Value-Sensitive Design of Unmanned Aerial Systems:

Using Action Research to Bridge the Theory-Practice Gap

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ABSTRACT

What happens when an engineer attempts to address the value-neutral paradigm and the holistic deficits in engineering science? This paper sets out to account for the interplay between an unmanned aerial system engineer acting as a "champion" of value sensitive design (VSD) and their more objectivist research organization. Action research methods are used by the authors in an attempt to implement VSD in a real-world research organization and thereby bridge the theory-practice gap. Primary empirical data are collected which indicate the engineer has internalized and often utilizes a VSD approach. Both barriers and catalysts to wider adoption of VSD within the organization are experienced, and recommendations for overcoming paradigmatic, strategic, structural, and cultural barriers are addressed. This work demonstrates how action research can be used to shift engineering away from a value-neutral paradigm towards the value-sensitive approach advocated by the authors.

KEYWORDS

Action Research, Bottom-Up Organizational Change, Organizational Learning, Positivism, Unmanned Aerial Systems (UAS), Value Sensitive Design (VSD), Values in Engineering Design

INTRODUCTION

In this work, we use action research - conducted at the Unmanned Aerial Systems Center at the University of Southern Denmark - to bridge the theory-practice gap by implementing value sensitive design in a real-world engineering context.

Action Research

"Action research is an orientation to knowledge creation that arises in a context of practice and requires researchers to work with practitioners" (Bradbury-Huang, 2010). Unlike conventional social science, action research's purpose is not primarily or solely to understand social arrangements, but to effect desired change as a path to generating knowledge and empower stakeholders. We may therefore say that action research represents a transformative orientation to knowledge creation in that it seeks "to take knowledge production beyond the gate-keeping of professional knowledge makers" (Bradbury-Huang, 2010). The action research approach is chosen for the study to promote the use of value sensitive design in a transparent, accountable, and contextually-aware way.

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Value Sensitive Design and the Theory-Practice Gap

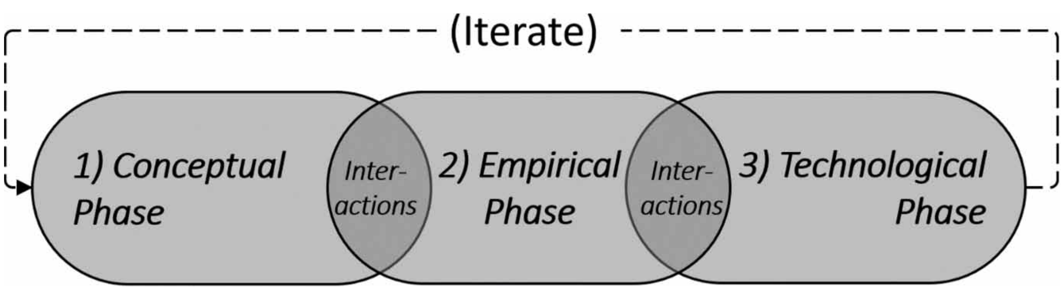
Value sensitive design (VSD) is a theoretically grounded, interdisciplinary approach to technological development which actively considers ethics, human values, and the social impacts of the technology during the design process (B. Friedman & Hendry, 2019; B. Friedman, Kahn, Borning, & Huldtgren, 2013). VSD's theoretical construct includes three main phases: 1. conceptual, 2. empirical, and 3. technological as shown in Figure 1. The conceptual phase focuses on human values, stakeholder engagement - of both directly and indirectly impacted stakeholders – and ethical considerations. Philosophers of technology, social scientists, applied ethicists, and technology ethicists are particularly well-suited to the work in the conceptual phase. The empirical phase is used to explore and understand the interactions of the technology with individual people and society more broadly; this phase may be conducted by social scientists. The technological phase is where the inputs from the conceptual and empirical phases are embodied within the technology - a process sometimes referred to as the translation of human values to design requirements (van de Poel, 2013). The VSD process is iterative and interactional, with each input or design change in one phase impacting the others. VSD utilizes a holistic worldview where the inputs of multiple stakeholders – even critics - are included in the design process (Cuppen, Pesch, Remmerswaal, & Taanman, 2016).

Despite being developed over 20 years ago and being the subject of hundreds of academic research articles, VSD's application within real engineering projects has been limited. In one study, 219 publications about VSD were identified, but only 17 of these utilized the approach to actually build technology (Winkler & Spiekermann, 2018). The application of VSD within the public sector is more opaque than within academia, and companies claiming to utilize a VSD approach is also limited.

In this paper we employ action research to uncover and point to theoretically and empirically founded paradigmatic, strategic, structural, and cultural reasons why uptake of VSD may be limited, as well as providing solutions to overcoming some of these barriers in an attempt to bridge this theory-practice gap.

THEORETICAL GROUNDING

Figure 1. The value sensitive design approach consists of three inter-related phases: 1. conceptual, 2. empirical, and 3. technological. Graphic by the authors, based on (B. Friedman et al., 2013).



We will begin by explicating relevant theoretical groundings to better contextualize the empirical work, which follows in the Methods section.

A dominant narrative in the technical sciences - and a barrier to implementing value-driven design approaches - is that engineers do not have to, or cannot, take responsibility for their creations since technology is value-neutral. This is referred to as the neutrality thesis in the philosophy of technology literature (Spahn, 2015; Vermaas, Kroes, Light, & Moore, 2007). Arguably, organizational, institutional, and societal sub-optimization is prevalent, and indeed notions such as bounded rationality and the ensuing impossibility of controlling the usage situations of technologies point towards the absolution of responsibility of engineers. However, the emergence of a multitude of "wicked problems" in market-driven economies connected to ecological, social, and technological sustainability make new demands of engineering. Engineers may be eager to contribute to solutions, but are also embedded into professional and organizational cultures and contexts that can constrain individual agency and carry with them strategies, values, and interactional complexity. This could be traced back to a lack of emphasis on the contextual aspects of technology which is evident in accounts of engineering educational and organizational cultures (Schein, 1996). Empirical evidence from the United States shows that engineering students' level of engagement with public welfare *decreases* during their studies, suggesting a "culture of disengagement" with holism and contextual aspects in the engineering sciences (Cech, 2014). Paradigmatic foundations and traditions in the practices of engineering science play an important role in perpetuating these patterns. Shifting from a positivist, value-neutral to a holistic, value-sensitive perspective involves change on an organizational, educational, and personal level: a commitment to true reflexivity to achieve double-loop learning (i.e. learning that asks not just what it takes to uphold the system, but also if the system itself should be changed) (Solitander, Fougère, Sobczak, & Herlin, 2012) and where reflection leads to development and action. In the following, we will elaborate on how this can be attained, what roadblocks one might encounter underway, and how they may be overcome.

Three main categories of barriers to adoption have been identified to have bearing on incorporating responsible, reflexive, or ethically informed practices and teachings in educational institutions: strategic, structural, and cultural barriers (Solitander et al., 2012). We adapt this framework to also include paradigmatic barriers, in order to approach the issue from a foundational level and to show how to utilize philosophy as a practical tool for overcoming the very barrier it creates. Potential methods to overcome the barriers are developed and summarized later in Figure 4. A key aspect of the approach is that of "champions", "sponsors" of a new way of doing things who "dare to enact their own criticality" (Solitander et al., 2012). In an engineering context, this can be considered a form of "activist engineering": "someone who not only can provide specific engineered solutions, but who also steps back from their work and tackles the question "what is the real problem and does this problem 'require' an engineering intervention?" (D. Karwat, 2020; D. M. Karwat, Eagle, Wooldridge, & Princen, 2015).

Paradigmatic Barriers

The value-laden worldview is in stark contrast with positivism, a still dominant paradigm in the technical sciences, although considered outmoded by most scholars in philosophy of science. "Worldviews, also referred to as paradigms, are basic sets of beliefs that guide action, a 'general philosophical orientation about the world and the nature of research' that the researcher brings to the study" (Guba, 1990) as cited in (Cawthorne, 2020). "In engineering, a dominant worldview is positivism (Sismondo, 2009; Vermaas et al., 2007); positivism is grounded in the idea that there is one, objective reality (Gamborg, 2018). Research should be value-free, and the researcher must be independent and objective. Experimental methods are utilized, data are often quantitative, and the research design is fixed (Gamborg, 2018). Positivists see the researcher as being separate from the world they study" (Guba, 1990) as cited in (Cawthorne, 2020).

Under a non-positivist worldview, "research cannot – and should not - be value-free, and the researcher must accept that they are not fully independent or objective. Non-experimental methods are utilized, data are often qualitative, and the research design is flexible. Non-positivists see the researcher as being part of the world they study (Guba, 1990)" as cited in (Cawthorne, 2020).

The researcher's world view has important implications to responsibility; if technology is value-neutral then the engineer cannot be responsible for any "built-in" values, and responsibility is therefore assigned to the user. If, however, technology embodies values, then the engineer shares some responsibility, along with the user. A technological mediation stance views this as the interplay between the technology, the designer, and the user, all situated in a context of use (Verbeek, 2008). Responsibility is often associated with holding one accountable for wrongdoing, but here it encompasses both blameworthiness for having done something bad, but also praiseworthiness for having done something good. It should be noted that there is also an important distinction between being *held* accountable by external parties, and *accepting* responsibility for one's own actions.

In VSD, engineers may be considered "strong" and to have a responsibility to consider human values during the design process. "Strong designers are powerful, and there is a strong causal connection between the intended uses of the product and the actual uses (Vermaas et al., 2007). By contrast, weak designers are constrained, for example, by economic, political, institutional, social, and cultural norms, and the causal connection between intended uses of the product and actual uses are weak (Vermaas et al., 2007)" as cited in (Cawthorne, 2020). VSD-methods could lead to a "shift in responsibility from users to engineers, and hence to a stronger designer/engineer" (Cawthorne, 2020).

Incommensurability of Paradigms

Value Sensitive design is highly interdisciplinary in nature. It seeks to combine the insights from such markedly different fields as engineering, philosophy and sociology. While this is not an impossible endeavor, it does present several fundamental challenges, in terms of defining goals and agreeing on means to achieve those goals - or even establishing when a goal can be said to have been achieved. Thomas Kuhn describes in his seminal work (Kuhn, 1962) how different fields and schools in academia have their own internal logics, that rely on social, historical, ideological, and methodological factors. In different fields logics emerge and are reinforced over time as the field is legitimized and institutionalized. This tends to entail specialization in terms of not only theory but also which methods are applied, what constitutes good data, ontological and epistemological questions about the nature of reality and what access we have to it. It also comes across in how results are communicated, via which journals, and using what types of visual aids or metrics. It is very much a language or code in which one attains fluency – or not. Failing to master the codes of a field will formally disqualify any work, or simply render it peripheral, effectively ridding it of impact. This leads to several problems to be dealt with, that holds relevance to the dissemination of VSD as well as any other interdisciplinary effort. According to Kuhn, paradigms are incommensurable in as much as an argument that is considered valid in one field may well be considered invalid in another. It is in the very nature of science, i.e. specialization into a narrowly scoped field, that much is excluded, complexity is reduced, and only features that speak to a specific specialization will be addressed. Referred to by Kuhn as "the essential tension" (Kuhn, 1977), this is the strength of science and also perhaps its biggest weakness, since specialization can have us overlook important elements, due to the fact they are not addressed by our paradigms.

Similarly, the ontological foundations of fields differ. Qualitative methods tend to be applied in interpretivist ontologies, where there is less focus on what is objectively in the world and more focus on subjective interpretations of the world. Since qualitative research concerns itself with a deep and thorough understanding of and accounting for the meaning and sensemaking of the life worlds of respondents, it tends to rely on thick, detailed descriptions, that leads to theorization - less broad generalizations, and more deep idiographic understanding. The researcher is a very active and important part of the research process and is sometimes likened to a tool that co-produces the results, and therefore needs to account for their position and biases. Conversely, quantitative methods seek to generalize, and tend to take as point of departure a more objectivist ontology, which allows for much broader generalizations and quantification of results. The researcher is considered an outside observer of the phenomena that is being studied and any influence on the results from the researcher is considered a source of errors. In positivism, the phenomenon that is being studied is isolated from its context, in order to prevent environmental effects from polluting the data, leading to a favoring of laboratory experiments. In interpretivism the object of study is viewed as being in an interdependent relationship with its context, and removing the object from its context will render results incomplete at best and misleading at worst.

Holism, perhaps positivism's farthest removed counterpart, is the approach that is attempted/applied in VSD. The object of study is viewed as being in an interdependent relationship with its context. Engineering science and engineers hold immense power over not only our present but also future social reality, a reality that the paradigm is ill-equipped to deal with, since it cannot within the paradigmatic limitations understand nor account for how humans interact with technology.

The task of considering the contextual implications when the ontology and features of the object of study themselves are variables that are up for negotiation is immense and sometimes referred to as "moral overload". This appears when "an agent is confronted with a choice situation in which different obligations apply but in which it is not possible to fulfil all these obligations simultaneously" (van den Hoven, Lokhorst, & van de Poel, 2012). Moral overload is acute in value-based engineering because now the engineer must take into account not only technical but also social and ethical considerations. This significantly increases the complexity of already complicated technologies such as drones. Whereas a humanist might analyze the phenomenon of drone technology from a philosophical perspective, or a social scientist might investigate the human impact of a new technology (an "actor's value" approach), VSD requires study of both the human impact as well as the technology itself (Spiekermann, 2015).

Strategic Barriers

Organizational strategy is traditionally defined by Mintzberg as "how organizations make and interrelate their significant ... decisions" (Mintzberg, 1978). Implementing VSD practices in any organization has serious implications for that organization's strategy and may prove to have strategic barriers. At a university, an organization that holds many highly specialized departments and groups, each with their own separate strategies, in addition to the overall organizational strategy of the university, setting one that aligns all around can be complex. In addition to departmental and organizational strategies, the severe financial dependency on external funding comes to introduce a third strategy in organizational activities, namely that of the funding agencies that the organization vies for support from. Since securing external funding is so crucial in academia today, both for individual researcher's career paths, as well as for research organizations, the funding agencies come to act similarly to a board of directors external to the organization - or what traditional management literature refers to as shadow leadership, i.e. leadership with great impact, but without formal power, authority or accountability/responsibility. As such, the incorporation of several unaligned strategies can lead to a complexity-overload for organizational members and leaders alike. With a surplus of change and adaptation happening, including further perspectives and engaging in double-loop learning (Solitander et al., 2012) may seem especially cumbersome for organizational members. Yet in real academic research projects this is the setting in which VSD will be introduced.

Structural Barriers

An organizational structure defines how tasks are allocated, how the organization is coordinated, and how it is supervised (Pugh, 2007). When we bridge theory into practice, the incommensurability of paradigms often manifests in conflicts in interdisciplinary efforts. What is considered a legitimate argument in one field is wholeheartedly rejected by another. This takes place on an individual level, but the differences are institutionalized as well. Academia incentivizes prolific production of publications in highly specialized journals, that adhere to field-specific logics and codes. Failure to master the codes or adhering to the logics is punished by simply not being published, i.e. removing the voice and reducing the impact of interdisciplinary research. In a Foucauldian sense, academics/researchers come to self-discipline by becoming increasingly more specialized and adhering to field-specific logics in order to remain employed. Publish or perish is currently the credo of many academic institutions, and since academia is a highly globalized industry, what is a benchmarking point in one part of the world quickly becomes standard practices globally. Fierce competition leads to sub-optimization, not only on department level, but also between individual researchers. The incentives to take on interdisciplinary research are few, and addressing the wicked problems of late capitalism - which are by nature interdisciplinary – may become an undesirable choice for which one is likely to be (with more or less intentionality) punished by the structural and strategic powers that be.

The funding landscape also has great impact on which research projects and agendas are taken on. Utilitarian and market-logic abiding roles for universities and academia are increasingly and uncritically portrayed by politicians, opinion leaders, funding organizations, etc. and these discourses are inevitably making their way to research institutions, formally and informally.

Cultural Barriers

Edgar Schein defines organizational culture as "the basic tacit assumptions about how the world is and ought to be that a group of people share and that determines their perceptions, thoughts, feelings and overt behavior" (Schein, 1996). While there is overlap between paradigmatic and cultural barriers, the paradigmatic approach allows us to utilize philosophy as an educational tool, while the cultural approach allows us to point to how paradigmatically based assumptions play out in everyday behavior and practices. A full description of the organizational culture at the drone center is outside the scope of this paper and will be addressed in future work. Here we include only elements that pertain to the already outlined structural and strategic barriers, to illustrate how these issues become part of the organizational culture, and how, along with the paradigmatic foundations, cultural conceptions guide actions at a largely tacit and unconscious level since we are largely unaware of the basis of our cultural assumptions and we rarely make them explicit (Schein, 1996). They therefore need to be acknowledged, identified, and addressed, to challenge/critique/alter malapropos practices and conceptualizations.

In summary, the Theory section has outlined the grounding for the barriers encountered empirically which are introduced in the next section.

METHOD

The empirical part of this work utilized the action research approach (Bradbury-Huang, 2010) described earlier, where a transformative world view is used in a participatory effort to reform a practice. Here, the aim is to reform the practice of drone development to utilize a value sensitive design approach. In this study, the action researcher is the first author (Andersen), and the practitioner is the second author (Cawthorne).

The study took place at the University of Southern Denmark's drone engineering research activities. The University of Southern Denmark's Unmanned Aerial Systems Center, or Drone Center, was established in 2015 (SDU, 2020). The Danish state saw the potential for "high tech" job creation and economic benefits, and invested heavily in *drones* - flying robots with some level of autonomy (Villasenor, 2012) - in a bid to be a "first mover" within Europe (Research, 2015). The Danish state had a National Drone Strategy in 2016 (Science, 2016), and the Drone Center was one of the results of these initiatives. Today, the Center consists of 26 employees, most of whom are teachers and researchers, all working within drone-relevant fields. The mission statement of the Center reads:

We focus on research, education, innovation, and collaboration in the UAS domain for the benefit of society. (SDU, 2020)

The Center's main research directions include developing autonomous drones that can fly long-range beyond the view of the operator, large-scale perception including drone-mounted camera systems, system modeling, and energy efficient algorithms and components (SDU, 2020).

The empirical research was conducted between February and November 2020. The process can be divided into three iterative data collection and analysis stages:

Stage 1: The first stage consisted of two rounds of data collection, focused on the practitioner: first, an in-depth, qualitative interview (Kvale & Brinkmann, 2009) with the practitioner on his practices and personal values in engineering, in order to 1: be able to account for these and 2: be able to compare and contrast the practitioner's practices and values, with the practices and values of the organization that the practitioner belongs to. The interview was semi-structured and highly exploratory to allow for an inductive approach where the practitioner's own conceptualizations come forth, rather than being superimposed by either the researcher/interviewer or the theoretical framework. The interview was audio recorded and lasted two hours.

The second method in the first stage was participant observation of the practitioner in the laboratory. The practitioner was video and audio recorded while working on a prototype value sensitive designed drone. This part was carried out to observe and enquire about how, and indeed if, the aforementioned values manifest in the building of a VSD based drone, and to cast light on catalysts and barriers to adoption of VSD. This first stage was concluded with a data session with the practitioner and researcher analyzing the data, to arrive at a strategy to advance the application of value sensitive design in the organization.

Stage 2: The second stage consisted of participant observation in the laboratory and during flight tests of the drone while finalizing the prototype. The participant, as well as colleagues, students and external users of the labs, were observed over a period of two months, intermittently audio and video recorded, rendering ca. 15 hours of audio/video recordings, such as that shown in Figure 2. The second stage included observation of colleagues, students, and collaborators interacting with the practitioner to cast light on organizational culture and interactions, paradigmatically based underlying assumptions, and strategic and structural barriers as perceived by the practitioner and other organizational members. It was concluded with a data session between the practitioner and the researcher to further the strategy to advance the application of value sensitive design in the organization.

Stage 3: The third and final stage entailed a data session to attain an overview of the insights uncovered in the previous stages and further focus the future effort on advancing the VSD approach. The data session was video and audio recorded, and lasted three hours. The practitioner's values, virtues, and organizational actions were inductively analyzed and then deductively mapped onto existing VSD and organizational theory.

Intermittent with the above-mentioned major data collection events, were also ongoing discussions and analyses recorded through documents, emails, text messages, field, and audio notes. The entire data set was reviewed after stage 3 and relevant data was selected for further analysis.

RESULTS

The action research approach and the three data collection and analysis steps introduced in the Methods section produced the following results, which have been categorized following the theoretical grounding outlined in the Theory section. This section includes both results and analysis concurrently, following the action research approach in which these two processes are performed together.

Figure 2. The practitioner readies the prototype drone for its first text flight test while two colleagues and a student look on. Observations took place over a period of two months and were intermittently audio and video recorded (Image by the authors).

Paradigmatic

Paradigmatic barriers to implementation of VSD in the drone center were encountered and documented throughout the data. In the following we account for these barriers and propose solutions.

Problem: Metrics. One field/paradigm does not accept another field's metrics, which makes interdisciplinarity difficult. Values, as found in VSD, are cumbersomely quantified - although plenty of other social or societal contextual elements will hold the same inherent lack of unquantifiability (see Theoretical Grounding Paradigmatic Barriers). This also poses problems in terms of publishing, which is discussed in the Strategic Barriers section. "How can we measure it?" "Where are the numbers, how can we quantify?" "If there are no numbers, it's not research!" "That's not science!" "This is a technology project." (in response to asking for an ethical perspective, i.e. ethics is outside the realm or paradigm of technological research and is thus rendered outside the scope of projects - an illegitimate point of view/concern.)

Solution 1: Educate engineering students that positivism is a paradigm, not "the truth", i.e. there is more than one paradigm, so paradigms need to be understood, selected and argued for, not taken for granted. We suggest introducing philosophy of science into the foundational education of engineers by applying Karl Maton's Legitimation Code Theory (Maton, 2014). As engineering students are traditionally not very engaged by the tacit and abstract nature of philosophy of science, we suggest this framework, as it allows the educator to take as point of departure the life world of students as well as the tacit communicative and contextual academic traditions of their main field by applying codes or language that is considered legitimate to the students. This allows the educator to legitimize interdisciplinary knowledge thus ensuring relevance and impact of interdisciplinary teachings to monodisciplinary students. In order to succeed in interdisciplinary efforts - in education and elsewhere - it is paramount that the codes and contextualization of knowledge or theoretical insights are adapted to attain legitimacy with the receiver in question (Maton, 2014). In the case of adaptation for engineering audiences, we suggest utilizing visualizations and examples that are familiar to engineers. Functional approaches with ontologies subscribing (or proximal) to realism from the social or humanistic sciences may resonate better with engineers than highly constructivist ones with radical ontological positions, and may therefore render better outcomes.

Solution 2: Seek out, write for, and legitimize new interdisciplinary journals. This also builds relevance and content for new journals that will carry such work in the future. Communicate the existence of these journals to colleagues to ensure that people know there is bibliometric credit to be achieved outside of traditional monodisciplinary journals.

Solution 3: Communicate the critique of the value-neutral fallacy inherent in positivism - the dominating paradigm in engineering. Challenge your fields underlying assumptions, using a dialogical, non-confrontational communication strategy. The value-neutral fallacy is easily refutable, but someone has to start the conversation. And understand that resolving the kind of ensuing cognitive dissonance that comes from challenging underlying assumptions can take time and effort – it is a marathon, not a sprint.

Problem: Conceptualizing of the engineers as "weak" or low on agency. "We cannot control the usage situation ; We are working with drones, not their potential societal contexts. ; We cannot control the design process fully, there are partners and management and suppliers and other stakeholders that steer the process. ; Engineers have very limited power. ; Engineers are tools. "

Solution: Engineers are constrained, but they are certainly not without agency. Sadly, this conceptualization of engineers as tools can become a self-fulfilling prophecy. Educate engineers to know this via educational reform, and teach them reliable scientific methods like VSD for holistic thinking so that those who are so inclined feel confident to enter into discussions based on scientific evidence.

Problem: Moral overload - the engineer is overwhelmed with the endless number of variables that arise when taking on a holistic approach. The practitioner experienced this many times, especially when first working with VSD: "The struggle of balancing all of these - often conflicting - ethical *and* technical requirements can be overwhelming. At one point I remember I felt paralyzed - even choosing the motor manufacturer seemed to have serious and dire consequences! What were the working conditions in the factory, what about resource depletion of rare earth metals, etc. etc.?"

Solution: VSD is the problem and solution simultaneously. When first applying the framework to the development of a technology, the number of variables are overwhelming. But over time, VSD comes to act as a guiding framework that helps alleviate this exact pressure and sort out priorities in a systematic manner. One mantra in the VSD literature is "progress, not perfection" (B. Friedman & Hendry, 2019).

Strategic

Strategic barriers to implementation of VSD in the drone center are encountered and documented throughout the data. In the following we will account for the encountered barriers and propose solutions.

Problem: As described in Theoretical Grounding of Strategic Barriers, organizational strategy based on bringing in external funding can effectively appropriate the strategies of external funding agencies' and insert them into the educational organization's strategy and modus operandi. Societal discussions about the utilitarian role of research as an agent for societal economic growth seeps into the organizational identity by way of both economic structures as well as political discourse (Richter & Hostettler, 2015).

The drone centers strategy reads as follows: "We conduct research in drone technologies and future drone applications within areas such as agriculture, inspection, energy, health and emergency management… We are an interdisciplinary team of researches with specializations within e.g. design and construction, robotics, computer vision, software and embedded systems. Together we create drone solutions to the benefit of society." ("About SDU UAS Center," 2020). Benevolence towards society is a frame that leaves plenty of room for interpretation and while admirable for its honorable intentions, it is also a mission statement that can accurately contain highly heterogenous projects, without formal conflict. This effectively means that the guiding effect of such a mission statement is minimal. Instead of formally qualifying or eliminating the uptake of a project, such a mission statement instead renders the individual project, and indeed, what the benefit of society even means, up for discussion. While this seems conveniently malleable when working with numerous different partners and collaborators – and it does hold the potential to invite critical discussion about each potential project – this lack of mission clarity effectively leaves a strategic gap which could be filled out by partners. This holds the potential to destabilize the strategy of the educational organization rendering them in many cases less consequential than the strategies of external partners. This in turn not only renders organizational survival contingent on external partners, it also adds to the internal organizational complexity for organizational members. This is reflected in the data through the frequent appearance of the argument against application of the VSD approach in the data, made by both colleagues and students, that it fails to align with market logics and it will ruin the business or market potential of any given technology. Business potential and market logics are not mentioned in the UAS center mission statement. It is nonetheless strongly present in discussions about the utility of VSD in the data, showing how market and business concerns play a strategic role, with little transparency as to when or why.

Solution: For this problem, VSD actually offers itself as a solution. A framework like VSD can be utilized as a tool for a systematic screening process for new projects. This would allow the organization to maintain the plasticity of its current mission statement to attract a broad array of potential partners, while internally managing the actual uptake of projects in a systemic and transparent manner. In a time where the role and purpose of research and science is negotiated heavily (Richter & Hostettler, 2015), internal and managerial clarity about purpose and boundaries of activities within research organizations is paramount.

Problem: Suboptimization and infrequent interaction and internal communication between highly specialized departments in this large educational organization leads to a lack of synergy - such as interdisciplinary, holistic projects - between fields and departments.

Solution: Be visible and communicate your work, in your own department but very importantly also outside your own department. Try to keep an open door policy. Many seeds were planted in the early days of the practitioner's work with VSD that took months or years to come to fruition. Maintaining a long-term time orientation and understanding that this sort of effort will mature slowly is key. Communicate when invited to, but simultaneously try to be proactive and seek out opportunities to communicate the agenda across the organization. While doing so allies emerged over time to the practitioner, both inside the organization (students, colleagues, support staff) and outside the organization. Former students became future collaborators more than once, so investing time in planting these seeds eventually paid off.

Problem: Metrics: One field does not accept another field's metrics. This poses strategic problems in terms of publishing, since publishing is part of any researchers output and legitimacy.

Solution: Actively seek out and target new journals as a strategic, concerted effort. This also builds relevance, legitimacy, and content for these new journals, which will hopefully publish such work in the future. Communicate the existence of these journals to colleagues. Again, there is bibliometric credit to be achieved outside of traditional monodisciplinary journals.

Structural

Structural barriers to implementation of VSD in the drone center were encountered and documented throughout the data. In the following we will account for the encountered barriers and propose solutions.

It is clear from the data that when positivism fails to legitimize value-free or non-holistic approaches, it is frequently replaced by arguments based on modernist conceptualizations of the sovereign reign of the free market. Adherence is found with organizational members to 1. the conceptualization of the governmental research organization as comparable to any other profit-generating organization, and 2. conceptualizations of the corporate responsibilities of profit-generating organizations similar to outmoded views like that of Milton Friedman, frequently paraphrased as "the business of business is business" (M. Friedman, 2007). This implies that social responsibility or sustainability *can* be a priority in business, but only if it is made explicitly so by management, i.e. there is no ethical imperative about social or environmental responsibility inherent in running a business. And on the face of it, it might seem like the logic of VSD has no place in a market logic. VSD practices do not align with market logics, at least not to the extent that the concept of "value" is conceived of as something more than economic value. But even abiding by current market logics and practices, responsible and sustainable business practices are becoming a standard practice in organizational branding as a path to organizational legitimacy. The tech industry is being held accountable for the social impact of their technologies to a much greater degree than when Milton wrote his then seminal work in the 70s; the conflicts and trial-like hearings that "the big 5" tech companies are being subjected to exemplify this, along with the explosion of the field of Corporate Social Responsibility (Rushe & Paul, 2020). The greater the success of the technology, the larger the impact, the greater the power, the greater the assignment of responsibility. Legislation is always trying to catch up with technological innovation and in this vacuum appears CSR as a field and discipline, potentially making out a playbook for striking that balance. Yet the lack of responsibility literature and practices in engineering science and education is striking. Responsible business practices, responsible communication practices, responsible medical practices, etc. have been standard disciplines in their fields for decades (Morsing & Schultz, 2006).

Problem: Suboptimization and lack of frequent interaction and internal communication between highly specialized departments in this large educational organization leads to a lack of synergy - such as interdisciplinary, holistic projects - between fields and departments. "I really enjoy SDU internal communication and news, I'm always surprised at how much different stuff is going on all over campuses and also finding people in other fields working on related areas to my own." This also relates very closely to paradigms. "I'll never forget the first time I went to the humanities to talk about drones. The atmosphere was overtly hostile towards them." What comes across as hostile to someone from an objectivist paradigm may simply be critical from an interpretivist. It will be hard to know the difference if one is not familiar with critical schools of thought prevalent in both the humanities and social sciences. These approaches are useful for investigating and critiquing power but may seem very foreign to engineers. Perhaps more importantly, the interdisciplinary contact - even for a few minutes - highlights the practitioner's own approach to drones or technology to himself: "over here (at the drone center), we love technology, we're excited about the potential…and we can't deal with what comes after its produced anyway. So we're much more excited about the designing and building part and it's not so much about what happens *after* we've developed the technology."

Solution 1: Set up interdisciplinary workshops for colleagues and students. Based on the workshops, seminars, and presentations carried out by the practitioner throughout their three year experience working with VSD, we cannot overstate how powerful the interdisciplinary experience is in terms of igniting this interest in people. If there is any potential with colleagues or students taking an interest in VSD, it will come out in an interdisciplinary workshop or other academic activity.

Solution 2: Be visible and make sure to communicate your work. Do so in your own department but very importantly also outside your own department. Try to keep an open-door policy. Much of the work with engaging colleagues and students started slowly, but seeds that were planted early on grew strong over time. Communicate when invited to, but try to also be proactive and activist, by seeking out opportunities to communicate the agenda across the organization. This will cause allies to emerge over time, both inside the organization – such as students, colleagues, and support staff - and outside, where former students can become future collaborators. As stated before, investing time in planting these seeds truly pays off over time.

Cultural

Cultural barriers to implementation of VSD in the drone center were encountered and documented throughout the data. In the following we account for the encountered barriers and propose solutions.

Problem: The cultural construct that has been referred to as "the problem of many hands" is an example of how paradigmatic foundations, strategy, and structure come together to form a cultural construct that guides behavior in engineering in general and the drone center specifically. "In addition to responsibility ascribed to a collective of people, responsibility can also be distributed over different people. When a large number of people are involved, it may be problematic to identify the person responsible for a negative outcome" (Meijers, 2009). Almost all modern technical design projects, including drones, involve more than one engineer and thus decision making power, responsibility, etc. are distributed over many people or groups. While there are real structural, strategic, and paradigmatic issues at stake that constrain the agency of engineers, the understanding that this is the case comes to act as a cultural construct which guides actions and over time ceases to be questioned. The risk involved with this cultural construct is that during the development and production of technologies *no one* take full responsibility for what is being created. The practitioner has encountered this throughout his applications of VSD. There seems to be no space carved out for considerations like these in engineering collaborations, and while the perspective may be allowed, the decision *not* to pursue a given technology is rarely taken. Relegating ethical considerations as "non-functional features", defining them by what they are not (functional) speaks volumes about how they are conceived - as being secondary by engineers and researchers alike.

Solution: The cultural construct surrounding the problem of many hands is something we hope to effect through the introduction of holistic paradigms and further empirical research into what sort of opportunity spaces occur for engineers. But as this problem is heavily tied into organizational and societal structures far beyond the reach of our influence, it is not one we have sufficient knowledge of at this point and will require future work to be able to confidently propose a valid solution for.

Problem: The neutral technology fallacy: Engineers traditionally approach technologies as neutral. In this specific case, the data shows consistent protests and initial lack of acknowledgement of ethics as an issue for engineering: "this is a technology project".

Solution: Introduce these discussions as well as paradigms or frameworks that address the issues in your own teaching to create educational and cultural legitimacy. For communication with colleagues, it is important to approach the issues through overtly dialogical communication and avoid lecturing monologues when at all possible. As ethics is normative in nature, avoiding taking on the role of "the ethics police". Approaching your role as "the helper", not "the hero" is paramount to acknowledge the personal agency and research domains of colleagues.

A summary of barriers, including specific challenges - in addition to potential champion actions and recommendations for long-term developments - are listed in Figure 3.

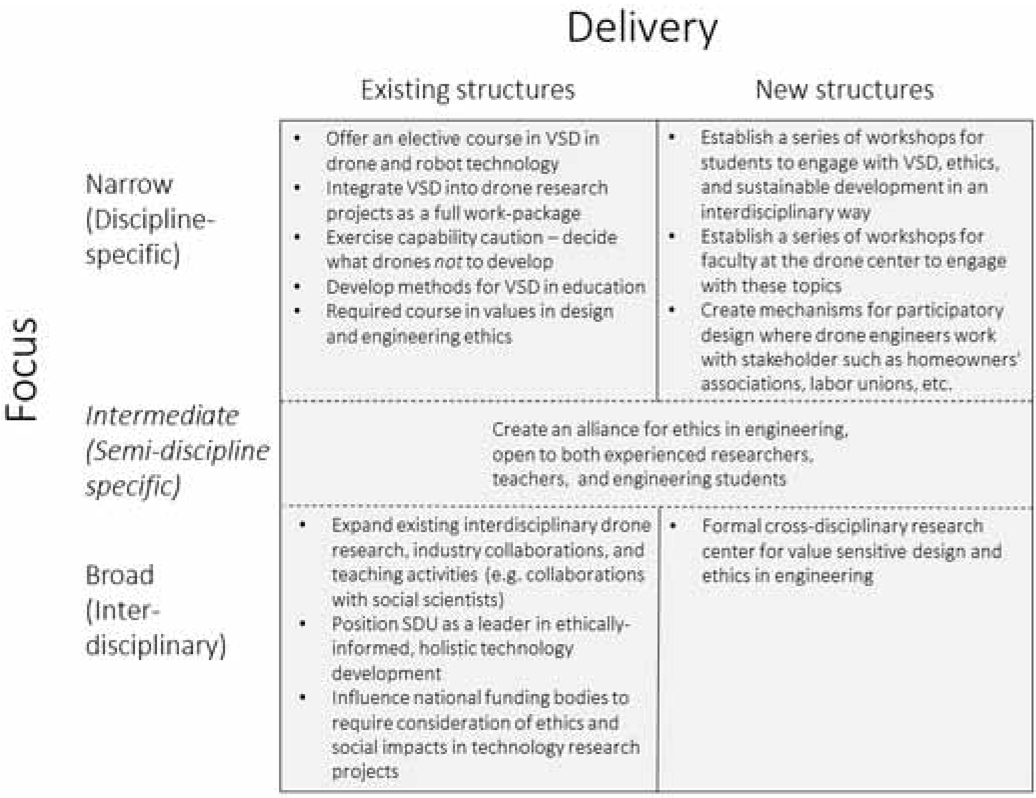
Figure 3. Main barriers, actions that can be taken by champions, and recommendations for changes to practice; based on (Solitander et al., 2012)

	Challenges	Champion actions	Recommendations
Paradig-matic barriers	• The value-neutral/value-free paradigm in engineering sciences • Issues of engineers' responsibility • Engineers as "weak", i.e. with limited causal connection between design and embodied values	• Explicate the paradigm • Accept more responsibility for one's own work; encourage others follow suit • Demonstrate how drones embody values (such as safety privacy)	• Select an appropriate paradigm for the research task • Lead by example • Approach drone design and engineering from a holistic, value-sensitive perspective
Strategic barriers	• VSD being overshadowed by similar efforts such as the United Nations Sustainable Development Goals (UN SDGs)	• Embrace similar efforts; use f.x. the UN SDGs to demonstrate the usefulness of VSD in addressing "wicked problems"	• Support initiatives that are similar to VSD, while asserting the unique features of each
Structural barriers	• Lack of funding and recognition for interdisciplinary collaboration • Market logic limiting the implementation of VSD and similar approaches	• Influence funding bodies to prioritize interdisciplinary projects/"wicked problems" • Demonstrate VSD's potential economic benefits and unique technological designs	• Increase funding for interdisciplinary collaboration • More incentives for including ethics in technology design, and more punishments for transgressions
Cultural barriers	• Cultural belief about the limits of engineers' agency with regards to technologies' impacts • The belief that engineers do not have power over the use of technology or its political and human impacts • Focus on technology over humans	• Encourage and practice reflexivity about the extents and limits of engineers' agency • Utilize participatory and deliberative approaches in technology development • Expose themselves and peers to other cultures/ paradigms/fields via interdisciplinary collaborations	• Utilize both top-down (mission statements) and bottom-up (workshops facilitated by champions) approaches to slowly shift to a value-oriented engineering culture • Embrace participatory methods • Learn from other cultures/ paradigms/fields via interdisciplinary collaborations

Solitander et al. have outlined the framework of Focus and Delivery to create a strategic and actionable overview of processes related to championing an agenda in a research and education organization. The framework is divided into focus and delivery, and further subdivided into narrow, intermediate, and broad focus, and existing and new structures for delivery. Figure 4 utilizes this structure and explicates various actions that could be taken by the practitioner and collaborators that are discipline-specific, semi-discipline specific, and interdisciplinary. What this figure casts light on is how important it is to work strategically both with colleagues in one's own field as well as outside. The practitioner has experienced othering from colleagues in his own field regarding the inclusion of ethical issues that have been easier to take in by colleagues outside his own field. Simultaneously, though, there is no purpose in developing ethical frameworks for engineers to work with, if it is done in a manner that does not make sense to engineers but only to social scientists or philosophers. Staying in touch and continuously collaborating with peers from all three groups outlined in the Focus boxes will create a better adapted message and research/education products, than neglecting any of the perspectives.

By using action research with a VSD agenda we impart normative ideals; but technology development is not value neutral in any case, and since we know we are not neutral, we must not purport to be, rather, we must acknowledge our own positioning and make it clear for all to see in order to maintain scientific rigor. Additionally, since VSD is a participatory research practice that emphasizes the inclusion of stakeholder perspectives, choosing a method like action research which

Figure 4. Ways to integrate VSD into drone research, industry collaboration, and education; based on (Solitander et al., 2012)



places a similar or heavier emphasis on participation, contributes to methodical and paradigmatic consistency.

CONCLUSION AND FUTURE WORK

This work contributes by using action research to both identify and address some of the challenges of implementing VSD in a real engineering context. Based on our findings, it is crucial to understand and acknowledge the immensity of what one is asking of a traditionally trained engineer when taking on holistic approaches. These approaches tend to not come very easily to engineers due to the issues outlined above, so we further recommend utilizing relevant communication strategies for cross-disciplinary legitimization of knowledge. To address the paradigmatic conflicts, we further recommend implementing holistic perspectives in engineering education to address the problem of the positivist foundations of the discipline.

The recommendations listed in Figure 3 and Figure 4 further identify myriad opportunities for future work to expand and refine the current study. Some of these recommendations will be easier to implement, such as those utilizing existing structures, while others will require completely new structures to enact. The lessons learned and approach taken in this study may prove even more valuable in the future should engineering shift away from value-neutral or value-free technological development, towards value-sensitive technological development as we recommend.

Further fieldwork is needed to create an ethnography of the drone center. Such cultural analysis will allow for a more complete account of the organizational culture and enable application of

Legitimation Code Theory which outlines how to facilitate interdisciplinary activities in education that ensures both relevance and legitimacy to engineering students, colleagues, and leadership. Moving forward, we see great potential in utilizing action research to create even more insights to help bridge the VSD theory-practice gap – within drone design, and beyond.

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