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A System Development Life Cycle for Persuasive Design for Sustainability

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Abstract. The impact of a system development lifecycle (SDLC) often determines the success of a project from analysis to evolution. Although SDLC can be universally used design projects, a focused SDLC for a specific complex design issue could be valuable for understanding diverse user needs. The importance of sustainability elevation using a persuasive system is not new. Previous research presented frameworks and design principles for persuasive system design for sustainability, while an SDLC of sustainable system development also exists. However, at present no SDLC for persuasive design aiming for sustainability is evident, which was proposed in this paper. An existing sustainable SDLC established earlier by the authors was taken as the reference framework. A cognitive model with established persuasive design principles was then analyzed and mapped within the context of the reference framework to come up with the resulting life cycle. Finally, extensive discussions and future work possibilities were given.

Keywords: Sustainability, SDLC, Persuasive System Design, Cognitive Model, Persuasive System Design for Sustainability, Life Cycle for Persuasive System Design.

1 Introduction

The search for solutions to solve the eminent problem to reach a balance and achieve a sustainable future is pervasive in research [15]. The research field of computer science has also participated in this quest, e.g. green IT and sustainable human-computer interaction. The design of different interaction processes and the system is important, since badly designed systems can contribute to social and environmental degradation [32]. The design phase of a system is often considered to be the core of information systems research since it could be considered the construction of a socio-technical system—the artificial [31]. A computer-mediated persuasive system is thus a socio-technical system created with a specific purpose in a defined context based on certain assumptions. The pattern of existing persuasive technology has been criticized in recent years as not being adequate for sustainable system-design solutions [4], [19]. The nature of persuasive system aiming for sustainability has been limited within a certain scope of interests and therefore a call for expanding the possibilities of using large-scale system design and long-term design problems were identified to be the most

important upcoming challenges for the individual sustainable human-computer interaction (HCI) researchers and the sustainable HCI community as a whole [4]. Also, since there is a considerable difference between green design and green engineering, a building of knowledge for the green-design domain, originating from green engineering, is important and to fill this gap is a challenge for the designers. For promoting sustainability goals, both green design and green engineering are important and the role of persuasive design has already been known to be an effective and powerful design strategy for green-design issues. However, while the possibilities and scopes of sustainability need to be broadened for an effective use of persuasive design, it is at the same time important to realize what the appropriate and right design procedure could be, because a design process can become more complicated for the designers as the complexity and size of a problem increases. Selecting the right methodologies would therefore play a vital role for an organization to be successful by means of their design in terms of productivity; the demands along with a fast and predictable return on investment. System development life cycle (SDLC) is a type of model that could play a critical role in the development of complex systems. Building an appropriate SDLC is difficult for a specific type of information system (IS) design since it involves and requires careful preparation and administration to guarantee the standard and the quality of an end design that delivers a robust, effective, and efficient system that ensures what it is supposed to do. Nevertheless, doing this successfully could help IS designers and analysts to compare different parameters and factors of the designed system to take critical decisions, such as selecting between different available design options. Expenses like time and cost usually play a major role in the development of IS and proper SDLC would estimate these factors properly for the effectiveness and efficiency of an organization's design policy.

With the demanding nature of complex persuasive system design for sustainability, it would be appropriate to have a specific SDLC that could ensure a reduction of complexity during the design process, resulting in a successful end design for the users. Although an eight-step design process of persuasive design was presented by Fogg [12] that was more like some general guidelines and was established from different practical industrial design success demonstrations. While Fogg [12] played the part of a pioneer and major contributor to persuasive design, designers were still not specifically informed of what should be a general design flow of persuasive design. With several guidelines and design structures along with a few evident design principles [3], [6], [20], [23], [28], an SDLC for persuasive design with sustainability goals could not be found to be described by researchers in academia or to be used by practitioners to date. This was the underlying rationale behind this research paper, in which we have proposed an SDLC for persuasive system design for sustainability, and the formulated underlying research question of this paper is thus: 'What are the appropriate design phases that need to be associated in a persuasive system design aiming for sustainability?' To answer this research question two previously established theoretical frameworks were selected and used as a basis on which to constitute our theoretical framework, for which an SDLC for a persuasive system for sustainability was proposed in a methodological form.

This paper is divided into six sections. A concrete background in Section 2 introduces the notions of a persuasive system and sustainability along with SDLC. The background of the selected theoretical frameworks in this paper is then presented,

followed by the proposed SDLC for persuasive design for sustainability in Section 3, in which different phases of the proposed life cycle are briefly described. Discussions are given in Section 4 and finally a future work direction is addressed in Section 5 followed by the conclusion in Section 6.

2 Background

2.1 Persuasive Design and Sustainability

Based on Festinger's cognitive dissonance theory [10], persuasion as an instrument to change people's attitudes and behavior is a well-explored research field in psychology [34]. 'Persuasive design' is the designing of experiences to influence people's behavior [11]. Computers can be used as persuasive technology (a study labeled by Fogg as 'captology' based on an acronym derived from 'Computer As Persuasive Technologies' [13]) to support persuasive design. Persuasion is defined by Fogg as "an attempt to change attitudes or behavior or both (without using coercion or deception)" [13]. The belief in the power of persuasive information systems mediated by computers is firmly set by the collective research from Festinger [10]. Oinas-Kukkonen [26] showed, in research on the behavior change support system (BCSS), that the persuasive system-design (PSD) model is a state-of-the-art vehicle for designing and evaluating BCSSs. A PSD with a sustainability goal could be made to alter individual users' behavior and to impact a larger part of society. Sustainable HCI has, since 2007, been an active research area of HCI [8]. The persuasive research in the sustainable HCI community is mainly about shaping people's behavior through a system. Computer-mediated persuasive systems could also play an important role in healthcare [17] and may be considered to facilitate personal sustainability. Recent research about developing a persuasive system displays a goal setting to make the user behave in a sustainable manner and reduce their use of resources like water or electricity, or to drive in a more eco-friendly way [10], [14], [18]. One problem could be the top-down selection of measurements by the designers to calculate the users' behavior [4].

Sustainability could be derived from the conception of the World Commission on Environment and Development (WCED) regarding sustainable development: "... that it meets the needs of the present without compromising the ability of future generations to meet their own needs" [35]. Sustainability thus works by reversing or minimizing the effect and impact of different human-induced processes. Sustainability can be seen as a complex and dynamic problem, not only linked to the environment but also a way to better understand the possible complexity to use the quadruple bottom line (QBL). QBL relates sustainability to environmental/practical, personal/spiritual, and social needs with which economic concerns—the economic is not seen as natural condition of being a human but as a human construction—mediate the ability to satisfy these three needs [33]. This implies a need of a holistic view regarding sustainability. In previous research conducted by Nyström and Mustaquim [24] the importance of a holistic view of sustainability is emphasized in order to be able to capture this mentioned complexity of sustainability and the multiple dimensionalities that must be considered in the design of a system to make it stand a chance of successfully reaching sustainable goals.

2.2 System Development Life Cycle (SDLC)

Many different system development methodologies exist and the SDLC is one of them. An SDLC can be used together with different development models, e.g. the classical waterfall model, the joint application model, and rapid application development (RAD). Due to the complexity of system development, the predictive waterfall model has emphasized the use of iterative lifecycle models [22]. The models can be mixed into hybrids, e.g. something that seems to be more prevalent than the concept of methodology in the traditional systematic sense [21]. For the ease of understanding this, in this paper the classic waterfall model introduced by Royce [29] is used. However, with several models the methodological complexities arise and it might be necessary to use multiple models for addressing different complex design issues in a system-design setup. The development of unique SDLC for a focused system-design problem, e.g. persuasive design, could thus be beneficial as it would reduce different complexities associated through the use of multiple models. For example, Pollard et al. blended SDLC with Information Technology Service Management (ITSM) life cycle concepts [27]. The main feature of SDLC is the use of different phases that are used in the system development process. The number of phases can vary, but often consist of: feasibility study, systems investigation, analysis, design, development, implementation, and maintenance [2]. Once the deliveries from one phase are reached, the next phase can begin or an iterative process may be initiated [2]. The process of design could be simplified into three main activities: “the need identification”, “the development of a solution”, and “the implementation of the solution” [7].

2.3 Theoretical Background

A cognitive dissonance model (based on PSD) aimed at persuasive design for sustainability was developed and presented by Mustaquim and Nyström [24]. The model includes five principles: equitability, inclusiveness, optimality, privacy, and transparency, which have an impact on three persuasive factors identified by Fogg [11]: motivation, ability, and triggers that work in a bidirectional way. By including equitability in the design, potential users would contribute to the thinking concerning the design process and designing inclusiveness can manifest possibilities that the system will facilitate regarding a group rather than an individual. One example is to make things more fun and engaging, as in gamification with the goal of changing consumers’ consumption behavior [16]. Targeting the optimum design would make an end system inclusive and would increase the possibility of customizing for gaining the most possible effect. The other two principles—privacy and transparency—will follow and are crucial to guaranteeing a successful persuasive system, since the user must trust and be fully aware of the content and the possible results that their interactions will give, thereby guaranteeing that they feel secure to use and give information to the system.

The developed framework for SDLC [25] is composed of three phases: definition, development, and operation. In the definition phase the analysis and design is made and it is important to consider the simplicity and flexibility that would maximize the system benefits and targets. It is important to be aware of the difficult balance of requirements for the future, since too little will make the system lack capabilities and be future proof, although on the other hand too many requirements will make the system too complex and expensive to construct and maintain in the future. The development

phase includes implementation and maintenance and in this the practice of design for all is of uttermost importance since with a maximization of additional users who are involved in the process, the better the system will be and will have an increased possibility to reach sustainability targets. In the development phase important tradeoffs must be considered, e.g. functionality versus cost and time. Also important synergies must be identified that could be combined with properties and considerations taken from the definition phase. The operation phase consists of maintenance and planning and of importance here is the sustainability impact-assessment, since it will measure the outcome of sustainability and decide the direction and future of the system. It will also be concerned with long-term intergenerational issues that will influence the development to tackle newly discovered problems facing the sustainable IS.

3 Proposed System Development Life Cycle

As mentioned in Section 2.3, our theoretical foundation for proposing an SDLC for persuasive system design for sustainability was based on two previous research frameworks. The design principles and cognitive dissonance model by Mustaqim and Nyström [24] was the first one and a sustainable system development life cycle (SSDLC) proposed by Nyström and Mustaqim [25] was the second theoretical basis. These were reflected in proposing an SDLC in this paper on the basis of the classical SDLC. The proposed SDLC was shown in Figure 1. Different phases associated with the proposed life cycle were explained and discussed in this section along with the context of classical SDLC.

Motivation

The motivation phase could be compared with the definition phase of the SSDLC in parallel with the development life cycle that was shown in Figure 1. Different phases are associated with the analysis and design phase of the classical SDLC. Minimization of resources in design was included here as stages of procedure, since resources for developing systems are always scarce and tradeoff decisions are always necessary. Understanding the individual behavior of the user group is important for reasoning what sustainability could achieve in a focused user group. What sustainability is for most users might be simply switching towards some green behavior in the form of a low-hanging fruit while the appeal through the design for sustainability could mean a lot more than this and might make a larger impact towards sustainability and may impact different levels, such as the community or organizations, and not merely at an individual level. At the same time, fulfilling the need of the users has also to be accomplished through the design. On the other hand, it is not possible to achieve sustainability by focusing on individuals, since often a systematic and thorough change is needed to reach a sustainable set goal. Individuals could be biased and motivated towards a certain sustainability action, while they see that other users of the same system are practicing that too. This could be connected with making the system 'fun' and users can compete or collaborate towards a set sustainable goal. Therefore the motivation stage of the persuasive design for sustainability is critical and involves deep knowledge and an understanding of users and their requirements, analyzing users' individual needs, combining mainstream users and their requirements together to fo-

cus on them as a bigger group to solve the problem as a whole, and finally finding the different possibilities of solving the addressed problem. Maintaining consistency in design has always been a big challenge for the designers, who therefore need to be benefited by sufficient information of sustainability from the beginning of the design process, and the motivation stage of the proposed life cycle can initiate this task. Over time, designers can rely on a certain service which could be based on the motivation-stage analysis of different types of system design and thereby they can consult and share experiences with other experts or designers facing similar design challenges. Different types of motivational forces could be compared and benchmarked against each other and perhaps it would be possible to find a better practical solution that can be implemented when sustainability goals are set in a similar context, e.g. a similar approach that enterprise resource-planning systems use to standardize their platforms and offer standard solutions for companies.

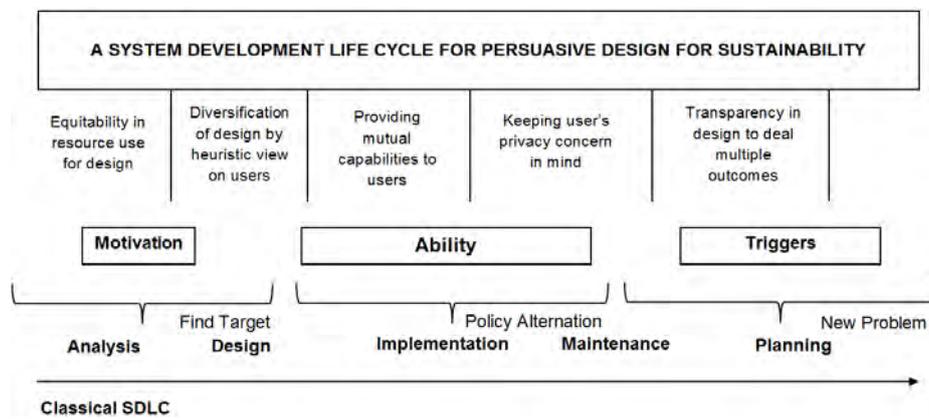


Fig 1. System Development Life Cycle of Persuasive Design for Sustainability

Ability

The ability phase could be compared with the development phase in the SSDLC, and may be correlated to implementation and maintenance in the classical SDLC. By practicing design for all it would be possible to deliver a system that brings mutual capabilities to different users, independent of their prior knowledge, different physical needs, e.g. color blindness or limited vision, or difference in learning style, i.e. abilities, and would thus impose an easy way to interact with the system and maximize their chance of active use and participation. The more users that a system can maintain as active the better, since users can compare and work together to overcome challenges in sustainability and may reach a set sustainability goal. The system should therefore be easy to modify and reconfigure, to fit individual needs; something that could be guaranteed by iteration of the previous stage. The more users that use the system the better, since their different abilities can be detected and the strengths and weaknesses of the system can be found. Problems could be solved in an appropriate way. Trust is always an important issue for users and the transparency of how collected data will be handled is central to building a trust and thereby creating the user interaction with the system. Different options should be possible for the user to choose

from since individuals have different preferences and the features of the system could require different needs of keeping user data private. For a healthcare system designed for persuasion of behavior towards sustainability on a personal level, the privacy could be of uttermost importance and even regulated by laws. On the other hand, in other settings the sharing of data among users could be important and might enhance the ability to participate and help each other towards a sustainable goal. Since a combination of technology and behavior design result persuasive technology, it is very important to remember that individuals might have a different threshold level for their behavior to be modified. This is particularly important for the ability phase since it would define the micro or macro persuasion in design since any required policy alteration based on user capabilities and privacy could create value through the overall end design or generate certain features in design to persuade.

Triggers

The trigger phase is analogous to the operation phase of the SSDLC, and is comparable with planning in the classical SDLC. The design should be ready for different outcomes and the transparency of the design plays an important role in enabling this. Since the design of the artificial is a constructed socio-technical system made for persuasion towards a set sustainability goal and is a complex system, the outcome can be difficult to predict. Systems should therefore be designed to be prepared for this. Some unwanted side-effects could occur, e.g. if a system to make it easier to drive vehicles is energy-efficient by updating the traffic route, to have as few traffic stops as possible and avoiding the traffic jam. This system for efficient driving could in one way make it more enjoyable to drive, the effect could be for users to drive more, and then the set sustainability goal will not be reached. This kind of unwanted outcome could be dealt with if the design is transparent and the system could be modified, and also might count other parameters. The user behavior thus needs to be persuaded a little to make it possible to reach the set sustainability goal; in this example, perhaps by including the total driven mileage when assessing the user's behavior. The behavioral, cognitive, and emotional aspects of a design should thus be properly realized by users. Therefore a challenge is to present a design in which the persuasion could take place in the form of an optimum and appropriate user experience for enhanced usability. These issues are very important to consider in the planning phase. These design issues are, however, very contextual in nature. This means that the type of user experiences necessary for achieving a sustainable goal could be totally independent in nature for two different persuasive design problems. Consequently, persuasive technology is often thought to be working as a catalyst to change the behavioral environment and hence impact the change of the behavior of the users of a system. So, the planning phase would also focus on identifying new problems, which would then be taken into consideration as a next-design problem. This also is therefore a step associated with the trigger stage. Whether the new problem should be solved by keeping users in a non-coercive PSD category or if the design should work as a trigger for users intentionally, in an adoptive or interactive and easy or difficult way, etc. should be completely taken into consideration while identifying new problems in this phase of the life cycle. This should be done by also exploring the causes for which the identified problems could not be solved, based on those design criteria.

4 Discussions

Designing a socio-technical system like a persuasive system for sustainability is important, since it is going to try to make an impact by bringing about changes and is not only trying to make sense of the world, as Carlsson et al. [5] denoted to be the core of design-science research. The established SDLC of Persuasive Design for Sustainability was an effort to introduce a novel methodology that could be used to design solutions that confront the problems of developing a persuasive system that changes people's behavior towards a set goal like sustainability. While the call for the compulsion of sustainable HCI research on the environmental sphere of sustainability is inevitable, Dourish [9] pointed out the need of accompanying sustainable HCI research through different theories and concepts for broadening its context. The proposed methodology in the form of a life cycle for persuasive design could thus be seen as one of such accompanying frameworks to impose on existing work and design relating to a persuasive design for sustainability. Three phases of the suggested SDLC are important and have different properties and challenges that need to be solved. No almighty solution that is working in all different contexts will ever be found, as sustainability is a very complex and contextual issue. One of the strengths of the proposed SDLC is that it would help designers and system analysts to look into the subjective criteria for sustainable goals instead of objective criteria, which, according to Huber and Hilty [16] often is the case and thus critical for persuasive technology. Several important subjective criteria like deep thinking, wide collaboration, respecting values of users, preventing users from acting on values, improving relationships between technology and sustainable social change, etc. and their importance in persuasion for sustainability through advancing the sustainable HCI research was addressed by Silberman et al. [30]. We believe that the practice of our proposed SDLC would be able to address these issues for improving sustainability goals through persuasive design. Nevertheless, it is very important to understand the different outcomes that the choice of the sustainability goal will have on the development and efficiency and effectiveness of the development process, as well as the management of the running system. It is central to acknowledge the importance by keeping in mind that the persuasive system must not be static, but instead must be able to meet new technological trends, user preferences, and changes in the collected knowledge about sustainability and its effects. We believe that the proposed SDLC methodology has these features addressed and could thus be used in the long run to persuade people towards the set sustainability goal.

Our theoretical reference frameworks [21, 22] are structured on an advanced concept of universal design (UD), in which the notion of UD was used beyond the scope of its traditional practice-accessibility. Therefore the concept of UD could be used to expose a new dimension in persuasion by expanding its traditional concept. UD could add new values in generating new design principles for persuasive design. For instance, understanding simplicity, intuitiveness, and reduced effort during the use of persuasive systems could be redefined in the persuasion context, which in turn could help in developing new cognitive models for persuasive design. Such an attempt was demonstrated in our reference framework, in the work of Mustaqim and Nyström [24]. Based on this it would be possible to establish new driving factors as design parameters through the practice of the proposed life cycle in a specific design setup.

About the utility of our proposed SDLC, it is still highly theoretical and contextual at this stage of the research. No doubt that persuasion is a complex phenomenon and sustainability also is a delicate issue. Combination of these two could be more delicate in different cases and the proposed SDLC could be used to ease such complexities. For example, Aleahmad et al. [1], discussed the impact of direct and indirect persuasion on sustainable attitudes. When it is necessary to result in this kind of complex persuasion through the design, then the proposed SDLC could be useful for identifying proper user needs and thus could contribute towards achieving sustainability through a successful system design. Also, even though persuasive technology could be a powerful tool for engaging stakeholders with sustainable behavior it is still important that they are already aware and convinced about the importance of sustainability, since failure to do so would make them not to choose a persuasive technology to use [1]. The proposed SDLC could be a key tool in this respect for handling these types of issues throughout its different phases and thereby make sure that the end design would be ready to be accepted by users.

Ethics have always been an important issue in discussing persuasive design. While achieving sustainability goals through design is important, it is also significant to remember that any higher power in design decision should not be misused to initiate unwanted impacts on user actions for any commercial success only for organizations. The proposed SDLC could be used to identify sensitive issues and factors in design in the direction of subsidizing the ethical aspects of design in persuasion for sustainability.

Further, the tendency of quickly switching to a green solution and changing human behavior towards green materials through persuasive design is often seen as a quick methodological fix towards achieving sustainability, which should really be prevented from occurring since this is and should not be the only perception of sustainability or sustainable action. The proposed life cycle would be able to realize other different issues that could be associated with a focused sustainability problem. It could then be solved using persuasive system design to be identified truly as persuasion towards sustainability goals. The research question addressed in the introduction section could thus be answered here by stating that one way to successfully design persuasive systems for sustainability could be to follow the proposed SDLC. And yet, system designers alone should not be expected to be benefited by the use of the proposed life cycle to claim the end design to be successful, since, as mentioned earlier, sustainability is a multifaceted complex issue and active involvement of different stakeholders from our collective society is centrally focused on the optimistic change of attitude towards this issue through the persuasive design.

5 Future Research

The proposed SDLC opened up some interesting research opportunities worth mentioning. First of all, this life cycle could be followed to design a program intending persuasion for sustainability. Then it could be compared with a system that was developed without following this process. The feasibility of using the proposed life cycle could then be realized. Likewise, systems designed by following two different processes could go through usability studies to see the impact of a design process on

the end sustainability goal. New methodologies could thus be formulated for shaping the success of the proposed SDLC. Secondly, the context of sustainability could be realized in an improved way through the practice of this life cycle. Subsequently changing user behavior through design is not enough only in persuasion; what other factors could be important to consider in the design could be realized in different phases of the design process. Finally, the proposed life cycle could give system designers a new way of looking into the evaluation of sustainability. Since new entities of sustainability could be realized during the design process, they could also be evaluated later for measuring sustainability. On the other hand, new entities would be able to contribute towards developing or improving design principles for persuasive design.

6 Conclusions

This paper has considered reflecting through two previously established frameworks of a cognitive dissonance model for persuasive design for sustainability and an SDLC process in design for sustainability. These frameworks were analyzed and mapped together to formulate a new SDLC, pointing in the direction of persuasive system design for sustainability. The new framework was then explained and discussed within the context of persuasive system design aiming for sustainability. Despite the fact that changing the user's behavior or actions towards sustainability is concerned with what the concept of classical persuasive design is built on, within the context of sustainable HCI this perception is rapidly taking a shift. At the same time, available technologies are peaking, fast improving and altering. This reality will force and lead organizations that are facing new, tougher competitions and challenges in design. A proper SDLC, in hand as a systematic methodology, could be a fit within the existing structure of organizations, making it easier for them to identify the right problems faster and to answer their internal demands on different design solutions. The underlying philosophy behind the pillar of this paper—universal design—should also thus be mainstreamed, escaping from its traditional practice and one of such examples is shown in this paper and its reference to theoretical frameworks. With the trending shift of sustainable HCI and persuasive design for sustainability together with the research towards large-scale design problems and design for everyday use, the proposed SDLC in this paper could be highly promising in contributing to and supporting organizations and designers, focusing upon issues like persuasive design for sustainability. The proposed persuasive design life cycle of sustainability in the form of a methodology thus demands empirical verification for further interesting results.

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