level dominated by text-heavy materials that often disengage students. At the same time, the potential of digital comics as an innovative pedagogical alternative are insufficiently examine. Hence, this study examines the impact of digital comics (IMP) on students' learning in economic subjects at Universiti Teknologi MARA (UiTM) Melaka, with particular focus on the mediating role of attitude (ATT). A quantitative design was employed using structured questionnaires distributed to 146 diploma and degree students to measure the determinants of perceived IMP. Data were analyzed using the partial least squares–structural equation modeling (PLS-SEM). The findings show that ATT and subjective norms (SN) significantly influence the IMP, while digital literacy (DL) and perceived behavioral control (PBC) exhibit no direct effects. In addition, ATT significantly mediates the relationships with SN, PBC and the IMP. Practically, the findings suggest that lecturers can embed digital comics into case-based class activities to enhance engagement and conceptual understanding. The novelty of the study indicated that this is the first studies applying theory of planned behavior (TPB) to digital comics in economic education. This study also offers future research which can be extend the studies into experimental, longitudinal and cross-sectional.

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Corresponding Author:

Hainnuraqma Rahim

Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Negeri Sembilan
Kampus Rembau, UiTM Street, Kampung Paya Lebar, 71300 Rembau, Negeri Sembilan, Malaysia

Email: hainnuraqma@uitm.edu.my

1. INTRODUCTION

The higher education environment is seeing significant transition as digital technologies alter the methods of knowledge, delivery, consumption, and retention [1]. In a worldwide context, traditional instructional methods reliant on text-based materials are being contested by educational innovations that prioritize visual elements, interactivity, and engagement [2]. Contemporary students are digital natives with diminished attention spans and elevated expectations for engaging learning settings [3]. These evolutions require educators to reconsider how complex the subjects are taught in the twenty-first century.

Challenges in economics education remain particularly evident. Economics is a specialized field that is crucial for understanding modern social and financial systems. However, it often faces criticism in education for relying heavily on complex, text-heavy resources that require significant abstraction [4]. Students globally encounter challenges in connecting theoretical concepts with practical applications, which

not only impedes understanding but also interest and engagement in the classroom [5]. This issue is particularly relevant in growing economies like Malaysia, where cultivating graduates with robust analytical and problem-solving skills in economics is essential for national development. Evidence indicated that undergraduate students at institutions such as Universiti Teknologi MARA (UiTM), Melaka campus, still view economics as excessively theoretical and disconnected from practical application, resulting in diminished engagement and lower retention of knowledge.

Digital comics have emerged as a promising instructional alternative in response to these pedagogical challenges [6]. It integrates visual storytelling, textual explanations, and interactive designs, aligning with global trends in Education 4.0 that prioritize creativity, collaboration, and learner-centric methodologies [7]. Various studies suggest that digital comics enhance reading engagement, foster critical thinking, and improve knowledge retention compared to traditional methods [8], [9]. The early applications of digital comics at the secondary level demonstrate positive reception and improved conceptual understanding. However, existing scholar predominantly concentrates on science, technology, engineering, and mathematics (STEM) or early education context. It leaves limited empirical evidence on the effectiveness and adoption of digital comics in tertiary-level economic education.

The significance of psychological and behavioral systems in mediating the effects of these digital tools is equally unexplored. The theory of planned behavior (TPB) offers a valuable framework for examining these aspects [10]. The TPB asserts that behavior is influenced by three primary antecedences, which are attitude (ATT), subjective norm (SN), and perceived behavioral control (PBC), with ATT frequently acting as the most direct catalyst for behavioral intention. Although previous research has investigated digital literacy (DL) and access as factors influencing learning achievement, few studies have directly assessed whether students' views towards innovative media impact actual learning outcomes in [11], [12]. This justification signifies a theoretical gap in both the applications of the TPB and studies in media-assisted learning. As to date, no prior study has examined how ATT mediates the impact of digital comics (IMP) in economics education at the tertiary level.

This study aims to rectify these shortcomings by examining the influence of digital comics on economics education among UiTM Melaka students, focusing specifically on the mediating effect of ATT. This research situates itself within the global discourse on digital pedagogy and is grounded in the Malaysian higher education context, thereby enhancing theoretical comprehension of TPB in education and offering practical insights for economics educators aiming to engage a generation of learners who require relevance, interactivity, and innovation in their studies.

The paper is structured as: first, a literature review that examines the core constructs and establishes the conceptual framework. Subsequently, a comprehensive research methodology is presented, detailing the quantitative design and data analysis protocols. The third section presents the analysis of the findings from the descriptive, measurement, and structural models. Finally, a discussion of the results, followed by the study's implications, limitations, and overall conclusions.

2. LITERATURE REVIEW

2.1. The impact of digital comics

The integration of digital comics in education has gained its place in many institutions' practices. Digital comics serve as engaging tools that facilitate learners' critical thinking and improve their reading interest [13]. For example, the use of digital comics has been proven to improve lexical competence in foreign language learning, particularly in virtual environments [14]. They encourage creativity and dynamic engagement, leading to better retention of vocabulary.

In the context of this study, digital comics have been developed as learning media for economics, particularly in high school settings, demonstrating positive feedback from both students and experts [15]. In microeconomic theory courses, the use of digital comics has been shown to improve student learning outcomes, suggesting their efficacy as instructional tools [16]. Conversely, while digital comics enhance engagement, there are concerns regarding the potential oversaturation of digital content, which may lead to diminished attention spans and critical thinking skills among students [17]. Visual narratives can increase student's engagement. However, an overreliance on digital media may impair deep cognitive processing, especially if students start acting more like passive consumers than active content interpreters [18]. Furthermore, learners may become distracted from fundamental economic reasoning processes if they are overstimulated by multimedia components [19].

These opposing opinions imply that students' psychological preparedness and critical ATTs regarding the use of digital comics may have an impact on their efficacy in addition to their design. This highlights the need for a balanced approach in integrating digital comics into educational frameworks. Hence, the current study intends to address this gap by assessing the IMP on economic subjects among students of UiTM Melaka.

2.2. The mediating role of attitude

According to the TPB, ATT determines one's evaluation of performing a particular behavior [20]. In the context of this study, ATT represents students' tendency toward accepting and benefiting from a new educational tool, such as digital comics. Empirical studies indicate that factors such as DL, SN, and PBC significantly shape students' ATTs toward technology-mediated learning and, in turn, influence learning effectiveness. For example, learners with higher DL tend to develop more positive ATTs toward online learning, which then enhances their engagement or learning outcomes [21].

Within the TPB framework, ATT acts as the psychological mechanism through which the factors impact behavioral intentions and outcomes. This means when students believe in their digital capabilities (DL) and control over learning tools (PBC) and perceive supportive social pressure (SN), these beliefs foster a positive ATT, which then increases the effectiveness and impact of using digital comics in economics education. Even new tools like digital comics can fail to help students learn if they think they are too distracting, too simple, and not academically challenging enough [22]. Hence, ATT is an important way to judge how digital comics might help or hurt people. Hence, the researchers are proposing ATT as a mediator between all the independent variables and the dependent variable. Therefore, the hypothesis proposed are: ATT has a positive effect on the IMP in the economics subjects (H4)

2.3. Digital literacy

DL refers to the ability to comprehend, analyze, and use information from diverse sources accessible via digital devices [23]. As technology continues to advance and reshape educational landscapes, the importance of DL is growing significantly. In higher education, DL is a prerequisite for fostering better learning experiences. Past studies have found that there is a positive correlation between high DL levels and higher perceived educational quality among postgraduate students, suggesting that a robust curriculum emphasizing digital skills leads to more effective learning outcomes [24].

In this context of study, digital comics serve as a medium for how economic concepts can be taught in educational institutions. It can pique one's interest and stimulate their cognitive processes [15]. For instance, the use of digital comic media significantly increases students' reading interests, enhancing their willingness to engage with instructional content like that found in economics classes [25], [26]. Concurrently, it demonstrated that digital comics provide viable instructional media that enhance learning outcomes in microeconomic theory courses, emphasizing both viability and efficacy in improving students' understanding of economic concepts [13]. On the other hand, students with limited DL may experience cognitive overload when engaging with multimedia-rich instructional tools [27]. It can potentially diminish the intended pedagogical advantages. Therefore, the following hypothesis is proposed:

- DL has a positive effect on the IMP in economics subjects, mediated by ATT (H1).
- DL has a positive effect on the IMP in economics subjects (H5).

2.4. Subjective norms

SN are defined as the social pressures or influences that impact an individual's behaviors or decisions. These norms can significantly affect the integration of digital comics within educational frameworks. The presence or absence of social support, peer engagement, and institutional support can heavily influence students' participation in digital learning environments. Past study noted that support from colleagues and school administrators substantially informs teachers' beliefs and practices related to digital tool implementation in education [28].

Furthermore, SN can determine students' engagement with digital comics as well. The facilitative impact of DL on happiness among low-income groups underscores the importance of social perceptions in fostering positive ATTs towards digital engagement [29]. When students observe their peers successfully utilizing digital tools, they are more inclined to follow these behaviors. However, conforming to peer or institutional expectations does not inherently ensure meaningful engagement. Students may utilize digital tools to adhere to social pressures rather than authentic learning motivation [30]. This reflects the influence of SN in shaping acceptance towards digital comics in education. Therefore, the following hypothesis is proposed:

- SN have a positive effect on the IMP in economics subjects, mediated by ATT (H2).
- SN have a positive effect on the IMP in economics subjects (H6)

2.5. Perceived behavioral control

PBC is defined as an individual's perception of how easy or difficult it is to perform a particular behavior [20]. It allows students to feel more in control of their learning process, which can enhance their motivation and engagement with digital comics as a learning medium [16]. The use of economic comics has also shown significant improvements in post-test scores compared to traditional methods.

Moreover, past literature has highlighted the positive relationship between perceived behavior control and the adoption of e-learning [31]. Students who perceive higher control over their learning resources and methods are more likely to embrace innovative tools such as digital comics. Apart from that, the successful application of digital comics has been highlighted across various subjects, suggesting their effectiveness in boosting student motivation and perceived control [32]. On the other hand, students who think they have more control than they really do and do not have enough cognitive discipline may not realize how hard it is to learn economics [33]. It could make it harder for them to fully understand the concepts. Therefore, the following hypothesis is proposed:

- PBC has a positive effect on the IMP in economics subjects, mediated by ATT (H3).
- PBC has a positive effect on the IMP in economics subjects (H7).

2.6. Conceptual framework

The conceptual framework of this study, as shown in Figure 1, is underpinned by the TPB, which states that one's behavior is determined by three key factors, namely ATT, SN, and PBC. In the context of education, the theory has been widely applied to explain students' acceptance and use of technology-mediated learning tools. Extending this theoretical foundation, the present study incorporates DL as an additional factor, acknowledging its critical role in shaping students' acceptance to engage with digital platforms in higher education.

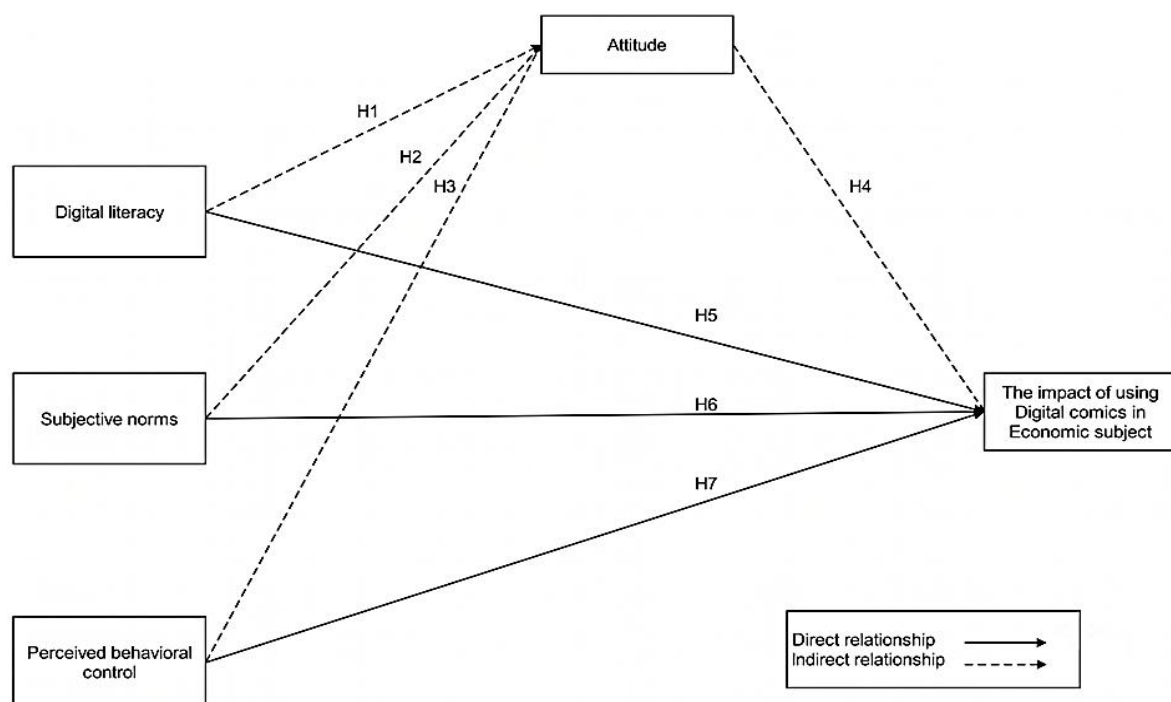


Figure 1. Research framework

3. METHOD

3.1. Research design

This study adopts a quantitative research approach to collect numerical data for statistical analysis. A structured survey was the primary data collection method, enabling the efficient gathering of responses. The study's population comprised students at UiTM Melaka enrolled in economics-related courses. Data was collected from 146 respondents through a cluster sampling method, representing young undergraduates in various business and finance programs. The questionnaire is designed to measure key constructs objectively, including students' ATTs, SN, PBC, and their perceived impact on using digital comics. Additionally, the study examines the mediating role of ATT in the relationship between these factors and its impact, aligning with the study's focus on the psychological and behavioral dimensions influencing the adoption of digital comics in economic education.

3.2. Research sample

The population for this study consists of UiTM Melaka students enrolled in economics-related courses (e.g., economics, business, and accounting). For the sample selection, a cluster sampling method was employed for its practicality and efficiency within a university setting. The population, consisting of UiTM Melaka students enrolled in economics-related courses, was first divided into naturally occurring groups, or “clusters”. In this context, the clusters were the individual economics classes active during the research period. From a list of these classes, a few clusters were randomly selected. All students within these chosen classes were then invited to participate in the survey. This method resulted in a final sample of 146 respondents enrolled in various business and finance programs. This approach allowed for efficient data collection while maintaining the principles of random selection.

Cluster sampling was considered suitable in this context as students are inherently grouped into cohesive classroom units, which rendering individual random sampling impractical within academic timetables. This method improves logistical efficiency while maintaining representativeness across various programs. However, it could also lead to intra-class homogeneity. It means that students in the same class have similar learning experiences or are taught in the same way. These clustering effects could limit variability, so they should be taken into consideration when observing those results.

3.3. Research instrument and data collection

The primary instrument for data collection was a structured questionnaire based on the TPB. It was designed to measure several key variables: ATT, which referred to students’ evaluation of the usefulness of digital comics; SN, which assessed the influence of peers and lecturers; PBC, which captured students’ perception of the ease or difficulty of using digital comics; and the IMP, the dependent variable that measured the tool’s effect on learning. The questionnaire employed a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), to quantify responses, allowing for consistent measurement of students’ ATTs, perceptions, and the IMP. Table 1 outlines the item questionnaires adapted from past studies.

Table 1. Questionnaire item measurements for every constructs

No	Constructs	Item	Source
1	DL	i) I can easily navigate and use digital devices such as smartphones, tablets, and computers. ii) I feel confident in using online learning platforms (Google Classroom, i-Learn). iii) I can troubleshoot common technical problems when using digital tools. iv) I am familiar with accessing and reading digital content (e.g., e-books, online articles). v) I am able to use multiple digital tools to support my learning effectively	[23], [24]
2	SN	i) My lecturers encourage the use of digital learning materials in Economics. ii) My classmates think using digital comics is a good way to study Economics. iii) People around me would approve of me using digital comics for academic purposes. iv) I feel social pressure to try new digital tools for learning. v) I am influenced by others’ opinions when deciding to use digital learning materials.	[28]
3	PBC	i) I believe I have enough skills to use digital comics effectively in learning Economics. ii) I have access to the necessary devices (e.g., smartphone, laptop) to use digital comics. iii) I can understand the content of digital comics without external help. iv) Using digital comics does not require too much effort from me. v) I am confident that I can manage my time well when using digital comics for studying.	[16], [31], [32]
4	ATT	i) I have a positive attitude towards using digital comics in learning Economics. ii) I believe digital comics are a useful and innovative learning tool. iii) I enjoy learning when digital comics are used as part of my Economics subject. iv) I am open to adopting digital comics as a regular part of my learning materials. v) I would recommend the use of digital comics to my peers in Economics courses.	[20], [21]
5	The IMP in economics subject on UiTM Melaka students’ learning	i) Using digital comics in my Economics subject helps me understand concepts more effectively. ii) Digital comics make Economics learning more interesting and engaging. iii) Digital comics improve my motivation to study Economics. iv) Using digital comics enhances my ability to remember and apply Economics concepts. v) Digital comics positively influence my overall learning experience in Economics.	[13], [15]

3.4. Data analysis procedure

The quantitative data was analyzed using a dual-software approach with SPSS version 20.0 and SmartPLS version 4.1.1.2. The analysis process began with data cleaning to ensure the reliability of the dataset. First, SPSS was used to perform descriptive statistical analysis. This included generating frequencies and percentages to describe the demographic profile of respondents, while means and standard deviations were used to summarize the key variables [34], [35].

Subsequently, SmartPLS was employed to conduct partial least squares-structural equation modeling (PLS-SEM) in two stages. The first stage involved the measurement model assessment, where reliability and validity were evaluated using factor loadings, Cronbach's alpha, composite reliability, and average variance extracted (AVE). The constructs shown good internal consistency reliability, with Cronbach's alpha and composite reliability values above the recommended level of 0.70 [36]. The AVE values for all constructs were higher than 0.50, which showed that convergent validity was true [37]. In the second stage, the structural model assessment was conducted to test the hypothesized relationships between the constructs. This analysis focused on the direct effects and the mediating role of ATT, providing a comprehensive understanding of the factors influencing the IMP as a learning tool.

4. RESULTS

4.1. Descriptive analysis

Table 2 provides an analysis of the demographic profile, digital usage habits, and the perceived IMP on 146 respondents from UiTM Melaka, Malaysia. Furthermore, the data reveals that the respondents are highly integrated with digital technology for their academic work, and a majority have prior exposure to digital comics. A substantial portion uses them for 3–4 hours (31.5%, n=46) or more than 6 hours (32.2%, n=47) daily. In total, over 87% of the students use digital devices for three or more hours per day for their studies. A clear majority of the students, 66.4% (n=97), reported having used digital comics before, suggesting a general familiarity with the medium. Conversely, 33.6% (n=49) had no prior experience.

Table 2. Demographic profile of respondents

Items	Categories	Frequency (N)	Percentage (%)
Age	18-20 years old	76	52.1
	21-23 years old	58	39.7
	24-26 years old	8	5.5
	27-29 years old	1	0.7
	30 years old and above	3	2.1
Gender	Female	91	62.3
	Male	55	37.7
Program of study	Bachelor of Business Administration (Hons.) Finance	45	30.8
	Bachelor of Business Administration (Hons.) International Business	3	2.1
	Bachelor of Business Administration (Hons.) Marketing	2	1.4
	Bachelor of Business Technology Management	25	17.1
	Diploma in Business Studies	24	16.4
	Diploma in Business Management	21	14.4
	Diploma in Banking	15	10.3
	Bachelor of Business Management	3	2.1
	Bachelor of Office System	2	1.4
	Diploma in Accounting	3	2.1
	Bachelor of Business Economic	3	2.1
Current semester	Semester 1	5	3.4
	Semester 2	1	0.7
	Semester 3	74	50.7
	Semester 4	60	41.1
	Semester 5	6	4.1
Frequency of using digital devices for academic	Less than 1 hour	2	1.4
	1-2 hours	16	11.0
	3-4 hours	46	31.5
	5-6 hours	35	24.0
	More than 6 hours	47	32.2
Have used digital comics before?	Yes	97	66.4
	No	49	33.6
Level of understanding before usage	Very low	11	7.5
	Low	51	34.9
	Moderate	59	40.4
	High	16	11.0
Level of understanding after usage	Very high	9	6.2
	Low	4	2.7
	Moderate	27	18.5
	High	85	58.2
	Very high	30	20.5

A key finding was the positive shift in students' self-reported understanding before and after using digital comics. Prior to using digital comics, the students' perceived understanding was concentrated in the lower to middle ranges. The largest group reported a moderate level of understanding (40.4%, n=59),

followed closely by those with a low level (34.9%, n=51). Only a small fraction of respondents felt they had a high (11.0%, n=16) or very high (6.2%, n=9) level of understanding. A positive redistribution occurred after the usage. Most respondents shifted to the higher end of the scale, with 58.2% (n=85) reporting a high level of understanding and 20.5% (n=30) reporting a very high level.

The combined percentage of students reporting “high” or “very high” understandings surged from 17.2% to 78.7%. Concurrently, the proportion of students with ‘low’ or ‘very low’ understanding plummeted from a combined 42.4% to just 2.7%. This suggests that the use of digital comics as a learning tool had a strong, positive impact on the students perceived academic comprehension.

Table 3 shows the descriptive analysis involving mean and standard deviation for each variable. The variable of DL measures students’ confidence and skills with technology. The results show a relatively high level of self-reported DL, with an overall mean of 3.87. Students felt most comfortable with basic device navigation (M=4.06) and least confident about troubleshooting technical difficulties (M=3.61). This indicates that while students are proficient in using digital tools, some still face challenges in solving technical problems independently.

Table 3. Descriptive analysis of item measurements

Variables	Items	Mean	Standard deviation
Before using digital comics			
DL	i) I can easily navigate and use digital devices such as smartphones, tablets, and computers.	4.06	0.707
	ii) I feel confident in using online learning platforms (Google Classroom, i-Learn).	3.95	0.693
	iii) I can troubleshoot common technical problems when using digital tools.	3.61	0.708
	iv) I am familiar with accessing and reading digital content (e.g., e-books, online articles).	3.85	0.688
	v) I am able to use multiple digital tools to support my learning effectively	3.87	0.677
SN	i) My lecturers encourage the use of digital learning materials in Economics.	3.86	0.681
	ii) My classmates think using digital comics is a good way to study Economics.	3.77	0.682
	iii) People around me would approve of me using digital comics for academic purposes.	3.84	0.734
	iv) I feel social pressure to try new digital tools for learning.	3.38	0.872
	v) I am influenced by others’ opinions when deciding to use digital learning materials.	3.56	0.743
PBC	i) I believe I have enough skills to use digital comics effectively in learning Economics.	3.59	0.681
	ii) I have access to the necessary devices (e.g., smartphone, laptop) to use digital comics.	3.89	0.676
	iii) I can understand the content of digital comics without external help.	3.55	0.665
	iv) Using digital comics does not require too much effort from me.	3.70	0.718
	v) I am confident that I can manage my time well when using digital comics for studying.	3.70	0.647
ATT	i) I have a positive attitude towards using digital comics in learning Economics.	3.84	0.695
	ii) I believe digital comics are a useful and innovative learning tool.	3.91	0.674
	iii) I enjoy learning when digital comics are used as part of my Economics subject.	3.88	0.680
	iv) I am open to adopting digital comics as a regular part of my learning materials.	3.76	0.668
	v) I would recommend the use of digital comics to my peers in Economics courses.	3.82	0.661
IMP	i) Using digital comics in my Economics subject helps me understand concepts more effectively.	3.81	0.647
	ii) Digital comics make Economics learning more interesting and engaging.	3.86	0.628
	iii) Digital comics improve my motivation to study Economics.	3.88	0.649
	iv) Using digital comics enhances my ability to remember and apply Economics concepts.	3.81	0.625
	v) Digital comics positively influence my overall learning experience in Economics	3.82	0.682

Note: All items were measured using a 5-point Likert scale ranging from 1=strongly disagree to 5=strongly agree. Mean scores were interpreted as: 1.00–1.80 (very low), 1.81–2.60 (low), 2.61–3.40 (moderate), 3.41–4.20 (high), and 4.21–5.00 (very high).

The variable of SN reflects the influence of social factors, such as peers and lecturers, on students’ willingness to adopt digital comics. The average mean score was 3.68, suggesting a high level of social support. Students perceived the strongest encouragement from their lecturers (M=3.86), while they felt the least social pressure to try new tools (M=3.38). These findings highlight the importance of educator and peer influence in shaping ATTs toward digital learning tools.

The variable of PBC measures students’ confidence in their ability to use digital comics effectively. The mean score was 3.69, reflecting a high level of control. Students reported the highest confidence in having access to the necessary devices (M=3.89) and the lowest in understanding content without external help (M=3.55). This suggests that while students feel adequately equipped, some may still require additional support in navigating and interpreting the learning material.

The variable of ATT captures students’ overall perceptions and beliefs about using digital comics. The results show a generally positive ATT, with an average mean of 3.84. Students strongly agreed that digital comics are a useful and innovative tool (M=3.91) and reported enjoying the learning experience when comics were integrated into their economics subject (M=3.88). Their willingness to recommend digital comics to peers (M=3.82) further reinforces this positive sentiment.

Finally, the variable perceived IMP reflects students' evaluations of the effectiveness of this tool in supporting their learning outcomes. The mean score was 3.84, suggesting students found digital comics to be both engaging and beneficial. The highest agreement was for improved motivation to study economics ($M=3.88$) and enhanced interest in learning ($M=3.86$). Overall, students agreed that digital comics helped them understand concepts more effectively ($M=3.81$) and improved their overall learning experience ($M=3.82$). In summary, the descriptive analysis indicates that students reported strong DL, positive ATTs, moderate social support, and a fair level of perceived control when using digital comics. More importantly, they perceived digital comics as an engaging and effective medium that improved motivation, comprehension, and overall learning outcomes in economics.

Table 4 portrays the reliability analysis measured by Cronbach's alpha. Generally, a Cronbach's alpha value of 0.70 is considered acceptable, above 0.80 is preferable, and 0.90 or higher is excellent [34], [35]. DL ($\alpha=0.883$), SN ($\alpha=0.813$), and PBC ($\alpha=0.893$) demonstrated good reliability, while ATT ($\alpha=0.944$) and perceived impact ($\alpha=0.941$) achieved excellent reliability. These results confirm that the measurement scales used in this study are highly reliable, ensuring consistency and credibility of the findings. This high reliability strengthens the validity and trustworthiness of current findings, making the conclusions more dependable.

Table 4. Reliability analysis

Variables	Cronbach's alpha
DL	0.883
SN	0.813
PBC	0.893
ATT	0.944
Perceived impact (IMP)	0.941

4.2. Measurement model assessment

Figure 2 shows the graphical output of measurement model assessment carried out in this study. The analysis of the measurement model begins with an assessment of its reliability and convergent validity, as detailed in Table 5. The analysis shows high internal consistency, with Cronbach's alpha and composite reliability values exceeding the 0.70 threshold. Furthermore, strong convergent validity was established, as the AVE for every construct was well above the 0.50 minimum.

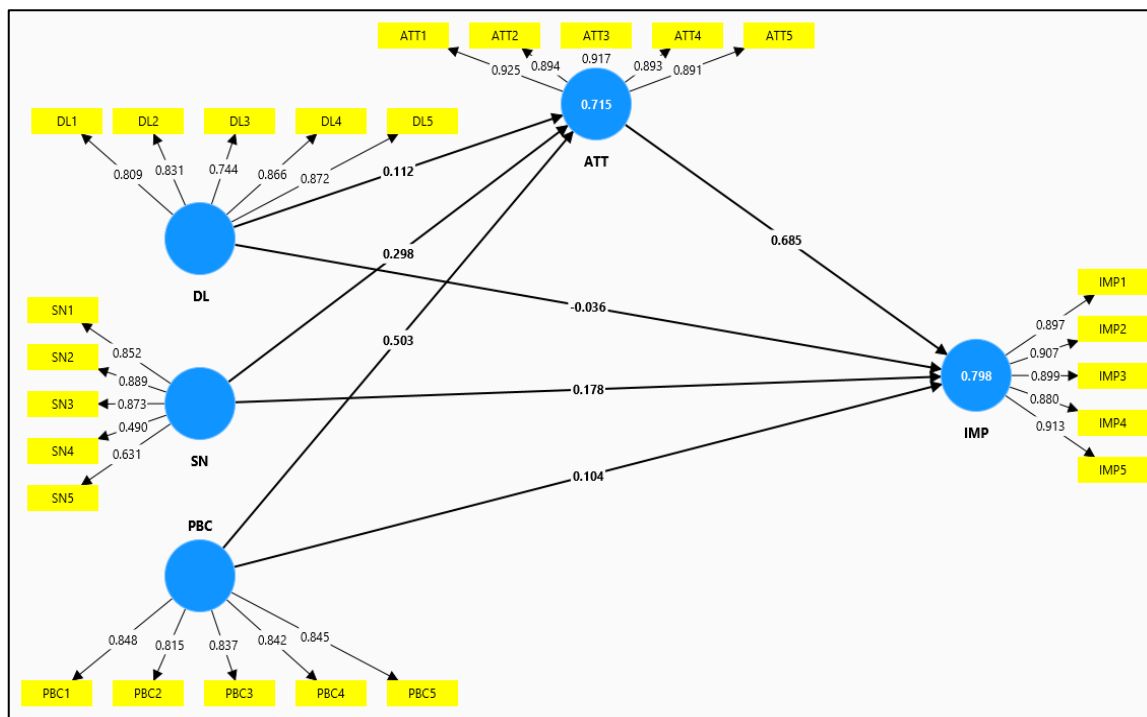


Figure 2. Graphical output of measurement model

Table 5. Construct reliability and validity

Construct	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	AVE
ATT	0.944	0.945	0.957	0.817
DL	0.883	0.899	0.914	0.682
PBC	0.894	0.895	0.922	0.702
SN	0.823	0.888	0.870	0.583
IMP	0.941	0.941	0.955	0.809

Next, discriminant validity was examined to ensure that each construct is distinct from the others. The Fornell-Larcker criterion, as shown in Table 6 was first applied, which requires the square root of a construct's AVE to be greater than its correlation with any other construct. This criterion was met for most constructs. However, an issue was identified with SN, as their correlations with ATT (0.766) and PBC (0.785) were higher than the square root of their own AVE (0.764). This initial finding suggests a potential lack of distinctiveness for the construct of SN.

To further investigate this issue, the cross-loadings were examined, as shown in Table 7. This analysis revealed that while most items loaded strongly onto their respective constructs, items SN4 (0.490) and SN5 (0.631) exhibited weak loadings on their intended SN construct. These poor-performing indicators are the likely cause of the discriminant validity issue identified by the Fornell-Larcker criterion. Based on these findings, it is recommended that SN4 and SN5 be removed from the model to improve the measurement quality and ensure the distinctiveness of the SN construct [38].

Table 6. Discriminant validity (Fornell-Larcker criterion)

Construct	ATT	DL	PBC	SN	IMP
ATT	0.904				
DL	0.672	0.826			
PBC	0.818	0.724	0.838		
SN	0.766	0.658	0.785	0.764	
IMP	0.882	0.616	0.778	0.761	0.899

Table 7. Discriminant validity (cross loadings)

Construct	ATT	DL	PBC	SN	IMP
ATT1	0.925	0.625	0.751	0.721	0.791
ATT2	0.894	0.599	0.705	0.646	0.759
ATT3	0.917	0.599	0.729	0.719	0.853
ATT4	0.893	0.593	0.775	0.700	0.781
ATT5	0.891	0.622	0.735	0.675	0.800
DL1	0.543	0.809	0.588	0.524	0.485
DL2	0.511	0.831	0.556	0.498	0.498
DL3	0.409	0.744	0.544	0.456	0.410
DL4	0.583	0.866	0.620	0.515	0.504
DL5	0.680	0.872	0.668	0.684	0.615
PBC1	0.633	0.575	0.848	0.634	0.616
PBC2	0.722	0.696	0.815	0.662	0.678
PBC3	0.639	0.637	0.837	0.654	0.618
PBC4	0.669	0.528	0.842	0.629	0.642
PBC5	0.748	0.593	0.845	0.702	0.693
SN1	0.707	0.667	0.688	0.852	0.672
SN2	0.693	0.528	0.703	0.889	0.692
SN3	0.720	0.632	0.723	0.873	0.710
SN4	0.170	0.215	0.290	0.490	0.214
SN5	0.373	0.271	0.431	0.631	0.402
IMP1	0.800	0.526	0.717	0.703	0.897
IMP2	0.803	0.567	0.671	0.672	0.907
IMP3	0.769	0.550	0.688	0.705	0.899
IMP4	0.796	0.555	0.692	0.671	0.880
IMP5	0.798	0.573	0.729	0.670	0.913

4.3. Structural model assessment

Figure 3 illustrates the graphical output of structural model, which is consistent with the research framework. On the other hand, the Table 8 summarizes the model fit and explanatory power. The R² value of the IMP is 0.797. It indicates that DL, SN, PBC, and ATT collectively explain 79.7% of the variance in the dependent variable. It represents substantial explanatory power according to PLS-SEM guidelines [39]. The adjusted R² value of 0.792 further confirms the robustness of the model after accounting for the number

of predictors included. In addition, the reported f^2 value of 0.662 indicates a large overall effect size. It suggests that the structural model demonstrate strong and predictive relevance. The chi-square and Bayesian information criterion values are also presented for model comparison purposes. Conclusively, these statistics indicate that the proposed model provides strong explanatory capability in understanding the IMP in economics education.

The results shown in Table 9 indicate that ATT plays a significant role as a mediator for perceived behavior control and SN, but not for DL, in influencing the IMP. The bootstrap confidence interval (-0.044, 0.164) of DL contains zero, confirming the lack of a significant effect. The findings confirmed that ATT significantly mediates the relationship between PBC and the IMP (H3: $\beta=0.310$, $p<0.001$), as well as the relationship between SN and the IMP (H2: $\beta=0.250$, $p<0.001$).

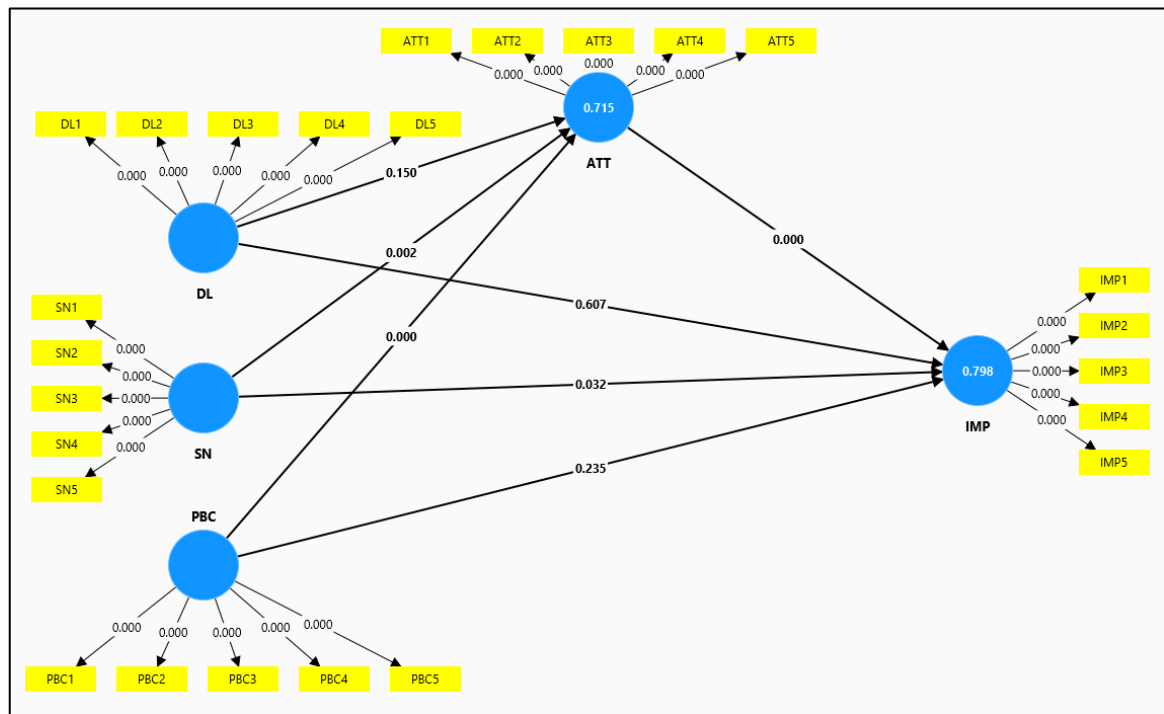


Figure 3. Graphical output of structural model

Table 8. Model summary

Criteria	Value
R square	0.797
R square adjusted	0.792
F square	0.662
Chi-square	679.881
Bayesian information criterion	-209.691

Table 9. Summary of hypotheses results

Path	Path coefficient (β)	T value	P values	BCI LL	BCI UL	Decision
H1: DL→ATT→IMP	0.059	1.047	0.295	-0.044	0.164	Rejected
H2: SN→ATT→IMP	0.250	3.489	0.000	0.115	0.395	Accepted
H3: PBC→ATT→IMP	0.310	3.895	0.000	0.170	0.492	Accepted
H4: ATT→IMP	0.674	8.068	0.000	0.508	0.833	Accepted
H5: DL→IMP	-0.043	0.592	0.554	-0.184	0.101	Rejected
H6: SN→IMP	0.180	1.953	0.051	0.011	0.381	Accepted
H7: PBC→IMP	0.116	1.351	0.177	-0.047	0.285	Rejected

BCI LL=biased-corrected confidence interval lower limit, and BCI UP=biased-corrected confidence interval upper limit

5. DISCUSSION

The objective of this study is to assess the IMP on the economics subject among UiTM Melaka students. Four out of seven proposed hypotheses are accepted, while another three are found to have

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insignificant relationships. The structural model demonstrated good explanatory power, accounting for 79.7% of the variance in the IMP. Indicating the robustness of the proposed framework. The findings reveal that ATT and SN are significant direct predictors of the outcome. Furthermore, the results confirm the mediating role of ATT between SN and PBC towards the IMP. This can be supported with past studies [40], [41]. The influence of social approval from educators and peers not only helps shape a more positive student ATT but also directly signals the importance of digital comics as a learning tool in economic subjects.

This finding supports the main idea of TPB, which is that external social influence and perceived control do not directly affect behavior unless they are evaluated through ATT. In this context, students assimilate the influence of peers and lecturers, along with perceived abilities, into a positive or negative assessment of digital comics, which subsequently affecting their learning outcomes. Furthermore, the study expands the TPB by illustrating that ATT serves as primary psychological mechanism that converts social and control beliefs into educational outcomes in digital pedagogy.

Despite the significance of DL highlighted by past studies [42], [43], this research found it to be an insignificant predictor. This may be explained by the demographic characteristics of the sample university students in this context of study. They are often considered digitally adept, which contributes to a high level of digital competency in the survey questionnaire. When there is a little variation in a variable within a sample, it is statistically difficult for that variable to emerge as a significant predictor of an outcome. Prior studies in educational technology have similarly reported non-significant findings for technical skill-related variables when the study population consists of university students, suggesting that most participants already possess the necessary skills for the task. Thus, DL may not have been a differentiating factor in this study simply because the entire cohort was already sufficiently skilled.

5.1. Implications

The findings of this study validate and extend the TPB by applying it to the context of digital comics adoption in economic subjects. The results confirm that ATT, SN, and PBC are significant predictors of the IMP on economic subjects. This contributes to a more detailed understanding of how these TPB constructs operate within a technology-mediated learning environment. For educators, the primary takeaway is that fostering a positive ATT is the most critical factor for ensuring the successful impact of digital learning tools. Lecturers can make digital comics on real-life economic situations that let students follow story-driven problem-solving steps. Interactive panels with reflective questions, mini-quizzes, or branching decision paths can help people think more analytically. In addition, using digital comics in tutorial discussions instead of as extra reading may make them seem more relevant and academically rigorous. It is also imperative that digital comic platforms are accessible and user-friendly so they can boost students' confidence and, consequently, their ATT. Apart from that, active encouragement from lecturers and peers about the benefits of digital comics can create a supportive social environment that improves ATTs and increases the impact of the educational tool.

These results have implications for curriculum design in Malaysian higher education in addition to strategies for the classroom. It is because ATT and SN have such a big effect on how digital comics work, curriculum planners and qualification agency might want to include digital comic materials in economic syllabus instead of just using them as extras. Incorporating structured comic-driven case analysis, scenario-based economic simulations, and reflective discussion prompts into course outline could improve student engagement while keeping the academic level high. At the institutional level, adding digital pedagogy training to professional development programs for teachers could make it even easier to use these new ideas effectively. This approach fits with Malaysia's bigger plan for higher education, which focuses on integrating technology, student-centered learning, and skills that will help graduate get jobs in the future.

5.2. Limitations and future research

This study still needs direction by examining its limitations. First, the relatively small sample size ($n=146$) may limit statistical generalizability although it remains adequate for PLS-SEM analysis. Second, the study employed a cross-sectional design, restricting causal interference between constructs. There will be common-method bias and social desirability effects if there is still reliance on self-reported questionnaire data. As an example, students' perceptions of ATT and learning impact will not be accurately reflect objective academic performance. However, this issue can be mitigated by strong measurement reliability and validity of the measurement model and the high explanatory power of the structural model. That suggestion indicated that the observed relationships are robust within the TPB. The study was carried out at a single public university, UiTM Melaka, with a sample consisting primarily of young undergraduate students with future-ready talent engaged in business programs. Therefore, it limits the relevance of the findings to other institutions, fields, and age groups. A second limitation is the requirement to exclude two items (SN4 and SN5) from the SN construct due to insufficient indicators. That limitation is recommended by the PLS-SEM

assessment criteria [35]. Even though this improvement enhances the construct's discriminant validity, future research should focus on developing and validating SN constructs tailored to higher education learning perspectives. In addition, while the findings emphasize the relevance of ATT and social influence, the study does not address the underlying learning barriers students face or their reliance on support systems when interacting with digital comics. Hence, it is recommended that future studies apply a qualitative design, such as interviews and focus group discussions. This recommendation is to provide greater insight into future-ready talent viewpoints. This study focuses on the perceived impact of learning. Hence, future research should incorporate objective outcome indicators, such as academic accomplishments, experimental or quasi-experimental methodologies, and pre- and post-test assessments. Specific instruments for assessing future-ready talent qualities, such as critical thinking, creativity, teamwork, and communication, must be established to fully investigate the IMP on future-ready talent development. Further study should seek to replicate the model in various cultural and institutional settings to investigate the stability of TPB relationships within diverse educational contexts. Longitudinal designs are also recommended to determine if the beneficial impacts of digital comics on learning outcomes are maintained over time rather than restricted to short-term perceptions.

6. CONCLUSION

The results of this study provide empirical evidence that digital comics serve as an effective and innovative pedagogical tool for enhancing students' learning in economic subjects in higher education institutions. The findings highlight that ATT and SN are crucial in influencing the IMP, with ATT serving as a key mediator between PBC, SN, and learning outcomes. These results underscore the importance of fostering positive ATTs and creating supportive social environments to maximize the educational benefits of digital learning tools. However, all models should be subject to further validations to strengthen their predictive ability and explanatory power in order to be valid and useful under different contexts, thus increasing their usefulness to researchers. While DL was not found to be a significant predictor in this context, the result highlights that university students may already possess sufficient digital skills, suggesting that future interventions should focus more on motivational and attitudinal aspects rather than technical capabilities. Overall, the study enriches the application of the TPB in the field of technology-mediated learning and contributes practical insights for educators aiming to integrate digital comics into economics education.

ACKNOWLEDGMENTS

The researchers would like to extend their gratitude to all respondents who participated in this study.

FUNDING INFORMATION

The authors would like to express our sincere appreciation to the Malaysia Ministry of Higher Education for the financial support provided under the Fundamental Research Grant Scheme-Early Career (FRGS-EC) [grant number FRGS- EC/1/2024/SS01/UITM/02/32] and Universiti Teknologi MARA.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Hainnuraqma Rahim	✓	✓	✓	✓		✓		✓	✓	✓			✓	✓
Abd Hadi Mustaffa	✓			✓			✓			✓	✓	✓		
Norashida Othman						✓	✓			✓		✓	✓	✓
Putri Aliah Mohd Hidzir		✓	✓		✓			✓	✓	✓				

C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : **O** : Writing - **O**riginal Draft

E : **E** : Writing - Review & **E**editing

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Authors state no conflict of interest.

ETHICS STATEMENT

All respondents gave their informed consent before collecting the data, and their response were strictly kept as private and anonymous during the study.

DATA AVAILABILITY

The data that supports the findings of this study are available on request from the corresponding author, [HR]. The data, which contain information that could compromise the privacy of research participants, is not publicly available due to certain restrictions.

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BIOGRAPHIES OF AUTHORS



Hainnuraqma Rahim     is a senior lecturer at the Faculty of Business Management, Universiti Teknologi MARA (UiTM), Negeri Sembilan branch, Rembau Campus, Malaysia. She earned her Ph.D. in Islamic Economics from Universiti Sains Malaysia (USM) in 2018. Her research focuses on Islamic finance, socio-economic development, and sustainability assessment, with particular interests in zakat management, microtakaful adoption, financial inclusion, and MADANI-based empowerment models for the B40 community. She has contributed to numerous national and international research collaborations and has received awards in innovation competitions for student development. Her work emphasizes integrating Islamic economic principles and Maqasid Shariah into community-focused development and financial well-being frameworks. She can be contacted at email: hainnuraqma@uitm.edu.my.



Abd Hadi Mustaffa    is a senior lecturer at the Department of Economics and Finance, Faculty of Business and Management, Universiti Teknologi MARA, Malacca City Campus. He obtained his Ph.D. in Business Management from Universiti Teknologi MARA in 2022. His research interests focus on sustainable finance, financial resilience, household finance, and broader business and economic areas. He actively contributes to the academic community as an expert panel member at conferences and as a reviewer for several Scopus-indexed journals. He can be contacted at email: hadimustaffa@uitm.edu.my.



Norashida Othman    is a senior lecturer at Universiti Teknologi MARA (UiTM), Puncak Alam campus. She completed her bachelor's degree in Economics at Universiti Kebangsaan Malaysia (UKM) before pursuing a master's in Economic Development, also at UKM. She was awarded a scholarship to undertake her Ph.D. in International Economics at Universiti Putra Malaysia (UPM). Currently, she serves as the Treasurer and Board Member of the Association of Malaysian Environment-Behaviour Researchers (AMER) and as an Advisor for *Gerakan Pengguna Siswa* (GPS UCS). Passionate about research, she is actively engaged in various research grants and consultancy projects. Her previous consultancy work has involved prominent agencies such as the Malaysian Construction Industry Development Board (CIDB), Institut Darul Ridzuan (IDR), the East Coast Economic Region Development Council (ECER), the Subang Jaya City Council (MPSJ), and the Majlis Pembangunan Bumiputera, Pulau Pinang. Additionally, she has won several awards in innovation competitions. She can be contacted at email: shidaothman@uitm.edu.my.



Putri Aliah Mohd Hidzir    received the Ph.D. degree in Business Management from the Universiti Teknologi MARA (UiTM) Melaka. She is currently a lecturer at Universiti Malaysia Perlis, Faculty of Business and Communication. Her current research interest includes entrepreneurship, financial well-being, innovation, as well as Islamic social finance. She has been actively involved in national and international conferences and has participated in innovation competitions focusing on financial literacy. She can be contacted at email: putrialiah@unimap.edu.my.