Value Sensitive Design in Design Science Research Projects: The Cases of Affective Technology and Healthcare Technology

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Abstract. Design Science Research (DSR) constitutes a major part of Information Systems research. Here, DSR projects exhibit ethical challenges. Especially for novel and complex technologies, for which the potential outcomes cannot be assessed entirely, it is necessary to face these challenges systematically. Value Sensitive Design (VSD) is a systematic approach to face ethical challenges in DSR projects. However, it needs to be further deployed in practice to gain insights into its suitability and appropriate application in different settings. We have therefore applied VSD in two DSR projects and present the most significant findings from our research, the experiences we made, and lessons learned. We learned that VSD should be treated as a source for creativity and guidance and not as a method to restrict the freedom of researchers. Yet, design decisions remain ambiguous.

Keywords: Value Sensitive Design, Design Science Research, Ethics, Affective Technology, Healthcare Technology

1 Introduction

Design Science Research (DSR) constitutes a major part of Information Systems (IS) research [1]. DSR projects are commonly funded by a public or private third party and aim at developing a novel technology over a certain period of time. The overall goal of DSR is the development of IT artifacts and the creation of design knowledge [2]. Theoretical knowledge created in DSR can be divided into design practice theories, which describe how an artifact should be constructed, and explanatory design theories, which explain why an artifact should be constructed with a specific design [3]. The development of both types of design theories within research projects has in common that the design of an IT artifact is necessary and follows a process including theoretical work and practical implementation, mostly in collaboration with project partners from research and practice.

DSR projects exhibit ethical challenges. These challenges can be specific regarding the technology, the application domain, or the project itself. For instance, design science researchers have to decide for which purposes they design an artifact, for which target groups they design, or theoretical and practical contributions they plan to make.

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From these challenges the ethical responsibility of the researcher arises, since these decisions have a normative character. This is reflected by the fact that explanatory design theories are normative theories, which means that at least one dependent variable is regarded as desirable or undesirable [2]. It means that every design science researcher decides on what is desirable or undesirable for specific groups and with which technological design desirable outcomes should be achieved.

Especially for novel and complex technologies, for which the potential outcomes cannot be assessed entirely, the researcher's responsibility makes it necessary to face these challenges systematically. As the concept of Responsible Innovation [4] calls for, researchers should aim at developing outcomes which are good for society. For this, Responsible Innovation provides a framework with four demands: anticipate, reflect, engage, and act [4].

Value Sensitive Design (VSD) is a systematic approach to face ethical challenges in DSR projects [5]. It is an approach to the design of technology that accounts for human values throughout the design process [5]. It demands using different methods and tools to ensure that technology designs are "good" and have a positive impact on society. The conceptual, empirical, and technological investigations within the VSD framework foster continuous anticipation, reflection, engagement, and action by the design science researcher.

Since VSD provides a promising framework to deal with ethical challenges within DSR projects, it needs to be further deployed in practice to gain insights into its suitability and appropriate application in different settings. Although the number of VSD cases published in IS literature is increasing [e.g. 6, 7], it still needs further exploration for how to effectively and beneficially apply it in DSR settings. The reasons for this are that, first, VSD leaves much room for its concrete implementation and, second, DSR projects constitute complex and diverse research settings from both a theoretical and practical perspective. Our research question therefore is: "How can DSR projects benefit from VSD?"

We have therefore applied VSD in two DSR projects and, in the following, present the most significant findings from our research, the experiences we made, and lessons learned. We especially learned that VSD should be treated as a source for creativity and guidance and not as a method to restrict the freedom of researchers. Yet, design decisions remain ambiguous.

2 Ethics in DSR

2.1 Ethical Challenges for the Design of Information Systems

The widespread use of IS has raised ethical issues and debates, for instance regarding privacy or intellectual property [8]. DSR relates to ethical issues in two ways. First, through the IT artifact itself: It is supposed to meet certain goals (e.g. process efficiency) and to have specific characteristics (e.g. usability). This makes it necessary for design science researchers to determine the goals and characteristics an artifact should be aligned with. Second, through the implementation process: The development and implementation of IS in the multitude of real life organizational issues, work processes and other systems that the new IS must operate with can have a major positive or negative impact on its users.

However, the ethical dimension is rarely explicitly addressed in DSR papers and the lack of this dimension can lead to ethical violations caused by IS. The reason for this is that DSR projects are inevitably based on an "invisible" ethical foundation [9]. It may be assumed, therefore, that IS design science, whether it explicitly addresses ethical issues or not, is built upon various ethical standpoints. To counter this, Johannesson & Perjons provided a list of ethical principles for DSR [10]. Myers & Venable call for an agreement on a set of ethical guidelines among design science researchers [11].

Specific ethical challenges can be illustrated with the example of specific technologies or application domains. So-called affective technology, for instance, is technology which can sense or express human emotions [12]. It therefore puts its user into a high risk of providing personal data to others. From a devil's advocate perspective, the detection, recognition, or manipulation of emotions by a technology is the "ultimate breach of ethics and will never be accepted by users" [13] (p. 61). As a consequence, the acceptance of affective technology highly depends on trust as well as emotional and technical skills of the potential user [14]. However, design science researchers are very interested in developing affective technology, since it can be useful in many different application fields such as in education, security, healthcare, entertainment, or marketing [15].

As an example for ethical challenges within a domain, digitized healthcare comes with complex ethical concerns due to the different stakeholders involved (e.g. physicians, patients, and caregivers) and different or even contradictory opinions on the efficiency and effectiveness of treatments (cf. [16]). Therefore, novel healthcare technology needs ethical sensitivity for its users, their habits, needs, concerns, and attitudes [6]. To address this, Barry et al. demand ethical pluralism for the design of healthcare technology [17]. Chandra et al., for instance, explored needs, concerns, and different value sets from musculoskeletal disorder patients and suggest visualizations which are easy to understand to address the need for comprehension [18].

2.2 Methodological Approach: Value Sensitive Design

Value Sensitive Design is a methodological framework which demands conceptual, empirical, and technological investigations around human values [5]. Friedman et al. define a value as "*what a person or group of people consider important in life*" [5] (p. 2). In other words, human values represent the societally desirable and thereby provide direction for the design of technological solutions. Conceptual (theory work), empirical and technological considerations are already inherent in DSR. Thus, VSD can be an appropriate way for guiding DSR projects.

Literature from IS and related disciplines provides cases in which the principles of VSD have been deployed. Deng et al., for instance, identified relevant values which underlie the duality of empowerment and marginalization of crowd workers and derive practical implications for the design of crowd sourcing platforms [7]. Another VSD study focused on empirical investigations on the role of technology in the self-management of chronic diseases [6]. Based on their findings, the authors suggest that

DSR can develop design principles which "are more attentive to patients' needs and preferences" (p. 102), for example, by supporting the value of hope that can guide the design of system features. The implementation of VSD research projects can furthermore lead to methodological advancements within VSD. Yoo et al. and Friedman et al., for instance, have developed a new design method called the "Multi-Lifespan Information System Design" aiming at stimulating the participants' visions of future information systems in a project for transitional justice in Rwanda [19, 20].

However, VSD remains rather scarce in DSR publications. To fully grasp the potential of VSD for DSR, it needs to be applied in further DSR projects with different technological, domain-, and project-specific issues. Only by applying VSD in DSR projects we can comprehend how to make use of VSD and which contributions it can make in the IS discipline.

3 VSD in DSR Projects: Two Cases

DSR projects deal with the design, implementation, and evaluation of novel technologies following specific purposes and deployed in specific application domains. The project team usually consists of several researchers and/or practitioners. Design knowledge and innovative IT artifacts are the main deliverables of such projects. In the following, the characteristics and findings of two DSR cases, in which VSD has been applied, will be presented.

3.1 Affective Car Assistance System for Traffic Safety

Project. The first exemplary case deals with the design of an affective car assistance system. The application is based on affective technology. It makes use of a camera installed in the car, which captures the driver's face, to calculate the emotional state of the driver. If the affective system recognizes strong feelings of anger, happiness, or fear, it can, for instance, give situation-specific warnings. The goal of the DSR project is to increase traffic safety. The project team comprises researchers from psychology, pattern recognition, and technology design as well as practitioners from the car industry and market research. The project was presented in our published short paper, but with a different focus in the findings section [21].

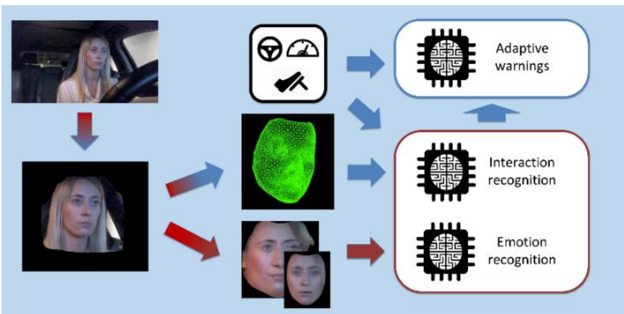

Figure 1. DSR project "Affective Car Assistance System"

VSD Process. To identify the relevant values, we chose a top-down approach: We first derived seven technology-based categories and, in a second step, identified 23 values based on an analysis of technology-related literature (Table 1). We then presented these values to our project partners within a project internal survey and, following this, a project-internal workshop. We further conducted qualitative interviews with potential users with focus on the values which we identified as being "critical". We defined critical values as values which offer potential for disagreement within the project team, for conflicts with other values, and for which the development of specific designs was a complex matter. In the course of the project, we regularly reflected on the values and the designs and discussed with our project members in how far we were able or not able to address the values in our project adequately.

Table 1. Categories and values in DSR project "Affective Car Assistance System"

Categories	*Values*
Primary purpose	Interactivity, traffic safety, driving comfort
User interface	Aesthetics, emotion neutrality, design-for-all, system transparency, system controllability
Data collection	Error prevention, driver focusing, anonymity
Data storage	Data economy, temporal storage, data transparency
Data access	Data security, transmission ban, privacy,
Data analysis	Risk prevention, reliability, robustness
Intervention	Stimulus poverty, user autonomy, customizability

Findings. In particular, three values emerged as being highly critical. These values shifted to the center of interest within the ethical reflection of the project.

1) *Design-for-all* requires the affective system to be inclusive and usable for everyone from all demographic groups (independent from age and gender). However, due to the camera technology in use, the accuracy of the identification of the driver's emotional state differs depending on ethnic or cultural origin. Skin colour, form of the norm-based face, facial paralysis, or cultural-based expressions of emotions can only hardly be unified in one model. It was not possible to create such a high diversity within the input data with which the pattern recognition algorithm "learned" how to recognize emotions. Although some of the developers had known this problem for some time, it had not been made transparent due to reasons of implementation effort and scientific irrelevance.

2) *Anonymity* requires the affective system to capture data in a way that they cannot be associated with a specific person. Yet, an affective technology is categorically based on learning algorithms. In order for the algorithms to work, the system has to store personal data. Thus, anonymity cannot be guaranteed 100%. Nevertheless, the developers are required to protect anonymity by taking appropriate measures. This, for instance, includes the absence of cloud-based solutions and of such personal data which are not really necessary for the functioning of the system. Furthermore, the solution masks out all information which are not related to the driver to protect the anonymity of other passengers.

3) *System transparency* requires the functioning of the system and the data it stores to be comprehensible and accessible to its user. This is not only important to increase trust into the technology, which in turn is an essential driver for its acceptance, but also because of the user's interest to be informed about what kind of technology they actually use. However, there are at least two reasons to challenge the value of system transparency: First, project-internal results show that the knowledge and awareness about the camera-based recording leads to significant changes in driving behaviour. Hence, system transparency can possibly lead to unwanted behaviour. Second, it is unclear which information a user should get, since too complex information would overwhelm the user and miss its purpose. To answer this question, further research would be necessary.

3.2 Sensor-based Physiotherapeutic Assistance System for Home Therapy

Project. The second exemplary case deals with the design of a sensor-based assistance system to support physiotherapeutic activities at home. It supports the so-called Vojta therapy, which was developed for children with a malfunctioning central nervous system. In most cases, the parents of those children have to execute complex exercises at home on a daily basis. The project members from research (technology design, pattern recognition, micro systems) and practice (physicians, therapists, technology developer) have identified three major support potentials: 1) provision of contextual feedback and information regarding the treatment execution, 2) measurement of quality and quantity of treatment sessions, 3) support of training for apprentices. The findings presented here will in part and in more detail be published in a conference paper [22].

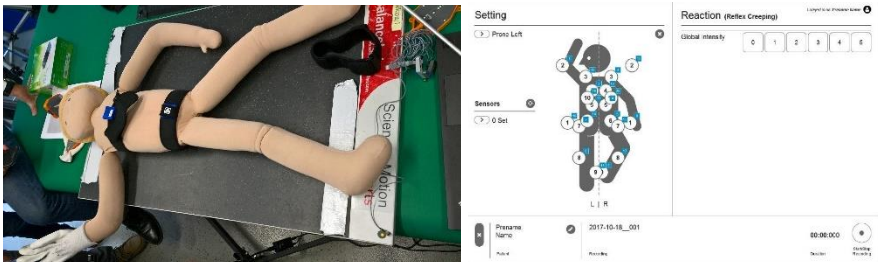

Figure 2. DSR project "Sensor-based Physiotherapeutic Assistance System"

VSD Process. Within an initial exploration phase, we conducted four focus groups engaging stakeholders from domains which are involved in the project (i.e. technical development and IT consulting, healthcare and physiotherapy as well as social and computer sciences). We elaborated an initial set of four ethical issues (autonomy, competence, privacy, diversity) regarding the technology, domain and project. In the second phase, we conducted interviews engaging parents who treat their children at home. In total, we identified eleven values (well-being, trust, privacy, certainty, assurance, competence, autonomy, continuity, humanness, accuracy, usability). In the last step, we identified value conflicts and discussed initial design approaches to solve these conflicts by specific technology designs.

Findings. In particular, our focus within this project lied in the identification of value conflicts, since these conflicts make the design of an IT artifact especially challenging and represent the ethical discussions within the project. When it comes to design, a conflict occurs if “one value will point in the direction of one particular design and another value in the direction of another” [23] (p. 90). In the following, the conflicts are presented and potential design solutions are discussed:

1) *Well-Being vs. Autonomy*: The main purpose of using technology in therapy is to support well-being. As soon as the use of technology is effective in doing so, technology-restricting solutions might be in conflict with well-being. The value of autonomy requires the technology to deal with deviations from the ideal way of executing the treatment. Although a certain degree of autonomy is needed for the well-being of child and parents, too much autonomy might endanger the effectiveness of the therapy. Since the well-being of patients and caregivers should always be prioritized, designers can opt to create some form of awareness regarding the benefits the system provides. This can be complemented by empowering the user to freely choose and adjust the degree to which the system preserves privacy and autonomy during treatments.

2) *Humanness vs. Accuracy*: Parents desire frequent face-to-face contact with the therapist. Yet, as soon as technology is capable of replacing a human because it provides a more accurate assessment of the therapy, the question arises whether the frequency of face-to-face sessions has to be maintained. As a design solution, the system might incorporate ‘human-like’ features while still providing highly accurate measurement and feedback. One way to render technologies more human is to increase their social presence, which describes the degree to which another person and mutual interactions within a mediated communication is perceived [24].

3) *Competence vs. Certainty*: Parents need a sufficient degree of competence to effectively carry out the treatment at home. As a consequence of technology use, parents might (over)rely on the technology and lose their competence in executing the tasks in the long-term, which have been taken over by the technology. To antagonize this, the instructional strategy of ‘adaptive guidance’ can be implemented within the system. The strategy suggests to provide users with descriptive feedback on past performances and complements it with future-oriented information on what they should focus on in order to achieve ‘mastery’ in what they are doing and learning [25].

4 Theoretical and Practical Implications

We applied VSD in two DSR projects to gain theoretical and practical insights into how DSR can benefit from the VSD framework. Based on our findings and experiences we made, we derive several theoretical and practical implications.

First, DSR requires normative decisions by researchers. These decisions regard, for instance, the questions which user group they want to support, how this group is adequately supported, which other groups might be affected, or which designs are appropriate. VSD delivers tools to justify normative decisions by design science researchers in every phase of the DSR lifecycle. Conceptual, empirical, and technological investigations around human values complement theory and empirical work in DSR. For instance, the value of system transparency opens up the room for DSR to investigate how to adequately implement system transparency into a complex system and, at the same time, offers ethical guidance. At the same time, VSD makes normative decisions more transparent and comprehensible.

Second, VSD supports DSR in doing research "for the good", as the concept of Responsible Innovation calls for. It does not do that by instructing the researcher with do's and don'ts, "good" or "bad" design alternatives remain ambiguous. It rather "forces" the design science researcher to deal with ethical concerns within their project. The systematic identification of value conflicts, for instance, leads to creative and "better" design solutions than otherwise. Without the conflict of well-being vs. autonomy, for instance, the designers would probably not have come up with a feature to adjust the degree of autonomy. At the same time, VSD does not prevent design science researchers from conducting "traditional" DSR.

Third, VSD has to be applied in a pragmatic way. The huge number of values and potential value conflicts might overwhelm the researcher, who certainly cannot solve every issue within a DSR project. It is therefore advisable to focus on specific issues. Moreover, the conceptual, empirical, and technological investigations in VSD can be conducted in a way that they are publishable in DSR journals and conferences. Conceptual investigations around system transparency, for instance, can support theory work around the design of an information system. The evaluation of an IT artifact, in turn, can inform technological investigations within VSD.

Fourth, the focus on human values can support the long-term creation of design knowledge and theory. Based on a value or a value conflict, design knowledge can emerge in form of design practice theories or explanatory design theories. Based on the value conflict of competence vs. certainty, for instance, design theories from different technological foundations or domains can deal with the question how to resolve this conflict within their specific setting and, at the same time, contribute to overall design knowledge. Values and value conflicts help to connect design theories and promote new design knowledge.

5 Limitations and Future Research

The paper at hand has several limitations, motivating further research. First, VSD has been applied in two specific project settings. Technology-, domain-, and project-specific ethical issues can widely vary in their emergence and solutions. We therefore encourage the application and evaluation of VSD in further DSR projects. Second, the effectiveness of VSD in DSR has not been scientifically measured. It can be assumed but not objectively said that the application of VSD has improved the designs of the IT artifacts. Here, an objective measurement of and stronger evidence for the benefits of VSD for DSR would be desirable. Third, we did not systematically obtain feedback from our project partners. It would be helpful to know whether and why project team members perceive VSD as valuable.

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