Analyzing Persuasive Mobile Healthcare Architecture Using Systematic Process Design

Mustafa Moosa Qasim, Mazida Ahmad, Mazni Omar
School of Computing, Universiti Utara Malaysia
mazida@uum.edu.my

***Abstract*—More broadly within the healthcare domain, the prospective value of persuasive mobile technology is seen in changing individuals by incorporating persuasion features into the design of mobile phone technology. In this regard, most of the researchers have paid attention to develop persuasive applications, but they yet failed to provide guidance on how the persuasive guidelines can be implemented, in particular in software architecture. Hence, the studies existed before did not follow any systematic processes into software architecture for analysis and designing the persuasive technology applications. Therefore, the distinct gap in the previous researches relating to transform the persuasive components into software requirements and functionalities. In light of those major reasons, this paper proposes a general systematic process to analyze the customers' significant requirements of the software to be used independently of the problem domain. One of these domains is an obesity problem among Malaysian children, and the most significant treatment of this case is parents' involvement. To this end, this paper applied a systematic process in monitoring the children's obesity status among parents. Findings showed that systematic process is suitable and convincing for collecting required requirements from stakeholders to set final software design in the right way.**

***Index Terms*—Software Architecture; Systematic Process; Mobile Healthcare; Persuasive Components; Child Obesity.**

I. INTRODUCTION

Notably, mobile healthcare (m-Healthcare) has witnessed a considerable interest and opened up new opportunities to develop applications that care about human health. One challenge of health's applications is the capability to establish long-lasting behaviour change among patients and their respective health care provider, or both [1]. To tackle this challenge, there are several endeavours have been made by incorporating persuasive features [2]. The key reason behind this incorporation is that persuasive components have remarkable impacts on changing users' attitudes or behaviours [3, 4]. Stories of using persuasive components to change the users' behaviour can be seen in various facets such as weight loss [5], diet and physical activity [6], treatment adherence [7], and disease management [8]. Thus, in mobile health application, it is highly recommended to endow the software architecture of such applications with persuasive power. However, current studies pointed out that the incorporation of persuasive components in mobile healthcare is not detailed clearly [9]. Adding to this, most of the studies did not follow systematic processes while analyzing persuasive software applications [10]. With respect to mobile software architecture, it is yet to be integrated with persuasive components [11]. Clearly, these are one of the reasons of failure in most studies in providing the relevant information needed for the analysis of the compelling applications into the software architecture. Therefore, there is a need for more guidance on how the persuasive guidelines can be implemented. Software architecture (SA) is considered the essence of software systems, and it plays a vital role in the success or failure of any software system [12]. SA constitutes a model of how the system is structured, and how its components interact with each other to carry out the required behaviour [13]. It also helps practitioners to clearly understand the components of the system and their relations without looking at the details of the implementation. Generally, one of the related studies for analyzing persuasive mobile in the domain of healthcare has been provided by [14] where they proposed an initial evaluation model as the basis for analyzing persuasive systems in the mobile healthcare. Their aim was to determine the consistency of the persuasive approaches in engaging users' acceptance. However, the current studies revealed that the incorporation of persuasive strategies in mobile healthcare is too general [15]. Adding to this is the scarcity of studies on persuasive mobile architecture [8, 11, 16] particularly on mobile healthcare to monitor the children's obesity status. Obesity among Malaysian children is the highest in Southeast Asia [17], and the higher among children in the urban areas according to [18]. Therefore, the best significant treatment to tackle this problem is parents' involvement [19, 20].

In this regard, the present studies lack in the architectural analysis of the persuasive mobile healthcare, especially those that can be used for persuading parents to monitor their children's obesity. Hence, this paper presents a novel systematic process for analyzing parents' requirements in monitoring their children's obesity status. Consequently, this systematic process can be generalized as a mean to analyze the requirements of software architecture in relation to the persuasive applications of other domains.

The remaining part of this paper is organized as follows: Research method is given in Section II. In Section III, the study presents the activity of architectural analysis. Then Section IV describes the activity of architectural synthesis. Section V presents the results and discussion and finally, the paper provides the conclusion and future work in Section VI.

II. RESEARCH METHOD

The methodology of this study is divided into three stages: (a) problem identification, (b) solution design, and (c) evaluation. Each stage is clarified below.

In the first stage collect all possible information to enhance the understanding every aspect of the problem including its causes. Therefore, this stage has been carried out as a theoretical study to gather information related to the theories

and strategies of persuasion, or persuasive models to understand the domain of the study. As a result of this stage, a critical analysis was conducted on the previous works to ensure the gap of research. This stage found that most of the current mobile healthcare architectures lack persuasive features that can persuade parents to monitor their children's obesity status [8, 11, 16]. Software architecture is the fundamental step in designing applications that can implement various persuasive strategies in order to instil the required behaviour. However, software architecture is yet to be integrated with persuasive strategies, particularly those of mobile healthcare architecture [8, 11]. Correspondingly [10] pointed out that most researchers did not follow systematic processes while designing the persuasive technology applications, and they also failed to provide some of the relevant information needed to design the persuasive applications.

The second stage of this methodology is the design of software architecture that is adapted from a general model that identified by [21]. The key reason for developing the general model that suits any software architecture design process is due to the complexity and the wide use of various types of methods. Hence, the literature is immersed with a number of software architecture designs methods that were developed to exhibit domain characteristics and emphasise different goals [22]. For instance, developing a software architecture design to suit information systems requires an emphasis on data modeling while developing a software architecture design to suit telecommunication software requires an emphasis on continues operation, live upgrade, and interoperability. Another fact is since many methods were developed independently and thereby a misunderstanding was appeared due to different descriptions and terminologies were established. Moreover, other differences between different methods may include methods designed for large organizations vs. methods suitable for a team of software developers, methods for product families vs. methods for developing the small system.

The general software architecture in this study was adapted by using two main activities which include; the architectural analysis and the architectural synthesis of software, but this paper is only focused on the first activity of general model which is an architectural analysis as explained in section III.

The last stage of research method is the user evaluation; this stage is testing the architectural prototype approach to validate the proposed systematic process of mobile persuasive design in the healthcare domain. The architectural prototype called persuasive mobile child's obesity monitor (PMCOM). It is an executable program which considers helpful and necessary to reflect critical architectural components of the proposed system for experimental purposes. Therefore, the researchers conducted a survey approach to gather information directly from Malaysian parents. Thus, the purposive sampling, which is one of the non-probability sampling techniques was used to provide an adequate level of confidence to satisfy study purpose. The main constraint of selecting these Malaysian parents who have obese children is that they are unknown individuals and cannot be reached easily. Consequently, this purposive sampling technique is appropriate since it is intended to be used when only a limited number or category of individuals can be approached [23].

A total of 115 parents who have obese children between age 5-14 years old and who are capable to interview was targeted. This sampling should be acceptable, according to [24] recommended that the sample size of 100 is sufficient. Additionally, most of the researchers such as [25, 26] stated that the minimum sample acceptable size for statistical analysis is 30. The instrument was adapted from relevant previous studies. Table 1 illustrates the variables and the sources of the instrument. The questionnaire covers measurements which include; reminder message component, reduction component, historical information component, suggestion component, praise component and with the final measurement to recognize the persuasion to all components. Reminder message component: Person can be convinced by using a specific application would raise up the person's ability by providing him/her a reminder message at the right time [3, 27]. Reduction component: Person can be convinced by using a specific application if it can reduce the complexity of the required process through easy and simple steps [3, 27]. The historical information provides reasonable and accessible information about the user's past behaviour as it relates to his/her goals. Historical data should accommodate changes in lifestyle goals over time and provide for the portability of data across devices [28, 29]. Suggestion component: Person can be convinced by using a specific application would increase the person's motivation level through introducing suggestions at the opportune moment [3, 27]. Praise component: Person can be convinced by using a specific application would increase the person's motivation level through the expression of praise, with words, figurative, signs, or expression [3, 27]. Finally, the perceived persuasiveness or persuasion: This refers to the general perceptions about the extent of person's persuasion in using the application with all components [16, 29-31]. A seven-point numerical scale was in this research, which it simply provides numbers rather than a semantic space or verbal descriptions to identify response options or categories (response positions) [32].

III. Activity of Architectural Analysis

The process of understanding software requirements always refers to architectural analysis, thus the analysis activity will focus on the input or functional requirements of persuasive m-health care. As well as, to find relevant components of the m-healthcare architecture and its relationships will be identified and documented. To achieve that, this study has been suggested a systematic process to analyze the significant requirements of the system and problems related. Further explanations about a systematic process will be argued in the next section.

A. Systematic Process Design

The design and implementation of a systematic process are the opportunities aimed at handling the errors and failures that have happened in the previous research due to the misunderstanding or negligence. This paper applies a systematic process for monitoring the children's obesity status among parents.

Requirements analysis activity has a great impact on software development process. It is an essential step to be implemented before developing any application. Pertinent to developing an application that can help parents to monitor their children obesity, requirements are gathered as stated in [42]. [43] mentioned that some parents have no willing or irresponsible in monitoring their children's obesity status due to time limitations, work constraints and not enough

motivation or ability to do so. From the lines mentioned above, it would be a great challenge to investigate the key reasons that hinder parents of using what is good for their children and thereby persuasive components will be developed to help parents and their children through incorporating software architecture with persuasive components. Based on the results of previous literature reviews, it is quite obvious that the incorporation of persuasive strategies in mobile healthcare is clearly very general. Hence, most of the trials in the literature adapt the concepts from [3] without showing how the incorporation and the implementation of the strategies have been made. [11] asserted that there is a scarcity of studies on the persuasive mobile architecture, in particular, Mobile healthcare. Moreover, most of the current mobile healthcare architectures lack persuasive features to persuade parents to monitor their children's obesity status [8, 11]. As well as, there is a need for more guidance in order to describe how the persuasive guidelines can be implemented, which also means that there is a highly need for a way to transform the persuasive components into software requirements and functionalities. Hence, in the stage of architecture analysis will use a systematic process design for analysis of persuasive software application before designing mobile software architecture.

Table 1
The Dimension and Elements of Questionnaire

Dimension	Element	Items	References From
Trigger	Reminder Message	1. The PMCOM app sent me a reminder message whenever I did not use it after a month.	[27, 33, 34]
		2. The reminder message of PMCOM app helped me in monitoring my child's obesity status.	[3, 33, 35-37]
		3. The reminder message of PMCOM app did not disturb me.	[35, 36, 38]
Ability	Reduction	1. The PMCOM app provided simple steps to monitor my child's obesity status.	[3, 27]
		2. The PMCOM app made the tasks of monitoring my child obesity status easier.	[27, 33]
		3. The PMCOM app's ability in monitoring my child obesity status is worth more than overcoming the consequences of the obesity.	[33, 39]
		4. I took a shorter time to monitor my child's obesity status using the PMCOM app compare with the conventional approach.	[33, 39]
		5. The PMCOM app helped me to monitor my child's obesity status with less mental effort.	[33, 40]
		6. The PMCOM app did not interrupt my routine life, and I will continue to use it.	[33]
		7. The PMCOM app is suited of the norm of society, thus I felt comfortable in using it.	[27, 33]
	Historical Information	1. The PMCOM app enabled me to track my child's obesity status anytime.	[3, 27, 28]
		2. The PMCOM app allowed me to track my child's obesity status at any specific date.	[3, 27, 28]
Motivation	Suggestion	1. Suggestion's information motivated me to monitor my child's status for fear of the impact of obesity in the future	[3, 33]
		2. Suggestions information motivated me in keeping my child from socially rejected by his/her peers.	[33]
		3. I accepted the PMCOM's suggestions on my child obesity status; therefore I will encourage other parents to use it.	[33]
		4. I felt guilty whenever my child is obese or overweight; however, the suggestion's information helped me to handle the situation.	[33]
	Praise	1. Reading the PMCOM's praise messages encouraged me; therefore I was happy to use it.	[3, 33, 41]
		2. I was pleased to see the PMCOM's praise messages because it did not disturb my parental feeling.	[3]
		3. The praise messages of the PMCOM app gave me hope to continuously monitor my child status.	[33]
Perceived Persuasion	Persuasiveness	1. Are you convinced in using the PMCOM app to monitor your child's obesity status?	[16, 29, 31]

A systematic process design can take the advantages of concepts, models and processes that put forward [3, 33, 44, 45] to create products with the aim of persuasion, as well as some principles [28].

Initially, according to [44], many developers have little or no experience in creating persuasive products with its goal and yet to follow a systematic process in designing persuasive applications. He stressed that lack of well-established process to design persuasive technology leads people to adopt the methods of the other fields, such as usability engineering, or to make guesses to identify and develop their products. To meet this challenge relied on his expertise for fifteen years in this field and pointed out eight-steps for creating successful persuasive technologies. He also explained that the eight steps are not intended to be used as a rigid formula, but can be modified or cut sequence of steps to suit the conditions of design.

Given the importance of these steps in the design process of persuasive technology, this study decided to adopt three steps that are very appropriate to the design of persuasive mobile healthcare as part of the persuasive architecture. These steps are; 1) defining simple behaviour to target, 2) selected a receptive audience, and 3) find relevant examples of persuasive strategies (similar behaviour, audience, mobile application). Similarly, one more step should be included in order to attain the designing of a persuasive mobile technology [45]. This step is selecting a target behaviour. Moreover, all these steps (defining simple behaviour, select receptive audience, select target behaviour, select relevant example) must be implemented sequentially as a systematic process design as illustrated in Figure 1.

In [44] pointed that the first step in the selection of a simple behaviour is the most important aspect of designing successful persuasive technologies. He added that many

projects are too ambitious, and thus are set up for failure. Moreover, many researchers [46-49] have emphasized that simple behaviour is an important first step to make a major change in health behaviour. Therefore, this study considers the choice of simple behaviour is a crucial matter. As a result, a systematic process design will begin with choosing a simple behaviour to target like monitoring children obesity using a smartphone. Consequently, this simple behaviour will constitute a good starting point for reducing obesity among Malaysian children

The second step of a systematic process design involves selecting the right audience to intervene and should identify the audience who has a desire to improve the desired behaviour. Hence, the parents will be the target audience. [45] stressed that the persuasive design lacked in taxonomy and a terminology that allows precise discussions about different types of target behaviours. Therefore, the third step of this process aims to use Fogg's behaviour grid which specifies fifteen types of behaviour change as a method for matching target behaviours. Many former researchers indicated the importance of matching psychology to target behaviour [50, 51]. Consequently, this step strives to apply behaviour grid in the framework of this study because it is considered a systematic way of design for successful behaviour change. According to this grid, the blue span behaviour is familiar to target parents but for a period of time. This means that most parents have smartphones that can be used to monitor their children obesity amongst aged 5-14 year. In order to achieve a blue span behaviour, three key factors must come together at once, namely; 1) trigger, 2) motivation, and 3) ability.

The following steps are essential to attain the blue behaviour;

- Focus on Triggers firstly, Not Motivation.
- If a change with the trigger does not work, ability should be tackled secondly.
- If a change does not occur, in this case, a person's motivation is too low; a motivation level must be triggered as a third step.

Many behaviour theories and models stress the importance of motivation and ability in changing behaviour [52-63]. Nevertheless, [33, 44] has emphasized that three factors (motivation, ability and trigger) are important and necessary for behaviour change. Therefore, this study adopts these three factors in changing the parents' behaviour in monitoring their children obesity through the use of mobile technology as a channel to trigger the required behaviour.

The fourth step of a systematic process design is finding the relevant examples of successful persuasive strategies which adapted from [44]. This phase of the persuasive design represents a successful step, according to Fogg's experience, because it enables the designer to look at successful strategies in order to be imitated. But, these relevant examples must match the target behaviour, target audience and chosen technology channel (i.e., a mobile phone). Searching for relevant examples of successful persuasive techniques is a daunting task. Therefore, finding one example that matches to the precise behaviour, target audience, and technology channel is accepted [44]. Otherwise, nine examples in total must be searched: three that achieve a similar behavior, three that reach a similar audience, and three that use the same technology channel to select the relevant examples. This step is more flexible in dealing with different persuasion strategies in all areas, which can be obtained from previous studies. Thus, this work is not confined only in persuasive technology that has been identified in [3]. After the completion of the previous four steps, choose simple behavior, identify the audience with matching target behavior, and identify the successful persuasive examples, a further step is needed which is, choosing appropriate persuasive strategies to target change behavior in order to classify it based on the Fogg Behavior Model [33], which are strategies to trigger lack of motivation, strategies to trigger lack of ability, and strategies to trigger lack of a well-timed trigger to perform the behavior.

In summary, understanding this systematic process enables software practitioners to be more confidence for generalization it on the other domains. It may even help them to design a more efficient or effective intervention in developing persuasive applications.

IV. Activity of Architectural Synthesis

The process of architectural construction always refers to the synthesis (candidate solutions). However, this study is not focused on this part, so here we are not going to provide a comprehensive description of candidate solutions during the activity architectural synthesis. Of course, there are already in literature papers and surveys that support architects in identifying candidate solutions; in order to help the reader to approach, identifying candidate solutions, this section sketches some the common candidate solutions as references in this article.

[64] has set taxonomy or catalogs of software architectural styles including data flow architectures (e.g., batch sequential, pipe and filter, and process control), data-centered architectures (e.g., data repository and blackboard), hierarchical architectures (e.g., main- subroutine, master-slaves, layered, and virtual machine), implicit asynchronous communication architectures (e.g., event-based and buffered message-based), interaction architectures (e.g., model-view-controller), distributed architectures (e.g., client-server and service-oriented architecture), and component-based architectures.

In like manner, [65] has set a list of common types of systems appropriate for classifying architectural patterns, namely data flow systems (e.g., pipe and filter pattern), data-centered architectures (e.g., blackboard pattern), hierarchical systems (e.g., main- subroutine pattern, layered pattern), interactive systems (e.g., model-view-controller pattern), distributed systems (e.g., client-server pattern, broker pattern). However, note, [64, 65] both are depicting the same thing of classifying architectural patterns to be the equally important. Based on the above references, the researcher has proposed generalizable software architecture in mobile healthcare to be used independently of the problem domain. One of these domains is Malaysian parents' problem in monitoring their children's obesity status. The study was designed to collect final evaluations among experts, greater details have been discussed in [66]. Overall, that work considered as a guide for software engineering researchers towards the development and improves software architecture for mobile applications in the future.

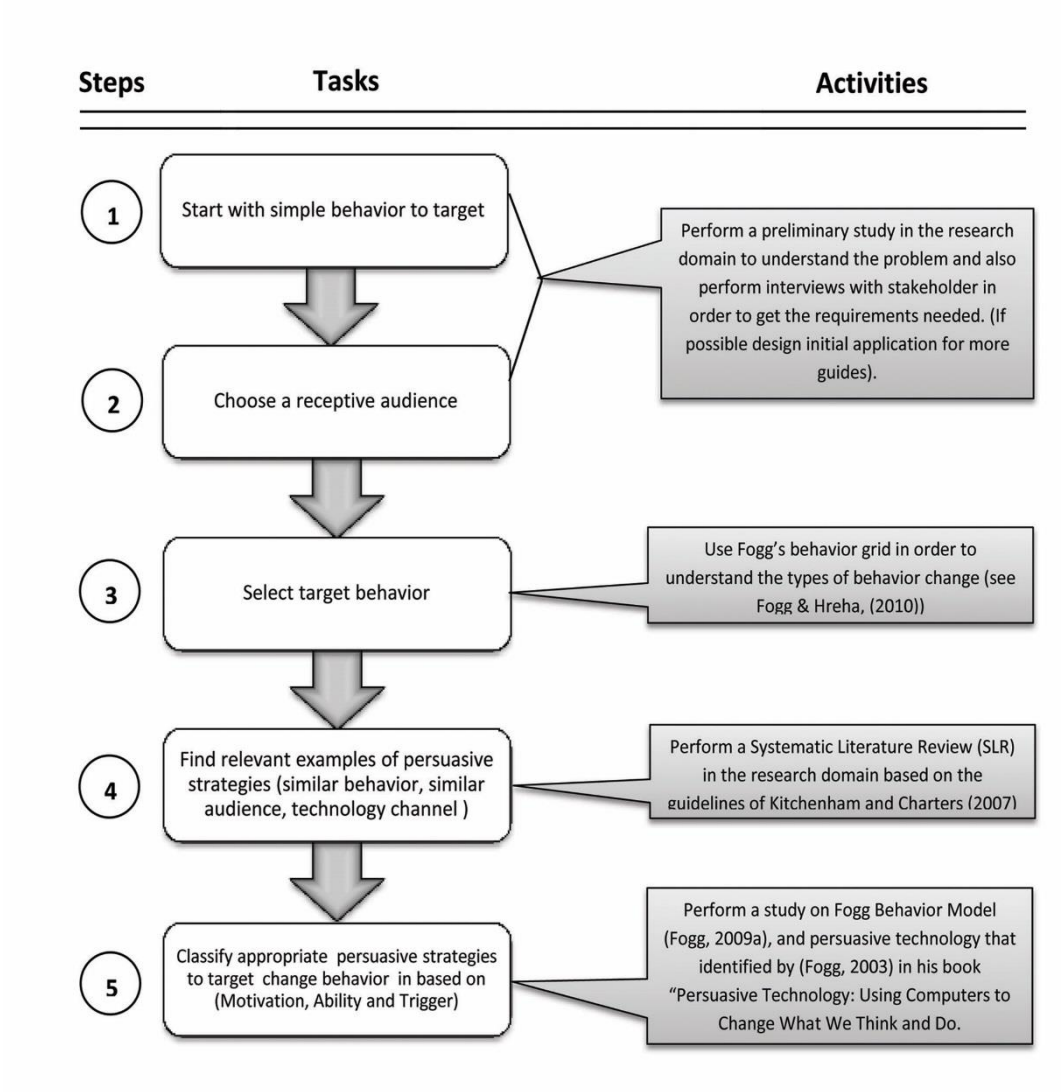

Figure 1: A systematic process for design persuasive system

V. RESULTS AND DISCUSSION

To list the results, 105 of parents are responded to study. For all the data analyses, the SPSS version 23 for Windows 7 was used. Where the descriptive statistics and reliability analysis were performed. The reliability is an indicator of a measure's internal consistency and it can be measured in a number of ways. Internal consistency represents a measure's homogeneity or the extent to which each indicator of a concept converges on some common meaning [32]. More specifically, internal consistency is the degree to which differences among persons' responses to one item are consistent with differences in their responses to other items on the test [67]. One of the most popular approaches to assessing the reliability is internal consistency reliability coefficient by using Cronbach's alpha [23]. However, the value of Cronbach's alpha should be equal to or higher than (0.70), which indicates that internal consistency is acceptable [68, 69]. While, [70] pointed that the value of Cronbach's Alpha is equal to or higher than (0.60) is an acceptable value. In a similar way, [71] suggested the minimum level of Cronbach's alpha is 0.6. Since all the dimensions have Cronbach alpha values of greater than 0.8 as are shown in Table 2, therefore, all of them satisfy the internal reliability criterion as recommended by above researchers.

In sum, these findings refer that the questionnaire scale of this study has a high degree of stability and can be a demonstration of the possibility of repeatability. Therefore, can conduct other statistical tests based on these results.

Table 2
Reliability of the Measurements

Measurement	Number of items	Cronbach Alpha
Reminder messages	3	0.805
Reduction	7	0.931
Historical information	2	0.950
Suggestion	4	0.830
Praise	3	0.915

The assessment of the users' perspective is important to measure their opinions towards the extent of persuasion they have by using the PMCOM application. This happens if the majority of users agrees or strongly agrees on using the PMCOM application to monitor their children's obesity. Accordingly, the results of users were interpreted based on the recode seven-point scale into three groups which adopted from [72]. The three groups are classified as follows: 1) Negative (Disagree): 1–3; 2) Neutral (neither agree nor disagree): 4; 3) Positive (agree): 5–7. On this basis, the descriptive statistics were presented by using the means and

standard deviations for all the measurements and items as shown in Table 3.

The upshot indicates that all respondents have agreed on these measurements and items. This shows that the mean value of reminder component is 6.1143 with a standard deviation of 0.64023. This clearly portrays that the majority of the parents was agreed that component can easily work to remind them to monitor their children's obesity. A result of convergent is found in reduction component with a mean value of 5.9456 as well as the standard deviation is 0.73764. This shows the extent of users' ability to perform the behaviour in monitoring their children's obesity. In this regard, the parents have positive views on all questions relating to reduction component. The mean value of the historical information component is 5.4810 with the standard deviation of 0.94798. This means the parents have a good response to track their children's obesity status anytime and any specific date. The other mean value for suggestion component is 5.7079 with the standard deviation of 0.85821. This shows a positive tendency of users when they found good advice that relates to their children's obesity. Further, the mean value of praise component is 5.6598 with a standard deviation of 0.85929. This also indicates that most of the parents were agreed with the component of praise. Concludes the mean value of a persuasion component is 6.0000 with the standard deviation of 0.66506. This refers to the parents have a good degree of persuasion in using the application with all components.

In a nutshell, this paper is to gauge the tendency of the responses by descriptive statistics among Malaysian parents through using the PMCOM application to monitor their children's obesity. Therefore, the scientists asserted that behavioural perception deals with the variability that comes from studying people. People are not all the same; they have different attitudes, opinions and behaviour.

Table 3
Descriptive Statistics for All Items

Measurements and Items	Mean	Std. Deviation
Reminder	6.1143	.64023
1. The PMCOM app sent me a reminder message whenever I did not use it after a month.	6.0857	.70866
2. The reminder message of PMCOM app helped me in monitoring my child's obesity status.	6.1524	.82952
3. The reminder message of PMCOM app did not disturb me.	6.1048	.71956
Reduction	5.9456	.73764
1. The PMCOM app provided simple steps to monitor my child's obesity status.	5.8857	.86951
2. The PMCOM app made the tasks of monitoring my child obesity status easier.	5.9048	.88278
3. The PMCOM app's ability in monitoring my child obesity status is worth more than overcoming the consequences of the obesity.	5.8286	.91417
4. I took a shorter time to monitor my child's obesity status using the PMCOM app compare with the conventional approach.	5.9238	.86264
5. The PMCOM app helped me to monitor my child's obesity status with less mental effort.	5.8857	.85838
6. The PMCOM app did not interrupt my routine life, and I will continue to use it.	6.1238	.80498
7. The PMCOM app is suited of the norm of society, thus I felt comfortable in using it.	6.0667	.94326
Historical information	5.4810	.94798
1. The PMCOM app enabled me to track my child's obesity status anytime.	5.5143	1.04802
2. The PMCOM app allowed me to track my child's obesity status at any specific date.	5.4476	.88775
Suggestion	5.7079	.85821
1. Suggestion's information motivated me to monitor my child's status for fear of the impact of obesity in the future.	6.0286	.98505
2. Suggestions information motivated me in keeping my child from socially rejected by his/her peers.	6.0952	.89361
3. I accepted the PMCOM's suggestions on my child obesity status; therefore, I will encourage other parents to use it.	5.9333	1.09427
4. I felt guilty whenever my child is obese or overweight; however, the suggestion's information helped me to handle the situation.	5.9714	.81403
Praise	5.6598	.85929
1. Reading the PMCOM's praise messages encouraged me; therefore, I was happy to use it.	5.6762	.95570
2. I was pleased to see the PMCOM's praise messages because it did not disturb my parental feeling.	5.6857	.90207
3. The praise messages of the PMCOM app gave me hope to continuously monitor my child status.	5.7619	.92533
Persuasion	6.0000	.66506
1. Are you convinced in using the PMCOM app to monitor your child's obesity status?	6.0000	.66506

VI. Conclusion and Future Research

In conclusion, this paper focuses to perform the systematic process for designing persuasive systems. Hence, enable the practitioners to analyze the significant requirements of the system and problems related. This process is suitable and convincing for collecting required requirements from stakeholders to set final software design in the right way. From this point of view, it becomes very important to apply requirement engineering in the phase of architectural analysis depending on systematic processes.

This means if practitioners know each and every requirement of customers before the actual process, thus in a later phase, the complexity will be reduced. In short, systematic process to design persuasive systems enables practitioners to transform the requirements of the user into software development. The main aim of this study is to develop the systematic process works as a reference for practitioners to analysis and implementing the persuasive strategies into software architecture in the future research. Future work, in terms of practical work, can conduct the verification with numbers of experts in ensuring whether PMCOM application has achieved the criteria-based assessment. As well as, this work recommended further study to increase the size of sampling and apply it in the other domains.

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