

IT-enabled management of project complexity - An Action Design Research project

1. Abstract

Project complexity has been researched extensively. The majority of publications is searching for law-like relations or developing descriptive frameworks. More prescriptive knowledge is needed to guide project managers in navigating the project complexity in their pursuit of success. Identifying the complexities of a given project is a real-world problem for project managers (Mikkelsen, Venable, & Aaltonen, 2021)

Based on a longitudinal case study, this paper uses Action Design Research (Sein, Henfridsson et al. 2011) (ADR) to research the management of project stakeholder complexity. ADR is a variation of Action Research with inspiration from Design Science (Hevner, March et al. 2004) where an artifact is designed to solve a real-world problem. In this case study, an Information System was configured in collaboration with the project managers of the case organization. The affordance of the system is monitoring the stakeholder's perceptions to provide the project managers with additional perspectives on the complexities of the project. The design principle (Gregor, Chandra Kruse et al. 2020) used in developing the information systems is an abduction of the concept 'outside view' (Lovallo and Kahneman 2003) developed to counter the delusional optimism.

Among the project managers, who were very engaged in the co-design, the majority refrained from activating the information system and get the outside view from the stakeholders. Interviews afterward identified 'fear of bad project ratings from the stakeholder' as the main course of resistance to deploy the surveying information system. The stakeholders on the two projects, that did evaluate the information system, demonstrated very high response rates on the frequently posed surveys, indicating that stakeholders appreciated the opportunity to participate in the ongoing monitoring of project performance.

The paper contributes on two levels. The paper presents a novel approach to researching project complexity based on engaging the stakeholders in generating a common perception of the ongoing state of the projects. The paper also provides insights into reasons for reluctance on the part of the participants (the project managers) of the recipient organization and hereby adds to the understanding of the organizational change aspect of actions research in the research of project management. The paper concludes with the identified benefits of using ADR in research on project complexity management and gives recommendations for future research.

2. Introduction

Research on the characteristics of project complexity has been undertaken for more than a quarter of a century, and many frameworks and models have been investigated. The authors of a structured review of the literature on project complexity argued for the need for a paradigm shift 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" (Geraldi, Maylor, & Williams, 2011, p. 986). The subsequent review of research literature shows that only a few scholars have followed up on the call for practical research. One of the papers following up, investigated the "understand – reduce – respond approach" (Maylor and Turner 2017) and recommended future research to provide empirical data on whether it is effective (i.e. improves project performance) as part of regular project work. Another recent paper, also building on Geraldi et

al. (2011), argued that “it is important to pursue further research to identify the weight of each dimension, the limitation of the proposed framework, among others. Additionally, a future research agenda can also focus on how the importance of each dimension changes over the lifecycle of a project or program.” (de Rezende and Blackwell 2019). A recent systematic literature review on complexity in IT concluded that “Most research simply stops at concluding that metrics and tools are required but not available or not reliable. (...) Further research is needed for developing methods and tools for the measurement and management of complex IT projects, in tight correlation and with direct impact in the industry.” (Morcov, Pintelon et al. 2020).

Based on these calls for research, this study pursues a contribution based on research-based practical guidance to project managers embedded in an information system with the following research question: How can an information system giving affordance for project complexity management be developed in collaboration with practitioners?

The answer to this question will be limited to the use of the Action Design Research methodology in a single case study. Investigation of the development is limited to prototyping the implementation of a preselected framework onto an existing ICT platform, thereby investigating the affordance to the management of projects when navigating project complexity.

The remaining of the paper is structured as follows: In section 3, a literature review is conducted and is presented as background. In section 4, the framing concepts are presented and further developed. Section 5 presents the methodology, section 6 results, and section 7 contains the discussion of both the results and the methodology used in the context for researching project complexity. The paper concludes with section 8.

3. Theoretical background

Various definitions for project complexity have been presented. The paper adopts the following conceptualization: “Project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behavior, even when given reasonably complete information about the project system” (Vidal, Marle et al. 2011). This definition focuses more on the consequences and less on the ontology of project complexity. There is much disagreement on the content of descriptive models of project complexity. However, the absence of a common accepted descriptive model is less of a problem when trying to help practitioners, because in practice project managers deal always with perceived complexity (Vidal and Marle 2008). Consequently, when it comes to helping the practitioners, the limited research on perceived project complexity (Mikkelsen 2020) is considered to be a much more significant problem than the scholarly disagreement on descriptive models.

Bakhshi et al. (2016) identify three schools of thought in the literature of project complexity. These are 1) PMI perspective, 2) Complexity theory, and 3) System of system approach (SoS). In turn, Morcov, Pintelon, and Kusters (2020) categorize project complexity into perceived and objective project complexity, where the latter was divided in structured and dynamic complexity.

Building on these inputs, a depiction of branches of project complexity research is developed in figure 1. Particularly descriptive and perceived project complexity as well as system of system approach are relevant for understanding the development and positioning of the present study.

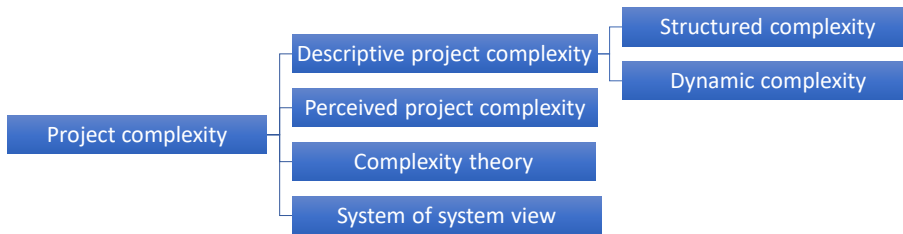


Figure 1: Branching the project complexity (based on Bakhshi et al. 2016 and Morcov et al. 2020).

3.1. Descriptive project complexity

The research stream on project complexity started with Baccarini, who found that the term ‘complexity’ was used in project management literature without clarity. He stated that project complexity is “consisting of many varied interrelated parts” (Baccarini 1996), and argued that it could be operationalized in terms of differentiation and interdependency. Furthermore, he inferred that complexity in projects can be managed by integration. Baccarini (1996) also noted that there is both an organizational and a technological aspect to the concept. The definition of Baccarini has later been coined as ‘Structured complexity’.

The actual branching approach to project complexity was initiated by Williams (1999) who argued that project complexity can be characterized by two dimensions, each of which has two sub-dimensions: Structural complexity (number of elements and interdependence of elements) and uncertainty (uncertainty in goals and uncertainty in methods). In other words, William labels Baccarini’s definition, structural complexity, and uncertainty. In turn, focusing on IS project complexity, Xia and Lee (2004) integrated prior complexity research and developed a 2-by-2 matrix based on (Baccarini 1996), (Turner and Cochrane 1993), and (Williams 1999). One axis consists of organizational and technological domains, as Baccarini defined it ten years earlier. The other axis is devoted to structural versus dynamic complexity.

To make sense of prior literature, Geraldi, Maylor et al. (2011) conducted a systematic review that concluded that project complexity has evolved to encompass five dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political. The first three dimensions are accreted to (Baccarini 1996), (Williams 1999), and (Xia and Lee 2004) in order of appearance. However, Xia and Lee (2004) argued that uncertainty is a part of dynamic complexity. The pace dimension was identified via (Williams 2005) and the socio-political dimension was identified via (Maylor, Vidgen et al. 2008).

Many other attempts to determine the structure and ontology of project complexity can be found in the literature. The underlying intention in these approaches is to define law-like relations, where the complexity of a given project can be measured. One model for assessment of project complexity is found in (Bosch-Rekvelde, Jongkind et al. 2011), where the authors have developed a questionnaire to access the project complexity on three dimensions: Technological, Organisational, and Environment. The latter is an addition to the thinking in the papers (Baccarini 1996) and (Xia and Lee 2004) mentioned previously. Another model for assessment with a descriptive approach is found in a handbook tool developed by PMI (2014) aiming to give guidance to navigate the project complexity with a questionnaire measuring the ambiguity, the human behavior and the system behavior.

3.2. Perceived project complexity

The division between perceived and descriptive project complexity depicted in figure 1 has been suggested and elaborated by Vidal and Marle (2008). They provide the following definitions of descriptive versus perceived project complexity. 1) “descriptive complexity considers complexity as an intrinsic property of a system, a vision which incited researchers to try to quantify or measure complexity,” 2) “perceived complexity considers complexity as subjective since the complexity of a system is improperly understood through the perception of an observer” As argued previously, perceived project complexity is relevant for understanding how practitioners handle project complexity, as Vidal and Marle (2008) explain: “For all practical purposes, a project manager deals with perceived complexity as he cannot understand and deal with the whole reality and complexity of the project.”

Overall, it is rare to find models of project complexity developed in cooperation with practitioners. One example is MODeST complexity model based on grounded research (Maylor, Vidgen et al. 2008), where the dimensions are Mission, Organisation, Delivery, Stakeholders, and Team. This model is very different from the models developed by scholars alone, which can be seen as an indicator, that practitioners have a very different take on project complexity than scholars. Furthermore, focusing on the lived experience and on how to respond to project complexity Maylor and Turner (2017) identified strategies used by the practitioners to respond to structural complexity, socio-political complexity, and emergence complexity. They concluded that there exists a duality between the response and the perceived project complexity.

Given the perception is always subjective, there will be multiple perceptions of the complexity of a project. Based on a large survey among practitioners, Mikkelsen (2020) found that the project stakeholder role influenced how the concept of complexity is understood, hence there are many layers of the perception to include when trying to understand the overall perception of project complexity.

Adopting the lens of perceived complexity, Maylor, Turner et al. (2013) developed the Complexity Assessment Tool (CAT) which contains 21 questions to assess the structural complexity, 11 questions to assess the socio-political complexity. The third dimension, emergence, is assessed by the tool by asking if the 21+11 answers was expected to change. Another way of assessing the project complexity in a perceived manner is found in the handbook (Remington & Pollack, 2016), where project complexity is divided into structural, technical, directional, and temporal complexity. In an assessment model intended for dialog, de Rezende and Blackwell (2019) developed a multi-dimensional framework for project complexity (de Rezende and Blackwell 2019). They stress, that this framework is for dialogue – not for measuring project complexity, which is the case for the two previously mentioned assessment tools.

3.3. Complexity theory

The use of Complexity theory was introduced relative late in the research stream of project complexity, with (Cooke-Davies, Cicmil et al. 2007) as a renowned example. The focus here is radical unpredictability. The potential of complexity theory looked promising, as indicated by one paper coining it: "project management second-order" (Saynisch 2010). However, only a small amount of research literature has followed this research stream. The use of complexity theory has not caught on in the project management research communities, which might have to do with the fuzziness of strange attractors, butterfly effects, and the like, hence little research has followed this path.

3.4. System of system view

The third school of thought identified by Bakhshi et al. (2016) provide only one example, the Cynefin framework (Snowden & Boone, 2007), as an implementation of the SoS view. In subsequent years,

additional contributions to the SoS perspective have emerged in the project management literature. These additions include the work of Kiridena and Sense (2016), where complicated systems, complex systems, and complex adaptive systems are used as stratifications. A similar dichotomy is found in (Daniel & Daniel, 2018), here labeled as regulated versus emerging system properties. Daniel and Daniel (2018) introduce three levels of complexity: algorithmic, stochastic, and non-deterministic. In a paper on distinguishing complexity from severity, Remington, Zolin, and Turner (2009) discuss the SoS perspective (without labeling it as such) and refer to work like that of (Moldoveanu, 2004), where the domains of simple, complicated, complex, and chaotic are presented.

Mikkelsen et al. (2021) use the system of system view to develop four distinct managerial approaches depending on what kind of system the project adheres to. The framework is labeled the Complexity Navigation Window (CNW) and is depicted in figure 2.

| | | |
|-----------|--|---|
| 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 2: The Complexity Navigation Window (CNW).

3.5. Synthesizing the literature review

The descriptive approach seems most valuable when the task is to compare projects. However, when navigating one given project the perceived perspective needs to be considered. The complexity theory might give a very accurate description of the workings of projects but has little to offer when it comes to prescriptive knowledge. The System of Systems perspective can provide prescriptive managerial knowledge, but the challenge is to determine the current state of the project. Here, the other perspective might prove helpful. With this presumption, the CNW was selected as the prior artefact for the Action Design Research project.

4. Conceptual framing of the study

As depicted in figure 3, a conceptual framing (F) can supplement the selected Methodology (M) with answering the research questions that arise for the real-world problem (P) found in the areal of concern (A).

The conceptual framing helps structure the collection and analysis of data from P to answer RQ; F_A draws on concepts from A, whereas F_I draws on concepts independent of A.

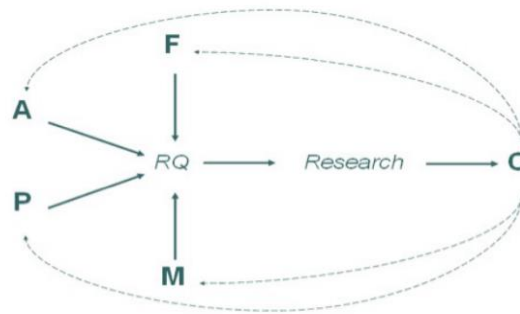


Figure 3: A generic structure of an engaged scholarship study. Copied from (Mathiassen, 2017) with permission.

4.1. Chronological perspectives on project complexity

Three chronological perspectives on project complexity can be adopted, as presented in Figure 4.

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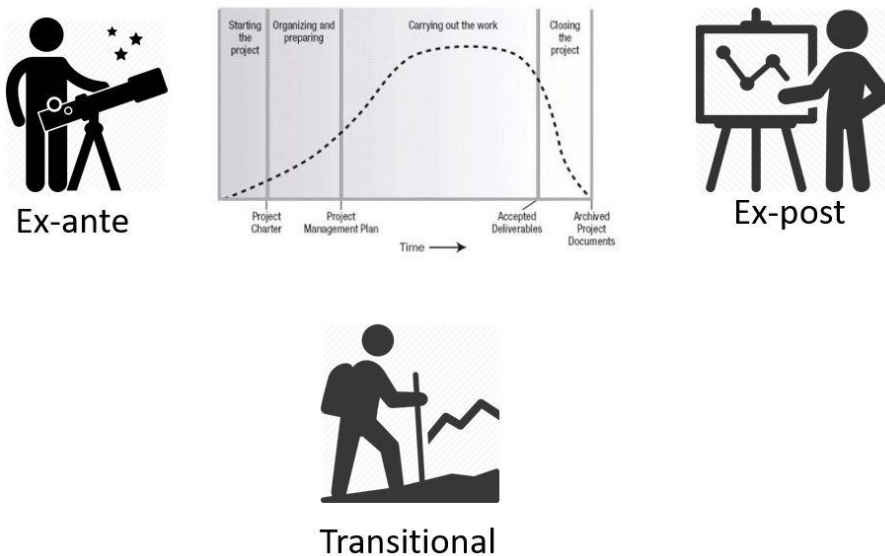


Figure 4: Three chronological perspectives

The differences between the three chronological perspectives can be illustrated as follows:

- The *ex-post* perspective on project complexity addresses the question: *How challenged was the management due to the assessed complexity of the project?* This question can be answered objectively or subjectively, depending on the research methodology. This way of viewing projects is useful to researchers who want to compare the complexity of the project to other constructs of interest, such as project success.
- The *ex-ante* perspective on project complexity addresses the question: *How managerially challenging do we expect the project to be based on the assessment of the complexity of the project?* The research here will be limited to the design and evaluation of tools for assessment or researching the human capability to estimate/predict the future and to research the disagreement on such estimates/predictions.
- The *transitional* perspective on project complexity addresses the question: *Are the challenges of the currently assessed project complexity managed well?* This question is very relevant to project leadership; however, the question is not an easy research topic because it only applies to a single project case with very little possibility of generalization. Instead, research can focus on the design and evaluation of information systems or other tools to guide the leadership of the project.

4.1.1. Hindsight/foresight misconceptions in project complexity research

The chronological perspective provides a lens for detecting misconceptions in prior project complexity frameworks and literature. In the following, two examples are presented. Geraldi et al. (2011) state that utility of their framework is information for business case development, strategic choice, process choice, managerial capacity, managerial competencies, and problem identification (Geraldi et al., 2011, pp. 983-984). This application can be used as part of the project initiation, and therefore the framework arguably takes an *ex-ante* perspective on projects.

This is however problematic because some of the dimensions are mostly *ex-post* or at least occur rather late in the project life cycle, hence deploying a transitional perspective. The framework developed by Geraldi et al. (2011) states that the dynamic dimension expresses change that has happened. "The most suitable attribute embracing all indicators related to dynamic complexity is 'a change in any of the other dimensions of complexity'" (Geraldi et al., 2011, p. 980). This information can however not be obtained from an *ex-ante* perspective on the project. Another problematic issue of the framework is the social-political dimension, where 'hidden agendas' are frequently mentioned as a source of socio-political complexity in the paper from Geraldi et al (2011). Hidden agendas can per definition only be known (to others) in hindsight. In the *ex-ante* perspective, the sociopolitical dimension would include the observable interest of project stakeholders, both present and future.

In short, the Geraldi (2011) framework presumes to assess (part of) the project complexity *ex-post*. This does not support the suggested *ex-ante* utility of the framework. It is not possible to make a complete use of the framework in an *ex-ante* way. While this may not prevent the framework from being useful for practitioners, the above is still a relevant misconception.

Another example comes from the TOE model (Bosch-Rekvelde, Jongkind, Mooi, Bakker, & Verbraeck, 2011). The model has three dimensions of project complexity: technical, organizational, and environmental. The dimensions are assessed using 50 indication questions (Bosch-Rekvelde et al., 2011, p. 736), where some concern the future ("Do you expect ..."), some are concerned with the present ("What is ..." and "Do you ..."), and some are concerned with the past ("Did the project ..."). The mixing of tense indicates that the authors have not given much thought to when the observations should be made in a chronological perspective.

These two examples indicate that misconceptions of foresight/hindsight do occur in project complexity research literature; however, no effort has been made to investigate the commonness of this issue.

4.1.2. Matrix of perspectives on project complexity

Combining the dichotomy of perceived and descriptive complexity with the chronological perspective described in section 4.1 gives a 3x2 matrix, which is depicted in Table 1.

In Table 1, the indicator used to differentiate between descriptive versus perceived complexity is the single measurement (in principle) of project complexity versus the multiple interpretations of project complexity.

| | Ex-ante perspective | Transitional perspective | Ex-post perspective |
|---|---|---|--|
| Descriptive project complexity. <i>One measure</i> of project complexity – the information on the complexity exists ‘out there’ independently of an observer. | Descriptive tools for the ex-ante assessment of the complexity of the given project ahead of the project start. | Framework for assessing the current project complexity throughout the project life cycle. | Projects as finalized objects, e.g. researching low-like relations – often across multiple projects. |
| Perceived project complexity. <i>Multiple (subjective) interpretations</i> of the complexity of a given project, because the complexity exists in the eyes of the beholders, i.e. project manager and project stakeholders. | The multiple forecasts of the dynamics of project complexity. | <i>The lived experience of the dynamics of project complexity.</i> | Multiple interpretations of the history of the given project. |

Table 1: Matrix of perspectives on project complexity (conceptual framing).

The focus of the present paper is to investigate “*The lived experience of the dynamics of project complexity*”, a topic positioned in Table 1.

4.1.3. Positioning research literature in the matrix of perspectives on project complexity

Table 2 displays samples of literature on project complexity positioned in the 3x2 matrix depicted in Table 1. The correct position of each paper can be debated and is used here only to give an illustration of the concept of the 3x2 matrix.

| | Ex-ante perspective | Transitional perspective | Ex-post perspective |
|---------------------------------|---|--|---|
| Descriptive project complexity. | (Gerald et al., 2011), (Bosch-Rekvelde et al., 2011), and (Kian, Sun, & Bosché, 2016) | (PMI, 2014) and (Zhu & Mostafavi, 2017) | (Nguyen, Nguyen, Le-Hoai, & Dang, 2015), (Qureshi & Kang, 2015), (Bjorvatn & Wald, 2018), and (Zaman, Jabbar, Nawaz, & Abbas, 2019) |
| Perceived project complexity. | (de Rezende & Blackwell, 2019) and (H. R. Maylor, Turner, & Murray-Webster, 2013) | (H. Maylor, Vidgen, & Carver, 2008), (H. Maylor & Turner, 2017), and (Ahern, Leavy, & Byrne, 2014) | (Davies, Dodgson, & Gann, 2016), (Florice, Michela, & Piperca, 2016), and (Davies & Mackenzie, 2014) |

Table 2: Examples of the research literature positioned in the matrix of perspectives on project complexity.

4.2. The lived experience of the dynamics of project complexity

In the eyes of a practitioner, the complexity is dealt with one decision at a time (Brockmann and Girmscheid 2007). The reverse can also be the case. To some extent, the complexity of a given project will be the result of project decisions. A lot of decisions are made from the first decision of initiation until the last decision of project closure (finish or not). As one example, a decision can be to downscale the project scope or divide the project into two separate projects. Here, the decision-maker has consequently changed the project complexity. Vice versa, the decision-making will be influenced by the current complexity of the project. Not only because complexity-driven unpredicted events force decisions, but also because decision-making will be done in face of high uncertainty due to complexity. From a practitioner's point of view, there is a double-sided cause and effect between complexity and decision making. The decision-making is done based on perceived complexity because this is what the project manager can deal with – according to Vidal and Marle (2008). The management of a given project perceives an unpredictable endeavor evolving through the influence of chance and multiple stakeholders. This perspective can be called the “lived experience of project complexity”, with inspiration from the statement that “Complexity is a subjective notion, reflecting the lived experience of the people involved” (Maylor, Turner et al. 2013). The lived experience of a project exists in-between the ex-ante and ex-post assessment of the project. This is coined as the transitional perspective and is, the perspective on the project as it evolves from initiation to closure. In practice, there might not be a formal assessment ex-ante nor ex-post, but the ‘lived experience’ exists anyway. Similar to the expression ‘the lived experience’, ex-ante perceived project complexity can be labelled “the expected project complexity” and the ex-post perceived project complexity can be labelled ‘the remembered project complexity’. All three expressions point to the subjective perception of project complexity.

4.2.1. Outside view on project complexity

Since the introduction of bounded rationality (Herbert A Simon, 1972), the impediments of human decision-making have been the subject of much research. Among this research, the concept of “delusional optimism” (Lovallo & Kahneman, 2003) is very relevant to the conceptual framing of a study of project complexity. Central to this concept is the difference between the inside view and the outside view. The outside view can prove vital to the current assessment of the project complexity of a given project based on the stakeholder's perspective.

The outside view (Lovallo & Kahneman, 2003) is a mainstay design principle in the artifact developed in this ADR project. The outside view is explained in the following paragraphs and in Figure 5.

Thinking in terms of ‘Bounded rationality’ (Herbert A Simon, 1972) was a disruptive concept, changing the research on decision making dramatically. In the years since, there have been many contributions to an understanding of the impediments of human decision-making, including work on delusional optimism (Lovallo & Kahneman, 2003). Delusional optimism is based on the inside-out view of decision-makers and can be countered by deploying an outside view of the project. Among others, Bent Flyvbjerg has argued for the relevance of delusional optimism in project management research, where “there is a strong case for the use of outside view in project management” (Bent Flyvbjerg, 2006b),

The outside view has inspired the development of an estimation technique called Reference Class Forecasting (RCF) (Bent Flyvbjerg, 2007; Bent Flyvbjerg, 2008). In essence, this technique estimates the cost and duration of a given project based on historical projects of the same class: “This technique

requires the decision-maker to obtain a reference class of past, comparable cases when making predictions about costs and benefits of a new project” (Bent Flyvbjerg, Garbuio, & Lovallo, 2009).

Research has documented that this technique provides more accurate estimates than does the use of inside-out techniques like the use of work-breakdown-structure and estimation of the resulting work packages. The concept of “outside view” requires the decision-maker to rely on external information instead of on the possible delusions from her/his inside view (Lovallo & Kahneman, 2003). The inside view gives rise to delusional optimism which is “the tendency to overemphasize projects’ potential benefits and underestimate likely costs, spinning success scenarios while ignoring the possibility of mistakes.”

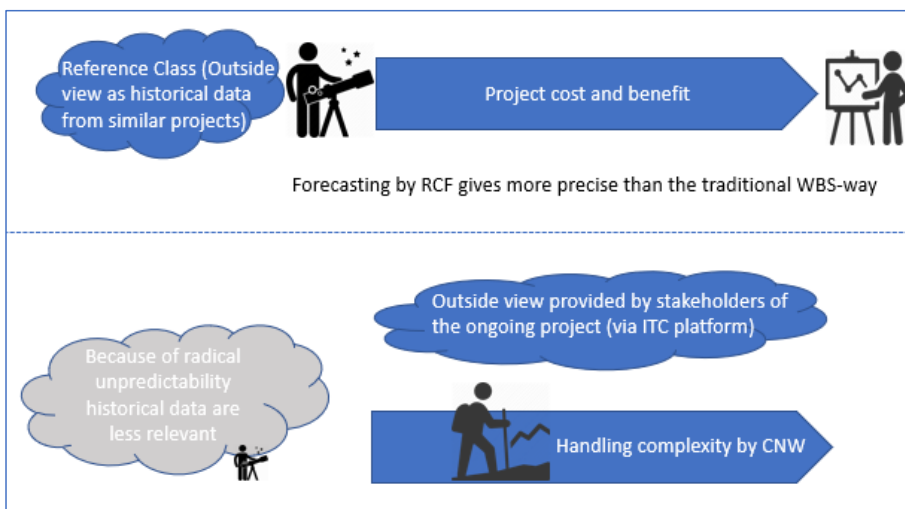


Figure 5: Illustration of the outside view deployed as RCF compared to the outside view deployed in the transitional perspective.

The purpose of the design depicted in Figure 5 was to help the practitioners overcoming the challenge of assessing the situation at hand, i.e. the current complexity of the project reported in (Mikkelsen et al., 2021). The primary design principle used here was “Outside view” (Lovallo & Kahneman, 2003). The reason for this design choice was the presumption, that a project manager would favor the Regulation strategy from CNW. In other words, the assumption was, that a project manager would perceive the project as an orderly system if his/her inside view was not challenged. While they in the workshop might give themselves the benefit of doubt and presume an aporetic view, they would in the real world fall back on the presumption of the project system being controllable by regulation.

5. Methodology

5.1. Action Design Research (ADR)

Action Design Research (ADR) is a branch of Design Science Research (DSR) often used in the research of Information Systems. DSR and ADR is seldom used in research of Project Management even though the methodology is suitable to the research topic.

The DSR methodology was popularized by Hevner, March, Park, and Ram (2004). The design-science paradigm has its roots in engineering and the sciences of the artificial (Herbert A Simon, 1996). DSR is fundamentally a problem-solving paradigm where the research is based on use of artifacts and design principles.

ADR used inspiration from Actions Research (AR) to diverge from DSR, but early on ADR was still seen as equal to DSR (Järvinen, 2007). However, the methodology found is unique form in a paper from Sein, Henfridsson, Purao, Rossi, and Lindgren (2011). Further clarification of the methodology can be found in (Chandra, Seidel, & Gregor, 2015) and (Mullarkey & Hevner, 2015). ADR comes in several forms, where PADRE (Haj-Bolouri, Bernhardsson, & Rossi, 2016) is an example with even more focus on the participatory element, but the process still resolve around central artifacts which the researchers brings to the table. However, the border between AR, ADR, DSR is not always clear (Collatto, Dresch, Lacerda, & Bentz, 2018).

In ADR the researchers work together with one or more clients both (1) to solve the clients' (or participating research practitioner's) problem, which motivates the client to participate in the research and provide access to their organization, and (2) to develop new knowledge. In the case of ADR, the new knowledge is about a new purposeful artifact and its utility for achieving its purpose. ADR has four activities and seven principles, as shown in Figure 6

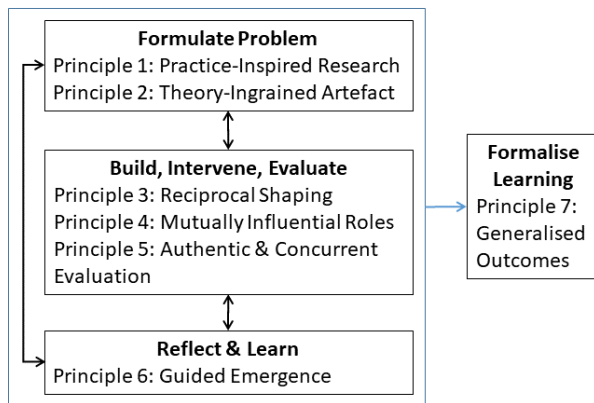


Figure 6: Action Design Research activities and principles based on (Sein et al., 2011)

Following ADR Principle 1, the research for this thesis 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 choice of organization was based on personal relation to the head of project management. Together with the head of project management, the CNW was selected as the starting point. (Principle 2). The CNW is explained in Figure 2 in the theoretical background. Section 4 explained the theoretical foundation for selecting the Outside view as design principle.

Similarly, ADR Principles 3, 4, and 5 guided the artifact design and evaluation process, with multiple Build, Intervene, Evaluate (BIE) cycles and reflection by the participants (both researchers and clients) to guide the artifact design through the BIE cycles. In practice, these cycles were conducted during and between the workshops described in a later section.

The CNW artefact was presented to the practitioners, the eight project managers. So was the concept of the outside view as design principle. The practitioners codeveloped in the implementation on an ITC platform called Benelizer ©, with could deploy questionnaire on smartphones to participating stakeholders (end-users) of projects of the project managers. The participatory element of the project managers was the design of questionnaire for ongoing stakeholder perception of the project. This design served as a bridge between the IT platform and the conceptual window for navigation the project complexity.

The plan was that all practitioners, should be end-users on the alpha version. However, as described in the coming section on finding, only two project managers deployed the system. A lot of effort went into persuading the remaining six project managers to deploy the system too. The role of the researchers was challenged by this extra burden. Meetings with individual project managers that was planned as structured interviews evaluation the benefit of the information system, was converted into coaching session trying to make the project managers follow through as agreed.

The loop involving principle 6 happened several times and informed the problem formulation further. The iteration came about in the evaluation became naturalistic as explained in the next paragraph.

5.2. The outcome of the ADR project

In ADR the evaluation is integrated into the process. The outcome is generalized learning, the fourth activity addressed by Sein et al. (2011). The evaluation, as we have seen in DSR, is in ADR a repetitive activity in the second stage, leading to reflection and learning in an ongoing cycle. The formalization of learning is the final stage. Sein et al. argue, "Generalization is challenging because of the highly situated nature of ADR outcomes that include organizational change along with the implementation of an IT artifact". The resulting ensemble is, by definition, a bundle of properties in different domains. This ensemble represents a solution that addresses a problem. Both can be generalized. We suggest three levels for this conceptual move: (1) generalization of the problem instance, (2) generalization of the solution instance, and (3) derivation of design principles from the design research outcomes" (Sein et al., 2011, p. 44). These three kinds of formalized learning (the fourth activity in ADR) will be addressed in the discussion.

DSR and ADR have different emphases on evaluation. DSR ends with a summative evaluation, where ADR focuses more on the wider concept of "Learning." Haj-Bolouri, Östlund, Rossi, and Svensson (2019) argue that "work-integrated learning can be seen as an outcome of using ADR in practice."

DSR is more objective, while ADR follows a more subjective paradigm. In the context of scholarly traditions, realism seeks the "truth" that exists out there (outside the mind), while interpretive research seeks to understand (since the truth does not exist outside the mind). In practice, there is a continuum between "realism" and "interpretivism." On this continuum, ADR falls more toward the interpretive end with a focus on learning in the organization rather than discovering the truth through a summative evaluation.

5.3. Limitation of the findings

An ADR project is in essence as case study, where an theory ingrained artifact is tried out on a practices inspired research question in BIE iterative process (see Figure 6). (Bent Flyvbjerg, 2006a)

has made a compelling argument for the use of case studies in research. The argument from Flyvbjerg was criticized by Ruddin (2006). The disagreement seems to be based on terms rather than substance. Flyvbjerg's argument is based on the falsification utility of cases and the demonstration power (the case is possible/existing in real-world), and the demonstration power, in particular connected to learning. Flyvbjerg (2006) focuses mainly on falsification and demonstration as the prime utility of single-case research. Further Flyvbjerg (2006) argues that generalization can be done only if the case is carefully selected – A prerequisite that does not apply for the client organization nor the selected projects using the information system.

To assess the quality of findings, the framework from H. Maylor, Blackmon, and Huemann (2016) is helpful. The parameters of the framework are validity, credibility, reliability, and generalizability (H. Maylor et al., 2016, p. 374). The validity of this study is high because the findings very much reflect the reality being investigated. The findings are well-grounded, giving them high credibility. Reliability indicates whether the results can be repeated. Because case studies cannot be repeated under the same circumstances, the question of reliability and replicability remains open. The same problem also affects the generalizability of the work.

6. Findings

Atkins Denmark accepted the role of the recipient organization in the ADR project. The department head of project management was the client representative and selected eight project managers who reported to him as participants in the ADR project. A series of workshops facilitated the co-design of the questionnaire used for projects. The prototype was ready for deployment in early spring 2019. The task of the project managers was to initiate the evaluation by providing a list of stakeholders with e-mail addresses. The researchers and the ICT platform handled the rest of the process. By the end of 2019 the situation was as follows:

| Number of PMs | Type of result | Description |
|---------------|------------------------|---|
| 1 | Resignation. | One of the project managers resigned from his job before he started to initiate the evaluation. |
| 1 | Re-allocation. | One manager was reallocated to work on a larger project with responsibility for a sub-project. She promoted the system in the new setting. However, the project director of the project did not want to have the sub-project participate in the research, so the project manager refrained from further activity. |
| 1 | Change of heart. | One project manager asked to be excused because he no longer wanted to participate, without giving a specific reason for the decision. |
| 3 | Continues prolongment. | Three of the project managers had the opportunity to deploy on their respective projects. Did return a list of stakeholder's e-mails needed to configure the system. The project managers were repeatedly reminded. When prompted for explanations, the reasons given were: "I need to re-design the general questions"; "It is too early in the project"; "I haven't had time to do the requested list"; "The project is too busy right now, later is better"; "We have issues with the client that needs to be resolved before the system can be deployed." When asked if they wanted to participate, the answers from all three were positive. |
| 2 | Successful evaluation. | Only two project managers followed through and handed in the list of stakeholders on their respective projects to configure and deploy the ICT artifact. Both successful implementations were conducted in the autumn of 2019, more than half a year after the initiation. |

Table 3: Evaluation results of the eight involved project managers

The two project managers who deployed the prototype were interviewed. Both gave a very positive evaluation of the system and the affordance in terms of early identification of troubles with stakeholders, both on the team and at the client's organization. See Project A and Project B below.

Project A:

The evaluation ran from September 2019 until May 2020. For the first three months, the response rate was 100% but fell thereafter to the lowest rate of 54% at the end of the project. Throughout, the customer gave the highest average ratings on the survey. Anticipation of this may be a motivation for the project manager to initiate the deployment of the system. Interestingly, the second-highest rating came from the project manager. This finding corresponds well with the concept of "delusional success". The project was very well managed with a keen eye on the stakeholders. Therefore, even though the information system was praised as useful, it is questionable whether the claimed managerial benefits of the system were real in this case. Project A might have been equally successful without the use of the developed information system.

Project B:

The evaluation of Project B ran from October 2019 to September 2020, much longer than that of Project A. Ten participants were included in the evaluation of the information system. The response rate was 100% for two months and then varied in a range between 44% and 87% (lowest during summer and Christmas holidays). In Project B, the client initially agreed to participate but then later declined. Their explanation for turning around and not participating was elusive. According to the project manager, their change of heart was due to some initial troubles in the project, and their political/tactical thinking was not to get too involved and have a clear position for later criticism. In spring 2020, the project manager was under pressure because of complaints from customers and did not focus on the system. However, the users kept replying to the surveys coming from the system. One might think that users would stop responding when they no longer saw project manager engagement, but not in this case. In the summative evaluation, users rated the benefits of the system very low because of the lack of project manager engagement.

In August, the project manager was replaced at the request of the client. At first, the organization fought this decision but eventually gave in. In the final interview with the project manager, when he saw the data in the system, he was surprised. The ratings from the most senior executive among the participating stakeholders of his organization had been steadily declining in the period when the project manager did not monitor the data coming into the system. This information, he found, could have changed the course of events in the internal struggle about the replacement of the project manager. The system succeeded in given an early warning, but the project manager failed to retrieve them. In project B, the project manager received the highest rating throughout the evaluation of the system, even during the period of trouble with the client, again confirming "delusional optimism."

Screenshots from the information system during this period is shown in appendix. The case story seen in the perspective of the CNW goes as follows: The project manager in the case story were busy working in plannable quadrant. The information system indicated that he should have used more time in the political quadrant. Unfortunately, the project manager realized this to late ... and was replaced. A sad story for the project manager - But a good demonstration of the potential benefits of an outside view information system.

6.1. Concluding on findings of the ADR project

Of the eight participating project managers in the ADR project, only two actualized the developed system. In the eyes of the researcher, one of the two did not really benefit for the system, although the

project manager reported to do so. The other project manager could have benefitted very much for the affordance provided by the system but failed to do so. The second case, explained in the window for navigating complexity (see Figure 2) is a case of a project manager being too occupied with the work in the Regulation domain, where the system indicated that attentions should have been given to the Divergence domain. This is where the project manager failed the overall task of navigating the project complexity. The above serves as demonstration of how an information system can give affordance for project complexity management.

Gregory (Scotland Yard detective): "Is there any other point to which you would wish to draw my attention?". Holmes: "To the curious incident of the dog in the night-time."

Gregory: "The dog did nothing in the night-time." Holmes: "That was the curious incident."

On this quote of Sir Arthur Conan Doyle, a perhaps more important emerging learning of this ADR's project, is curious reluctance among the participating project managers. As conveyed in Table 3, did six of eight project managers not actualized affordance of the information system they had used time and energy to co-develop. Of the six only two had 'legitimate' reasons for not actualizing. This finding is discussed in more detail in the following section.

7. Discussion

The prototype developed in the ADR project is an example of "IT-enabled project complexity management." The implemented information system gives affordance to project managers in navigating the complexity based on the outside view of a given project provided by stakeholders. The design is an important contribution, not only to the practitioners who reap the benefits but also to researchers looking for new ways of researching project complexity. An additional contribution is the utilization of ADR for researching specific project complexity and the use of ADR in the research of project complexity in general.

The preliminary findings of the empirically-based evaluation indicate that the developed artifact can be useful. The developed artifact demonstrated positive potential in the two projects where the system was evaluated. The artifact would probably not have been of the same quality if the design process had been done solely by the researchers of the project.

7.1. The benefit of the information system

During the ADR project, there was reluctance to deploy the information system among the project managers, only two of the eight project managers conducted summative evaluations of the information system, which is discussed later in this section. However, the relevance reported by these two project managers made the client organization realize the potential of an information system like this one and it went on to scale up the implementation. The development of a functional prototype of an information system giving affordance to project managers for navigating project complexity has demonstrated that the ADR methodology is usable in a research endeavour of this kind. The ADR project has highlighted conservatism among project managers when it comes to the use of information systems that include stakeholders, a topic that needs much more research. More generally, this case study has demonstrated that tackling a "real-world problem" is a complex endeavour with many agendas. Based on the previously given definition of project complexity, where the focus is on the managerial challenges, the affordance of the information system for navigating the project complexity can be formulated as the answer to the following question: Who is perceiving a current managerial challenge based on indicators of project complexity? The cornerstones of the information system is that the project complexity is a subjective perception of the stakeholder – not a truth about the project. Perceptions of the project complexity and probability of success are likely to change over time. To

understand the complexity of a given project the manager needs to be in constant dialog with stakeholders. Stakeholders will have different notions about project complexity influence by their project role and other aspects, hence the information system needs to collect information from many. Since the project manager cannot talk to all stakeholder all the time, the information systems need to point to the stakeholder who the project manager most needs to talk at the moment. Managerial challenges deriving from the complexity of the given project can have many indicators. The question relevant for the assessment of the current project complexity will change over the project life cycle.

7.2. The surprising reluctance among project managers

An interesting finding concerns the many project managers who refrained from using the system. The group that expressed enthusiasm but failed to implement the project presents an indication of resistance to change. In retrospect, it would have been interesting to evaluate further the commitment among the project managers. The reluctance among project managers did influence the ADR process much, because the researcher did slide into a role of being the agent of change rather than having a “cleaner” role in the process.

Based on the findings one can only speculate on the genuineness of the expressed motivation. There might have been a hidden agenda of looking like a proactive project manager in the eyes of the manager of project managers while at the same time there was no real interest in participating. Another explanation is that some had a real motivation but also conflicting feelings, like the threat of being exposed in the evaluation. Finally, the explanations given might have merits, hence there would have participated given other circumstances in their workload and conditions for the project. The topic “Resistance to change” has been investigated using AR (Erwin and Garman 2010), for example. There are fewer examples of the use of ADR to investigate “resistance to change,” one example being (Knoesen and Seymour 2016). Another might be the technology acceptance model used by (Davis 1985, Lee, Kozar et al. 2003). However, no papers addressing “resistance to change” as a part of an AR or ADR project. Contemplating the topic, it seems only natural that planned “actions” in AR and ADR will produce some negative and/or fearful reactions to the proposed new and unfamiliar tasks the participants are expected to carry out as part of the research project. One driver of the resistance to change among project managers might be a misperception of the affordance of the information system. Sometimes, project managers in workshops and interviews referred to the data in the system as a satisfaction measure. While researchers often corrected these references to a system for measuring and navigating complexity, the thinking of the project managers might not have changed accordingly. In retrospect, the affordance should have been labelled “early detection.” This affordance-labelling would have provided much better stickiness and may have corrected the misperceived affordance of “satisfaction-measure.”

7.3. Stakeholders appreciating the opportunity of giving feedback

Another interesting observation is the high response rates of the stakeholders using the system. Before the evaluation, the project managers and researchers expected the response rate to be a problem. According to the technology acceptance model, users might have needed an acceptance process before the use of the system. The 100% response rate in the first months of the evaluation period indicates that users understood and appreciated the affordance in form of influence on the project managers and other decision-makers in the projects.

7.4. The contribution in context of research

Following the call for research for developing methods and tools for the measurement and management of project complexity, in tight correlation and with direct impact in the industry, this paper reports on engaged scholarship to develop IT-enabled management of project complexity. The design principle was an “outside view” from the project stakeholders in the form of the “wisdom of

crowds” for navigating the complexity of projects. The evaluation indicates a promising future development of the artifact. Special attention should be given to the resistance to change among the participants in the cocreation of knowledge. There is also a need for more research to investigate the consequent impediments for Action Design Research in this context. Activity 4 in an ADR project (see Figure 18) is formalizing the learnings from the project. In practice, the researcher often conducts formalized learning in an ADR project separate from the collaborating organization (Mettler 2018). This common practice is also seen in this ADR project. It can be very difficult to convey all the lessons of such a project in text because the unstated knowledge gained in an ADR project is often extensive, both for the researcher and the collaborating participants. In retrospect, the research conducted for this project was based on the assumption that when you develop an information system, which the intended beneficiaries find relevant, they will apply and try out the system. In hindsight, this assumption seems almost naïve. Much thought focused on the question of whether the information providers (the stakeholders of the project) would use the system. If not, how could this challenge be addressed? It turned out that the majority of the stakeholders used the system without the need for persuasion of any kind. In other words, the researcher expected resistance to change when implementing the information system but was fundamentally mistaken about who would resist change.

7.5. Methodological reflections on the use of Action Design Research

The research project took on an experiment about how to handle project complexity via an information system, but the findings turned out to be more useful for answering another question: What information do project managers and decision-makers believe is needed to handle when managing project complexity? Sein, Henfridsson et al. (2011) suggest formalized learning to generalize the problem instance and the solution instance as well as for the derivation of design principles. The problem of “handling complexity” can be generalized to a problem of low rates of project success in general – or to be more precise the assumption that projects could be more successful than they are. The management of the case organization may have the generalized problem perspective. The solution instance can be generalized to obtain an outside view, not only to handle project complexity but also to improve project success rates in general. Research on critical success factors (CSF) may need to be revisited in the light of this project, and the discussion section will address CSF specifically. This project made use of the concept of outside view (Kahneman 2011) as the primary design principle. The trial demonstrated the high relevance of this design principle to project complexity management. Given the findings reported previously in the section, the outside view as a design principle is relevant for project management of complexity. Of course, a project manager should have an optimistic approach to the project, otherwise leading it might prove difficult, however, when assessing the project complexity and probability of success, the project manager should avoid delusional optimism, with a concept like the outside view can provide. The ADR methodology itself can be a useful design principle for solving complex problems in project management. This case study has demonstrated that affordance theory is a good supplement to ADR. As depicted in Figure 9, Pozzi, Pigni et al. (2014) recommended the use of perceived affordance as a temporal causal construct before affordance actualization. This case study verified that focusing on the recognition process is important. Its findings indicate the importance of looking out for misperceived affordance as this misunderstanding reduces the actualization of affordances. This case study revealed that collaborators in ADR may have hidden resistance to change. The inference of this case study is that ADR needs to be viewed through the lens of the theory of Organizational Change

7.6. Complexity or critical success factors?

A final reflection on the use of ADR might be the focus creep that can emerge when engaging the practitioners in a co-design and evaluation process. Did the practitioner focus more on “critical success factors”? The project aimed to investigate the navigation of complexity in the pursuit of

project success. Looking back, the researcher may have had a different focus from that of the practitioners. The researcher focused on project complexity, while the practitioners might have focused more on the opportunities for increasing project success. Especially the executive from the participating organization focused most on project success rather than investigating project complexity. One indication of this difference was the sort of questions the practitioner wanted to pose. Were they focused more on the prerequisite of success, rather than monitoring complexity? While the two are very similar, there are subtle differences. Upon reflection, complexity might not pose a problem as such for the practitioner; the real problem is the low rate of success compared to the potential rate of success for the projects. The complexity makes it difficult to realize the potential success of a given project. This difficulty might explain why the practitioner procrastinated in the initiation of the prototype because “stakeholders are not satisfied yet.” The hidden agenda here might be that they would rather preserve the illusion of success than getting a “good grip” on the complexity of the project. There is a subject within project management research called Critical Success factors, (CSF) (Belassi and Tukul 1996) which is dedicated to finding the prerequisites for project success. The subject has not received much attention in recent years. In practice, there might be a large overlap between the two separated research streams of project complexity and of CSF. If the ADR project of this thesis had not focused on complexity at the outset, it might instead have used CSF to build a theory-ingrained artifact and the resulting information system might very well have been quite similar. The research questions took the research down the path of examining the research literature on project complexity to design an information system that aided the management of the project, including the decision making. This approach seemed to be natural and straightforward. Early on it became clear that project success is a very large concept and required more literature research. However, it did not become clear that a related topic might have been even more useful as a foundation for the design of the information system. Taking a fresh perspective on the information system deployed – without thinking about what the research tried to achieve by deploying and evaluating this system – one might conclude that the research is about critical success factors. An interesting thought experiment is what would have been the result if the ADR project had taken CSF rather than project complexity as its focus at the outset. What would have been the differences in the prototype? Regardless of whether the research subject was CSF or complexity, the element of having a current outside view on the project is an important design principle for “IT-enabled project management,” on which much more research is needed, and ADR is a relevant methodology for this research

8. Conclusions and perspectives for further research

Using Action Design Research (ADR) the paper asked the following research questions: How can an information system be developed to provide affordance for project complexity management in collaboration with practitioners? The ADR project identified an artifact labelled the Complexity Navigation Window as usable for the investigation. Evaluation on workshops indicated high relevance but also user difficulty in determining which quadrant best depicted the current state of the project. The ADR project presumed that stakeholders might provide a beneficially outside view as a supplement to the project managers inside view, which might be biased according to the ‘delusional optimism’ (Lovallo and Kahneman 2003). The ADR project was set up in a collaboration with eight project managers from the recipient organization. In this collaboration, the CNW was implemented based on questionnaire developed by the ADR project. The developed information system gives affordance to navigate the perceived project complexity. The chief design principle has been the outside view. (Lovallo and Kahneman 2003). Setting up the information system for the given project, the selection of the stakeholders sourcing the outside view should be based on the stakeholder landscape keeping in mind, that the role of the stakeholder will influence their perceived project

complexity The findings indicate the information systems like this can provide navigational affordance when dealing with complexity. The outside view provided by stakeholders is a useful design principle. Further, the findings indicated that project managers suffer from delusional optimism when assessing the project complexity and probability of project success. In addition, the findings have highlighted resistance to change among project managers towards such an information system even though being a part of the ADR project developing it. Using ADR for the investigation of information systems for project management proved effective. In particular, having a theory ingrained designed artifact to foster the collaboration seem useful in an otherwise fluffy process of handling complexity in real projects. The practitioners help to keep the research focused on real-world problems. However, the collaboration also influences the research to move in unintended directions. In the given case study, the result might have move focus on the pursuit of project success than the assessment of the perceived complexity in a transitional perspective.

Based on the research following themes of future research are welcomed: Recommended future research to further the understanding of IT-enabled complexity management, the following future research is recommended:

- i) The framework for early detection in the navigation of complexity needs further development.
- ii) Summative evaluation of the information system using the outside view needs to be conducted in more organizations and sectors.
- iii) The potential of affordance as a portfolio decision-making information system needs investigation.

The methodology of ADR seems to have good potential as a research methodology in project management, but further research is needed to exemplify the benefits and pitfalls. Integration of ADR and Affordance Theory. ADR is the process of the research, where AT is the process of the artifact. The two theories might be integrated on a conceptual level in future research. The topic of "misperceptions" of the intended affordances needs further investigation and might lead to further development of Affordance Theory. Lastly, there is potential for cross-fertilization between ADR and the theory of organizational change and related topics

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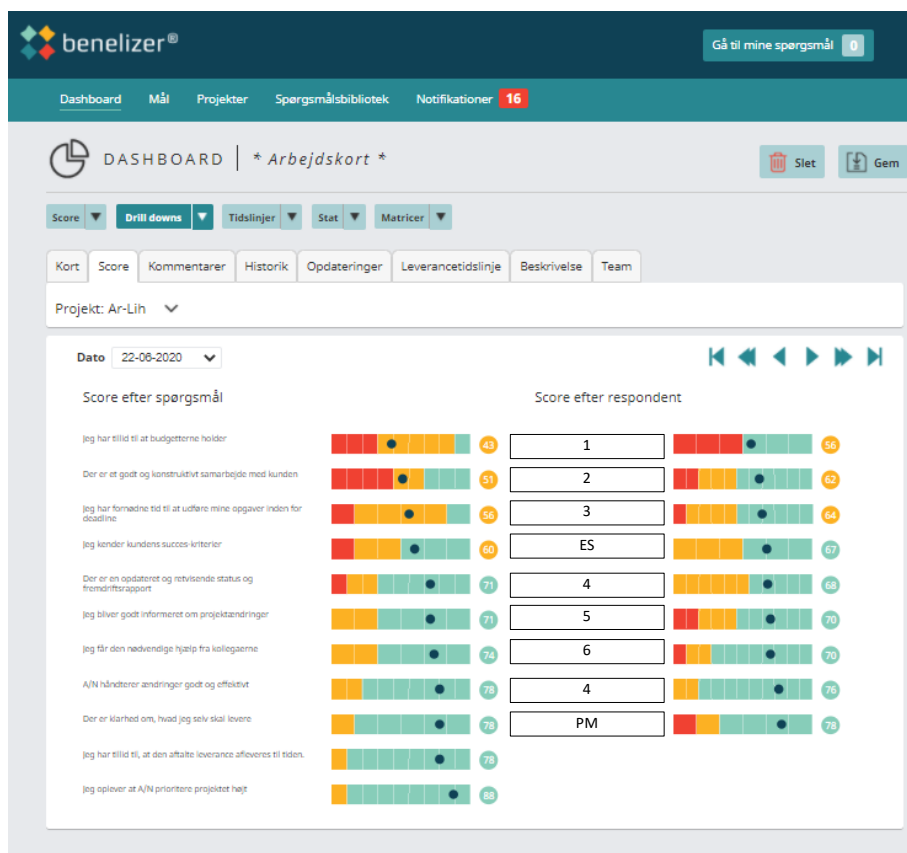
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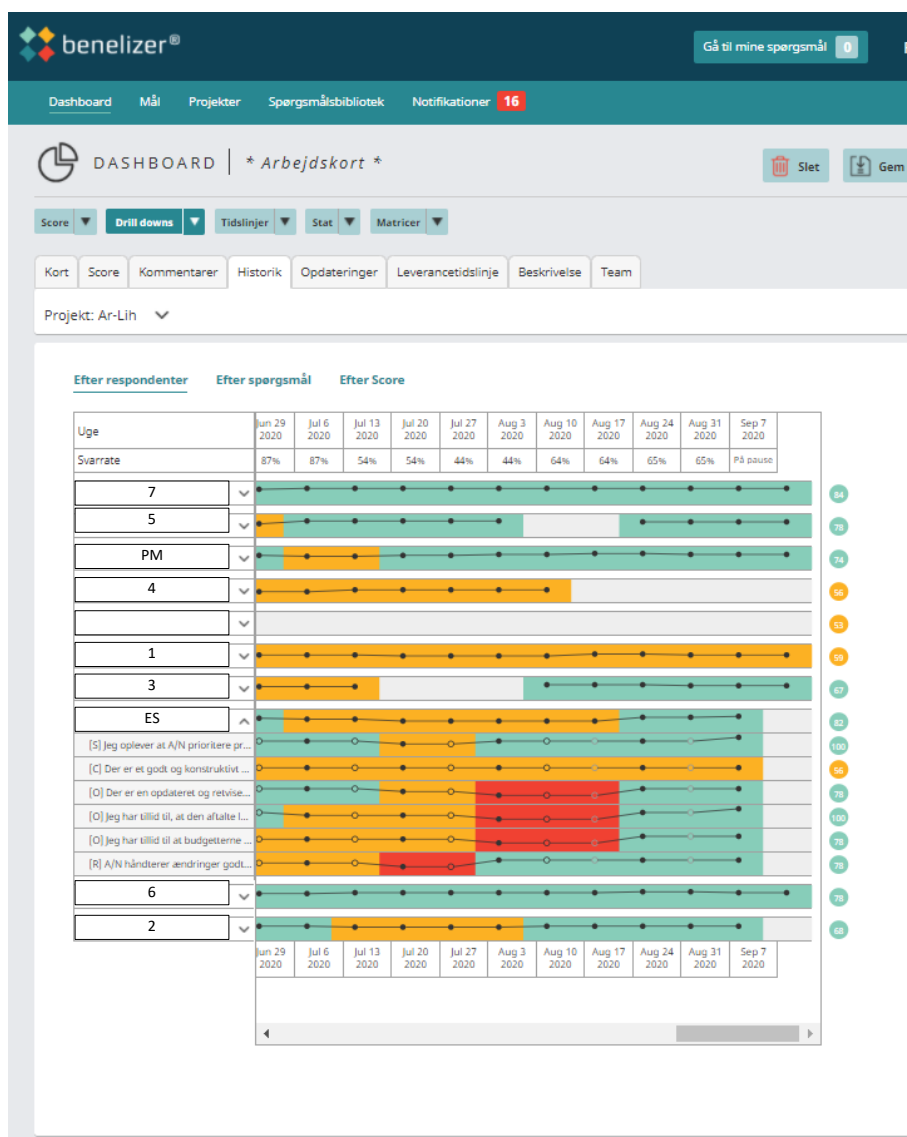
Appendix: Implementation in Benelizer – Questions/respondents

One of the drill-down options in the IT platform shows the score at a given time. Here the results are divided into posted questions and among all the respondents. The black dot is the average, and the red/amber/green bars show the variation. This drill-down indicates the disagreement among the project stakeholders. Project Manager = PM. Executive stakeholder = ES. Other stakeholders labeled 1, 2, 3 etc



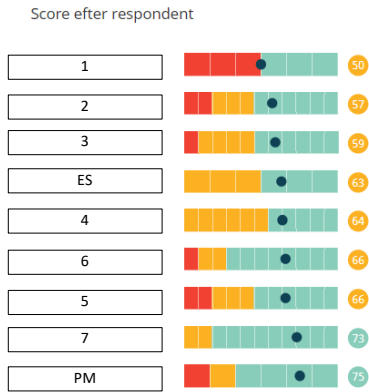
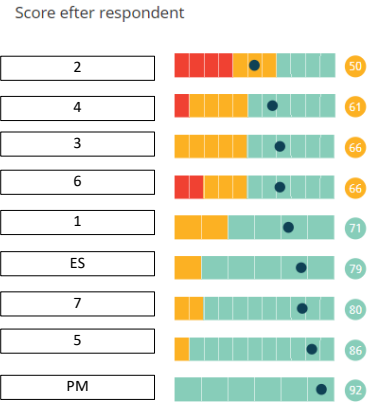
Implementation in Benelizer – Historic view of responses

The historical drill-down in the IT platform shows the rating from each stakeholder in each time-period (Weeks). The executive is here displayed to show the specific ratings on each question posed to that stakeholder. If the project manager had followed the monitoring of stakeholders' opinions during July 2020, he would have received an early warning on what was coming and might have been able to prevent his replacement as the project manager in late August 2020.

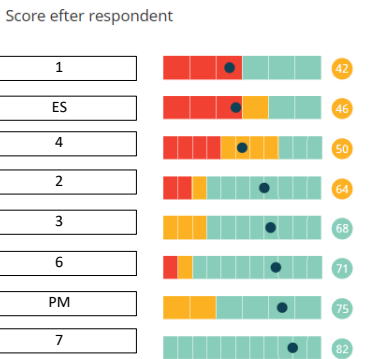


Implementation in Benelizer – Stakeholder response on four different dates

25th of November 2019:



10th of August 2020 (under the storm)



9th of September 2020 (after the storm)

