



Systematic Review of Persuasive Health Technology Design and Evaluation Models

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ABSTRACT

Persuasive technologies for promoting physical fitness, good nutrition and other healthy behaviors have been growing in popularity. Despite their appeal, the design and evaluation of these technologies remains a challenge and usually require a fully functional prototype and long term deployment just like any other information system. Hence, the focus of this paper is to review some persuasive and behavioral change models used in designing and evaluating persuasive technologies and identify their inherent limitations. To achieve the stated objectives, the systematic review method of research was done to understand the various persuasive system models and relevant information was extracted using the Inductive approach. Currently, the Persuasive System Design (PSD) framework is considered to be one of the commonly and most comprehensive framework for designing and evaluation of persuasive systems. However, some of its design features overlap and are difficult to analyze. This review research has brought to light the need to extend the PSD theoretical model with a measurable and integrated usability model which can adequately measure the efficiency and effectiveness of persuasive design outputs at the early phase of persuasive system development in future studies.

Keywords

Behavioral change models, Persuasive health applications, Persuasive systems, PSD model.

1. INTRODUCTION

More recently, social technology continues to penetrate into every areas of human lives at break-neck speed, most present medium of mass media have integrated some sort of social interaction and awareness into their messages. Social networks such as Facebook, Twitter, Netflix, Tumblr, Instagram, online dating sites, educational sites, amongst others, continue to draw and



lure millions of people into using social technology for multiple purposes. The influence of technology on humanity is affecting all sectors of human life both public and private, on-line and off-line [23] and one way or the other its effect on people’s behavior cannot be over emphasized. The word influence comes under the umbrella of the word persuasion which is an effort to influence/motivate/inspire people’s beliefs, thoughts, actions, feelings, motivations, intentions or behaviors [44] and in a scenario where software systems are designed to achieve such purpose, it is termed persuasive technology. Fogg, a leading and foremost researcher in persuasive technology, was the first scientist to invent the word Captology in 1996 which is “concerned with the domain of research, design, analysis and application of Persuasive Technology” [15]. Captology describes the area where technology and persuasion intersect as depicted in Fig. 1.

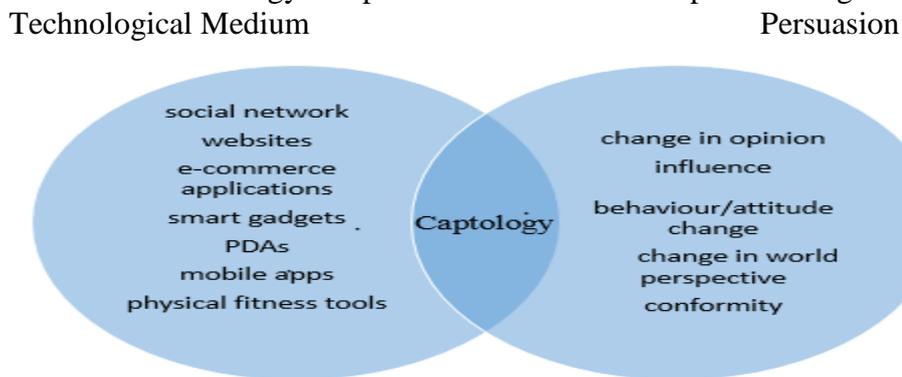


Fig. 1: Captology in view

Persuasion technologies are normally used in most areas of human lives ranging from education, politics, religion, marketing, sustainability, health, and training in any form amongst other applications. The main aim of persuasive applications is to change human attitude or behavior through the power of software designs [37].

There currently exist numerous persuasive technologies in existence whose purpose is to encourage or facilitate attitudinal change towards a healthier lifestyle [2] but evaluating these technologies remains a challenge and they normally require a system that has been fully designed and deployed for use over some period of time [25]. At the recently concluded 11th International Conference on Persuasive technology held in Austria, [1] also affirmed that most persuasive applications need to be tested before deployment but the problem is that there is really generally no agreeable way among such systems developers as designing these systems require lots of planning, time and other resources and what available models do is just to guide such applications developers during the design process of persuasive systems.

Persuasive technology is basically about automating behavior change, and in other to successfully code knowledge that results in behavioral change, there is a need for practical understanding of human psychology, precisely,



intuition about the causal factors of behavior change as also corroborated by [16] if not, researchers of persuasive technologies will just be replicating concepts that actually work without a thorough understanding of why those concepts work.

Hence, the focus of this work which is intended to serve as an overture towards further research, is to review the Persuasive System Design (PSD) model which is currently a highly rated approach to the design and evaluation of persuasive technologies [35] and other behavioral change models that are aimed at changing peoples' poor attitude to exercise and good diet that can help towards the prevention of diseases in other to come up with a more useful model that can aid researchers and developers towards the design of more usable, reliable, maintainable and more efficient persuasive systems that can readily be evaluated even before such systems are deployed. The remaining part of this work is arranged as follows: Section 2 gives the literature review presenting some common health behavioural change models and popular persuasive design models explains in detail the applicability of some models toward the design of persuasive systems, Section 3 explains the Methodology employed for this research, while Section 4 gives the conclusion and recommendations for further studies.

2. BACKGROUND STUDY

The current upsurge in untimely death and human ravishing sickness as a result of different diseases that can be prevented warrant urgent attention and behavioural change towards a healthier lifestyle by using a more technological and pragmatic approach towards preventing such diseases. There have been various Information systems that have been designed in an attempt at using technology to control/prevent/monitor or treat diseases such as expert systems, decision support systems and Persuasive technology systems that are aimed at changing people's attitude towards a healthier lifestyle [24] [47] [29].

The rise of social web and the use of mobile applications to create, share and access information in innovative ways has accelerated the opportunities for developing new kinds of Interactive Information Systems for influencing users.

In recent years, researchers' interest have continued to sway towards Human Computer Interaction (HCI) in designing persuasive systems that are aimed at improving man's quality of life [38]. Despite the plethora of research into Interactive Information Systems aimed at behaviour change [36], health-related behaviour change has attracted lots of attention e.g., physical activity [27] [10], diet [40], cardiac rehabilitation [30], and even the management of chronic illnesses (e.g. diabetes [31] [46], healthy sleep behaviors [14], kidney disease [45], asthma [26] amongst others.



The benefits of using computers to promote quality of life by persuading users as against traditional media is its interactivity and over human-human persuasion includes six distinctive reasons, as highlighted by [15] ranging from the fact that persuasive applications tend to be more persistent than human beings, they offer greater anonymity, they can manage large volumes of data especially in this big data era, they can use many tactics to influence, scale easily and lastly they are more ubiquitous.

Developing persuasive systems usually put a heavy strain on developers, so design issues should deserve more attention as they have real implications because if the systems are not properly designed then the persuasion potential will not really be achieved. More so, the most commonly studied and applied model to building Persuasive technologies is the PSD model but despite its use as a model to guide developers in designing Persuasive systems, its use as an evaluation tool for persuasive systems has been subject to criticisms amongst persuasive systems researchers. There is also a need for persuasive systems developers and researchers to understand the sociological, psychological and philosophical context behind various models that can be employed towards designing effective persuasive systems if not they will just be imitating other information systems and ascribing them as being persuasive in nature although some information systems have persuasive features but they cannot be said to be persuasive applications which have distinctive persuasive characteristics and features as also speculated in the PSD model.

2.1 Overview of Existing Health Behavioural change and Persuasive Design and Evaluation Models

[5] proposed the Health Belief Model (HBM) which was developed to figure out why people used or did not use preventive health services by public health departments. HBM theorizes that people's beliefs about whether or not they are at risk of a health issue, and their perceptions of the benefits of taking action to avoid it, influence their readiness to take action. [41] came up with the Trans-theoretical model (TTM) based on the concept of "stage of change" and it suggests that people are at different stages of readiness to adopt healthful behaviors. The notion of readiness to change, or stage of change, has been examined in health behavior research and found useful in explaining and predicting changes for a variety of behaviors including smoking, physical activity, and eating habits. The TTM has also been applied in many settings.

[4] introduced the Social Cognitive Theory (SCT) which is the cognitive formulation of social learning theory explains human behavior in terms of a three-way, dynamic, reciprocal model in which personal factors, environmental influences, and behavior continually interact. SCT synthesizes concepts and processes from cognitive, behavioristic, and



emotional models of behavior change. A basic concept of SCT is that people learn not only through their own experiences, but also by observing the actions of others and the results of those actions. There also exist the Social Ecological Model (SEM) which is based on the principles of social ecological models and these principles are also consistent with social cognitive theory concepts which suggest that creating an environment conducive to change is important to making it easier to adopt healthy behaviors as shown in Fig. 2. [17].



Fig. 2: Social Ecological Model [13]

Fishbein and Ajzen in 1980 proposed the Theory of Reasoned Action (TRA) which is based on the fact that that actual behavior could be determined by considering intention with beliefs associated with the given behavior as cited in [11]. They also claimed that behavioural intention could be determined by considering both attitude towards the actual behavior and the subjective norm associated with the behavior in question. A limitation of TRA is that some behaviors are not under a person's control and in order to address this limitation, Ajzen in 1985 went further by introducing the concept of perceived behavioural control just to improve on the predictive capabilities of the TRA and named this enhanced model Theory of Planned Behaviour (TPB).

Looking at health behaviour change from Elaboration Likelihood Theorists, [39] promulgated the Elaboration Likelihood Model (ELM). The model described how attitudes are formed and strengthened by persuasive arguments. The model proposed that people convey either high or low elaboration which is their level of effort when they are faced with a persuasive message. The level of elaboration will now decide which processing route the message will take either central or peripheral. [52] gave a very detailed and simple explanation on both routes in his online article on how to apply the ELM to design. The ELM is very similar to the Heuristic-Systematic model (HSM) proposed by [8] which just tries to describe how people receive and process persuasive messages.

[43], a German professor of psychology proposed the Health Action Process Approach Model (HAPA) which is an open framework of various



motivational and volitional concepts that are presumed to explain and predict individual changes in unhealthy behaviors towards a better one. HAPA suggests that the adoption, initiation, and maintenance of health behaviors should be conceived of as a structured process including a motivation phase and a volition phase. Motivation phase describes the intention development while the Volition refers to planning, and action. The model accentuate the particular role of perceived self-efficacy at different stages of health behavior change as shown in Fig. 3.

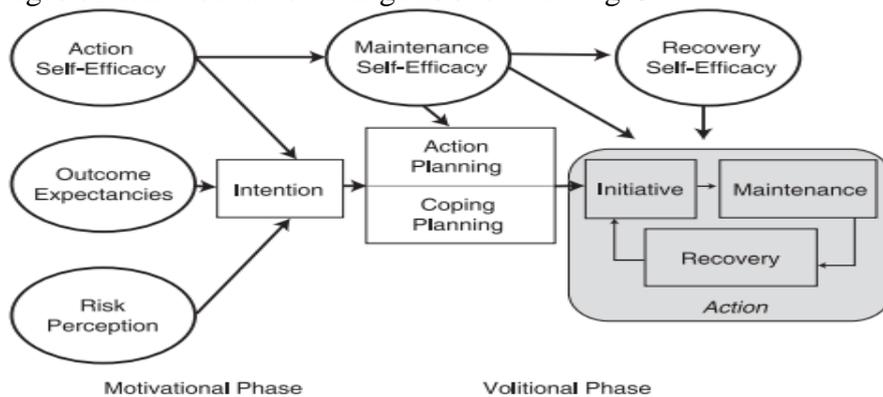


Fig. 3: HAPA Model [43]

Fogg Behaviour Model for persuasive Design (FBM) was proposed in 2009 to understand human behavior, he opined that behavior is a product of three factors which are motivation, ability, and triggers, each of which with its own modules as shown in Fig. 4. The FBM asserts that for a person to perform a target behavior, he or she must be sufficiently motivated, have the ability to perform the behavior, and be triggered to perform the behavior with each of these behaviors happening simultaneously if not, the behaviour is highly unlikely to happen. Fogg’s behavior model provides an understanding of relationships between motivations, abilities and triggers. However, it does not explicitly discuss persuasive features implementation in designing a persuasive system.

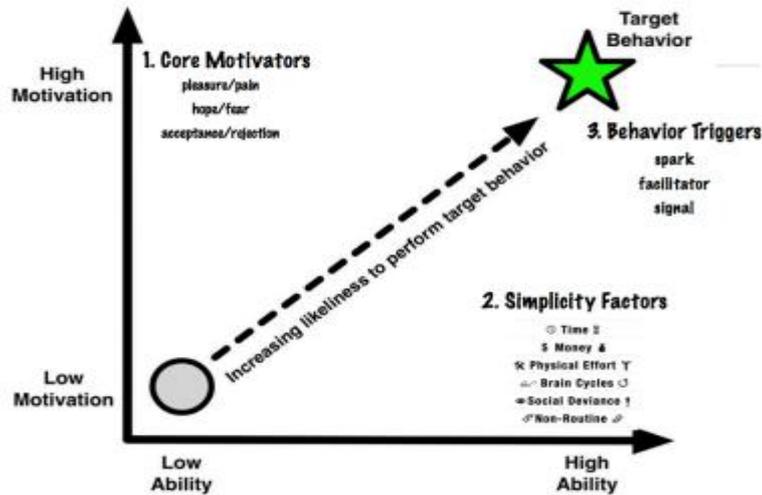


Fig. 4: FBM with the 3 factors and their subcomponents [16]

Dan Lockton addressed behaviour change from a perspective dubbed “Design with Intent” (DwI) which he defined as a “*design intended to influence or result in certain user behaviour*” [28]. The DwI Method is intended to be generally applicable to influencing user behaviour. The latest iteration of the model is comprised of two modes: ‘Inspiration’ and ‘Prescription.’ In the ‘Inspiration’ mode, the designer takes inspiration from a set of headline design patterns that are applicable to a wide range of target behaviors, grouped into six different ‘lenses,’ representing particular disciplinary perspectives on using design to influence behaviour. In the ‘Prescription’ mode, the designer formulates a range of target behaviors or intended outcomes describing interactions and, as a consequence, a subset of the most applicable design patterns from each ‘lens’ is presented for each target behavior.

Health theories help to understand why people do/do not practice health promoting behaviors, identify what information is needed to design an effective intervention strategy and provide insight into how to design a successful persuasive health program. They help to explain behavior and also suggest how to develop more effective ways to influence and change behavior although the success of the adoption of persuasive technologies will largely depend on the grounded understandings of these theories as noted by [9] but the reality is that there exist numerous theories aimed at behavior change but they are majorly used as a checklist or rules of thumb for software systems rather than a systematic design methodology to the design of user interface.

[3] also presented this same view in their conference paper produced for the Global Summit on telemedicine and eHealth. A lot of these behavioural change models are psychological in nature and offer little information on how to design and implement persuasive systems as also confirmed by [32]



which is why researchers interested in persuasive systems tend to focus more on Fogg's persuasive design principles and the PSD model although there exist other persuasive design models but they are yet to be as popular and widely accepted as Fogg and PSD model.

Fogg's model is a functional triad and the design principles introduced in it signify the first and highly used generalization of persuasive technology. The model was developed by [15], a leading researcher and an authority in the field of persuasive technology. In his eight step model, developers are guided towards creating a persuasive technology. However, Fogg asserts that *"the eight steps are not intended to be a rigid formula; instead, the steps serve as milestones to make the design process more effective"*. These steps are highlighted and well explained in [48].

Fogg also explained the three roles computing technology can play in the functional triad which are to act as a tool, media or social actor in the act of persuasion from users' perspectives. Fogg also identified persuasive technology tools which are interactive products that are designed to change attitudes or behaviors or both by making desired outcomes easy to achieve. Such tools include Reduction, Tailoring, Tunneling, Suggestion, Self-monitoring, Surveillance and Conditioning.

The model just helps to understand the concept of persuasive technologies better but it is too restrictive to be applied directly to persuasive system development and/or evaluation. The major weakness that is inherent in this model as claimed by [35] is that it does not really indicate how the proposed design principles can be modified into software requirements and moreover executed as software features; but to be able to design and evaluate the persuasiveness of a software system, it is very important to understand both the information content and the software functionalities which is what gave the PSD model more popularity in its usage as against the Fogg's model in designing persuasive systems.

The PSD model is a conceptual framework for developing persuasive systems and it was postulated by [35]. It has gained so much popularity amongst persuasive systems designers and researchers. The model has been successfully applied in so many domain like in health, education, amongst others. It explains the means of designing and evaluating persuasive systems and also explain what kind of content and software functionality may be found in the final product as depicted in Fig. 5 below. The model lay emphasis on seven fundamental assumptions or hypothesis behind persuasive systems where two of these postulates relate to how users are seen in general, two of the postulates relate to persuasion strategies, and three of the postulates address actual system features. The model highlights ways to analyze the persuasion context which include the intent (this could be exogenous, endogenous or autogenous), the event and the strategy. It also

lists twenty eight design principles for persuasive system content and functionality.

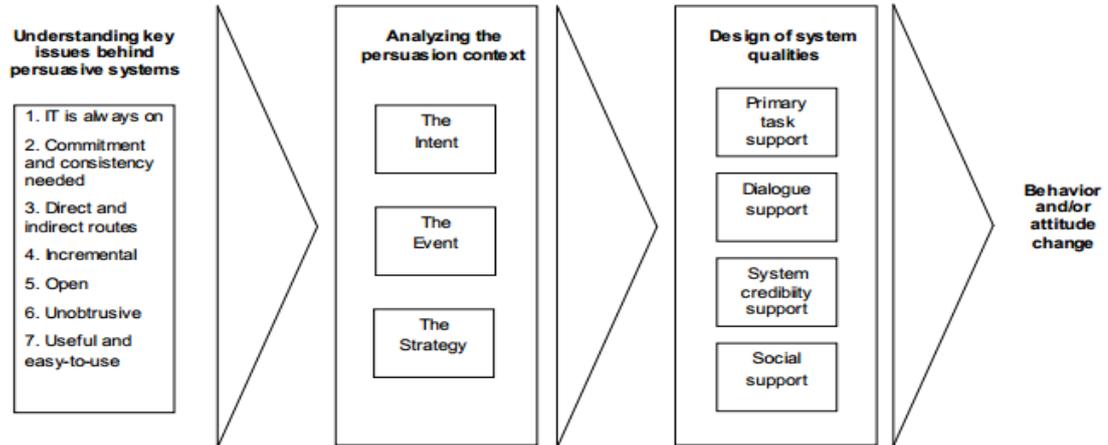


Fig 5: Phases in Persuasive System Development [35]

This model is an improved version of Fogg's model and most of the design principles in this model was adopted and modified from Fogg's model. The PSD model has been widely acknowledged as being suitable for designing persuasive systems but it cannot promise the success on any behavioural change support system [34]. The goal of the PSD model is not really to implement all the design features suggested in it but to choose the right features based on the system's context of use and domain as claimed by its proponents. Its limitation is that some of these features overlap with one another and usually difficult to analyze. Hence, new persuasion techniques to evaluate and fortify persuasive components need to be ascertained. Other models include the 3D-RAB model proposed by [50] and they showed how it can be applied in classifying users based on changes in levels of cognitive dissonance. The model tends to present a method that can be used to analyze the user context on the PSD model. In the model, it was postulated that eight states of cognitive dissonance among users should be considered. This approach was evaluated using an already existing BCSS and designers were encouraged to apply the 3D-RAB model in order to design solutions for targeted users.

The model is just an approach to analyze targeted users and it cannot be used to design persuasive technologies as also claimed by its proponents. [33] aimed to look at analyzing persuasive designs from a data analytics point of view by trying to integrate analytical models into persuasive designs for improved results and the researcher also tried to describe how to represent human behaviour as a mathematical model so as to overcome the limitations of a systematic approach to persuasive design evaluation as seen in other models, theories and frameworks for persuasive design. Although this is very novel approach to systematic persuasive applications design, the idea is still very abstract in nature as the actual mathematical model based



on their identified factors was not shown as it is still a research work in progress although this model comes closest at trying to analyze persuasive applications both quantitatively and qualitatively.

2.2 Applicability of Models in the design of Persuasive Systems

[49] described an interface during an attempt to develop a persuasive system that is aimed at motivating physical activity among university students in their day to day activities to curb the modern issue of obesity. The trans-theoretical model of behaviour change and Fishbein and Ajzen's theory of reasoned action were used as the principle that governed the interface design. Several prototypes were developed for this study and each prototype was evaluated both for design and functionality with a total number of 41 users. The system could not be implemented as the work was just a conceptual description. As a part of the PEGASO European project, [6] created a persuasive system based on mobile technology in motivating teenagers to easily adopt a healthy lifestyle. They used the Virtual Individual model (VIM) and some of Fogg's behavioural model idea like Tailoring, social network integration and the trigger concept. They intended doing pilot studies in 3 different countries to validate the effectiveness of their approach after the successful completion of their project.

[42] designed a fictional system called Fit4Life; a system that encourages individual to address the larger goal of reducing obesity in society by promoting individual healthy behaviors by using the PSD model to outline the persuasion context, its technology, its use of persuasion messages and an experimental design to test the system's efficacy. [22] designed a persuasive mobile application to support controlled alcohol usage by using the user centered design approach based on ISO 9241-210 and Google Inc. user experience design experience on an android platform. The persuasive features in the system was evaluated using 12 of the design principles in the PSD model as against the 28 defined principles.

[19] did a field trial of the Polar FT60; a fitness watch with Global Positioning System (GPS) and heart rate monitor to describe and understand findings from a three month long qualitative field trial to explore how a training program in a new prototype heart rate monitor promotes proper exercising. The PSD model was used to identify distinct strategies and techniques that were embedded into the system and 12 users' responses to these strategies were also explored. They only demonstrated how persuasive techniques can be identified, embedded into system functionality and also how persuasive techniques function together in real world settings. They were able to find out that leveraging goal settings, tracking performance, adopting social roles along with a high overall perceived credibility influences user behaviour. The studied persuasive principles were limited to the design of the particular product that was investigated and the researchers



did not participate in the design process. [18] investigated how the PSD model can be utilized so as to support the development of personal health and well-being systems. In order to achieve this, they integrated the PSD model into the development of 2 health related Behaviour Change Support System (BCSS). In the first study, their aim was to use the PSD model to identify new persuasive functionality within a fall risk assessment and fall preventive system. In the second study, their aim was to use the PSD model to identify new persuasive functionality and new service concepts within an existing smart phone app for mental well-being. Their study showed that the PSD model can be used in the development of BCSSs to describe the overall process, analyze the persuasion context and design qualities. They also used the PSD model to evaluate both systems by providing heuristics of expert evaluation and systematic ways to analyze user experience data. Both human centered and iterative process were used in designing both systems. As a result of their research, they were able to ascertain that although the PSD model purposes how persuasive systems should be developed in a very holistic manner, its limitation is that it does not explicitly give advice on how to include a framework or theory into the development of the content delivered via the system and users it does not also give advice on how to include users in the development process which is very important according to [21].

[51] designed a persuasive fitness app that can enhance physical activity behaviour of individuals by conceptualizing the persuasive technology design principles embedded in social cognitive theory which suggests that individual behaviour is determined by triadic, dynamic and reciprocal interaction among cognitive, personal factors and environmental influences.

[7] focused on building a persuasive system for behaviour modification around emotional eating by undertaking 3 user studies. The first study was done to gather emotional eating patterns using a custom built app called EmoTree so as to understand users' emotions associated with eating. The second study was done to learn about a suitable intervention technique for emotional eating based on self-reported ratings of emotions to gather early feedback before actual system implementation and they found out that there exist lots of individual differences in emotional eating behaviour. Their last objective was to build a wearable, sensor system for detecting emotions using a machine learning approach to predict users' emotions. In this work, no particular design method was followed and no formal theory of behaviour change was considered.

As noted from various attempts at designing persuasive systems, developing persuasive systems puts a very rigorous burden on software developers as there are lots of theories, design approaches and principles to be considered at the early design stage hence effective evaluation at the early design phase is an important requirement that needs to be strictly adhered to so as to save



cost and reduce designers time as evaluating a system after the overall product has been designed can be very tasking, time consuming and expensive. Most of the existing health behavioral change theories help to explain, understand behaviors and also suggest how to develop more efficient ways to influence and change behavior but most of them can only act as guide towards designing persuasive systems as to our knowledge, there presently exist no tool or framework yet for evaluating persuasive technologies except for the PSD model whose limitation is that some of the 28 design features coincide with one another and are usually difficult to analyze, moreover most of these features are also just to guide designers in making persuasive systems more influential hence, new persuasive techniques to evaluate and fortify persuasive components need to be ascertained. In addition, most of the recent work in persuasive design using the PSD model are still at the conceptual level.

3. METHODOLOGY

To achieve the stated objectives, the systematic review method of research was done to understand the various behavioral change and Persuasive System models and relevant information was extracted using the Inductive approach towards research in which past theories for designing and evaluating persuasive designs was thoroughly analyzed. Patterns, resemblances and regularities in past theoretical premises were observed to identify their limitations and a new theory/model was proposed to be generated in subsequent studies without discarding ideas gotten from past models. This form of research is mostly based on grounded theories according to [12]. It starts with observations and theories which are proposed towards the end of the research process as a result of the observations which is depicted in Fig. 6 below.

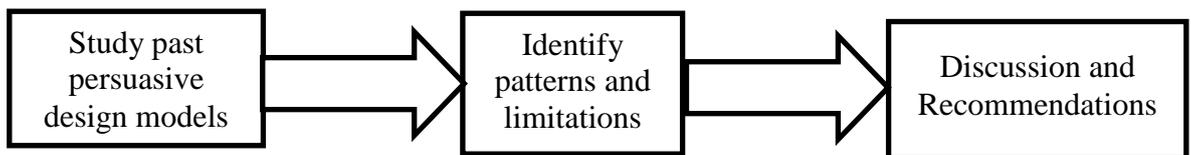


Fig. 6: Inductive approach

Most of the papers reviewed were gotten from Google, Google scholar and Association for Computing Machinery (ACM) databases using keywords such as Persuasive technology, behavioral change models, and persuasive design models amongst others.



4. CONCLUSIONS

Persuasive technologies for promoting physical fitness, good nutrition and other healthy behaviors have been growing in popularity. Despite their appeal, the design and evaluation of these technologies remains a challenge and usually require a fully functional prototype and long term deployment just like any other information system. Most health behavioral change models cannot adequately measure the effectiveness of persuasive systems as they can only be used as guides during the design process by most persuasive systems developers and researchers. The PSD model is currently the most widely used model in designing and evaluating persuasive technologies but its limitation still remains apparent especially in evaluation purposes.

A new framework will be proposed and evaluated in subsequent studies to extend the PSD model by integrating the requirement engineering approach, new Human Computer Interaction (HCI)/User centered principles and effectiveness evaluation using a the Integrated Measurement Model for Evaluating Usability Attributes designed by [20]. A prototype health application will be designed and an attempt will be made to predict the usability of such systems at the early phase of the design process using the fuzzy analytical hierarchy process as usability has also been identified as one of the most important construct used in evaluating the effectiveness of a system. The Evaluation framework is also being proposed in further studies to be formalized using Fuzzy logic to deal with imprecise usability attributes and to also enable a more systematic approach to persuasive technology evaluation.

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