Internet of things: the acceptance and its impact on well-being among millennials

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Abstract: This study explores millennials' intention to use smart home appliances and devices, and the impact on their perceived quality of life. It focuses on perceived usefulness, perceived ease of use, attitude and behavioural intention. Considering the intention-behavioural gap, this study extends the technology acceptance model by including expected quality of life as an effect of behavioural intention. A total of 206 respondents completed the questionnaire. The findings reveal that perceived usefulness, perceived ease of use, and attitude have a positive significant influence on millennials' intention to use smart home devices and appliances. Further, the findings demonstrate that attitude partially mediates the relationship between perceived usefulness and behavioural intention. The outcome shows that intention to use smart technology will influence one's expectation of a better quality of life. This study contributes to the development of the smart home device and appliance industry, particularly in developing new technology.

Keywords: internet of things; IoT; technology acceptance model; TAM; well-being, smart devices and appliances; millennials; quality of life; perceived usefulness; perceived ease of use; attitude; behavioural intention.

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1 Introduction

In the late 18th century, the world witnessed the beginning of the first industrial revolution that transformed the handicraft and agrarian economy into industrial manufacturing, with the invention of steam power. A century later, the second industrial revolution relied on the use of electricity, making the assembly-line mass production in manufacturing industry a reality. The third industrial revolution began in the 1970s with

advances in computing-powered automation that enable us to program machines and networks. Although there was a huge increase in the industrial world, innovations never end and creative thinking never dies. Currently, we are moving towards the fourth industrial revolution with digital technologies, artificial intelligence and the internet of things (IoT) spreading across the globe. The fourth industrial revolution is universally recognised as Industry 4.0. The underlying concepts are related to advances in technology whereby the internet and other digitalised automation integrate humans and machines, to produce a new kind of intelligence. This is the world of IoT.

Minerva et al. (2015) refers IoT as "a worldwide linkage system structure, where physical and virtual objects, things and devices are connected through intelligent objects, communication and actuation capabilities." Computers, laptops, tablets and smart phones that constitute the bulk of the IoT are being joined by smart watches, smart devices and appliances, cars, light bulbs and an array of other devices that are connected through invisible integration. More interestingly, many of today's home devices and appliances are equipped with IoT. Just imagine when you reach your house, the gate is automatically opened for you and the lights and air-conditioning are switched on when they detect your presence. The lights and air-conditioner are embedded with sensors to detect the presence of human temperature to control the electricity consumption, while the refrigerator is automated with information to notify the contents of food items, by smell detection and other interesting features. Furthermore, you might have a washing machine, toaster, radio and other devices that can be controlled using smart phones. Above all, Kumar et al. (2017) were of the opinion that smart infrastructures are capable of improving the quality of life. These technologies change the way we live today, compared to our lives a couple of years before. The question now is, how do millennials, the demographic cohort reaching young adulthood in the early 21st century (see Section 3), accept the IoT? How does it impact their well-being?

Based on the data obtained from Internet World Statistics, 31 December 2017 (https://www.internetworldstats.com/stats.htm), there were some 4,156,932,140 internet users around the world, representing 54.4% of the total world population of 7,634,758,428. Specifically, in Malaysia there were 24,554,255 internet users as at 30 June 2017, representing 78.8% of the country's total population of 31,164,177; 88% of the smart phone owners are millennials (Poushter, 2016). As the majority of Malaysians are internet users, the internet is not something new to them. Around 23.59 million (96.3%) of Malaysian internet users are using it for text messages and communication. However, recent technological advances show that the internet can do much more than providing communication platforms, and the current issue is whether users are ready to accept a more advanced role of the internet in their lives, especially in home appliances and devices. Most research articles on IoT highlight its use in manufacturing industries and the corporate world. Little is known about the acceptance of IoT on home devices and appliances, especially among millennials, or its impact on well-being. IoT in the home is therefore selected in this study, as home is an important place and its condition will affect the quality of life. Moreover, understanding millennials' views are important as they are the largest group of internet users employing the IoT in daily activities, and they represent future buyers of these products. In addition, there is a need to explore the acceptance of the IoT through smart home devices and appliances because the technology is still at the stage of infancy in Malaysia. As with any new technology, the biggest challenge is to ensure a positive outcome for its use. There is

currently a gap in the knowledge of the determinants and quality of life impacts for millennials acceptance of the smart home appliances and devices. Indeed, insight into millennials' perception is useful in encouraging the growth of smart house appliances and devices in Malaysia. These devices should reduce the cost of living through their energy-saving features.

With regard to the above issues, this study aims to explore the millennials' acceptance of smart home appliances and devices, and how these devices are perceived to affect their quality of life. This paper comprises a review of the literature; methodology and measurements; findings and discussion; and conclusions and future work.

2 Review of literature

2.1 Internet of things

The IoT is holistic and is used not only in manufacturing industry but also in healthcare, transportation systems, automotive, education and other applications. The support of IoT to manufacturing is by gathering data from devices and making them available to factory managers and employees, software systems and the supply chain (Caputo et al., 2016). This contributes to efficient and effective production and assembly processes and the expansion of the market through digital platforms. With regards to the healthcare sector, the IoT empowers accessible communication with patients, tracing them and their doctors' location, their medical information, medical supply chains, logistics and drugs (Tyagi et al., 2016). This will optimise the timeliness and accuracy of information. For transport systems, it is expected that the IoT will obtain real-time traffic information, traffic control and monitoring, and availability of parking spaces to provide efficient use of resources (Sherly and Somasundareswari, 2015). The IoT in the automotive industry is applied in the production, assembly, quality assurance, customer demand, warehousing and storage. Education sectors are not left behind, being used for monitoring students' attendance, their performance, health, enrolment, activities, etc.

Currently, the application of the IoT is spreading to home devices and appliances, ranging from small items such as lights and hair dryers to bigger items such as refrigerators, air conditioners and washing machines. Ryu and Park (2018) stated that smart televisions already access the internet to provide online content. Generally, there are three components in the process of the IoT in home devices and appliances. The first is hardware; it consists of sensors or devices involved in collecting data. The second component is middleware, that connects the sensors or devices to the cloud via various mediums such as satellite or cable. Data will then be processed and translated into the required information. Finally, the third component is presentation, whereby the information is made available to the users, for example controlling and monitoring automated gates. Other researchers have simplified this as the 'internet' being the hosting network that supports network access, while 'things' are the terminals that handle input and output (Shang et al., 2016). The automated systems in home devices and appliances are expected to improve the standard of living. The acceptance and impact of the IoT among millennials in Malaysia has gained huge interest from researchers, especially in mobile transactions such as banking, shopping and ticketing (Ghazali et al., 2018). However, the acceptance of smart home appliances and devices is still under investigation. In filling this gap, the current study uses the technology acceptance model

(TAM). It is expected that the components of TAM will be able to provide an insight into the acceptance of smart home devices and appliances among millennials in Malaysia. An equally crucial aspect is the expected impact of these technologies on well-being.

2.2 Technology acceptance model

Several scholars have chosen TAM to investigate the determinants for accepting new technologies (Al-Momani et al., 2016; Mącik, 2017; Patil, 2016; Singh et al., 2017). TAM is rooted in two established theories. First, it was constructed according to the theory of reasoned action (TRA), which idealised the concept of behavioural intention resulting from attitude and subjective norms. Second, TAM was grounded in the theory of planned behaviour (TPB), where behavioural intention is derived from attitude, subjective norms and perceived behavioural control. Moving forward, TAM proposed several factors in accepting new technology and explaining user behaviour over an extensive field of systems application and populations (Davis, 1989). There is a significant amount of research involving factors for accepting technology, and most researchers agree in the value of TAM's primary constructs (Davis, 1989). TAM acknowledges the existence of external variables as the causes of two constructs, namely perceived ease of use and perceived usefulness. Both constructs were theorised to affect individual attitudes. Subsequently it was expected that attitude will develop behavioural intention and actual use of technology. Perceived usefulness signifies an individual's confidence level that the application of the technology will enhance their work performance. In comparison, perceived ease of use considers the individual's perception with regards to the ease of handling the technology or device (Davis, 1989). Behavioural intention signifies the extent of certainty of the individual's intent to use the new technology (Alshare and Mousa, 2014). The current study uses perceived usefulness, perceived ease of use and attitude in determining the millennials' intention to use IoT for smart home devices and appliances. The actual usage will not be examined as currently there is limited use in practice. Moreover, smart home devices and appliances are seemed as future IoT services/products. Theoretically, previous researchers have highlighted the gap between intentional behaviour and action (Tudor et al., 2007). Thus, this study extends the TAM theory by including expected quality of life as an impact predicted by behavioural intention. This study proposes that the quality of life will be an immediate consequence after the intention is formed. Below are reviews of past studies on the relationships between the variables.

Dong et al. (2017) conducted an in-depth interview on the application of IoT systems among smart-house users and experts. They employed perceived ease of use and perceived usefulness as the factors for usage intention. Their research empirically proved that both elements have a positive impact on the intention to use IoT systems. A similar survey by Hsu et al. (2017) reported a statistical effect of perceived ease of use on perceived usefulness. Their study concluded that perceived usefulness does significantly affect attitude but has no significant influence on behavioural intention in using online audio and video media for fitness teaching. Meanwhile, Pal et al. (2018) investigated the acceptance of a smart house for elderly people using three complementary theories: TAM, TRA and TPB. Interestingly, perceived ease of use had a positive influence on perceived usefulness and attitude. Furthermore, their study concludes that perceived usefulness directly affects attitude and behavioural intention while attitude is statistically

proven to contribute to behavioural intention. Similarly, research by Agrebi and Jallais (2015) demonstrated that behavioural intention is positively impacted by perceived usefulness. Their result was based on data collected from 400 questionnaires distributed to French purchasers for mobile shopping. Roy et al. (2017) confirmed the positive association between perceived usefulness and behavioural intention on internet banking among university students in India. Additionally, both perceived ease of use and perceived usefulness were discovered to have an impact on the intention to use IoT technologies (Gao and Bai, 2014). Based on TAM and previous studies, the following hypotheses have been established:

H1 Perceived usefulness of using smart home devices and appliances is positively affected by perceived ease of use.

H2 Attitude to using smart home devices and appliances is positively affected by the perceived ease of use.

H3 Attitude to using smart home devices and appliances is positively affected by perceived usefulness.

H4 Perceived usefulness has a positive effect on the behavioural intention to use smart home devices and appliances.

Attitude towards acceptance of the IoT for home devices and appliances relies on the expectations and belief of the person in the effect of such technology. In other words, attitude refers to the preference or feeling that drives people's tendency to act in a particular way. TAM posited that perceived usefulness and perceived ease of use are the major contributors to attitude. Subsequently, attitude in the TAM model is predicted to influence behavioural intention in accepting innovative technology. This point is sustained by the work of Rafique et al. (2014), who found that attitude has a strong impact on intention towards online shopping. Using the internet as a medium to buy products or obtain services requires judgement whether to accept the technology or not. The connection between attitude and intention to accept technology has also caught the attention of Hussein (2017). In his study, he found that attitude has a significant positive correlation with acceptance of e-learning systems. Similarly, Chang et al. (2017) examined the acceptance of e-learning applications among undergraduate students. They discovered that the students' attitude is a predictor for accepting e-learning applications. Following TAM, this study further foresees that attitude will mediate the link between perceived usefulness and behavioural intention. Aside from TAM, this argument is supported by the evidence of a previous study (Gajanayake et al., 2013). In conjunction with these findings, the following hypotheses have been developed:

H5 Attitude toward using smart home devices and appliances has a positive influence on the behavioural intention to use them.

H6 Attitude will be a mediating factor in the relationship link between perceived usefulness and behavioural intention to use smart home devices and appliances.

Notwithstanding the elements highlighted in TAM, this study also investigates whether the intention to use smart home devices and appliances will contribute to expectations of a better quality of life. It focuses on quality of life expectation instead of actual adoption, as the previous literature highlighted the existence of an intention-behaviour gap (Sniehotta et al., 2005). It is also possible that not all intention will lead to actual

behaviour. Intention was proposed to lead to implementation in a study by Kang et al. (2019). Considering how implementation intention could be derived from intention, this study suggests a desirable outcome of implementation intention that is expectation of a better quality of life. Scherer (1996) refers to quality of life as life satisfaction and well-being. It is arguable that millennials expect a better quality of life in terms of comfort and happiness from using new technology such as smart home gadgets; otherwise the acceptance will be low. A study by Karahoca et al. (2018) on the IoT in healthcare technology products concluded that the technologies influence every area of life. Others agree that the lives of prospective consumers or users will be easy and comfortable using IoT technologies (Shah and Yaqoob, 2016). Within this context, it is worth considering whether the intention to accept smart home devices and appliances will affect expectations of the quality of life. Wahi and Ahuja (2017) pointed out that many technological innovations fail due to mismatched expectations from the technology. Thus, this study will provide new knowledge on the connection between intention to adopt new technologies and quality of life expectations. The following hypothesis has therefore been developed:

H7 Behavioural intention to use smart home devices and appliances positively affects millennials' quality of life.

3 Methodology and measurements

This study explores the intention to use smart home devices and appliances by examining the perceptions of millennials. Millennials have been selected for this study since their life has been moulded by high-tech advances during their childhood, college, career workplace, and they are recognised for their ability to consume many technological devices instantaneously (Gibson and Sodeman, 2014). The millennials in Malaysia who are currently using or will be using smart home devices and appliances in future are considered as the population for this study. How to identify a generation cohort is controversial. On one hand, previous researchers argue that a definition should be based on historical events and cultural distinctiveness (Gilleard, 2004). On the other hand, Kupperschmidt (2000) suggested that a generation is an identifiable group that shares birth years, age, location and significant life events. It is generally agreed that millennials are those born after 1980, who have grown up in the era of digital technology. The current study therefore suggests that millennials are those born from 1980 to 2000; children born after 2000 will be grouped as generation Z or post-millennials. Compared to millennials who were raised during the development of the internet, post-millennials have been exposed to the technology and global connections from an early age. This study adopted a convenience sampling technique to reach the targeted respondents, after considering the huge population from non-probability sampling.

Data was collected by distributing questionnaires both online and by hand. A description of IoT devices was outlined in the questionnaire to provide a clearer picture and better knowledge of the concept of smart home devices and appliances. It gave an example of IoT home devices as lighting and heating sensors, and of IoT home appliances as wireless, automated systems for washing machines, refrigerators and other

large home appliances. The questionnaire is separated into two parts, the first dealing with demographic data and the second represented by constructs for perceived usefulness, perceived ease of use, attitude, intention towards smart home usage, and quality of life. All the items were measured using a five-item scale. In the second part, four questions were used to measure variables except for perceived ease of use, with three questions. Questions on perceived usefulness were linked to the association between usage of smart home devices and appliances and household job performance in terms of saving electricity, an easy life, stress and health. Questions with regard to perceived ease of use reflected respondents' level of effort in adopting smart devices and appliances, while questions on attitude collected the respondents' beliefs about the use of smart home devices and appliances. Behavioural intention questions asked about the respondents' intention to use the smart home devices and appliances, and quality of life questions about their expectations of happiness and well-being from using smart home devices and appliances. A total of 206 respondents completed the questionnaire. The minimum sample size suggested by Hair et al. (2010) is according to the ratio of respondents to variables, which is 5:1. However, the recommended ratio is 15:1 or 20:1. Given that the number of variables in this study is only 5, a total of 206 respondents met the minimum sample for rule of thumb. Data from the questionnaires was analysed by the structural equation model (SEM) through analysis of moment structure (AMOS). SEM is an essential tool that makes it possible to assess the connections between multiple variables in the chains and analyses instantaneously in a model.

4 Findings and discussion

4.1 Demographic analysis

This study collected two items of demographic data; gender and age. The analysis reported that 47 (22.8%) respondents are male and 159 (77.2%) female. A total of 145 (70.4%) respondents were aged between 19–25 years and 61(29.6%) 26–35 years.

4.2 Measurement model assessment

In developing the structural model, this study estimated the measurement model's unidimensionality, validity and reliability. All the results are shown in Table 1.

For item factor loadings, 0.5 or above is generally recommended; otherwise the item should be removed from the model (Awang et al., 2010). All items here remained in the model, as the lowest factor loading, for QL3, is 0.57. The highest mean and standard deviation (SD) is for perceived usefulness (3.840) and quality of life (0.690) respectively. Reliability was tested by performing individual Cronbach's alpha on the variables, and all are above the recommended value of 0.7 (Awang, 2013). The current study also determines the average variance extracted (AVE), and all items achieve the rule of thumb for construct validity of 0.5. The highest AVE is for behavioural intention at 0.766, while the lowest is for quality of life at 0.676. After construct reliability, composite reliability (CR) was calculated. Again, the values are depicted in Table 1, ranging from 0.862 to 0.908, well above the minimum of 0.6 recommended by Awang (2013).

Table 1 Reliability of measurement model

	Factor loading	*Mean*	*SD*	*Cronbach's alpha*	*AVE*	*CR*
PU1	0.80	3.840	0.626	0.779	0.703	0.876
PU2	0.62					
PU3	0.84					
PEU1	0.79	3.816	0.615	0.845	0.764	0.907
PEU2	0.85					
PEU3	0.78					
AT1	0.80	3.778	0.594	0.839	0.756	0.903
AT2	0.79					
AT3	0.79					
BI1	0.79	3.838	0.647	0.850	0.766	0.908
BI2	0.81					
BI3	0.80					
QL1	0.83	3.827	0.690	0.758	0.676	0.862
QL2	0.77					
QL3	0.57					

Notes: PU = perceived usefulness, PEU = perceived ease of use, AT = attitude, BI = behavioural intention, QL = quality of life, SD = standard deviation, AVE = average variance extracted and CR = composite reliability.

Goodness-of-fit was also tested, with the results presented in Table 2. The outcomes of root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), standard root mean square residual (SRMR), comparative fit index (CFI), Tucker Lewis index (TLI) and normed fit index (NFI) achieved the target acceptance levels set by Awang (2013).

Table 2 Fitness indices for measurement model

Model fit	*Level of acceptance*	*Research model fit*
RMSEA	RMSEA < 0.08	0.072
GFI	GFI > 0.90	0.903
SRMR	SRMR < 0.08	0.029
CFI	CFI > 0.90	0.948
TLI	TLI > 0.90	0.934
NFI	NFI > 0.90	0.904

Upon confirming the acceptance of the goodness-of-fit indices, further in-depth analysis was carried out to test the proposed hypotheses. Table 3 presents the results of estimated path coefficient, standard error and critical ratio. H1 is accepted and the result implies that perceived ease of use positively and statistically impacts perceived usefulness ($\beta = 0.788$, C.R. = 8.349, $p < 0.01$). This result is consistent with Dong et al. (2017).

Since millennials grew up with technology, it appears that using smart home devices and appliances will be easy for them and are perceived as useful. The innovations are perceived to be convenient as they can control most of the situations through sensors and network access to their home appliances. Further analysis reveals that perceived ease of use has a significant positive influence on attitude ($\beta = 0.436$, C.R. = 4.429, $p < 0.01$) and thus supports H2. This outcome is in line with Hsu et al. (2017). When it comes to the topic of the IoT, most of us agree that millennials will handle the technology more readily than older generations. This will lead to a favourable attitude towards using smart home devices and appliances. This finding also indicates that perceived usefulness positively influences the usage attitude to smart home devices and appliances ($\beta = 0.499$, C.R. = 5.211, $p < 0.01$). Hence, H3 is accepted. This result has been empirically demonstrated by Agrebi and Jallais (2015). Millennials find that smart home devices and appliances are perceived to be useful to them as they are expected to assist in their daily life, and will offer a pleasant experience. Next, it was found that the perceived usefulness has a positive significant influence on the behavioural intention to utilise smart home devices and appliances ($\beta = 0.360$, C.R. = 2.608, $p < 0.05$). Therefore, H4 is accepted, concurring with Roy et al.'s (2017) study on intention to use internet banking. The millennials' perception of the usefulness of smart devices and appliances is likely to shape their intention to use them. In discussing H5, the outcome divulges that attitude to utilise smart home devices and appliances has a positive significant influence on behavioural intention. Hence, H5 is supported and is consistent with a previous study by Rafique et al. (2014). Undoubtedly, people who were exposed to the internet from a young age will intend to use the IoT's smart home devices and appliances.

Table 3 Structural model analysis

			Estimated path coefficient	*SE*	*Critical ratio*	*Hypotheses*
PU	<--	PEU	0.788	0.094	8.349***	H1 supported
AT	<--	PEU	0.436	0.103	4.429***	H2 supported
AT	<--	PU	0.499	0.096	5.211***	H3 supported
BI	<--	PU	0.360	0.138	2.608**	H4 supported
BI	<--	AT	0.654	0.148	4.429***	H5 supported

Notes: PU = perceived usefulness, PEU = perceived ease of use, AT = attitude, BI = behavioural intention and SE = standard error.
***$p < 0.001$ and **$p < 0.05$.

Having considered the importance of attitude in human behaviour, it is reasonable to examine how attitude bridges perceived usefulness and behavioural intention. In this study, attitude was being hypothesised as mediating the relationship between perceived usefulness and behavioural intention. This hypothesis is supported, and agrees with the research findings of Gajanayake et al. (2013). Table 4 depicts the results of direct effect ($\beta = 0.415$, C.R. = 4.293, $p < 0.01$) and indirect effect ($\beta = 0.360$, C.R. = 2.608, $p < 0.05$) of perceived usefulness on behavioural intention. A partial mediation relationship exists since the indirect effect of perceived usefulness on behavioural intention is still significant after attitude is introduced to the model, with the beta coefficient for perceived usefulness reduced from 0.415 to 0.36. Accordingly, H6 is supported. This finding is similar to that of Dong et al. (2017).

Table 4 Direct and indirect effect

			Estimated path coefficient	*SE*	*Critical ratio*	*Hypotheses*
Direct effect						H6 supported
BI	<--	PU	0.415	0.097	4.293**	
Indirect effect						
AT	<--	PU	0.499	0.096	5.211***	
BI	<--	AT	0.654	0.148	4.429***	
BI	<--	PU	0.360	0.138	2.608**	

Notes: BI = behavioural intention, AT = attitude, PU = perceived usefulness and SE = standard error. ***p < 0.001.

Finally, the result of the effect of behavioural intention on the use of smart home devices and appliances on millennials' quality of life is displayed in Table 5. It indicates a positive significant influence ($\beta = 0.581$, C.R. = 6.793, $p < 0.01$), and as a result H7 is supported. Millennials are expecting a better quality of life through their intention to use smart home devices and appliances because they believe that the technical innovation will lead to well-being and happiness. This indicates that it is possible that initial interest in using the smart home applications and devices will influence their expectation of a better quality of life before the intention is translated into actual behaviour. This proposition is similar to that of Gomes et al. (2018).

Table 5 Structural model analysis of behavioural intention on quality of life

			Estimated path coefficient	*SE*	*Critical ratio*	*Hypotheses*
QL	<--	BI	0.581	0.086	6.793***	H7 supported

Notes: QL = quality of life, BI = behavioural intention and SE = standard error. ***p < 0.001.

5 Conclusions and future work

5.1 Conclusions

The current study was performed to investigate the intention of Malaysian millennials toward using smart home devices and appliances. An integrated model was proposed by adopting TAM and its three main determinants. Consistent with TAM, a causal path was identified between perceived ease of use and perceived usefulness. In addition to examining the effect of behavioural intention on adoption as implemented in TAM, this study suggests a new perspective, which is the effect of behavioural intention on perceived quality of life. It is expected that a study of quality of life will provide a better understanding on the expectations from smart home devices and appliances. 206 millennials participated in the research, and analysis of the data in SEM using AMOS was found that the model suggested here is fit. Based on this analysis, the findings empirically prove the positive effect of perceived usefulness on perceived ease of use. This implies that when millennials believe that smart home devices are easy to use

and easy to learn, they perceive that they will be useful to them. This study further concludes the significant effect of perceived ease of use and perceived usefulness on millennials' attitude to use smart home devices and appliance. The result indicates that a tendency to use IoT home devices and appliances relies on expected benefits from their use, specifically perceived through low effort to use them, time saving and an enjoyable experience. The findings also suggest that millennial intention to use smart house devices and appliances was driven by their attitude. This predicts that millennials will use the smart home devices and appliances based on their judgement and assessment of the expected results. This denotes acceptance of smart technology usage. In short, attitude is established as a partial mediator in the association between perceived usefulness and behavioural intention. This implies that attitude is a vital determinant in the correlation between perceived usefulness and behavioural intention. Finally, the current study has proven that behavioural intention to use smart home devices and appliances will influence one's expectations of a better quality of life. The result points out that millennials' intention to use smart home devices and appliances will give rise to the expectation of a better quality of life, especially well-being and happiness, from the smart technology tools. Indirectly it provides an overview on the continuing debate pertaining to the impact of new technologies.

This study has theoretical implications by including expected quality of life in the TAM model. It presents empirical evidence that the intention to use smart technology is expected to contribute to a better quality of life. Indeed, it will be a starting point for future researchers to investigate this area further, as research in this context is rarely conducted. This study has strengthened the concept in TAM by testing the function of attitude as a mediator. The result proves that attitude mediates the relationship between perceived usefulness and behavioural intention.

Practically, developers may further extend the digital revolution in home devices and appliances. Findings from the current study verified that perceived usefulness contributes more towards attitude than perceived ease of use and attitude. Thus, it encourages inventors to produce smart house technology which will be useful to millennials. The specification of devices and appliances should meet millennials' needs and wants because they are the highest IoT users, and existing and potential customers for smart home devices and appliances. They constitute a large proportion of the population, and their purchasing power makes them targeted customers (Moreno et al., 2017). Therefore, the desired features, design and technology should suit them. In addition, the majority of millennials are willing to invest in technology, adopting the latest trends especially concerning modern lifestyle. The design of smart home devices and appliances needs to include innovative features as this has been empirically proven to be the most important subjective dimension of technological products (Okumuş et al., 2016).

The findings from this study are also beneficial in achieving sustainable development goal no. 11 that focuses on sustainable cities and communities. It foresees that smart technology will provide a more conducive living environment and reduce energy consumption, as most of the devices and appliances are connected to sensors that only operate in the presence of a certain signal.

Furthermore, these findings have important consequences from the social perspective. Particularly, millennials have a favourable attitude towards using smart home devices and appliances and the IoT complements their lifestyle. The discussion of IoT acceptance in fact addresses the larger matter of technology awareness among the whole community.

Smart home devices and appliances are indeed a way for having a greener environment by energy conservation.

5.2 Limitations and future research

Despite these contributions, there are some limitations that need to be addressed. First, the usage of the IoT is still in its infancy, especially in Malaysia, and some of the millennials might not be familiar with the smart devices and appliances. Future researchers might conduct focus group discussion to enhance understanding and gain insight into the acceptance of the IoT for home devices and appliances. Future study may also identify the critical success factors of smart home devices and appliances and their impact on social lifestyles and well-being. Lastly, in addition to attitude and perceived usefulness towards behavioural intention, researchers may include other determinants such as willingness to pay and the perceived quality of smart home devices and appliances.

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