Researching Navigation of Project Complexity Using Action Design Research

Abstract

Purpose – Project complexity is becoming increasingly challenging for project managers. Much valuable research has been done on the concept of project complexity. The research reported in this paper aims to provide a new means (the "Complexity Navigation Window") and guiding principles for the navigation of project complexity in practice.

Design/methodology/approach – This paper applied Action Design Research (a methodology for Design Science Research) to design and evaluate the Complexity Navigation Window (CNW), which will serve as a representation of project complexity as a key component of the user interface for a Decision Support System (DSS) for managing project complexity.

Findings – Formative evaluations of the Complexity Navigation Window by 16 project management practitioners indicated that the artefact is relevant, comprehensible, and heading in a promising direction to guide decision-making. The evaluation also highlighted project managers' difficulty in using the (conceptual) representation *by itself* to assess a project's current situation accurately, which in turn limits their ability to understand a project's current complexity and decide an appropriate course of strategy. A conceptual framework by itself is insufficient. This finding motivates further research to develop and evaluate a DSS that would partially automate the assessment process (by surveying stakeholders and automatically assessing and representing project complexity according to the CNW), which should aid in increasing the accuracy (and timeliness) of project complexity assessments and contribute to appropriate strategy formulation and timely revision.

Practical implications – The formative evaluation of the CNW indicates relevance for practitioners and the further features of the DSS may still yield even higher perceived utility from the full artefact.

Originality/value – The paper provides improved understanding of practitioners' perceptions of project complexity and ability to assess it for a given project. The paper describes the design of a new visualisation for navigating and managing complexity. The paper further presents four strategies for managing project complexity. Finally, the paper also provides a methodological discussion on the potential of Action Design Research in advancing project management research.

Keywords: Project complexity, Navigation principles, Project complexity management strategies, Design Science Research, Action Design Research, Evaluation strategy.

Paper type Research paper

1 Introduction

Projects, as temporary constellations of various stakeholders with diverging and changing goals and requirements, are inherently complex (Geraldi and Söderlund 2016; Söderlund 2004)~~(Geraldi and Söderlund 2016) (Burke and Morley, 2016; Söderlund, 2004)~~. Developing understanding of the different facets of project complexity has therefore been embedded implicitly on the research agenda of project scholars ever since project management began as a research field. The early days of project management research developed "best practice" guidelines (Geraldi and Söderlund 2018)-, (Geraldi and Söderlund, 2018), but there was not then an adequate theoretical basis concerning complexity and its management on which to draw. Following Kant, Geraldi and Söderlund (2018) recommend achieving a balance of theoretical and practical outcomes, in which theory informs practice and practice motivates theory.

Unlike many areas of project management, conceptual (rather than practical) advances have dominated the study of project complexity (Baccarini 1996; Geraldi et al. 2011; Thomas and Mengel 2008; Vidal and Marle 2008; Williams 2005). (Baccarini, 1996; Geraldi et al. 2011; Thomas and Mengel, 2008; Vidal and Marle 2008; Williams, 1999; Williams, 2005). Dealing practically with complexity remains an under-researched and daunting task for practitioners. Geraldi et al (2011) explicitly called for research to transform theoretical understanding into practical means to respond to, shape and navigate project complexity. Research to develop theory-informed approaches to manage complexity is, however, inherently difficult, since "Complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself" (Schlindwein and Ison 2004).

To address these issues, the present paper follows the logic of Design Science Research (DSR) (Hevner et al. 2004). (Hevner et al. 2004). DSR has been defined as "Research that invents a new purposeful artefact to address a generalised type of problem and evaluates its utility for solving problems of that type" (Venable and Baskerville 2012, p. 142). The DSR is under-represented in project management research – or at least rarely acknowledged. Recently, (Geraldi and Söderlund 2018)Geraldi and Söderlund (2018) classified project management research into three kinds, (1) traditional positivist research, (2) interpretative research, and (3) emancipatory (also known as "critical") research. While they assert that traditional positivist research "has its main interest on 'solving the problems' of project organising and increase its efficiency and effectiveness", it attempts to do so "through better understanding of causal relationships surrounding projects". However, such understanding does not *by itself* solve problems. Solving problems requires having the means to do so, which, in the absence of having existing means at hand, requires designing and developing (new) means to solve the problem, which is the express goal of DSR. Among the different methods for conducting DSR, the research reported in this paper employs the Action Design Research methodology (Sein et al. 2011), which combines DSR with Action Research (AR) (Avison et al. 1999; Baskerville and Wood-Harper 1996; Iivari and Venable 2009) so that DSR researchers work together with practitioner clients for mutual benefit.

Following DSR, the present paper engages with the practically relevant, real-life problem of how to manage and navigate project complexity. To do so, the paper attempts to develop a new, theoretically-informed, and practical solution to this problem. In this manner we are responding to the call by Geraldi et al (2011, p. 986) advocating that "It is vital that this research begins its own paradigm shift and builds on a common language that moves the debate from defining complexity and its characteristics to developing responses to project complexities. Maybe then, we can help practitioners and their organizations to manage complexity, instead of creating an even more complex (and complicated) reality." Thus, the paper seeks to start bridging the gap between and integrating practical and theoretical knowledge on project complexity.

The paper further seeks to heed the call of ~~Söderlund~~ Söderlund (2011) ~~(2011)~~ – "To aid the world of practice, project management scholars would arguably have to provide solutions on how best to design structures which correspond to many challenges facing present-day projects, so that the relevant processes are initiated to take projects to fruition – be that behavioural, social or technical processes." In line with Söderlund's call, this paper focuses on developing a practical solution to aid practicing project managers in managing project complexity.

Importantly, while prior empirical literature on the management of complexity focused on the structural elements and characteristics of project complexity (e.g. number of tasks and their interdependencies), the emphasis in the present paper is particularly on *project-stakeholder-related complexity*, which is caused by the multiplicity, variety of goals, equivocality and change dynamics that actors may induce in projects. This is highly relevant, as practitioners of project management constantly report that "multiple stakeholders" and complex organizational arrangements are the most important characteristic of project complexity (Cooke-Davies 2013). Multiple stakeholders lead to complexity particularly when their goals and interests diverge. The resulting power struggles, conflicting coalitions, resistance, and the like need to be taken into account when making project decisions in order to create value for stakeholders and make a project feasible (Lehtinen et al. 2019). This is not only crucial during the project's initiation and planning stages, but highly relevant throughout the entire project life-cycle ~~(Aaltonen~~ (Aaltonen and Kujala 2016) ~~and Kujala, 2016)~~. This suggests that designing, constructing, and deploying a Decision Support System (DSS) for monitoring, navigating, and managing the project-stakeholder-related complexity arising from multiple, unaligned stakeholders has strong potential for improving the handling of project complexity.

The specific focus of this paper is on one of the biggest design challenges of designing a DSS: the design of a representation ~~(Sprague~~ (Sprague Jr and Carlson 1982) ~~and Carlson, 1982)~~, in this case for visualising and navigating project complexity, which is a key aspect of the user interface for such a system. Navigation design for decision support in handling project complexity arising from the complex stakeholder set-up is the focus of this paper. While not addressing other system design issues, this paper takes a small step toward closing the gap between what science knows about complex project stakeholder constellations and what practitioners need by addressing the following research question: *How can the complexity of a given project be represented to facilitate the navigation and management of that project?*

In this paper, navigation is used as a metaphor for guiding project managers in taking action to deal with complexity. In classical navigation, there are two important activities. The first is to locate where you are. Your understanding of where you are also needs to be regularly updated as you move along. The second activity is planning how to get where you want to go from where you are. This may require re-planning as actions taken to move toward your destination may not get you precisely where you thought you would be at any time. Navigation can be used as a metaphor to guide decision-making and action-taking in many domains. In the case of dealing with complexity in project management, one needs to have a way of determining the situation (with respect to project stakeholder complexity) before deciding on an appropriate way to move toward the goal state (of a successful project).

While the present study makes its primary contribution to project complexity management research, it also introduces and offers guidance on how to utilize DSR (Hevner et al. 2004) ~~(Hevner et al., 2004)~~ in project studies. Although well established in the research fields of management and information systems, DSR has had limited utilization in project management to date. In our view, DSR as a problem solving approach is a promising means to address project complexity and other project phenomena, and offers opportunities for developing knowledge on projects and reconciling the sometimes differing knowledge interests of practitioners and academics.

Based on the DSR publication schema from (Gregor and Hevner 2013)Gregor and Hevner (2013),, the remainder of this paper is structured as follows: 2) Theoretical Background, 3) Research Methodology, 4) Artefact description, 5) Evaluation, 6) Discussion, and 7) Conclusion.

2 Theoretical Background

2.1 Overall view of project complexity

An early definition of project complexity defined it as "consisting of many varied interrelated parts" (Baccarini 1996). William Williams (1999 (1999) termed this 'structural complexity' and argued for adding uncertainty as a second dimension. Other researchers added other dimensions. A systematic review in 2011 argued that project complexity now consisted of five dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political (Geraldi et al. 2011). (Geraldi et al., 2011).. A recent systematic review showed further development and expanded the understanding of project complexity to eight dimensions: Structural complexity, Uncertainty, Emergence, Autonomy, Connectivity, Diversity, Socio-political, and Elements of context (Bakhshi et al. 2016). The diversification of dimensions unfolding the project complexity is however only one approach to research, as (Floricel et al. 2016) argue for a differentiation into structural complexity, dynamic complexity, and representational complexity, the latter resulting from the inability of actors and organizations to represent the reality and its dynamics. From a meta-perspective, Mikkelsen (2020) identified five ideal types of research in project complexity: 1) Positivistic modelling, 2) Complexity theory, 3) Ontological framework, 4) Managerial framework, and 5) Emancipative investigation. Each ideal type has a unique relationship with the perception of project success demonstrating fundamental differences within research on project complexity.

Among the many perspectives on project complexity, this paper adheres to the following definition "Project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system. Its drivers are factors related to project size, project variety, project interdependence" (Vidal et al. 2011, p. 719).

2.2 Project stakeholder complexity

Stakeholders can act as sources of project complexity through creating both unpredictability and diversity in a project system (Mok et al. 2017; Ramasesh and Browning 2014; Aaltonen and Kujala 2016). Particularly the early stages of projects are typically characterized by ambiguous, fluctuating and unexpected stakeholder requirements as the overall project goals are formulated and negotiated with the stakeholders (Kolltveit and Grønhaug 2004). Here, individual stakeholders seek to stabilize their position and goals in the project network and to maximize value creation in terms of how their own objectives relate to shifting project-level objectives (DeFillippi and Sydow 2016), which may further increase the complexity of the project.

In addition to the potential unpredictability and dynamics of stakeholders' goals and behaviours, diversity of project stakeholders' requirements is also a key issue in complex projects (Ramasesh and Browning 2014; Aaltonen and Kujala 2016). The more stakeholders there are with conflicting requirements and needs, the more challenging it becomes for the managers to include, balance and act upon the differing views, whereas having a set-up with aligned stakeholder requirements would provide a more manageable project complexity landscape (Ramasesh and Browning 2014).

The presence of multiple project stakeholders often leads to disagreements, which is a dimension in the so-called Stacey matrix. According to ~~Zimmerman~~ Zimmerman et al. (1998) ~~(1998)~~ the Stacey matrix depicts the level of complexity based on two dimensions: 1) degree of certainty (close to certainty as opposed to far from certainty) and 2) level of agreement (close to agreement as opposed to far from agreement). Furthermore, the higher the degree of diversity and unpredictability with regard to project stakeholders and their requirements, the more challenging it also becomes for project managers to interpret, analyse and act upon the project stakeholder environment (Aaltonen 2011). To address this challenge, different types of tools that would support visualizing information on the status of the project and stakeholders' requirements have been called for, as they could facilitate the appropriate management of stakeholder complexity (Aaltonen and Kujala 2016).

2.3 The system-of-systems perspective

One fundamental characterisation of complexity differentiates complicated versus complex projects (Remington 2016) and (Remington (2016),(Kiridena and Sense 2016)). A complicated system, e.g. a project (and the future in general), can be analysed based on past experiences. The complex system view presumes that projects as systems are by and large unpredictable. A similar dichotomy is found in (Daniel and Daniel 2018), here labelled regulated versus emerging system properties. The logic of the first is linear where the system is the sum of its parts. The logic of the second flips to emergence, where the system cannot be expressed by the sum of its parts. The combined perspective of systems is referred to as system-of-systems (SoS). The unique affordance of SoS theory is the changing system properties going from one type of system to another, where the intention is "gaining a better understanding of the range of complexity types" (Ireland et al. 2012, p. 248). SoS is identified as one among three schools of thought in project complexity by Bakhshi et al. (2016Bakhshi et al. (2016), the two others being the PMI-view (with reference to Project Management Institute) and the Complexity Theory perspective. As an example of the SoS perspective, Bakhshi et al. (2016) point to the Cynefin framework (Snowden and Boone 2007). The Cynefin framework is gaining interest in research literature and can support project decision making (Basha 2017), including portfolio management (Shalbafan et al. 2018). Cynefin is seen as a potentially important new tool for project managers (Vollmar et al. 2017) and is found in several more recent handbooks, like (Hermano and Martín-Cruz 2019), (Pirozzi 2018), and (AXELOS 2015).

As shown in figure 1, the Cynefin framework outlines five system domains, called obvious, complicated, complex, chaotic, and disorder (each described below). In figure 1, the original wording 'simple' has been changed to 'obvious' according to the latest development of the framework (Mikkelsen 2018). A central feature of this framework is that a different leadership approach is needed depending on what kind of system domain (e.g. in our case, a particular project system) is at hand.

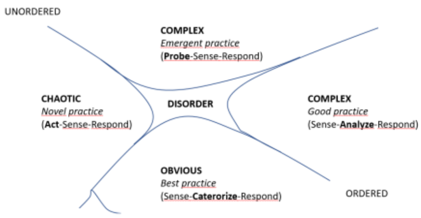

Figure 1: Cynefin framework (adopted from Mikkelsen, 2018)

1. In the *Obvious* domain, systems are causal, the cause and effect are obvious to all, and there exists a best practice to follow.

2. In the *Complicated* domain, there are also direct connections between cause and effect in the systems, but analysis is needed to reveal the causality. More options are available, and they are multifaceted. Therefore, there is no single right answer.

3. In the *Complex* domain, the cause and effect in the systems are loosely coupled, and they can only be seen in hindsight. This suggests emergent practice, where we discover useable paths as we progress.

4. In the *Chaotic* domain, the systems, according to the Cynefin framework's use of the term chaotic, are random. Here, the things we do cannot be based on experience since everything is random.

5. The *Disorder* domain is for when you don't know to which of the other four domains the situation belongs (Snowden and Boone 2007).

3 Research Methodology

When a research question asks "how can", the research endeavour often becomes a matter of design. The nature of this paper's research question focuses on creating a new purposeful artefact to address a general problem. Design Science Research (DSR) (Hevner et al. 2004) is exactly suited to this.

DSR has largely been developed in Information Systems research. However the approach is applicable in all applied disciplines, including business and management (Venable 2010). For example, it has been applied in management studies by such researchers as van Aken (van Aken 2004; van Aken 2005) and Romme (Romme 2003; Romme and Endenberg 2006). DSR projects typically undertake four main activities: problem diagnosis, purposeful artefact invention, purposeful artefact evaluation, and design theorising (*cf.* Venable 2006).

In DSR, a research opportunity arises in the environment (Hevner 2007), e.g. a problem occurring in business practice. We found our problem among project managers, who struggle with handling project complexity. The end goal of this research is to develop an IS artefact as a decision support system (DSS) that would support project managers to navigate complexity by providing a way to identify where they are (the current situation) with respect to project complexity and then to take appropriate action to move toward a desired destination (a situation that is less complex and therefore more easily manageable).

Sprague Jr and Carlson (1982) proposed the ROMC (Representation, Operations, Memory Aids, and Control Mechanisms) design approach to guide developers of DSS. This paper reports on the design of the problem representation for the interface for such a DSS. Considerations for how to collect and ensure the quality of data to be used in representing the problem will come later.

Gregor and Hevner (2013) describe a contribution matrix to highlight the kind of contribution made by different kinds of DSR. Their matrix has two dimensions. Solution maturity (high vs low) describes whether the technology proposed (in this case, DSS) is one where knowledge is well-developed and well-established. Domain maturity (also high vs low) concerns whether the domain of application of the technology (in this case management of project complexity) is matured. The research reported in this paper can be classified as ‘exaptation' since the solution maturity (DSS) is high, but the domain maturity (project complexity management) is low. In other words, a relatively established technology (or approach) is adapted from more commonly applied domains to a new or relatively immature domain. This paper covers the design and evaluation of a representation of the problem space (to aid in understanding where the project is with respect to complexity), which is a conceptual artefact to be included in the user interface to support navigation within a decision support system context.

There are multiple, disparate DSR methodologies available to guide DSR researchers. For a particular DSR project, a specific DSR methodology (or combination of methodologies) must be chosen. Venable et al. (2017) propose a method for choosing among six different DSR methodologies, which distils technological rules for making the choice. Because project managers have different decision-making styles, tool support needs, and subjective opinions and preferences concerning representations of the complexity of a project, the top-level technical rule in Venable et al. (2017) recommends choosing a DSR methodology that is subjectivist and interpretive. Furthermore, following the secondary level of technological rules, because the research has a small group of clients that want to engage in the research, we chose Action Design Research (Sein et al. 2011) as the DSR methodology for this research.

Action Design Research (ADR) is a research method and approach that combines DSR with Action Research. (Avison et al. 1999; Baskerville and Wood-Harper 1996; Iivari and Venable 2009). In ADR, like in Action Research (Avison et al. 1999) more generally, the researchers work together with one or more clients to both (1) solve the clients' (or participating research practitioner) problem (which motivates the client to participate in the research and provide access to their organisation) and (2) develop new knowledge. While it is possible for clients to pay for the research, that is not the case for this particular research project. In the case of ADR, the new knowledge is about a new purposeful artefact and its utility for achieving its purpose. ADR has four activities and seven principles, as shown in figure 2 below.

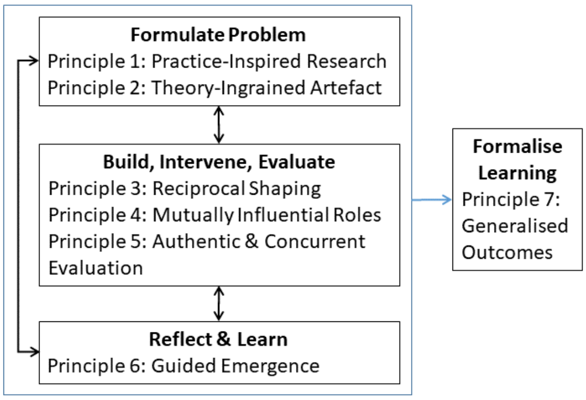

Figure 2: Action Design Research activities and principles (Sein et al., 2011)

In accordance with ADR Principle 1, the research was very much practice-inspired and the heavy involvement of multiple practicing project managers at the problem formulation stage helped ensure a clear understanding of the relevant problem from the various practitioners' points of view. The interactions were conducted as semi-structured workshops with 16 experienced project managers from 15 different companies, who responded to an open invitation to contribute research by participation in educational workshops. In accordance with ADR Principle 2, the design of the purposeful artefact (in this case the representation of the current situation's complexity) was based on literature on project complexity and complexity frameworks in general. How these translated into the artefact design is described in section 4.1.

Similarly, ADR Principles 3, 4, 5, and 6 guided the artefact design and evaluation process, with multiple Build, Intervene, Evaluate (BIE) cycles and reflection by the participants (both researchers and clients) to guide the emergence of the artefact design from the BIE cycles. In practice this was conducted on and in between the workshop described in a later section.

In addition to ADR, the Framework for Evaluation in Design Science (FEDS) (Venable et al. 2016) was applied to guide the design of the evaluation components of this research. The purposeful artefact developed in this research (a conceptual framework and visual representation for a decision support system) is heavily socio-technical, i.e. there will likely be different subjective perceptions of its clarity and utility for supporting detailed understanding of the complexity of the current project situation and careful use to decide a course of action. FEDS recommends using the Human Risk and Effectiveness (HRE) evaluation strategy for such a DSR project. The HRE strategy recommends quickly putting prototypes into the hands of practitioners as realistically as possible, in order to evaluate the subjective individual and organisational feasibility of the purposeful artefact, before investing heavily in detailed development. As will be described in section five, this strategy therefore seeks early formative usability evaluations and a quick transition to more naturalistic (with real users, on real problem situations, and a real or at least realistic artefact), rather than artificial, evaluations. Naturalistic evaluations better support evaluation of effectiveness (in real situations) rather than efficacy.

4 Designing an Artefact for Navigating a Project's Complexity

This section concerns the ADR principle 2 of "Theory-ingrained artefact", e.g. the thinking process leading to the chosen design, which we call the "Complexity Navigation Window" (CNW).

A theory-ingrained artefact needs to find a good balance between science and technology, where the goal of science is to grow the descriptive knowledge and goals of technology are to grow the prescriptive knowledge base of purposefully designed artefacts to improve human capabilities (e.g., decision-making) (Baskerville et al. 2018).

The purposeful artefact being developed in this research helps to improve the interaction between descriptive and prescriptive knowledge, and thereby aid project management practitioners in handling project complexity. The design is based on the System-of-Systems view of project complexity described earlier, since the models of this school of thought entail guiding principles for strategy, which can be adapted for project managers to navigate project complexity.

A 2x2 matrix is often used in research on project complexity to categorize entire projects into different complexity classes. One recent example is (Floricel et al. 2018), which focuses on classifying projects based on their complexity. However, projects often change significantly over their life, and project managers need to respond to the current situation. Therefore, a situational framework, like the Cynefin framework, is more relevant for helping project managers and decisions makers navigate the complexity of a given project.

The Complexity Navigation Window is a key piece in a larger picture of a DSS to help handle the management of complex projects. The overall system is expected to operate on two levels.

The lower level is where the various parts of a single project are positioned and distributed over the four windows (described below). The higher-level compares and balances a project in one position in the window against other projects' positions, which would enable the system to be used on the portfolio level as well. The data input for the DSS (not discussed in this paper) will be about internal and external stakeholders' perceptions of the given project or portfolio of projects.

4.1 Design of the Complexity Navigation Window

The design of the Complexity Navigation Window was inspired by the Cynefin framework (Snowden and Boone 2007). In practice, projects with their sub-projects are often spread across the Cynefin framework's Complex and Complicated domains with some ventures into the chaotic. Only projects including many replicated tasks, project teams, processes and a stable project environment may have a significant fraction in the obvious domain. As demonstrated by the literature search, the practical aspect of project complexity is very much about different opinions of multiple stakeholders, political conditions, ambiguity and uncertainty of goals, hence for projects the 5th domain, "disorder", is much more commonplace than it appears in the description of the Cynefin framework (Snowden and Boone 2007). A key insight, supporting the design of the Complexity Navigation Window, was the realisation that the 5^{th} Cynefin domain (disorder) corresponds to the disagreement among stakeholders mentioned earlier since the confrontation with opposite views (disagreements) often leads to a state of not-knowing for project decision makers and managers. Furthermore, the order–disorder dichotomy in Cynefin corresponds to the two levels of uncertainty, also labelled "regulation–emergence" in (Daniel and Daniel 2018). These two insights were central to designing the complexity visualisation artefact. The resulting design of the project complexity navigation artefact is shown in figure 3. The Complexity Navigation Window is a visual representation artefact to help project managers to choose a course of action based on the situational complexity characteristics of a given project. Capturing both where a project (and its various parts) is located (the 'Where are we?' part of navigation) and mapping strategies for moving a project forward (the 'How do we get there?' part of navigation) are the essence of the Complexity Navigation Window. Importantly, because subparts of a project can be expected to be spread over more than one quadrant, different strategies may be required for different project sub-parts.

Diversity	(3) Divergence "Discuss and align" Politically driven (Negotiation)	(4) Chance "Frame and experiment" Change driven (Experimental)
Consensus	(1) Regulation "Plan and execute" Goal driven (Analysis based)	(2) Emergence "Iterative execution" Vision driven (Iterative)
	Clarity	Unpredictability

Figure 3: The Complexity Navigation Window.

4.2 The labels of the artifact

1) The choice of labeling the first quadrant 'Regulation' is based on the dichotomy of regulation versus emergence (Daniel and Daniel 2018). The regulation quadrant corresponds with both the 'complicated' and the 'obvious' domains in Cynefin. A system in the regulation quadrant is causal and predictable and therefore the strategy of its project management should be 'plan and execute' and the project lifecycle can be guided by the initial defined project goal.

2) The second quadrant is labeled 'emergence' with reference to the work of Daniel and Daniel (2018) as above. In the emergence quadrant, the unpredictablility of a systems makes it complex (as opposed to 'only' complicated). The strategy of the quadrant should be iterative and the direction of the project lifecycle schold be guided by a vision (since an intial defined goal is not feasible). A vision to guide a project allows for the deliverables to be defined during the unfolding of a project (Lenfle and Loch 2010).

3) Divergence is chosen as a label for the third quadrant, where the situation entails many disagreements – but still with a clarity of which methods and goals to disagree about. The Webster dictionary defines the term divergence as 'to extend in different directions from a common point', hence the lack of consensus – or at least of a moderate coalition, strong enough to carry the project through in the face of resistance (Atkinson et al. 2006). The axis of disagreement is generalised to the broader term diversity, in order to include the project complexity dimensions mentioned in the previous section and also 'low levels of trust' (Remington 2016). Whereas iterative and agile principles are relevant in the Emergence quadrant, they are of no help when there is a divergence among the stakeholders and decision makers (Winter and Szczepanek 2017).

4) The fourth quadrant is labelled ‘chance' due to the high degree of randomness, which results in both big disagreement and high uncertainty. The quadrant name is inspired by the notion ‘return on luck’ (Collins and Hansen 2011). When a situation is characterised by both disagreement and uncertainty, the situation is on the edge of chaos. The chance quadrant also is relevant to the chaotic domain in Cynefin, where chance is understood as random cause and effect (Kurtz and Snowden 2003); the same thing will only happen again by chance.

4.2 Project management strategies in the Complexity Navigation Window

One essential contribution of the Cynefin framework is that it explicitly points out that there are distinctly different managerial strategies suited for different levels of complexity of the system. If the system is unknown to the decisions makers, hence positioned in the fifth domain (disorder), “The way out of this realm is to break down the situation into constituent parts and assign each to one of the other four realms. Leaders can then make decisions and intervene in contextually appropriate ways” (Snowden and Boone 2007, p. 4). This is similar to the division of project into subprojects in the Complexity Navigation Window, where each of the four squares calls for a unique strategy.

4.2.1 Strategy for the regulation-quadrant

Regulation refers to the deterministic approach to project management, where planning is essential, like in the Project Management Body of Knowledge (PMBOK) (Project Management

Institute 2017). The strategy entails the Instructionism form (Pich et al. 2002), where the focus is on the Critical Path Planning and Risk Management. The modus operandi of the regulation quadrant is "Plan and execute". The PM paradigm of regulation should be based on one early agreed upon 'iron triangle' (Daniel and Daniel 2018). In practice this not easy. In a survey (Bucka-Lassen et al. 2018, p. 18), practitioners were asked: "what is the most important reason for complexity caused by the stakeholders?" One option stood out in particular: "Unrealistic expectations from decision-making stakeholders on what is possible within the deadline and budget". In other words, the decision makers assume the system to be 'only' complicated. Given a consensus on unpredictability of the future can be established, this will move the situation form Regulation into the quadrant of Emergent. If no consensus can be reached, the situation slides into either quadrant 3 or 4 in figure 3.

4.2.2 Strategy for the emergence-quadrant

In the emergence-quadrant the hindsight does not (always) lead to foresight and the essences of the project management strategy here, is to deal with the unpredictability. The same things will not happen again, except by accident. By and large, the emergence strategy is complementary to strategy presented in PMBOK, with its focus on planning as the pivot point of all the ten knowledge areas (Lenfle and Loch 2010). The emergence quadrant involves a learning strategy where "Overall vision, Detailed plan only for next tasks, then high-level logic based on hypotheses, Plan learning actions, and Provide capacity for re-planning" (Pich et al. 2002, p. 1018). ~~(Pich et al. 2002, p. 1018).~~ This learning strategy is very similar to what is later referred to as "Agile project management strategy" (Fernandez and Fernandez 2008) and (Pope-

Ruark 2015). “Iterative execution” is the keyword for the strategy for the emergence-quadrant, and practically, the iterations can be structured like sprints in Scrum (Schwaber and Beedle 2002) or time boxes in agile PM (DSDM 2014) or PRINCE2agile (AXELOS 2015).

4.2.3 Strategy for the divergence-quadrant

This quadrant includes the social-political complexity (Geraldi et al. 2011) and the complexity due to low levels of trust (Remington 2016). Where consensus exists, the project can work toward a common goal – either in the shape of objectives or visions – but when consensus is missing, production work in the project is not relevant since no clear goals exist. Instead, the project has to work on the political agenda, aligning stakeholders in order to re-establish consensus – or a strong enough coalition (Al-Haddad and Kotnour 2015) If the project keeps producing without consensus, it faces the biggest ineffectiveness of them all: the perfect execution of a thing that should not have been done. In other words, doing the thing right, but not the right thing (Remington 2016).

In risk of the highest inefficiency of all: Perfect execution of things that should not have been done. Therefore the modus operandi here is “Discuss and align” meaning that the management of the projects is not so much the monitoring and control of productive work (like in the regulation-quadrant) but more communication and having meetings (Turner and Cochrane 1993). (Turner and Cochrane, 1993). The dichotomy of the regulation versus emergence-quadrant is well captured by the difference between management and leadership: In contrast to management's activity of organizing and staffing, leadership's activity is aligning people.

(Kotter 2001). The strategy can be exemplified by a quote from an experience projects manager on a workshop; “You should conduct a lot of political meetings; however, you cannot name the meeting what they are, because then important stakeholders won’t show up.” The strategy must be based on the assumption that hidden agendas exist (Winter and Szczepanek 2017), and that building trust and relationship can only to some extent make the agenda explicit for negotiation between involved parties. In the case of stakeholder non-alignment and user-incongruity, the following approach has been presented: “Early and forthright assessment of interests, expectations and needs. Negotiated, agreed-upon and documented compromises. Continuous monitoring of changes and introduction of adjustments” (Botchkarev and Finnigan 2014, p. 11)

4.2.4 Strategy for the chance-quadrant

The chance-quadrant will often be a transition phase the project (or part of a project) is going through due to a rapid change of circumstance inside or outside the projects.

As Pich et al phrase it: “When complexity prevents an evaluation of the causal mapping, it is impossible to choose a best policy. (Pich et al. 2002, p. 1019), and go on to argue for at a “Plan multiple trial projects. The same strategy is in Cynefin called “parallel safe to fail experiments” (Mikkelsen 2018). The parallel experiment is here ‘opposite’ to the agile serial time boxes approach. A more long-term stable situation in the chance-quadrant can be the fuzzy front end of an innovation project and new product development (Koen et al. 2001).

The fundamental challenge for this strategy to overcome is the disorder and chaotic conditions of the situation (based on Cynefin terminology). The combination of unpredictability and high diversity can best be described as confusing, stressful, and a case of 'issue-overflow', where people can no longer distinguish between problems and circumstances, without the wisdom to know the difference (Lazarus 1993). The time span for action is often very limited, hence it can be questioned if the classical definition of a project still applies, hence the quadrant can be thought of as an emergent and transitional phase of the project. The situation is on the edge of chaos, when the social constructed commonly accepted scope breaks down, there is no alignment on which problem to solve, and in what order. An appropriate strategy in this quadrant is as follows: Re-establish a common acceptable situational scope and a temporary problem break down structure leading to a set of experiments to be carried out, and the result which will inform the temporal problem break down structure and hence the situational scope of the project or sub-project.

4.2.5 An overarching strategy for **quadrant hopping**

Two things are important for the user of the Complexity Navigation Window to keep in mind. 1) The division of a project in sub-project is not a fixed or given break-down structure. 2) The positions of sub-projects in the window are likely to change during the project lifetime. A good heuristic for positioning is: if there is no evidence of consensus and clarity of the way forward, then a given project (project-part) is probably not in the regulation quadrant. If factors of disagreement and uncertainty are ignored or dismissed, the delusion of success (Lovallo and Kahneman 2003) prevails. Instead, the user might assume the worst, and contemplating based on being in the fourth quadrant, ask what experiments are needed to harvest enough information to determine whether there is consensus and clarity so that action can be taken based on understanding of any uncertainties or disagreements. For execution the situational contest of any task will be like quadrant one. Much attention must be given to move from quadrant four towards quadrant one – often via either through quadrant two or three. Strategies for this, can be found with inspiration in (Galli 2018)

5 Evaluation

This section first examines the chosen evaluation strategy (Venable et al. 2016) (Venable et al. 2016), then the methods for evaluation, and finally, the findings of the evaluation of the Complexity Navigation Window.

As introduced in section 3, this project used the Framework for Evaluation of Design Science (Venable et al. 2016). The FEDS evaluation design process is comprised of four steps: (1) explicate the goals of the evaluation, (2) choose the evaluation strategy or strategies, (3) determine the properties to evaluate, and (4) design the individual evaluation episode(s) (Venable et al. 2016).

The primary goal of the evaluations at this stage of the ADR process was to make sure that the artefact (a visual representation of complexity together with links to strategies) makes sense to practitioners of project management and gives sound recommendations for navigating the complexity of a given project. Further, the evaluation should measure the utility of using the artefact and the soundness of its recommendation. At the outset, it was expected that the personality traits of the participants might influence the evaluation of such a high-level artefact.

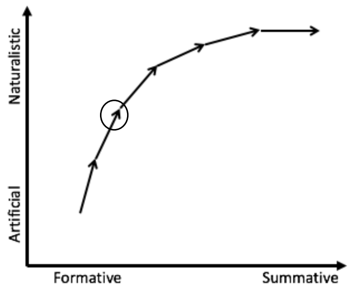

Figure 4: The Human Risk and Effectiveness evaluation strategy from the FEDS evaluation framework. Circle indicating the current state.

Based on an assessment of project goals and risks, the relevant FEDS strategy chosen for this work is the Human Risk & Effectiveness (a.k.a. human usability) strategy (see figure 4): focussing early on formative (compared to summative) evaluations, but moving quickly toward more naturalistic (instead of artificial) evaluations. Following this strategy, it was expected that a series of formative evaluations would confirm (or disconfirm) that the artefact was heading in a suitable design direction, identify any significant usability problems, and contribute to more precise instruction and clarification of the artefact. It was decided to conduct these formative evaluation episodes in a workshop setting, which is close to naturalistic for the participants, although not quite a real situation (where practitioners would use the artefact independently in their project, helping them with guiding recommendation for actual situations).

In this paper, there is emphasis on the formative evaluation, since this is an integral part of the process of ADR. The remaining of section 5 explains the process and results of the formative evaluation.

After completing an initial design of the artefact, practitioners managing projects were invited to workshops. At first the invitation stated that project managers and project owners were to come in teams working with their project. This resulted in only two teams accepting the invitation. Many project managers showed strong interest in participation, but they could not make their respective project owner prioritise the workshop. The evaluation strategy was revised so that project managers could come alone.

During the first part of the workshops, the artefact was presented orally by the researcher followed by a Q&A for clarification. The participants could ask questions in order to grasp the artefact. During the second part, the participants engaged directly with the artefact and applied it to analyse the complexity of their own projects. Then they worked in groups of two on each of their own projects in turn. The process was supported by the researcher answering process questions and providing clarification. Finally, evaluation was done first by filling in evaluation sheets based on their experience using the artefact to analyse their own projects. After that, the artefact was evaluated orally by the participants.

The survey focused on quantitative evaluation questions (ratings out of 10). Section 5.2 presents the results from the quantitative parts of the survey. However, space for qualitative comments were also included in the survey. After filling in the survey sheets, an oral session seeking and discussing suggestions for improvements took place. Section 5.3 presents findings from the qualitative survey questions and the oral improvement suggestion sessions.

5.1 Questionnaire for the Complexity Navigation Window

This section presents the results from the questionnaire given to workshop participants. Table 1 below shows the average and standard deviation of participants' ratings of different qualities of the Complexity Navigation Window. All questions were rated on a 0-10 scale. The statistical significance with small N is low, but this is not the issue here as this is not a summative evaluation. The scores given are only seen as indications.

#	Question	Aver-age	Stan. Dev.
1	Did the structure of the artefact, with four different situational approaches, make sense to you?	7.9	1.6
2	Does the artefact have good usability, is it easy to tell the difference of the four situations?	7.1	3.7
3	Did you find it easy to divide the project into issues to fill in the matrix?	7.2	2.3
4	Did you find the matrices of the model in the artefact consistent in use?	6.3	2.6
5	Did you gain new insights into project leadership initiatives for your project using this artefact?	6.4	4.4
6	Do you expect the position of issues to be changing during the project?	7.8	1.5
7	Would the artefact be of higher value if used in dialog with the project owner?	8.5	2.3

Table 1. The result of 16 Project Managers evaluations of the artefact

In Table 1, the average rating for question #1 (7.9 out of 10) shows that the Complexity Navigation Window, as part of an IS prototype of a DSS for project complexity, made sense to the participants. The small standard deviation (1.6) shows that there was largely agreement on that.

The highest score goes to question seven “Would the artefact be of higher value if used in dialog with the project owner?” We tried to have workshops where project managers and projects owners were invited in pairs of two, but there was no interest from project owners in these workshops.

The lowest score is on usability with the score of 6.3. While this is not bad, it does call for further development on the artefact. The test for efficacy (with the question: Did you gain new insights into project leadership initiative using this artefact) was at the same level, but came with a very high deviation, meaning that some participants obtained insights while others did not.

The evaluation sheets also contained a question on what areas of project management the participants saw as relevant, as summarised in Table 2.

#	How much inspiration does the use of the artefact give for each area of handling complex projects?	Average	Stan. Dev.
1	Project-setup	8.5	4.1
2	Organizing	6.7	4.6
3	Communication plan	6.4	4.6
4	Stakeholder management	8.7	0.7

5	Risk Management	7.5	3.0

Table 2. The results of 16 Project Managers' evaluations of the artefact in the area of use

Based on Table 2, the value of the artefact is most significant for project-setup and stakeholder management. The latter had a very low standard deviation, so there was a strong consensus on it. This is aligned with the central hypothesis of the artefact design's fitness for purpose (that navigating and dealing with the complexity of multiple, divergent stakeholders would have high utility). The high rating of risk management came as a no surprise.

The standard deviation was very high on the three first areas. Based on the comments on the evaluation sheets, the overarching reason is that the participants faced very different circumstances in their respective organizations.

5.2 Qualitative Evaluation of the Complexity Navigation Window

The flowing qualitative data is based on the observations of the researcher, the comments written on the evaluation sheets, and the subsequent oral evaluation of the workshop.

5.2.1 Notes from the presentation of the artefact:

When the Complexity Navigation Window was presented to the practitioners in the workshops, some struggled initially with the two dimensions: Uncertainty and Disagreement. The participants raised questions during the workshop revealing lack of clarity in the artefact. Questions from the participants included: "Uncertainty of what?", "Does uncertainty lead to disagreement – and vice versa?", and "Can disagreement exist if there is no or little uncertainty?"

Some practitioners struggled with the proposition that there is no true position on a given issue, since it depends on the eye of the beholder. Others delighted in that and saw a separate purpose of the Complexity Navigation Window to illuminate exactly this problem in the collaboration between the project owner and the project manager. These comments illuminated very different worldviews among the participants.

5.2.2 Notes from the use of the artefact

The practitioners were asked to divide their own project into a number of parts suited for positioning in the Complexity Navigation Window, e.g. themes, issues, focus area or another breakdown structure of their own choice. This part of the exercise was surprisingly difficult. For some, it was difficult to get started without a specified categorisation model. Others found it difficult to abandon the initial selected breakdown structure, even when it clearly was a dysfunctional structure (like for example dividing the project in its phases).

When a useful structure was found, the practitioners struggled with judging the parts in order to position them in the Complexity Navigation Window. One participant reflected: "How can I be certain that this issue belongs in the 'certainty' part of the window, when it might turn out unpredictable?" Another asked: "How many disagreeing stakeholders does it take to create 'divergence'?" There was much uncertainty among participants on the question "where does this item belong" in the window. The artefact lacked an information structure to help participants to figure out "where you are".

The borders in the Complexity Navigation Window gave a presumption that a binary classification was demanded. One participant argued, that in her case it was easier to arrange the parts in a continuum of decreasing certainty instead of using a dichotomy for sorting. Further, she argued that there would also be multiple kinds of strategies to be applied, not only two categories. The black and white appearance of a 2 by 2 matrix clearly can lead to wrong perceptions of the artefact. The presentation of the artefact might not have struck the best balance between clarity and applicability.

In their struggle to position the parts of the project on the disagreement dimension, many exclaimed that they really had little clue. However, encountering this difficulty helped them to realise that it revealed weaknesses in their own stakeholder analysis. As one put it "this makes me realize what I need to figure out", which was said in a positive note.

5.2.3 Notes from the oral evaluation after use of the artefact

Notes from the oral part after the evaluation sheets had been done. In one workshop, the overarching theme in the oral evaluation was the lack of control over project setup. This turned into the old discussion of plan-driven versus agile project management. The discussion revealed a lot of frustration on the restriction of how projects 'must' run in their respective organisations. Even when most parts of their projects are positioned in the uncertainty side of the Complexity Navigation Window, practitioners report being held responsible for the initial agreed-upon triple constraints (iron triangle). Sometimes there is a contract to be fulfilled, but other times there seems to be a lack of trust from project owners, or simply a matter of unrealistic expectations and lack of understanding of the unpredictability of the project.

In another workshop, the most commented theme was stakeholder management. There was a consensus that the window was a fine starting point for the stakeholder analysis and a useful supplement to the conventional models for analysing stakeholders in the project management toolbox. There was general agreement that doing this kind of analysis with the project owners would provide a better common ground for understanding the project.

6 Discussion

Given the research question, “How can the complexity of a given project be represented to facilitate the navigation and management of that project?” and the use of a Design Science Research approach to seek an answer to the question, it is appropriate to divide the discussion section into two parts, one covering the artefact itself and one on the use of design science in project management.

6.1 The Complexity Navigation Window

The primary finding is that the evaluation of the Complexity Navigation Window indicates high relevance according to the project managers participating in the workshops. The evaluation findings indicate that it is important to choose a project’s setup based on the situational factors of stakeholder diversity and unpredictability-.

Participants gave a high score on the question: “Would the artefact be of higher value if used in dialog with the project owner?” The evaluation included this question for a particular reason. We had invited teams of project owners and project managers to participate together in the first workshop, as this was our initial vision for artefact use. Sadly, however, only two teams volunteered. It is very hard to persuade project owners to come to workshops on project complexity. The reason for this is not quite clear, but might be based on a presumption that handling the complexity of a project is the task of the project manager. This is an important lesson in itself. Reflecting on the evaluations, one area for further development of the Complexity Navigation Window is to find a form that appeals to the project owner, not only to project managers.

Most significantly, the formative evaluations also indicated that practitioners of projects management have difficulty placing their projects within the four domains, i.e. they have difficulty assessing the levels of diversity and predictability of a particular project or sub-project. Project managers lack information needed to estimate these dimensions comfortably and accurately. This indicates that further ways or enhancements are needed to improve the clarity of the different domains – both to project managers and to project owners.

Rather than simply guessing or estimating where a project is currently positioned on the diversity dimension, project managers also have need for some means to obtain and interpret information about the actual state of diversity in a project. One possible way to clarify the actual position of a project on the diversity dimension is to gather input from actual stakeholders, analyse it, and represent it within the matrix to indicate the level of diversity among the multiple stakeholders. A computer-based Decision Support System could potentially assist in this process. The current direction of our research is to design a survey engine to obtain answers from multiple project stakeholders concerning various relevant topics on an ongoing basis. The DSS could analyse the data gathered to measure the current state of disagreement among stakeholders, thus placing a project on the diversity dimension of project complexity and providing more accurate and timely information to project managers, as well as guiding decision-making about appropriate strategies for managing the complexity.

6.2 Use of Action Design Research in project management research

Based on our exploration of principles for navigating project complexity using the Action Design Research methodology for DSR, we consider it to have fine potential as a structured methodology of pragmatic observation. “The pragmatic approach is to rely on a version of *abductive* reasoning that moves back and forth between induction and deduction.” (Morgan 2007, p. 71). With the very large body of knowledge of descriptive project complexity, but limited on prescriptive knowledge, there is a demand for much abductive research.

The research literature on project complexity is mostly descriptive. The fraction of knowledge with an empirical basis is limited. Often the foundation is Delphi methods for adjustment of dimension, as for example (Bosch-Rekveldt et al. 2011) and (Vidal et al. 2011). In the other end there are examples of grounded-theory-based research using workshops, like (Maylor et al. 2013). With ADR we find a middle ground, where the theory-ingrained artifact can foster a fruitful discussion between research and practice. With ADR it becomes possible for researchers to put a radical different ‘thing’ (like the Complexity Navigation Window) ‘out there’ to be tried and tested by practitioners and learn from the collaboration.

Based on our case, we argue that DSR is appropriate for research on project management, particularly where new means for improving project management effectiveness and solving project management problems are needed. We further argue that the Action Design Research methodology for conducting DSR is very suitable for explorative research endeavours. Research aimed at producing prescriptive knowledge for managing project complexity better is a combination of paradigms, and like Johnson and Onwuegbuzie, “we advocate consideration of the pragmatic method of the classical pragmatists (e.g., Charles Sanders Peirce, William James, and John Dewey) as a way for researchers to think about the traditional dualisms that have been debated by the purists. Taking a pragmatic and balanced or pluralist position will help improve communication among researcher from different paradigms as they attempt to advance knowledge. " (Johnson and Onwuegbuzie 2004, p. 16)

The use of Action Design Research has many similarities to agile project management (DSDM 2014), most obviously in the iterations within the BIE stage, which parallels an agile sprint, especially with the evaluation/review of the artefact by the stakeholders. In our case, the direction of the development changed in ways that could not have been expected.

Based on the literature research, we agree with Geraldi (2011) that there is a need for a paradigm shift in the research on project complexity. The mainstream of the research is based on a descriptive approach, which is not very useful for practitioners. However, going to the opposite side with Action Research, may reduce the benefit of legacy from the large body of knowledge. Staying on the middle of the road, with DSR, seems to be an optimal solution for deploying the body of knowledge on project complexity into the practical realm of project management, through the development of new purposeful artefacts that are based on existing descriptive knowledge and evaluating those artefacts to further enhance their effectiveness and utility for practitioners in ways that the descriptive knowledge may not suggest or anticipate.

6.2.1 Reflections on evaluation strategy

After evaluation of the Complexity Navigation Window, we reflected on an additional question: Do we need a more iterative approach to evaluation strategy? The fourth step in FEDS is “design the individual evaluation episode(s)”. It was assumed the episode would follow a ‘human usability strategy’ (Venable et al. 2016), with a curve as illustrated in figure 4 in a former section. Figure 5 is an elaboration on figure 4.

However, the described evaluation of the Complexity Navigation Window made us reconsider the path forward. Does is make sense to follow the planned evaluation trajectory, and make the next evaluation slightly more summative in a more naturalistic setting? Or should we proceed upward with the same level of formative/summative evolution, but in a more naturalistic setting than a workshop? Or a workshop like before but with a more summative evaluation? We could also go ‘backward’ and lower the level of “authentic” evaluation (Sein et al. 2011) in one of the “three realities” (Sun and Kantor 2006) – real users, real system, and real task (or context), hence redoing the evaluating of the Complexity Navigation Window in a more artificial setting, e.g. with a controlled experiment on a test case (rather than the participants’ own project cases). Or perhaps the best path is go ‘backwards’ in terms of the concurrent evaluation (Sein et al. 2011), hence be more formative (going left on the first axis of Figure 5) in the evaluation, for example in workshops co-designing with practitioners.

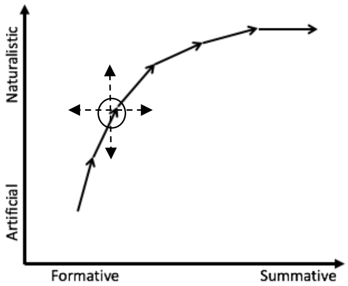

Figure 5: The path of the evaluation strategy can be hard to predict in exploratory DSR projects.

FEDS allows for hybrid approaches and also for flexibility (through re-planning) based on circumstances that arise during a DSR project. For example, while not following FEDS, which had not yet been published, ~~Johnstone and Venable~~ Johnstone and Venable

(2008)(2008) describe a project in which DSR activities were changed as new challenges and questions arose. But, what guidance could be provided on how and when to do so?

These are all valid questions, which make us reconsider the evaluation method. FEDS might be plan-driven to an extent that does not adequately support an exploratory DSR project.

7 Conclusion and Further Research

This research aims to design a new means to cope with the challenges of navigating project complexity. The research follows the Design Science Research (DSR) and applies the Action Design Research (ADR) methodology, which are not often used in research on project management. The design of the Complexity Navigation Window was based on extant conceptualisations of project complexity, more general frameworks of handling complexity, and strategies for project management and leadership handling of project complexity. The evaluation was planned and guided using the Framework for Evaluation in Design Science (FEDS), an oft-used evaluation methodology in DSR. The findings of the evaluation by project management professionals indicated high relevance of the designed artefact, but indicated lower perceived utility for resolving problems with complexity. The findings of the workshop evaluations should be taken with caution since the participants may become biased when collaborating with the designing researchers. However, since the evaluations were formative (aimed at improving the design, not providing evidence of the utility of a final artefact), the achieved the benefit of designer interaction with the users to better understand the reality of dealing with complexity and the potential for the new artefact to adequately address it.

Using DSR, in particular ADR, for research on project management, especially for overcoming problems associated with project complexity, has potential. Many insights on the practical working in projects were revealed through working on solutions to complexity, which might not have been surfaced using the classical (non-DSR, non-ADR) approaches.

More research is needed both on the given artefact and on the use of DSR in managing project complexity as well as on project management more generally. Future research may include (1) working on an improved understanding of the information needed for positioning in the CNW, hence the applicability of the artefact, (2) helping practitioners to identify appropriate project management initiatives based on complexity analysis, and (3) the extraction of more principles on which to base the leadership of projects and navigation of project complexity.

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