Towards Integration of Sustainable User Experience Aspects in Systems Design: A Human-Centered Framework

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Abstract: The usage of software systems has immense impacts on human psychological well-being (a primary user experience outcome). The World Health Organization refers to well-being as "a positive state", encompassing e.g., a good quality of life. Studies have shown that the human well-being is dependent on the satisfaction of certain psychological needs. However, normally, the software system development processes capture requirements that are needed to fulfill the purpose of the system itself and not the psychological requirements of humans who use and interact with these systems on an everyday basis. In order to address this challenge, this paper contributes a framework: Sustainable User eXperiences Enabled Human-centered (SUXEH) framework that addresses human psychological needs explicitly as one of the main modelling efforts in the early stages of the development process. The framework does so in a way that eases the integration of sustainable user experience aspects (mediated by the human needs) in the systems design phase of the overall development process. The framework is illustrated using a case study, the Taxi System.

1 INTRODUCTION

Conventionally, software engineering design methods include guidelines and/or rules on how to specify a system from the perspective of its functionality, that is, what and how the system performs its functions. The first objective is always to make the system work according to the specified requirements. The requirements that are mapped to the design phase are typically functional requirements. The non-functional requirements or the software quality requirements are mostly taken care of during the final product evaluation, referred as the product-oriented approach in (Mylopoulos et al., 1992). Whether functional or non-functional, these requirements are normally system-centered and not human-centered.

In contrast, recent studies from the more human-centered perspective (see e.g., (Monge Roffarello and De Russis, 2019; Granow et al., 2018; Orben and Przybylski, 2019)) have shown that the everyday technology we use has nuanced impacts on our psychological well-being. However, the psychological needs of the people, who use these socio-technical systems and interact with them, have not been normally taken into account during the main software system development activities. On the one hand, and partly due to the demand of short time-to-market and prevalent fuzziness in understanding human-psychological needs, the focus in software systems engineering and the user satisfaction of a system has remained always connected to the fulfilment of the system-centered requirements (Brown, 1997; Rosenbaum et al., 1999). On the other hand, software developers lack guidelines on how to cater and analyse human psychological needs during the development process. In this paper, we argue that the identification of human psychological needs at an early stage of software development can play an important role in making design decisions. Inclusion of these needs at later stages specifically once the system has been developed may be difficult, insufficient and expensive. In this work, we address these problems by answering the following research questions:

1. What human psychological needs may be taken care of while acquiring the requirements?
2. How can the requirements acquired in (1) be represented in requirements specifications?

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3. In what way can these human-centered requirements specifications provide valuable input to the design phase of the system development?

In late 2010s, it has been proposed in the Human-Computer Interaction (HCI) and User Experience domain that certain human psychological needs are mediators of long-term sustainable user experience outcomes like that of human well-being, engagement, and motivation (Peters et al., 2018). The term "user experience" is defined as "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" (ISO 9241-11:2018(en), 2018). In order to improve user experience and well-being, the authors in (Peters et al., 2018) emphasize on supporting certain psychological needs via technology designs using a model named METUX (Motivation, Engagement and Thriving in User Experience). Inspired by the METUX model, we propose a framework that addresses the above formulated research questions for inclusion of human psychological requirements essential to human well-being (and other long-term sustainable user experience outcomes) in the early stages of the software development process.

Whether it is in the HCI or software engineering domain, normally, the user-centered requirements are limited to the details of the direct interaction of the user with the system, rarely taking into account how they contribute to the overall sustainable human well-being (see Section 2 for details). One of the distinct properties of the METUX model is that it allows to analyse not only the direct impact of technology use on momentary human psychological experience, i.e., hedonic experiences (e.g., pleasure and comfort), but also the broader long term impact on other aspects of human life, i.e., eudaimonic experiences (or true flourishing) that are strongly linked to the concept of well-being (Hammer et al., 2018). Based on the METUX model, our framework proposes guidelines on how certain designs can be avoided that may satisfy human psychological needs on the interaction level but frustrates the human psychological needs of overall sustainable well-being by explicitly addressing eudaimonic experiences (more to come later in Section 3.2).

In terms of software engineering goals, our proposed framework assists software engineers from the requirements acquisition phase to the early design phase. During the requirements acquisition phase, the framework helps in identification of the basic human needs that are required to be satisfied for better user experience. Our framework provides the constructs to represent these requirements as the goals of a system, that is, in a form acceptable by the requirements specification phase or early design phase. For this, the framework uses the goals-oriented requirements language (GRL) that offers a graphical means of describing and structuring various types of concepts that appear during the requirement process. The GRL, like other goal modelling languages, is a valuable tool for discussions with stakeholders. It provides the constructs needed for our primary concerns of (1) reasoning of human-centered requirements (2) modelling human needs that are fuzzy in nature (3) describing impact (positive or negative) of system functionalities (satisfying specific needs) on overall human well-being.

Figure 1 serves to illustrate the overview of our proposed *Sustainable User eXperiences Enabled Human-centered (SUXEH)* framework. It consists of the functional requirements model of a system to be designed (the functionality goals component), human psychological needs (the enabling goals component), and the goals that are needed to be satisfied for sustainable outcomes of user experience (the user experience outcomes component). These components do not exist in isolation. They belong to domains that traditionally do not negotiate or interact with each other. The framework we propose identifies the links between these components that represent different domains, hence allowing these domains to interact and exploit the links between them for better system modelling in terms of improved and sustainable user experiences. These components are different views of the same system enabling us to design holistically for better human well-being.

The main contribution of the framework is the provision of guidelines on:

- The identification of basic human psychological needs relevant to the system to be specified
- The representation of these needs in requirements models
- How and to what extent the system can support these basic needs through its functionality
- Avoidance of designs that can hinder these needs by their negative influence on overall human well-being.

The rest of the paper is organized as follows. Related work is discussed in Section 2. The details of the SUXEH framework are provided in Section 3. In Section 4, we describe how to use the framework by applying the guidelines on a case study, the Taxi System. We discuss our research contributions in Section 5, and the conclusion and future work is presented in Section 6.

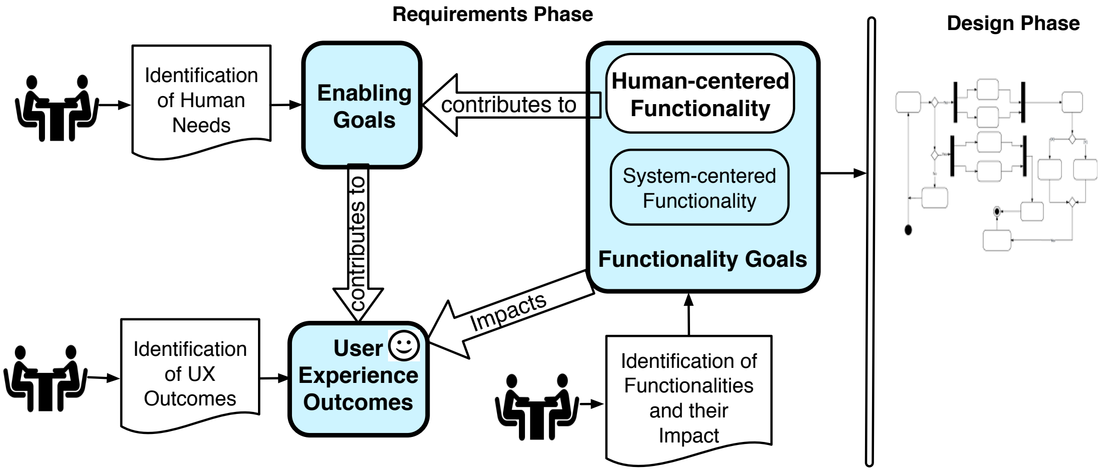

Figure 1: An Overview of the SUXEH Framework.

2 RELATED WORK

The human factors in software engineering have been studied in the past and several approaches are proposed (Checkland, 1981; Hix and Hartson, 1993; Mayhew, 1999; Farooqui et al., 2019) that can be embraced under the term "human-centered design (HCD)" by ISO (ISO 9241-210:2019(en), 2019). One of the first approaches was soft system methodology (SSM) (Checkland, 1981) that was applied also to capture the impacts on people involved (e.g. stakeholder, actors, and clients) and considered different views of interactive systems during development. The SSM, work done in (Acuña et al., 2012), and earlier HCD approaches overviewed in (Metzker and Reiterer, 2002) aim to merge HCI and user experience methods and practises in software development process in order to achieve usability goals in terms of user satisfaction. This requires extra resources and expertise along with other limitations listed in (Metzker and Reiterer, 2002).

In the recent past, there has been increased focus in exploring different human aspects (e.g., human diversity, human emotions, user involvement) and supporting them during software development. One of the recent works (Grundy et al., 2021), takes into account end-user human diversity in terms of software user age, accessibility challenges, ethnicity, language or gender in the digital health requirement models for which they use Domain Specific Visual Language (DSVL). The authors propose to incorporate these human aspects in one of the main stream software systems development methodologies, i.e., the Model-Driven Software Engineering (MDSE). The work is extended in (Grundy et al., 2022) where the authors presented a preliminary taxonomy of some of the end-user human diversity aspects for software developers guidance by dividing human characteristics in groups. In another work (Curumsing et al., 2019), the authors propose a requirements engineering approach to take into account emotional aspects of software usage in smart home technology for the elderly. Their definition of emotional goals refer to how users perceive the end product and hence it is product specific. This approach emphasize on linking emotional goals with functional or quality goals. Another perspective of addressing human aspects in software engineering in the past is to consider user involvement during software development life cycle to generate more usable solutions (see e.g. (Iivari et al., 2010; Klemets and Storholmen, 2020).

While relevant and bridging more towards the user and human perspective, the approaches discussed above do not explicitly consider and address the characteristics of user experience. None of the approaches provide design guidelines to support more than just immediate hedonic experiences. Their investigation mostly focus on the ease-of-use and usability of the systems and hence lacks a more holistic or realistic picture in terms of their broader impact on long-term eudaimonic experiences that contribute to sustainable human well-being. Further, the relationship between user experience outcomes and human psychological needs, as proposed in the METUX model, has not been taken into account (Peters et al., 2018). Moreover, the recent approaches proposed in (Grundy et al., 2021) and (Curumsing et al., 2019) are MDSE and product-specific respectively. Based on the METUX model, the framework we propose would allow design strategies to be identified that address these research gaps.

3 THE FRAMEWORK

Figure 2 illustrates the SUXEH framework given in Figure 1 with more emphasis on the types of relationship between the functionality of the system and the fundamental human psychological needs that enable sustainable user experience outcomes. The framework comprises three components distinguishing human-centered needs, user experience outcomes and the human-centered functionality. The decomposition into components helps in reducing the complexity of the modelling effort for these different domains. Based on this reasoning, the following components are defined as goal models:

- **Enabling Goals:** These are human psychological needs. The user experience outcomes are dependent on these goals, hence defined as enabling goals. These high-level goals are first defined within technology domain and then further refined into sub-goals to derive specific functionalities.
- **User Experience Outcomes:** This model identifies desired user experience outcomes. These outcomes are enabled by the satisfaction of the identified human needs in the “enabling goals model”.
- **Functionality Goals**: Enabling goals are achieved through the system functions identified in the functionality goals model. Therefore, apart from the system-centered functionality, this model contains functionality supporting specific human needs, i.e., human-centered functionality. There are possibilities that more functions emerge as enabling goals are refined.

3.1 The Enabling Goals Component

This component represents the human needs set as explicit goals to be taken into account during requirements acquisition. This enables software engineers and key stakeholders to focus on the appropriate set of needs for a given system and justify the system requirements accordingly. These goals may be refined in a way that the functionality goals component is able to define explicit functions for each enabling goal.

This section explains how the needs are first identified and then modelled during requirements specification.

3.1.1 Identification of Human Needs

There are variety of psychological theories on identifying fundamental human needs. The authors in (Sheldon et al., 2001) attempted to determine which needs are *truly* fundamental for humans. They identified a set of 10 needs: autonomy, competence, relatedness, self-esteem, physical thriving, security, self-actualization, pleasure-stimulation, money luxury, and popularity-influence. This set has a considerable range and represents prominent theories including Self-Determination Theory (SDT) (Ryan and Deci, 2000; Ryan and Deci, 2017) within the literature. Out of these 10 needs, Sheldon et. al. claim that the four needs, i.e., autonomy, competence, relatedness and self-esteem, are the most important ones. The METUX model also proposes autonomy, competence and relatedness (core elements of Self-Determination Theory) as the most critical needs within HCI contexts. Their absence is linked with ill-being and distress. The authors support their claim by referring to empirical research carried out by authors in (Ryan and Deci, 2017; Vansteenkiste and Ryan, 2013), whose work revealed that the three basic needs are the most predictive and reliable mediators of primary user experience outcomes: motivation, engagement and well-being.

Some of these needs may be more relevant for specific types of systems than others and not all of these basic needs may be relevant for all types of systems. Therefore, we propose to include all 10 needs identified in (Sheldon et al., 2001) for a better representative set of needs that is applicable to a considerable range of systems.

3.1.2 Modelling of Human Needs

The selection of basic psychological needs that are most relevant for the system is an important step towards modelling of the needs. Stakeholders involvement at this stage is important. The discussions are mainly facilitated by the designers in order to guide the overall process from the perspective of realizability of the selected needs. A challenge at this stage may be that users are not necessarily aware of their fundamental psychological needs and how these latent needs may drive their choices and the quality of their experiences. To this end, methods such as laddering (Rugg and McGeorge, 1995) and experience interviews (see e.g., (Fink et al., 2022) have been proposed in the literature.

In order to demonstrate how to model a basic psychological human need, we choose *autonomy* as an example human need. As mentioned earlier in Section 3.1.1, the motivation behind choosing autonomy mainly comes from the work of Peters et al. in (Peters et al., 2018). Also some aspects of human autonomy are listed in (Grundy et al., 2022) among the keys areas of human aspects that need careful consideration in software engineering life cycle.

The main challenge to model a human psychological need is to deal with the fuzziness of its require-

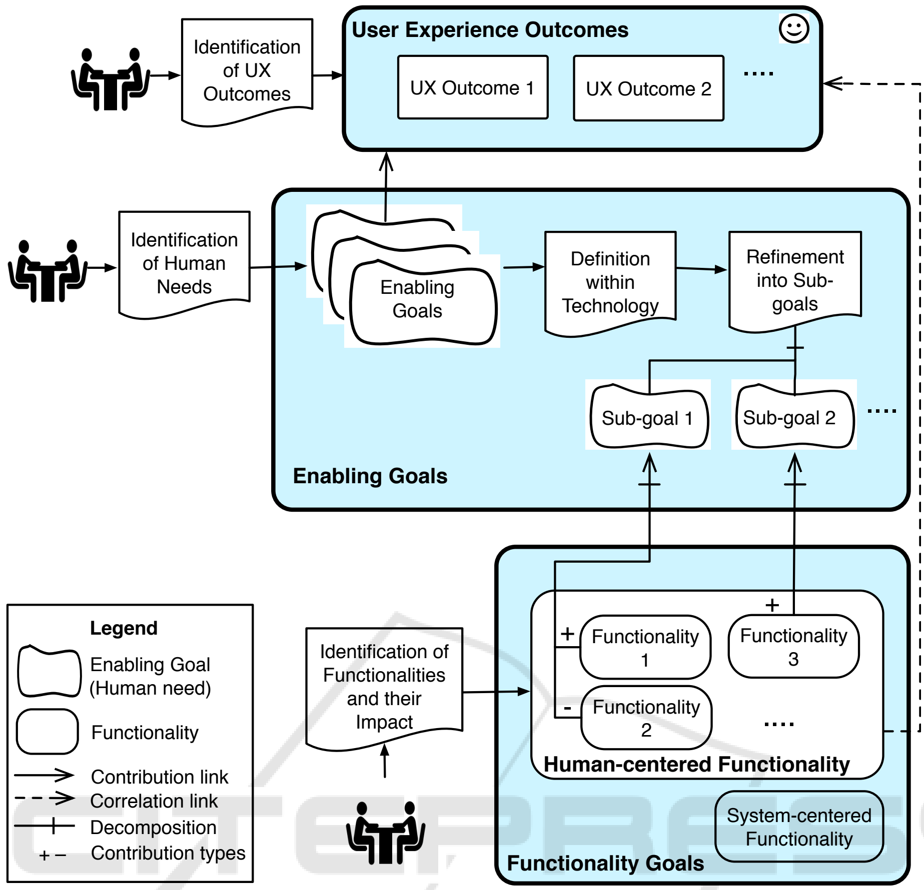

Figure 2: The details of the SUXEH framework shown in Figure 1 illustrating the framework guidelines and relationship between its sub-components.

ments in technology domain. In order to address this challenge, we propose the following guidelines in our framework to model an enabling goal (basic human psychological need) in the requirements phase:

- **Define the enabling goal within technology** domain to be clear on its meaning with the stakeholders.
- **Refine the enabling goal into sub-goals** in a way that potential design solutions in the form of functions can be driven out of them. This can be done by following the steps below:
  - Look into how the enabling goal is studied in the technology domain. For this, the findings in (Peters et al., 2018) provide a good summary on how technology can help users develop a better sense of autonomy for example.
  - Use Jakob Nielsen's usability heuristics (Nielsen, 1994) of the user experience domain in order to explore usability design requirements to support human autonomy.

In the following, the above process is illustrated for autonomy as the example human need.

Defining the Enabling Goal *(Autonomy)* **Within Technology:** We first need to look into the clear definition of autonomy in the technology domain. As mentioned in (Peters et al., 2018), autonomy does not merely mean doing things independently, but has a deeper meaning of acting with *"high willingness and in accordance with personal goals and values"*. It is important to mention here that the focus of our framework is on human-centered requirements of autonomy which differs from system-centered requirements of autonomous systems like that of robots and driverless cars. Human-centered requirements of autonomy explores human autonomy as part of overall psychological needs satisfaction.

Refining the Enabling Goal *(Autonomy)* **Into Sub-Goals:** After defining and having consensus with stakeholders on what is meant by autonomy generally in the technology domain, the next step is to decompose the enabling goals into sub-goals that are precise enough to support design of potential solutions in the form of functions. For this, we follow the guidelines mentioned above by starting with studying how the autonomy is studied in the past in the technology domain.

Various aspects of software systems have been identified in the past (Friedman, 1996) that can support or hinder user autonomy, i.e., system capability and complexity, misrepresentation and fluidity. These aspects are more focused on the direct impact of the system's use (referred as the *Interface* and *Task* levels of user experience in Section 3.2.1) and not the broader impact on other aspects of a user's life (i.e., on the levels beyond the *Interface* and *Task*). Other studies (Ryan and Rigby, 2018) have identified that systems that offer "options" and "customization" helps in creation of a sense of autonomy and ownership. This type of autonomy design is familiar to game designers and can have a broader impact on human's life. We take these aspects (offering "options" and "customization") as guidelines for our first criterion to identify autonomy-enhanced system functions in the functionality goals of our framework.

Authors in (Peters et al., 2018) highlighted the fact that, *all usability heuristics can be explained by the needs of competence and autonomy*. Following their direction, we propose to choose Jakob Nielsen's 10 heuristics of usability design (Nielsen, 1994) in software systems design as valuable guidelines to improve user experience. Nielsen's heuristics are widely accepted and well-supported in the user experience domain. In addition, these guidelines are small and easy-to-use, and hence can be equally used by non-user experience designers and stakeholders. Following are Nielsen's 10 heuristics (Nielsen, 1994):

1. Visibility of system status
2. Match between system and real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

It is important to mention here that the guidelines given in the above heuristics are not applied as an evaluation method of user interfaces. Instead they are used as a valuable tool to refine basic human needs (enabling goals) into sub-goals that are more precise in terms of their required system functionality.

For the sake of brevity, we summarize the factors, that manifests the above Nielsen's guidelines, in terms of specific functionalities that can enhance sense of autonomy (and competence): clarity on feedback and available actions; provision of consistent and standard order of operations and language; clearly marked emergency exits without extended dialogues; provision of constraints and confirmation of risky actions. Clearly, these factors can be satisfied with provision of system functions and hence must be addressed in requirements models. Though these factors are explained from the perspective of autonomy, they are equally important for the psychological need of competence (Peters et al., 2018).

3.2 The User Experience Outcomes Component

The user experience outcomes are represented by a specific component of the SUXEH framework. The framework also represents the relationship of user experience outcomes component with the enabling goals component via the GRL contribution links (see Figure 2). For the sake of comprehension of the framework, this paper focuses on the following primary user experience outcomes: motivation, engagement and well-being proposed in (Peters et al., 2018). However, the framework is not restricted to these outcomes and can include other outcomes as per requirements. Various other models linking UX to user/human goals have been proposed in the literature. An influential other view in this respect, is Hassenzahl's model of pragmatic and hedonic quality perceptions (Hassenzahl, 2018). It differentiates user experience from usability as UX anticipates outcomes beyond purely instrumental ones (e.g., efficiency, effectiveness) and is associated with the fulfillment of what Hassenzahl calls "be goals" (e.g., relatedness, stimulation, identification) (Hassenzahl, 2018; Hassenzahl and Roto, 2007).

Studies have confirmed that elements of human experiences like that of engagement and enjoyment do not always contribute positively to sustainable well-being. For instance too much engagement in video games (see e.g., (Sarda et al., 2016) and media consumption (see e.g., (Flayelle et al., 2020) can increase the user engagement to the extent that leads to health issues and impact overall well-being negatively. It is because usually the technology design is focused on the direct impact of the system's use on humans and not the wider impact on other aspects of a human's life. Therefore, when we talk about *sustain-*

able user experience outcomes, it is important to differentiate between immediate hedonic experience and long-term eudaimonic experience as recommended in the research conducted by (Ryan and Deci, 2017).

Experiences can be either eudaimonic or hedonic or both (see e.g., (Hammer et al., 2018) for a classification). Eudaimonic experiences are more about pursuing personal goals whereas hedonic experiences are largely about "momentary pleasures" like relaxing and with little lasting personal impact. Eudaimonic experiences have long-term importance and are often considered strongly related to the experience of *meaningfulness* and well-being than hedonia. Further, eudaimonic experiences were also found to be linked to positive affect in (Mekler and Hornbæk, 2016). The distinguishing concepts of eudaimonic and hedonic aspects of a user's experience that result from the use/anticipated use of a system facilitate the discussions on avoiding certain functionalities/design decisions (specified in the functionality goals component discussed later in Section 3.3) that have long term negative impact on human well-being.

3.2.1 Differentiating Levels of User Experience

In order to provide guidance on how to detach unhealthy positive experiences from healthy ones that contribute to sustainable user experience outcomes, the authors in (Calvo et al., 2014) have emphasized the importance of differentiating various levels of experience within which human needs can be influenced by technology. Four different levels or spheres of experience are identified in the METUX model within which need satisfaction can take place: *(1) As part of interacting with the technology via its interface (interface level); (2) As part of engaging with technology-enabled tasks (e.g. self-tracking) (task level); (3) In relation to the over-aching technology-enabled behaviour (e.g. exercise) (behaviour level); (4) As part of an individual's overall life (life level).*

As claimed by the METUX model, the consideration of these different levels of user experience provide guidance on avoiding creating designs that are need-satisfying (i.e., healthy) at one level and need-frustrating (i.e., unhealthy or addictive) at another. This facilitates to trigger the discussions between the stakeholders and designers on calculation of positive or negative impact of a certain design decision (a specific function) on the experience levels beyond mere interface. Therefore, in order to obtain long-term *sustainable* user experience outcomes we acknowledge these levels of experience. Accordingly, we identify positive and negative links between the framework components that contribute positively and negatively towards achievement of these sustainable user experience outcomes. More details on this are given in the next Section.

3.3 The Functionality Goals Component and Assignment of Its Impact (Positive/Negative)

Traditionally, functional model of a system contains those functions that are essential to make the system work and explains what the system does. As depicted in the detailed overview of the SUXEH framework in Figure 2, we propose to upgrade this functional model in a way that it defines or highlight explicitly also those functions that support the fundamental human needs.

The enabling sub-goals, resulting from refinement of human need (as explained for autonomy in Section 3.1.2), provide the required input for the functions in human-centered functionality goal component. In other words, this component manifests through its functions that how the goals identified in enabling goals component can be achieved. It is important to mention here that we do not say that a goal is accomplished or satisfied in a clear-cut sense. But it can be said that certain functions (design decisions) may contribute positively or negatively towards accomplishment of a certain goal. In this way, the framework can generate advance warnings to signal negative (and positive) impacts of a certain human-centered requirement to the next phases of the development process.

As discussed earlier in Section 3.2.1, there is a possibility that inclusion of a specific function that satisfies a certain human need (enabling goal) at one level of user experience may be need-frustrating in terms of its negative impact on the higher levels of user experience. Therefore, after defining the functions satisfying certain enabling goals/sub-goals, there is a dire need to check whether the functionality goals frustrate human needs on the levels beyond the *Interface* and *Task* spheres of user experience. In order to represent the relationship of how functions defined in the functionality goal component contribute (positively or negatively) towards achievement of enabling goals, we use the GRL *contribution links* that connects the framework components with each other with explicit notations of "+" and "-" on the links representing their positive and negative impacts respectively (see Figure 2). The GRL contribution links can have various degrees of impact but we only include links with positive and negative impacts in our framework to keep it simple enough to be understood by professional designers and non-professional stakeholders equally.

It is clear that the functionalities defined in the functionality goals component not only contributes to the enabling goals component but this helps towards fulfilling user experience outcomes. Such side-effects are called *correlations* in GRL that are represented using dashed arrows as depicted in Figure 2.

In the following, we demonstrate how the above guidelines can be applied to a case study, the Taxi System.

4 A CASE STUDY: TAXI SYSTEM

This section explains a case study, a Taxi System, that is here understood as a specific system example used to explain the framework (also referred as a demonstration case in (Host et al., 2012)). The case study is based on similar types of real systems but simplified in order to investigate and illustrate the proposed framework more precisely.

The Taxi System was proposed in (Fatima and Bræk, 2016) for illustration of a systems modelling approach. It is an example of distributed communicating systems. These systems maintain ongoing interaction with their environment. These are complex systems difficult to be designed because of the concurrency involved in their interactions with the environment and different parts within the system.

In the Taxi System, a user can book a taxi via an online booking system. A taxi dispatcher keeps an overview of the taxis and assigns an available taxi to the requesting user. If no taxi is available, the user is asked to wait. Once available, the taxi is assigned and contacts the waiting user.

In the following, the framework is applied to the case study to demonstrate how human psychological needs can be modelled as functionality goals of a system.

4.1 Identification of Functions Satisfying Enabling Goals: the Functionality Goals Component

In this section, we demonstrate how the factors, resulting from the refinement of enabling goals as subgoals in Section 3.1.2, can be applied to the Taxi system in order to identify its precise functions that have the potential to satisfy basic human needs. The process is illustrated by working around one basic need (i.e. the autonomy) to exhibit how a human psychological need can be translated into functions that are required to generate sustainable user experiences like that of engagement for example.

We assume that the system-centered functional requirements of the Taxi System have already been identified and their functions are modelled. Here, we are focusing on human-centered functionality component that defines functions to support human autonomy in the Taxi System. The sub-goals refined for autonomy in Section 3.1.2 (i.e., offering "options" and "customization"; visualization of system status, user control and freedom (and other Nielsen's heuristics not explained in this section)) are generic enough for HCI contexts. Against these generic sub-goals, the following Taxi System autonomy specific functions can be specified:

Generic Sub-Goal 1: Alternatives and/or Offering Options

System-specific functions: A user can choose

- different types of taxis based on their price, size, time-to-reach, distance from pickup point
- to change destination at run-time
- to change pickup location at run-time
- to register with specific profiles
- to register for rewards that are offered depending upon how often they use the service

Generic Sub-Goal 2: Customization (Flexibility and Efficiency of Use)

System-specific functions: A user can

- choose a taxi from preferred driver options (can also improve relatedness)
- choose from favourite pickup/destination locations based on their past orders
- create favourite list of destinations/pickup locations

Generic Sub-Goal 3: Visibility of System Status:

System-specific functions:

- Overview of taxis on a map with all the alternatives specified in the sub-goal 1 above.
- Taxis display other facilities they have like that of a baby seat.
- Clarity on "Taxi booked" and "Taxi cancelled" confirmations and other initiatives taken by the User.
- User is updated about their queue position
- User is shown the taxi remaining time-to-reach at pickup location and destination.

Generic Sub-Goal 4: User Control and Freedom

System-specific functions: A user can

- cancel/exit the taxi ordering activity at all steps while making the order
- cancel/exit the taxi order while in waiting queue

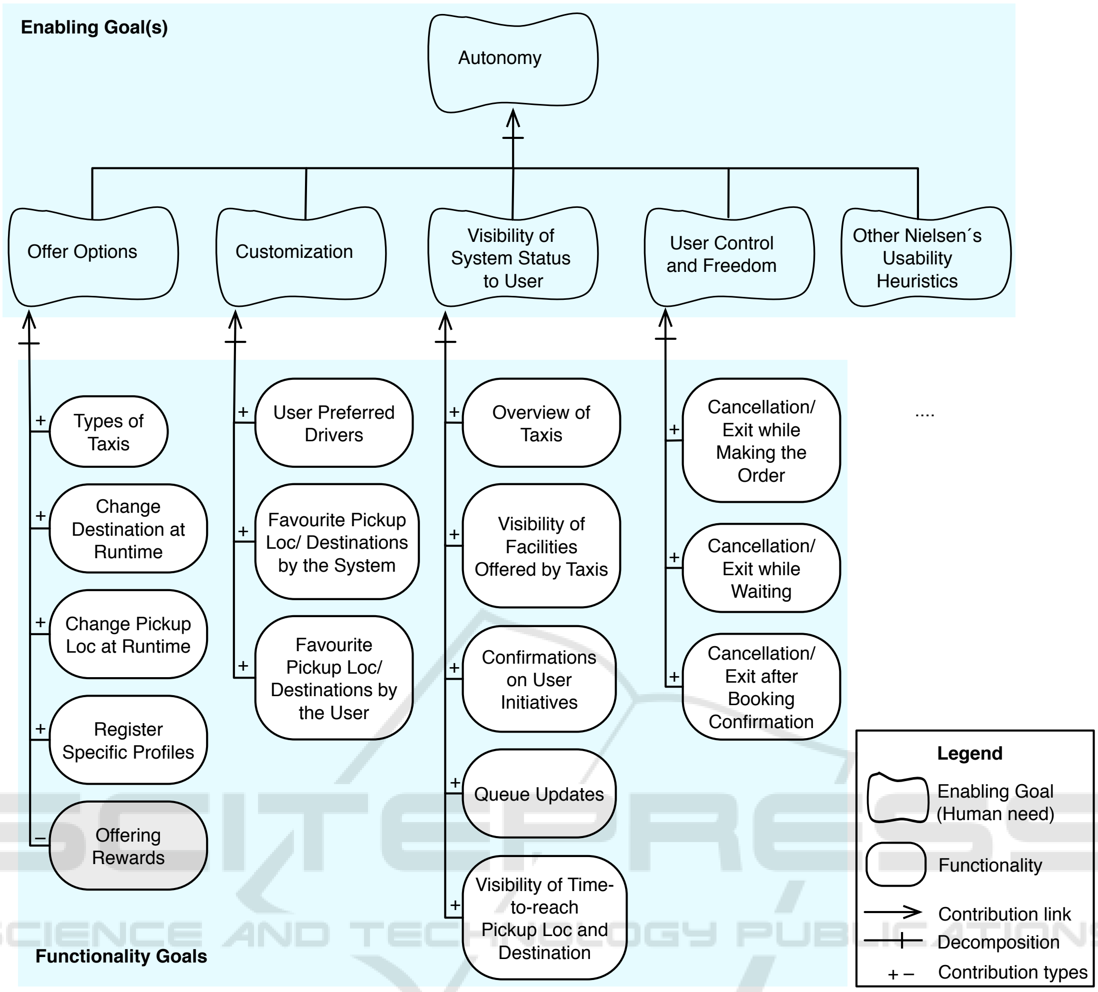

Figure 3: The SUXEH framework applied to the Taxi System illustrating modelling of *autonomy* as an example human psychological need.

- cancel taxi order after it is booked

The above functions are defined on one view (interface) of the system i.e., the customer view, and hence all the functions are defined from a customer's perspective. The Taxi perspective (not detailed here) shall add more functions. It can be clearly seen that the above functions of the Taxi System that contribute to the human psychological needs are the functional requirements of the system and hence must be addressed at this early phase of system's development.

As described earlier in Section 3.3, we use the GRL to represent modelling of human-centered goals and to refine them in terms of precise system functions. Figure 3 illustrates graphically how autonomy (an enabling goal) can be modelled in terms of less fuzzy and more refined functions (functional requirements) of the Taxi System. We utilize the GRL decomposition links to denote decomposition of goals into sub-goals and functions. The positive or negative contribution of a function towards achieving a goal/sub-goal is represented via positive and negative contribution links from GRL. We use the guidelines of differentiating levels of user experience given in Section 3.2.1 to mark these contribution links. For instance, consider the example of the function named "offering rewards" that contributes to the "offer options" sub-goal required to be designed for the satisfaction of autonomy (see Section 3.1.2). Apparently, this function increases engagement and motivation user experience outcomes mediated by increased autonomy and competence human needs (see Section 3.1). However, this happens only at the interface level of the user experience exhibiting the direct impact of the system's use. Because the criterion of "offering rewards" is how often a user uses the Taxi System, it can increase engagement to an extent where this function has negative impact on a human's overall well-being. Hence, this "offering rewards" function can contribute negatively towards achievement of autonomy via “offer options” sub-goal and therefore its contribution is marked with “-” sign. The framework allows to signal this possible negative impact of the function to the later stages of system development that involves major design decisions. Hence, this indication helps designers to design such functions carefully (with additional constraints that need adjustments for positive impacts) in order to avoid need-frustrations at higher levels of user experiences that impact overall human well-being. For instance, the function of “offering rewards” may be constrained only for long distances, and/or health warnings and saving money type of incentives may be given to the user for avoiding the taxi service for shorter distances. Alternatively, the criterion of “offering rewards” can be changed to how often the user uses a *shared* taxi to put less emphasis on individual taxi usage and more on the rides that are more beneficial for the environment and are less expensive.

In the case, where certain functionalities are decided to be dropped due to their negative impact, still the information encompassing the reasoning can be made part of documentation to avoid repeating the discussions in the future.

5 DISCUSSION

We have emphasized that software systems design decisions affect positively and/or negatively particular human psychological needs that contribute to sustainable user experience outcomes. These needs are not taken into account while requirements acquisition. This problem is addressed by our framework that enables software designers to capture and represent human psychological needs early in the software development process when the requirements are elicited and specified, and design decisions are justified, referred as the process-oriented approach in (Mylopoulos et al., 1992) as opposed to the product-oriented approach when the final product is evaluated.

Unlike the approaches proposed in (Checkland, 1981; Hix and Hartson, 1993; Mayhew, 1999; Farooqui et al., 2019; Acuña et al., 2012), and due to the limitations listed in (Metzker and Reiterer, 2002), the framework we propose does not integrate HCI or user experience design process as a whole in the software systems development process. However, we have used HCI and user experience domain knowledge in two ways: (1) In order to understand core elements of human psychological needs we have taken guidelines from a model (Peters et al., 2018) that explains these needs and their relationship with sustainable user experience outcomes in the context of HCI; (2) We utilize Nielsen’s usability heuristics (along with other criteria that are driven by human psychology) not as an user interface evaluation method but as an important input towards modelling the human psychological needs. These HCI and UX simple tools assist in formalizing simplistic yet effective guidelines that help in easy incorporation of basic human psychological needs requirements in the software systems development.

The SUXEH framework we propose includes notion of human aspects from HCI/UX discipline that help in building a more complete understanding of human psychological needs. This more holistic perspective also allows to focus beyond those traditionally considered as users (“user-centered design”) and adopts a broader, human-centered view on those the system is designed for or who may be affected by its use (ISO 9241-210:2019(en), 2019). As explained in Section 3.1, the human needs we emphasize leverage mainly Self-Determination Theory (SDT) that provides an empirically validated approach to explore factors that contribute to sustainable user experience outcomes like that of well-being. We choose to present detailed guidelines on how to model *autonomy* that is one of the three main constructs (along with competence and relatedness) that has a deep and clear link to more commonly verbalized concepts like meaning or happiness (Ryan and Deci, 2017). Hence the human emotions being modelled as target human aspects in software requirements for instance in (Curumsing et al., 2019)), discussed earlier in the related work, are actually the desired outcomes of basic psychological needs satisfaction that our framework emphasizes on.

Our framework promotes user involvement in terms of negotiations with stakeholders mainly facilitated by the designers. Since the human psychological needs are explicitly modelled in terms of system functions, the framework support early analysis of human-centered functional requirements in terms of their realizability from the designer’s perspective. This will help in reconciliation of designer’s and stakeholder’s point of views specifically on those requirements that (1) negatively affect human well-being, and/or (2) are not realizable from resource or technical point of view (for instance, requirements that may interfere with the system basic functionality). Since the framework provides clear visibility of reasoning (in terms of explicitly marked contribution links between the components) behind the decisions made by the stakeholders and designers collaborations, agreed-upon (and leftover) human-centered functionalities may be made part of the documentation elements important for future references specifically to avoid repetition of the same discussions.

Finally, while the framework aims to support the design of sustainable user experiences, we acknowledge that human-centeredness in system design may also trigger behavior that is unsustainable from e.g., an environmental point of view. For instance, in the Taxi System, the "offering rewards" functionality supports sustainable user experience in terms of addressing human autonomy but it may result in the usage of the system to an extent where it is not good for the environmental sustainability.

6 CONCLUSION AND FUTURE WORK

In this paper, we have presented a framework which we refer to as SUXEH (Sustainable User eXperiences Enabled Human-centered) framework that identifies and represents fundamental human psychological needs (that are based on mature psychological theories) explicitly as systems functions in early stages of software development. With the help of a case study, the Taxi System, we have demonstrated how our framework can be applied to represent human psychological needs by modelling autonomy as the detailed example need. This application of the framework shows that our framework is generic in a way that it is neither system specific nor end-user specific. It applies to different types of human users and equally to all types of software systems. We also believe that the requirements models that result from application of our framework can be used by all software systems design methodologies. We look forward to conduct empirical case studies/user studies that allow to further refine and validate the framework.

We do not claim that our framework provides complete guidelines on integration of human psychological needs in the early stages of requirement specifications, but we believe that our framework provides initial directions that guides beyond GUI design and usability, and provides more holistic and realistic picture of integration to address broader impacts on human well-being and other long term eudaimonic aspects of sustainable user experience outcomes. We emphasize that provision of this information in requirements specifications acts as a significant input in making design decisions during software systems development.

Our research presented in this paper can form a useful starting point to further investigate generic models of human psychological needs in software development process. Creation of new design methods or investigation of most appropriate design methods that can be improved to incorporate human-centered requirements is required. This is an open research question and we are looking forward to address this question in our future publications.

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