Potential Use of Smart Kitchen Management Application (SKM)

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Abstract—This research aimed to measure potential use of an application for smart kitchen management (SKM), designed to facilitate the users in managing the kitchen materials or items at a low cost and reduce the number of purchased kitchen items/ingredients derived from ignorant and unorganised behaviour. SKM could be an alternative aspect of kitchen management in which people could monitor how many items/ingredients left in the refrigerator or kitchen. The application also calculated and indicated the reorder point when the items/ingredients were about to run out or to be purchased. Psychological factors related to the potential use of SKM were also hypothesised and investigated. Both offline and online questionnaires were used to gather data from a sample of 180 participants. A seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) was used to measure all question items together with appropriate research instruments and statistical methods for data analysis, including technology acceptance model (TAM) and structural equation modelling (SEM). The results showed that there were strong indications of the potential adoption of SKM and significant relationships among the hypothesised constructs.

Keywords—SEM (Structural Equation Modeling), SKM (Smart Kitchen Management), Smartphone, TAM (Technology Acceptance Model).

I. INTRODUCTION

Recently, Phuket and Chiang Mai are two major cities driven by the Ministry of Digital Economy (DE) as Thailand's two leading smart cities [1], [2]. Smart living is one of the strategic attributes of smart city aimed to provide a better quality of health, well-being, happiness, and automation. According to IEEE [3], smart economy, smart mobility, smart environment, smart people, smart living, and smart governance are six key attributes of a smart city enabled by digital technologies. Smart living has become an emerging trend encompassing advancements providing people with the opportunity to benefit from new ways of living. It involves original and innovative solutions aimed at making life more efficient, more controllable, economical, productive, integrated and sustainable [4, p.3]. A smart refrigerator is one of smart living technologies allowing users to purchase food or ingredients via a touch screen interface.

There are a number of smartphone applications in the market due to rapid advancements in the mobile phone technology. The number of applications in the Google Play Store reached 2.8 million applications in March 2017 [5]. There are different purposes of the smartphone applications, e.g., entertainment, games, social media and communication. Many smartphone applications in the market are designed to support QR Code (Quick Response Code), a matrix barcode, initially designed in Japan but has been utilised by many smartphone applications. The QR code has been increasingly used in place of a barcode because of its faster readability, greater storage, and longer distance [6], [1]. A smartphone equipped with a QR code reader can be used to scan the QR code for a variety of purposes, including displaying text, opening a web page, or retrieving geographical information via GPS.

In previous work [2], smart kitchen management (SKM) was proposed as an alternative application for smart living, which allows people to understand the status of purchased kitchen items/ingredients. SKM was capable of reducing the number of purchased kitchen items/ingredients derived from ignorant and unorganised behaviour. In addition to technical perspectives, an experiment to understand users' perceptions is also essential since the SKM is designed to be used by individuals. These perceptions have long been considered as key factors behind user adoption of innovations. As a consequence, the main purpose of this article is measure potential use of SKM using TAM, a widely-recognised technique for predicting potential adoption of an innovation. The validity of TAM constructs will also be investigated in this article.

II. LITERATURE REVIEWS

This section provides literature reviews on two key topics of this article.

A. SKM

Smart kitchen management (SKM) is a smartphone application based on the use of QR Code to manage raw materials in a household kitchen [2]. SKM allows the user to add, delete, and modify the number of products used in the kitchen. The user can select the storage location, including refrigerator or kitchen. The application also generates a report representing the 'about to run out' kitchen ingredients by using the red colour indicator. SKM provides useful information for the user to manage his/her kitchen, e.g., the priority in the purchase of kitchen appliances, reminders, and preliminary cost estimations. SKM development was based on Android Studio and Fire Base online database. SKM was designed to be compatible with Android 4.4 or higher. SKM functionalities

were measured several times to ensure that there were no technical errors when used by the participants. All ingredient items were correctly stored, removed, and represented. Figure 1 represents major interfaces of SKM for users.

SKM usability was measured using the seven-point Likert scales questionnaire ranging from strongly disagree to strongly agree. The questionnaire comprised thirty question items, which were adapted from USE Questionnaire developed by Lund [7]. User attitudes towards four dimensions of usability, i.e., ease of use, ease of learning, usefulness, and satisfaction [8], were evaluated (Table 2).

Table 3 represents that there are positive relationships among ease of use, usefulness, and satisfaction consistent with the USE questionnaire developer [7], who pointed out that all these three dimensions are positively correlated with each other. However, these three dimensions have minimal negative relationships with ease of learning.

B. TAM (Technology Acceptance Model)

In computer science and related disciplines, TAM (Technology Acceptance Model), developed by Davis [9],[10],[11],[12], is one of the most prominent psychological models widely applied to measure the user's behavioural intention towards using an innovation. TAM contains several constructs to forecast the likelihood of the innovation being adopted by the user. Moreover, TAM can also be used to investigate psychological constructs underlying how the users interact with an existing system experienced by users [13]. Psychological constructs used in TAM are based on psychological theories, including TRA (Theory of Reasoned Action) [14],[15] and TPB (Theory of Planned Behaviour) [16]. There have been several TAM applications to study conditions associated with how users accept and use a system [17],[18],[19]. The relationships among psychological conditions have also been considered as a useful theoretical model explaining how a user and a system are interacted. TAM is considered as the only system acceptance model that has received the most attention in the information systems community [20]. TAM was pointed out to be more practicable than other integrated models that may not have better predictive power for acceptance of innovations [21],[22].

TAM defines that an individual's intention to use a system (ITU) is influenced by attitude toward using (ATT) referring to the extent an individual has an unfavourable or favourable assessment or appraisal of a material object [16]. ATT was introduced as another psychological element that influences actual system use [10]. ATT is driven by two constructs: 1) the perceived usefulness (the degree to which a person believes that using a particular system would enhance his or her job performance [9],[23]) and 2) the perceived ease of use (the degree to which a person believes that using a particular system would be free from effort [9],[11]). While PU was introduced in TAM constructs as a metric for measuring the extent of a particular system's utility to an individual, PEOU was also introduced in TAM constructs as a metric for measuring the extent to which a particular system reduces

effort used in performing a given task. As such, the following hypotheses were used in this research.

H1:   There exists a positive relationship between perceived ease of use (PEOU) and perceived usefulness (PU).

H2:   There exists a positive relationship between perceived usefulness (PU) and attitude toward using (ATT).

H3:   There exists a positive relationship between perceived ease of use (PEOU) and attitude toward using (ATT).

H4:   There exists a positive relationship between attitude toward using (ATT) and intention toward using (ITU).

H5:   There exists a positive relationship between perceived ease of use (PEOU) and intention toward using (ITU).

H6:   There exists a positive relationship between perceived usefulness (PU) and intention toward using (ITU).

III. METHODOLOGY

This section describes the methodology of this research, including instruments, measurement, and procedure.

A. Instruments

Participants in this study were 180 students from Phuket Rajabhat University (PKRU). The research involved the use of an online questionnaire. Participants were asked to answer different sets of questions about their perceptions of SKM in accordance with TAM constructs (e.g., perceived ease of use, perceived usefulness, attitude toward using, and behavioural intention toward using). Question items were generated from validated instruments in previous TAM experiments and modified to fit the SKM context. The questions were grouped in accordance with the TAM structure for participants to follow logically from one question to the other. Technical words were adjusted to be comprehensible for the participants. A pilot of the questionnaire was also tested with colleagues and students. The instrument was reviewed by academics and practitioners knowledgeable of survey design and TAM experiments. Modifications of the survey were conducted in accordance with the suggestions.

B. Measurement

The questionnaire contains different questions for measuring partipants' perceptions in accordance with TAM Questionnaire. A seven-point rating scale from 1 (strongly disagree) to 7 (strongly agree) was used to measure all question items on TAM factors. In addition, Cronbach's alpha, a scale reliability or internal consistency measurement of how a set of question items are closely related as a group, was also applied.
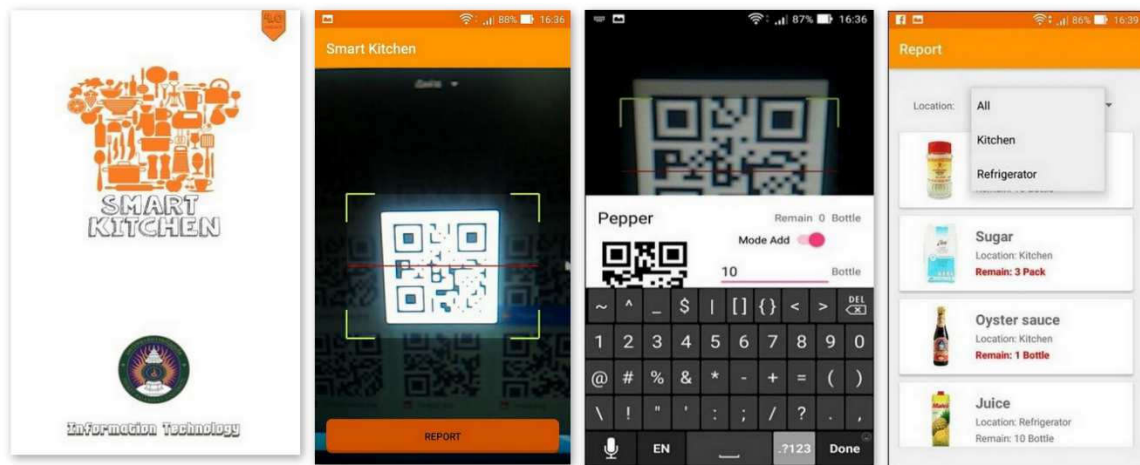
Fig. 1. SKM interfaces

Descriptive Statistics				
	Ease_of_Use	Ease_of_Learning	Usefulness	Satisfaction
Valid	180	180	180	180
Missing	0	0	0	0
Mean	5.703	5.894	5.440	4.871
Std. Deviation	0.8847	0.7380	0.9944	1.106
Minimum	2.200	3.670	2.170	1.330
Maximum	7.000	7.000	7.000	7.000

Fig. 2. The SKM USE

1) Perceived Ease of Use (PEOU): The scales used to measure PEOU were adapted from Davis, Bagozzi, and Warshaw [10],[11] with an excellent rate of Cronbach alpha coefficients ($\alpha = .91$). In this experiment, the overall reliability is very high and indicates a strong internal consistency among the five question items for measuring perceived ease of use of SKM ($\alpha = .899$). The correlations between PEOU1 and PEOU5 are significant, where $r = .784, .765, .794, .750, .697$ respectively. This can be used to assess how well one item's score is internally consistent with composite scores from all other remaining items.

2) Perceived Usefulness (PU): Six questions were adapted from the perceived usefulness, developed by Davis, Bagozzi, and Warshaw [10],[11], with an excellent rate of reliability ($\alpha = .97$). The overall reliability of PU question items for measuring perceived usefulness of SKM in this experiment is also very high ($\alpha = .942$). There are strong and positive correlations from PU1 to PU6 ($r = .789, .865, .833, .862, .842, .760$).

3) Attitude Toward Using (ATT): Six questions were developed from the highly reliable attitude toward using, with excellent rate of Cronbach alpha coefficients ($\alpha = .96$), adapted from Ajzen and Fishbein [14] in Davis, Bagozzi, and Warshaw [10]. There is strong internal consistency among the six question items used in this experiment for measuring attitude towards using SKM ($\alpha = .911$). There are strong and positive correlations between ATT1 and ATT6 ($r = .753, .815, .822, .715, .828, .645$).

4) Intention Toward Using (ITU): Behavioral intention is an indication of an individual's subjective probability to perform a given behavior. It is widely used in TAM as an immediate antecedent of actual usage of a system [16],[14],[15]. Three question items for measuring intention to use were modified from other validated TAM research. The overall reliability of ITU question items is very high and also indicates a strong internal consistency among the six question items for measuring intention to use ($\alpha = .914$). These question items are reliably measuring the same construct and confirms the reliability of question items for measuring behavioural intention to use ($r = .808, .860, .814$).

C. Procedure

The measurement of TAM constructs in this research is based on SEM (Structural Equation Modeling), a comprehensive statistical approach for testing relations among hypothesised (observed and latent) variables [24],[25],[26]. This approach is also widely used in the behavioural sciences, including psychometric design and measurements [27]. SEM is also recognised in various disciplines as a causal modeling or path analysis in which causal relationships among variables are hypothesised and tested with a linear equation system [28],[29],[30].

The hypotheses in a model represent the paths between psychological constructs and tested against the data collected from participants to evaluate fit indices. Path coefficients are used to examine the causal influence among the hypothesised constructs. The results are divided into (B) (an unstandardised coefficient) and (β) (a standardised coefficient). The CR Critical Ratio) is used to confirm whether there are causal relationships between two constructs. If the CR is less than 1.960, the null hypothesis is accepted and the path is rejected. Conversely, the null hypothesis is rejected and the path is

Pearson Correlations

		Ease_of_Use	Ease_of_Learning	Usefulness	Satisfaction
Ease_of_Use	Pearson's r	—	-0.112	0.675***	0.631***
	p-value	—	0.133	< .001	< .001
Ease_of_Learning	Pearson's r		—	-0.140	-0.138
	p-value		—	0.061	0.066
Usefulness	Pearson's r			—	0.728***
	p-value			—	< .001
Satisfaction	Pearson's r				—
	p-value				—

* p < .05, ** p < .01, *** p < .001

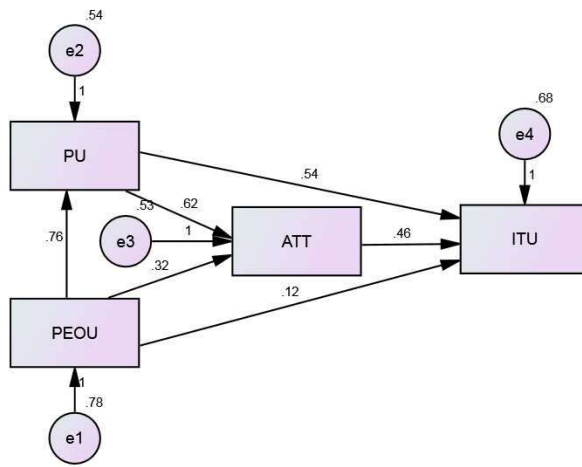Fig. 3. Correlations of Four Dimensions adapted from the Use Questionnaire

Fig. 4. The SKM hypothesised model

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
PU	<---	PEOU	.759	.062	12.238	***	
ATT	<---	PU	.617	.074	8.311	***	
ATT	<---	PEOU	.321	.083	3.848	***	
ITU	<---	PU	.538	.099	5.424	***	
ITU	<---	ATT	.464	.085	5.466	***	
ITU	<---	PEOU	.119	.099	1.210	.226	

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
PU	<---	PEOU	.675
ATT	<---	PU	.555
ATT	<---	PEOU	.257
ITU	<---	PU	.400
ITU	<---	ATT	.384
ITU	<---	PEOU	.079

Fig. 5. The relationships of TAM constructs for predicting SKM future use

accepted when $CR < 1.960$, which implies there is the statistical significance of the path coefficient at ($p < 0.05$). If $CR > 2.576$, there is the statistical significance of the path coefficient at ($p < 0.01$). When $CR > 3.291$, there is the statistical significance of the path coefficient at ($p < 0.001$), which is represented in the table as ***.

IV. RESULTS AND DISCUSSION

Figure 4 represents the hypothesised model based on TAM constructs. The overall fit indices were assessed for the measurement model by using different common measures: The Chi Square Test ($\chi2$), Normed $\chi2$ (ratio of chi square divided by the degrees of freedom), Tucker-Lewis index (TLI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR). The hypothesised model can be considered as a good model fit. All fit indices were within recommended guidelines [$\chi2 = 9.897$; $\chi2/df = 3.299$; $TLI = .945$; $CFI = .958$; $RMSEA = .063$; $SRMR = .0703$] [31],[25],[30]. The path coefficients linking most constructs in the model are significant at $p < 0.01$ level.

The results show that the relationships of TAM constructs share statistically significant relationship. The constructs are still valid when experimented on SKM. A significant positive relationship between PEOU and PU constructs ($\beta = .675$) confirms that PU is positively influenced by PEOU. Both PEOU and PU have a positive causal influence on ATT. Nevertheless, the relationship between PU and ATT ($\beta = .555$) is significantly stronger than that between PEOU and ATT ($\beta = .257$). These results also confirm the validity of TAM constructs that ATT is driven by PEOU and PU. Besides, there is a confirmation of positive relationship between ATT and ITU ($\beta = .384$). Since PEOU and PU are also hypothesised to be associated with ITU, the results show that the constructs are positively related to ITU. However, the relationship between PEOU and ITU ($\beta = .079$) is significantly less than that between PU and ITU ($\beta = .400$), which implies that the students continue using SKM mainly because they comprehend that SKM is useful. Figure 5 shows the user perception results regarding SKM based on TAM constructs.

V. CONCLUSIONS AND FUTURE WORK

The potential use of SKM was measured with TAM question items. The results not only represented the positive aspects of SKM potential adoption, but also yielded the validity of TAM structure. Nevertheless, the study emphasised the validity of TAM constructs on an existing system, but did not take effects of demographics into account (e.g., gender, education, computer skills, etc.). As a consequence, further studies should analyse such effects and extend to other specific segments. For instance, students in different colleges and different countries may contribute to interesting findings. In addtion, this article emphasises behavioural intention as a strong indicator towards actual use. As such, the relationship between behavioural intention and actual use should be further investigated.

Although behavioural intention has long been experimented in several psychological studies as a construct capable of predicting actual use behavior, a number of studies on actual use behaviours are pointed out by Tao [32] as self-reported usage. The author asserted that measuring self-reported usage is biased and can not accurately represent actual usage. Most question items used to measure actual use (e.g., frequency and duration)could reflect only general usage in different contexts and at different times. There was no significant impact of behavior intention on actual use and low correlations between intention and behavior. Actual use, in this case, should be obtained from objective usage records (e.g., computer logs and actual counts) instead of actual use question items about frequency and duration.

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