The Role of Gender and Education Level on Diffusion of Innovation and Use of Technology: A Case of LED in Malaysia

Hasti Khorasanizadeh*, Jussi Parkkinen, Rajendran Parthiban

***Abstract*- Looking back at the last decade, the lighting technology has undergone great development. Today LEDs are capable of generating white light with a 20 times greater efficiency than conventional light bulbs. This solid-state light sources will result in enormous benefits that includes energy saving, reduction in global-warming emissions and pollutants and financial saving. The present study undertook to understand how gender and education level affect the diffusion of adopting LED in Malaysian households. Two hundred twenty two Malaysians were surveyed using Unified theory of acceptance and use of technology. With regards to Malaysian's adoption of technology; social influence and facilitating conditions were significantly linked to behavioral intention. Effort expectancy and performance expectancy were found to significantly influence the variables of facilitating condition. Education level had a moderating effect, while gender had no effect on LED adoption in Malaysia.**

***Index Terms*—Diffusion of innovation, Unified theory of acceptance and use of technology (UTAUT), Education level, gender, LED**

I. Introduction

The energy-efficiency benefits, longer life span, and low operational and maintenance costs, make LED the best replacement for conventional lights. Furthermore, the continually decreasing price of LEDs is encouraging the LED market in many countries. LEDs have been installed in a number of European cities. According to the EU, these cities have reported energy savings of 50 – 60 %, translated into massive cost savings as compared to traditional street lighting [1-2]. Consumer behavior may be the most significant obstacle for energy saving. Lack of reliable information on the financial impact of different energy-efficient investments, as well as the challenges in making decisions in such investments, is one of the main problem for households. Even if abundant and relevant information were simply available, not many consumers would calculate the costs and benefits of these investments. The apparent risk of energy-efficiency investments is one-reason that consumers demand a higher rate of return as compared to other investment types. Looking at energy efficiency education programs, it is also reported by Samuelson [3] that attitudes guide behavior, and that positive attitudes towards energy conservation are required for savings to happen.

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II. Malaysia Electricity overview

Only a few percent of Malaysian electricity demand is produced using renewable energy sources. Natural gas is the basis for 59.1 % of generating capacity, while coal sits in the second position with 34.0 % of contribution. This is followed by 6.3 % of the energy produced using hydropower, whereas oil and other renewable sum up to only 0.6 % [4].

In Malaysia, the amount of electrical energy utilized by lighting along with devices, apart from air conditioning, in buildings is around 25–35 % of the entire energy consumption [5]. Meanwhile, the main energy consumption in the commercial segment is attributed the use of air conditioning and for lighting purposes showing 38-52 % and 18-52 % of the overall consumption, correspondingly [6]. This highlights the fact that the main buildings in consuming energy for lighting purpose and air conditioning include converted historical buildings, shopping complexes and offices as compared to other types of buildings [7].

Efficient utilization of the lighting energy could reduce the level of electric power utilization significantly. It should be noted that even though lighting might not be the highest energy consumer in every sector as paralleled to air-conditioning. However, proper use of lighting could eventually lead to reduction in the heat generated by the lighting source. This will reduce the energy required for cooling load leading towards a more favorable direction in reducing global warming and greenhouse effects. On the other hand producing this much of electricity, which is, very much dependent on fossil based fuels will introduce substantial amounts of CO_2 to the environment as well. In terms of CO_2 emissions, Malaysia achieves 374.5 MT that is 0.85 % of total global CO_2 emissions in 2011 (world resource institute). In the current context of Malaysia, it has been reported by [8] that residential buildings contribute to approximately 40 % of the greenhouse gas emissions. Hence, considering the valuation of green buildings by reconstructing or retrofitting these buildings seems to be essential. CO_2 emissions are projected to grow at a rate of 3.72 % per annum from 2000 until 2020 [9]. Efficient

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utilization of energy could lead to a decrease in the monetary and social prices caused by the development of new production content, and cut down the pollution levels of greenhouse gases as well as other pollutants into the environment. In developing countries such as Malaysia, energy efficient lighting is a significant technology for reduction of CO_2 among all the other techniques [10].

III. Previous Literature

To understand the adoption and usage of LED in Malaysia, it is worth considering previous literature related to the adoption of new technology. Researchers have long argued that technology acceptance factors perform as strong predictors of actual technology adoption [11-12]. Studies suggest adoption of CFLs is influenced by financial benefits, culture, electricity prices, environmental motivations, and the meanings of lighting in different cultures [13-16].

Many competing models of acceptance of technology have been elaborated and validated in the contemporary information system literature. These models included different sets of acceptance constructs derived from information systems, psychology and sociology [12]. These models were able to explain up to 40 percent of the variance in intention to use technology [17]. According to Venkatesh et al. [12], ‘‘UTAUT is a definitive model that synthesizes what is known and provides a foundation to guide future research in this area’’. The UTAUT was developed as a consequence of an evaluation and combination of the concepts of earlier models that describe information systems application behavior. Performance expectancy, effort expectancy, social influence, and facilitating conditions are four main aspects of this theory, which serve as determinants of utilization intent and behavior [18]. The UTAUT model was examined and used on various technologies as well, such as bulletin board [19], information kiosk [20], website [21], Telehealth [22] and enterprise systems [23] . UTAUT has largely been applied to projects involving the implementation of Information and Communication Technology (ICT), where user participation after implementation is critical. Several previous studies validated the UTAUT model in different environments such as education [24-26], banking [27], organizations [28] , health [29] and tourism [30].

Chung et al. [31] suggested that while PU, PEOU, and BI have been widely tested and accepted toward determining technology acceptance, moderators, such as age and gender, have remained largely untested. Both age and gender have shown to be moderators to PU, PEOU, and BI as per previous studies as related to overall technology acceptance [32]. When addressing Gender roles [32] researched performance expectancy and found that task-oriented accomplishment was more prominent towards men and found this to stem from gender roles and socialization. The literature provides strong evidence of these significant moderating effects. Bandyopadhyay and Fraccastoro [33] reported that gender moderated the relationship between performance expectancy, effort expectancy and social influence on the one hand, and behavioral intentions to use technology on the other hand. As for Cheng et al. [34], Females were found to be more sensitive to social influence than males and hence the effect of social influence on behavioural intentions was stronger for females. When looking at effort expectancy [32] found that the expectations women experienced are more significant than men and this too is related to gender roles. This was also found by Barnett and Marshall [35] who noted that women experience change more and accept change more readily. Perhaps this is because women tend to be more sensitive to others’ opinions; therefore, they are more salient when forming an intention to use new technology [32]. Venkatesh and Morris [32] also revealed that men’s ‘technology usage’ decisions were more strongly influenced by performance expectancy. In contrast, women were more strongly influenced by effort expectancy and social influence.

A study by [36] reveals that education level affected the diffusion of innovations. Study of adoption of various Information Technology Equipment (ITEs) in organizations [37], shows that there was a correlation among education with employees' level of comfort with ITE use. Awwad et al., [38] empirically validated the UTAUT model in the context of electronic library services within an Arab culture. The study investigated the moderating effects of students’ characteristics, including gender and education level on behavioral intention.

IV. Methodology and Sampling

A complete set of questionnaire was developed through a three stage process. First literature review was conducted to list candidate constructs and measures used in previous researches. Second, an interview was conducted to get public and expert point of view in terms of energy efficient technology. The result of this section is reported by Khorasanizadeh et.al. [39] A draft questionnaire was then developed, with each item is measured on a six-point Likert scale. In the third stage, a preliminary test was carried out to assure the reliability of the questionnaire constructs. Face and content validity of the survey was assessed qualitatively, using a panel of five experts, as it is a typical approach adopted in this type of research [40].This set of questionnaire was a comprehensive set of questions to study different aspects of technology adoption in Malaysia. A detailed study on the adoption factors regardless of age and gender has been conducted by the same researchers [41].

Data for the empirical analysis was collected by means of the generated questionnaire (online version via Google and paper based), which was conducted in several Malaysian cities including Kuala Lumpur, Selangor, Penang, Malacca, Kelantan, Johor, Sabah, Terengganu and Perak during October 2013 to January 2014. The sampling technique used in this study is “Convenience or accidental sampling” [42]. It means that members are selected based on availability regardless of their age, gender etc. Later, they were asked to help in identifying other participants to sample and this process continues until enough samples are collected (snowball sampling). The commonality in this group is they are Malaysian citizens who live in Malaysia. Two hundred and twenty one valid responses were collected (150 females and 71 males). Subjects were informed that the purpose of the study was to investigate the perceptions and attitudes of Malaysians toward using energy-efficient lighting technology, in particular, LEDs.

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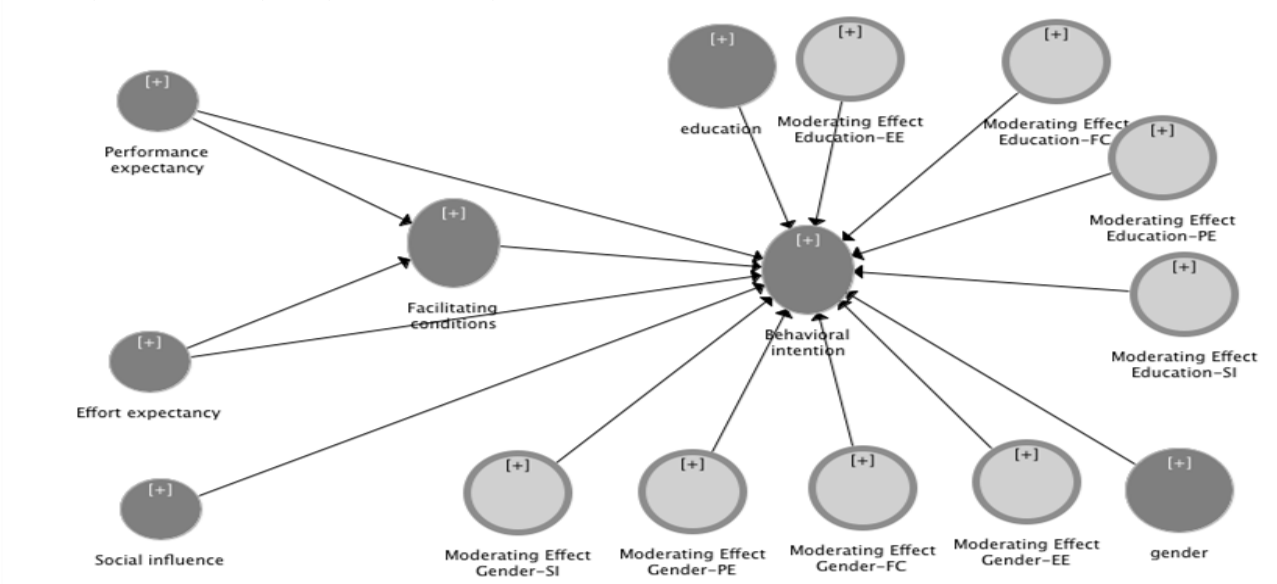

Figure 1. Overall model and study hypothesis

V. Data and Model Specification

The theoretical framework was based on the unified theory of acceptance and use of technology model (UTAUT). UTAUT, as a model, was intended to provide predictive model of end user uptake (acceptance) of technology through five core constructs: (a) performance expectancy (usefulness)- PE, the degree to which an individual believes that using the LED will help one attain gains in job performance; (b) effort expectancy (ease of use)- EE, the degree of ease associated with the use of the LEDs; (c) facilitating condition - FC, the degree to which an individual believes that an organizational and technical structure exists to support the use of the LED; (e) social influence -SI, the degree to which an individual perceives that important others believe he or she should use the LED; and (f) behavioral intention to use - BI, the degree to which an individual has formulated conscious plans to perform or not perform some specified future behavior regarding LEDs. Consistent with all models drawing from psychological theories, which argue that individual behavior is predictable and influenced by individual intention, UTAUT contended and proved BI to have significant influence on technology usage [43]. Intention to use refers to the strength of an individual's intensity of desire to use LED as a light source. Venkatesh et al. [12] reported that gender played a moderating role in the relationship between the psychological variables considered by the UTAUT model and behavioral intentions to use LED.

The overall framework for this study extends the UTAUT, as illustrated in Figure 1, and describes the relationship between UTAUT constructs, education level, and gender types. The proposed framework theorized that the technology acceptance factors differed between peoples' education level and gender types. The following hypothesis is proposed for this study:

1. The influence of FC on BI will be moderated by gender and education level.
2. The influence of SI on BI will be moderated by gender and education level.
3. The influence of BI on usage will be moderated by gender and education level.

VI. Results and Discussion

The measurement model was examined and reviled that all items loaded significantly on their respective constructs [44]. Convergent validity explains the degree to which two measures of constructs that theoretically should be related are related actually. Convergent validity is evaluated by examining composite reliability (CR>0.7) and average variance extracted (AVE>0.5) from the measures [45-46]. Table 1 presents the convergent validity results for the above model. As shown in Table 1, the CR of each construct ranged from 0.893 to 0.966, which exceeded the recommendation value of 0.7. All the AVE values in Table 1 are above 0.5. These results confirmed the convergent validity of mentioned model.

TABLE 1
CONVERGENT VALIDITY FOR THE MODIFIED UTAUT MODEL

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Behavioral intention	0.956	0.966	0.852
Effort expectancy	0.907	0.928	0.681
Facilitating conditions	0.849	0.899	0.691
Performance expectancy	0.931	0.944	0.708
Social influence	0.859	0.893	0.585

Discriminant validity defines "the degree to which the indicators of theoretically distinct concepts are unique from each other" [47]. The uniqueness is supported when the square roots of AVE of are larger than any other correlation [48-49]. Table 2 reports the correlation matrix. The elements in the diagonals represent the square roots of the AVE. in all cases, the AVE were greater than any correlation, supporting discriminant validity of the scales.

The bootstrapping approach was applied to estimate the significance (t-value) of the paths using 5000 samples, which were drawn from the complete sample. Table 3 presents the relationship between the hypothesis and the

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validation data based on T-Statistics and the significant path. Based on the T-test table for a study group of more than 1000 at a $p<0.05$ the T-value is 1.6. Table 3 indicates that 4 paths in the model were significant. As it could be observed in Table 3 the relation between effort expectancy and performance expectancy with behavioral intention to use LED is not significant. Effort expectancy and performance expectancy have positive significant effect on facilitating condition. Results in Table 3 shows that education has moderating effect on performance expectancy (p values 0.05) and gender has moderating effect on facilitating condition (0.002). This finding is in great agreement with the study on an Arab concept performed by [38] indicating that this result is valid regardless of race or nationality. Education and age do not have any moderating effect on any other construct of UTAUT model since their p-values were found to be greater than 0.05. Facilitating condition acts as a mediator between effort expectancy and performance expectancy and Behavior intention. The direct path between effort expectancy and performance expectancy with Behavior intention is not significant based on Table 3 (p values 0.546 and 0.127).

TABLE 2
DISCRIMINATE VALIDITY CORRELATION MATRIX

	Behavioral intention	Effort expectancy	Facilitating conditions	Performance expectancy	Social influence
Behavioral intention	0.923				
Effort expectancy	0.519	0.826			
Facilitating conditions	0.615	0.669	0.831		
Performance expectancy	0.516	0.665	0.572	0.841	
Social influence	0.664	0.661	0.642	0.628	0.765

The explanatory strength of the structural model is often examined based on the R^2 values, which stand for the quantity of variance described by the independent variables [50]. It is reported that the acceptable threshold values of R^2 could not be generalized by on a single account. In order to determine if a coefficient is acceptable or not individual studies should considered. However, it is agreed that the larger values of R^2, the better the variance is explained [51]. R^2 values for the constructs in this research model are 0.322 for behavioral intention, 0.554 for facilitating conditions, 0.443 for performance expectancy and 0.613 for social influence.

VII. CONCLUSION

The primary focus of this research is to study the two of the UTAUT's moderating variables, gender and education level on LED adoption in Malaysia. This research was performed to study the role and relationships of the moderating variables. It was revealed that the moderating variables had effect on the core UTAUT determinants of performance expectancy, effort expectancy, and social influence on intention (Behavioral Intention) and use (Usage Behavior). The preliminary belief was that the moderating variables based on past historical findings would significantly impact the effects of the core determinants of UTAUT model. This study provides contribution to business administrators, engineering managers as well as educators.

TABLE 3
SIGNIFICANT PATHS ON TECHNOLOGY ADOPTION

	Original Sample	T Statistics	P Values
Effort expectancy -> Behavioral intention	-0.051	0.604	0.55
Effort expectancy -> Facilitating conditions	0.518	7.950	0.00
Facilitating conditions -> Behavioral intention	0.345	3.549	0.00
Moderating Effect Education-EE -> Behavioral intention	0.036	0.380	0.70
Moderating Effect Education-FC -> Behavioral intention	-0.148	1.430	0.15
Moderating Effect Education-PE -> Behavioral intention	0.161	1.931	0.05
Moderating Effect Education-SI -> Behavioral intention	0.007	0.085	0.93
Moderating Effect Gender-EE -> Behavioral intention	0.100	1.122	0.26
Moderating Effect Gender-FC -> Behavioral intention	-0.239	3.111	0.00
Moderating Effect Gender-PE -> Behavioral intention	-0.043	0.553	0.58
Moderating Effect Gender-SI -> Behavioral intention	0.103	1.236	0.22
Performance expectancy -> Behavioral intention	0.111	1.526	0.13
Performance expectancy -> Facilitating conditions	0.227	3.214	0.00
Social influence -> Behavioral intention	0.414	4.830	0.00
education_ -> Behavioral intention	0.094	1.824	0.07
gender -> Behavioral intention	0.047	0.895	0.37

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