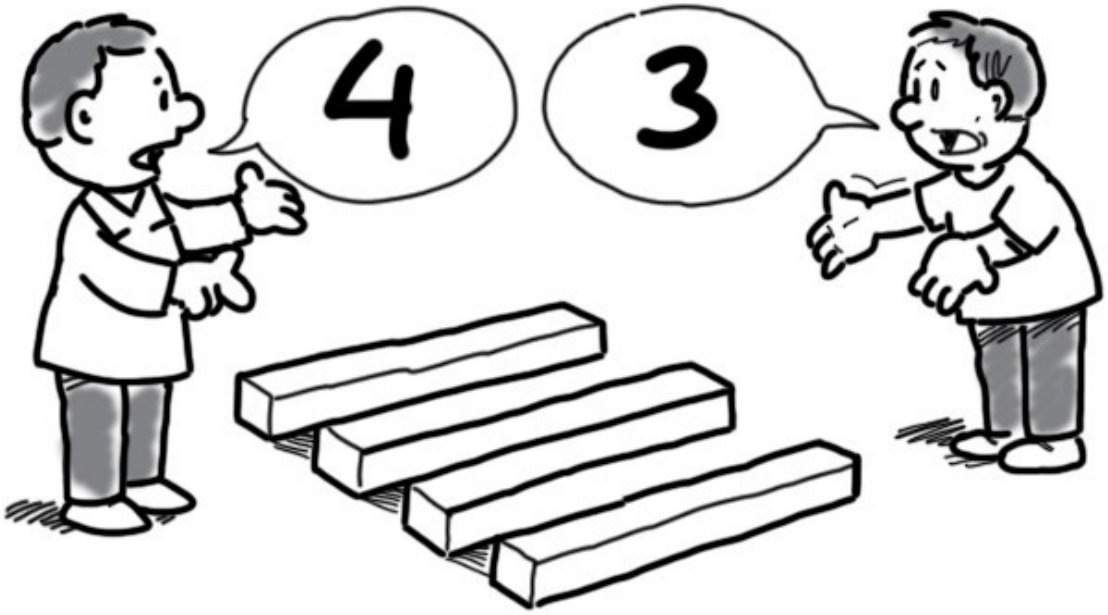
Ph.D. thesis:

Navigating complexity in pursuit of project success

Mogens Frank Mikkelsen, IT University of Copenhagen, November 16th, 2021



Preface

Summaries in Danish and English

The research project “Navigating project complexity in the pursuit of success” was conducted with Engaged Scholarship with Action Design Research as the chosen methodology. As part of the research a questionnaire was sent to practitioners of project management. More than 1,000 practitioners responded, making this study a unique survey of project complexity. The survey explored perceived project complexity. Through a series of workshops with practitioners, the project developed the “Complexity Navigation Window” artifact. A co-design process with project managers from Atkins Denmark implemented this artifact as an information system using the concept ‘outside view’ as a design principle. The contributions of this study include insights from the “IT-enabled project complexity management” case study.

Danish summary

Forskningsprojektet “Navigation af kompleksitet med projekt succes for øje” er udført som ”Engaged Scholarship” med Action Design Research som forskningsmetode. Indledningsvis blev en spørgeskemaundersøgelse blandt praktikere af projektledelse udført. Mere en 1000 deltog, hvilket gjorde den til en unik undersøgelse af projektkompleksitet. Undersøgelse blev brug til at forske i den opfattede projektkompleksitet. På en række workshops medvirkede projektledere med udvikling af værktøjet ”Kompleksitets navigations vindue”. Dette værktøj blev implementeret som et informationssystem baseret på ’Outside view’ som et design princip i en co-design-proces med projektledere fra Atkins Danmark. Forskningsbidraget er indsigter fra et casestudie af IT understøttet projektkompleksitetsledelse sammen med et forslag til teori for projektkompleksitetsledelse.

Author biography

Given that this is an engaged scholarship research project, my background is relevant to the readers of this cappa. Therefore, an author biography is included here. In 1990, I finished my Master of Science at the Danish Technical University. Almost three decades elapsed before I embarked on this Ph.D. study of project complexity. In those intervening years, I was a practitioner of project management for many years, mostly in IT companies. I then spent many years working as an instructor and leadership facilitator. After authoring a handbook for practitioners on project complexity, I felt the need to go deeper into the subject. Studying as a Ph.D. student at IT University, the research questions naturally took shape in the Information Systems (IS) field. As a freshman in research, I thought that the research on Project Management (PM) and that on IS had interacted and informed each other. However, a gulf exists between research in PM and in IS, leading to many troubles and heartbreaks along the road to getting published. Getting papers accepted has been a very interesting journey of its own. Looking back, this part of my endeavor entailed more “aha” moments about researching than about the subject itself.

Structure of the Ph.D. thesis

This Ph.D. thesis is written as a collection of published papers. According to the Ph.D. board of the IT University of Copenhagen, the thesis should include the following elements:

1. Summaries in Danish and English.
2. Abstract suitable for publication in article databases.
3. Stated and clear research objectives.
4. Description of the research project in the context of the international state-of-the-art within the specific subject area.
5. Summary of the results of the papers and their relation to the international state-of-the-art.
6. A critical discussion of the work of other researchers in the field, as well as a comparison between their findings, such that the student's work is seen in the context of the relevant ongoing work in the specific area studied.
7. Conclusions and perspectives for further research.
8. Citations and References.
9. The published papers or accepted manuscripts.

To fulfil the purpose of the thesis, this project was conducted as an engaged scholarship (Van de Ven, 2007). The research design took a structured approach based on (Checkland, 1991); based on this work Mathiassen (2017) proposed a more elaborate version, where contributions from the research are included.

Figure 1 shows the logical flow of the six elements of the research design, while Table 1 elaborates on the elements that are part of the structure of an engaged scholarship study.

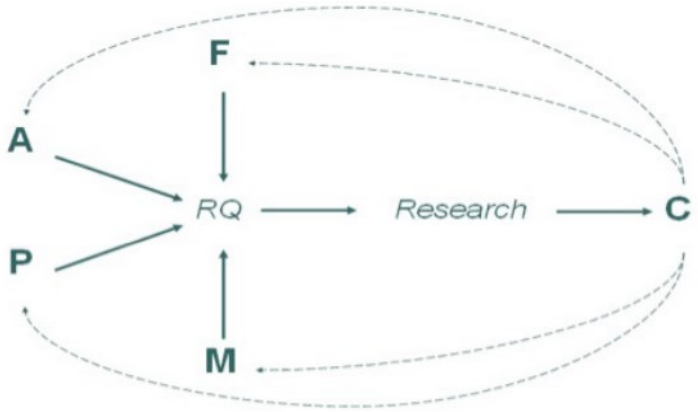


Figure 1: A generic structure of an engaged scholarship study. Copied from (Mathiassen, 2017).

P	The problem setting represents people's concerns in a real-world problematic situation.
A	The area of concern represents some body of knowledge in the literature that relates to P.
F	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.
M	The method details the approach to empirical inquiry, specifically data collection and analysis.
RQ	The research question relates to P, opens the way for research into A, and helps ensure the research design is coherent and consistent.
C	Contributions influence P and A, and possibly also F and M.

Table 1. Structure of an engaged scholarship study. Copied from (Mathiassen, 2017) with the permission of the author.

The cappa is structured based on the recommendations depicted in table 2. After the introduction, a short summary of the results of the papers and their relation to each other will follow. Elaborate summaries are presented in the result section. The full-length papers are attached to this cappa as appendices.

Generic Structure for Engaged Scholarship Publication

Section	Definition
Title	Express the essence of the research with emphasis on contribution (C).
Abstract	Provide the basic argument based on problematic situation (P), area of concern (A), conceptual framing (F), research method (M), and C.
Introduction	Introduce A and the motivation for the study. Introduce P, F, and M as appropriate for addressing the RQ. State principal results by making clear how C contributes to P and A.
Background	Present a review of extant literature on A. Substantiate the motivation for the study by evaluating what we know and don't know about A. ***Construct and articulate the opportunity to make a contribution*** and substantiate the choice of the RQ.
Framing	Introduce and argue for an existing, revised, or developed F (FA and F_I) as a means for structuring and supporting data collection and analysis.
Methods	Describe and argue for M. Introduce P to provide context for analysis. Detail and argue for approach to data collection and analysis to respond to RQ.
Results	Present results of data analysis based on F, following M, and to help answer RQ. Focus on appropriate structuring of analysis and use tables and graphs. ***Establish empirical foundation to make contribution.***
Discussion	***Explain and argue for contribution*** to P (C_P) and A (C_A) as response to RQ, based on results and background literature. Don't just repeat results. Discuss relationships to literature, explain conclusions with evidence for each conclusion, provide alternative explanations, and state theoretical and practical implications.

Table 2: Generic structure of an Engaged Scholarship Publication.

Table of contents

1. Abstract 7
2. Introduction 8
   2.1. Calls for research 8
   2.2. The problem 8
   2.3. Area of concern 12
   2.4. Conceptual framing – dependent on the area of concern 12
      2.4.1. Rethinking Project Management 12
      2.4.2. Development of chronological perspective as a framing concept 14
   2.5. Conceptual framing – independent of the area of concern. 14
   2.6. Method 15
   2.7. Research question 15
   2.8. Contributions 15
3. Background/Literature review 19
   3.1. Common definitions of Project Complexity 19
   3.2. The early research on Project Complexity 19
   3.3. A spark from Rethinking Project Management in 2006 20
   3.4. The post-RPM era of project complexity 21
   3.5. System of the system perspective in project complexity 23
   3.6. Types of theory in research on project complexity 24
   3.7. Complexity related literature review 25
4. Conceptual framing 26
   4.1. Conceptual framing *dependent* on the area of concern 26
      4.1.1. Perceived versus descriptive project complexity 26
      4.1.2. Chronological perspectives on project complexity 27
      4.1.3. Matrix of perspectives on project complexity 32
      4.1.4. Positioning research literature in the matrix of perspectives on project complexity 32
      4.1.5. Levels of descriptive project complexity 34
   4.2. Conceptual framing *independent* of the area of concern 35
      4.2.1. Affordance theory 35
      4.2.2. Cynefin framework 36
      4.2.3. Concepts of project success 38
      4.2.4. Stakeholder landscape 39
      4.2.5. Outside view 41
5. Methodology 45
   5.1. A questionnaire among practitioners 45

5.2. Design Science Research (DSR) 45
5.3. Evaluation in DSR 46
5.4. Changing from DSR to ADR 48
5.5. Action Design Research (ADR) 48
5.6. The outcome of the ADR project 49
6. Results 50
6.1. Getting a grip on the project complexity research literature 50
6.2. Results from the questionnaire 52
6.3. Designing an artifact for navigation 54
6.4. Implementation of CNW in an information system 55
6.5. Evaluation of the prototype 56
6.6. Formalized learnings 57
6.7. The troubled child 59
7. Discussion 61
7.1. RQ1: What kind of information is needed for handling project complexity 61
7.1.1. RQ1a: What is project complexity according to the research literature? 62
7.1.2. RQ1b: How do the practitioners perceive project complexity? 62
7.2. RQ2: How can an information system be developed to provide affordance for project complexity management? 64
7.3. What is project complexity management? 64
7.4. How can an information system be developed 65
7.5. Contextualizing the work in the project complexity research 66
7.5.1. Positivistic modeling 66
7.5.2. Complexity theory 67
7.5.3. Ontological framework 68
7.5.4. Managerial framework 68
7.5.5. Emancipative investigation 69
7.5.6. Summing up the contextualization of the study 69
7.6. ADR methodology for research on project complexity and project management 69
8. Conclusions and perspectives for further research 72
8.1. Recommended future research 73
9. References 74
10. Appendices 82
11. Included papers 90

1. Abstract

The ability to handle project complexity is increasingly important in project management. There has been much research on project complexity over the last two decades. The body of knowledge is overwhelming and the literature review identified five different ideal types of research on project complexity. Despite calls for additional research helping practitioners, only a few scholars have taken on the challenge of developing prescriptive knowledge of project complexity management. The majority of project management research is descriptive and takes a post-mortem approach to projects, while practitioners instead use an ex-ante approach to project complexity. The ex-ante approach is rare in the research literature. Of the found literature, all deployed an inside view, where the project is seen from the perspective of the management. The current study investigated the perceived project complexity and engagement of the stakeholder to provide an outside view as supplemental information for the navigation of project complexity. A challenge like this requires the involvement of practitioners; therefore this project was conducted as engaged scholarship using the methodology of Action Design Research (ADR). ADR is an intermediate research approach that stands between Action Research and Design Science Research. As a starting point for the ADR project, a large Danish-language survey was conducted to investigate the perceived complexity of projects. One important finding is that the perception of project complexity seems to be influenced by the perceiver's role in the project. This is a novel insight in the research of project complexity. One inference derived from this finding is that multiple stakeholders need to give input in order to assess the complexity of a given project and to obtain a comprehensive view of the perceived project complexity. Secondly, this insight questions the importance of finding the right dimensions (and weights) of project complexity when the aim is to help the practitioner. Adding to this, this insight has been used as a design principle for an information system providing affordance to the management of project complexity.

During workshops with project managers, the research developed a dashboard for the navigation of project complexity, called the "Complexity Navigation Window" (CNW). The CNW was implemented as a prototype of a Decision Support System (DSS) on an existing IT platform to support the project manager in navigating project complexity. The chief design principle was the concept of an 'outside view' on projects as a supplement to the 'inside view' that project management of is often limited to. The DSS was co-designed, implemented, and evaluated in a large Danish recipient organization. The evaluation of the information system indicates that the developed information system is relevant for project managers. The main affordance is the provision of early warnings of unpredictable events deriving from complexity. The findings also indicate the presence of delusional optimism among the project managers in the assessment of project complexity, hence demonstrating the importance of having an outside view of the project. The participating stakeholders were more enthusiastic than expected; however, the research findings indicated surprisingly high resistance to change among the project managers, even though they had participated in co-designing the artifact. Only one in four actualized the affordance of the information systems. After the evaluation of the developed DSS, the recipient organization decided to scale up its use. This decision is a good indication of the success of the ADR project.

More research is needed to examine the affordance of the designed information system in more detail. Further, it is recommended to investigate the potential cross-fertilization of ADR and theories on organizational change. The project also theorized the lived experience of project complexity. This theory also provides many opportunities for additional research as it is far from fully developed.

2. Introduction

The introduction presents the problem by first addressing calls for research. Following this is a section presenting an argumentation for real-world problematic situation. This is a prerequisite for the engaged scholarship according to table 1. Then follows the presentation of the area of concern, the conceptual framing used for this cappa, and the methodology used in the work. The section concludes with the research question along with a principal consideration of how the contribution may help advance research.

2.1. Calls for research

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 argue 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). Review of the research literature indicate that a few researchers have responded to this call for practical research of project complexity.

One of the papers which takes a practical approach investigated the "understand – reduce – respond approach" (H. Maylor & 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 & Blackwell, 2019, p. 139).

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, & Kusters, 2020, p. 14).

Based on these calls for further research, this project set out to make a contribution based on research-based practical guidance to project managers embedded in an information system.

2.2. The problem

Developing practical research contributions and demonstrating practical benefits is no simple task. In the research literature on project complexity, some papers claim that their contributions are helpful for practitioners. However, only a minority of these studies provide real evidence backing up their claimed relevance. The paper by de Rezende and Blackwell (2019) mentioned in 2.1 is an example of a paper that claims relevance for practitioners without conducting rigor in-situ evaluation to provide evidence. It is easy to imagine how others might benefit from one's contributions, but more difficult to prove the efficacy of the produced knowledge.

My personal story, particularly the fact that I entered research with extensive real-world experience of managing projects, can serve as an example. Before conducting the literature review, I expected to find a great deal of relevant knowledge on handling project complexity; knowledge that would prove useful in retrospectively improving my understanding of the experience gained in my thirty years as a project manager – and an instructor on project management courses. To my disappointment, I found only a few research papers worth counting as relevant reads for a practitioner of project management. Reflecting on my journey, it would be interesting to conduct an experiment where project managers were given a set respected research articles claiming to contribute to practitioners and evaluated the

relevance of the contributions. I presume that on average, the evaluation will demonstrate a low rate of relevance for the practitioners. This view is echoed by (Morcov et al., 2020, p. 14), mentioned previously.

To sum up, the starting point is that prior research and its contributions have not been practically relevant and give very little practical guidance for PMs on how to manage complexity. Furthermore, the discourse has been more or less theoretical, and the developed models have not been tested extensively so that their "practical value" could be assessed; instead, the authors have simply claimed that their results have practical value (without truly assessing/measuring this value).

Is project complexity a real-world problem?

According to Table 1, the problem addressed in the thesis needs to be a real-world problem. To investigate the practitioners' perspective on the problem of complexity, this study conducted a large national survey of practitioners together with the Danish consultancy company Mannaz A/S (Bucka-Lassen, Mikkelsen, Pries-Heje, & Bødker, 2018). According to this survey, which included more than 1,000 participants, project complexity is now the second most challenging aspect of project management. (The lack of resources is first on the list.) A similar survey, conducted four years earlier, identified complexity as the eighth most important challenge in project management. This difference indicates that dealing with project complexity has become an increasingly important challenge in the eyes of project management practitioners, and therefore a real-world problem worth solving through engaged scholarship.

Defining project complexity

This cappa adopts the following definition of project complexity: "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, & Bocquet, 2011, p. 719). The literature review in section 5 contains additional, varied definitions of project complexity.

The above definition focuses more on the consequences and less on the ontology of project complexity. In principle, many so-called 'project properties' can challenge the success of project management, including the 'lack of resources' mentioned in the survey result previously. Lack of resources can derive from unrealistic decision-making, which practitioners consider to be the most important source of stakeholder complexity (M. F. Mikkelsen, Marnewick, & Klein, 2020).

As the literature review will document, there is much disagreement on the content of descriptive models of project complexity. However, the absence of a commonly accepted descriptive model is less of a problem when trying to help practitioners, because "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" (Vidal & Marle, 2008, p. 1096). There exist only a few papers on perceived complexity. When it comes to helping practitioners, the lack of research on perceived project complexity is considered to be a far bigger problem than the scholarly disagreement over descriptive models.

Descriptive versus perceived project complexity

Vidal and Marle define the difference as follows (Vidal & Marle, 2008):

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"

An inference of that can be made about the dichotomy above is that perceived and descriptive project complexity might be two different constructs. If this is the case, it opens up yet another problem: Whose subjective perception will provide the best guidance when navigating project complexity? Is it sufficient to base the navigation on the inside view of project managers, with the potential of leading to 'delusional optimism' (Lovallo & Kahneman, 2003) or should (other) stakeholders be engaged in the assessment of project complexity?

Based on the dichotomy above, there are two main ways of helping practitioners. In the descriptive approach, the chief contributions are knowledge deriving from research of low-like relations and the ontology of project complexity. The descriptive construct assumes that project complexity exists 'out there' – like a truth independent of an observer. This approach can improve the management of project complexity on a general level. An analogy to this is that the tide will raise all boats. To further help navigation on a specific boat, one needs to get on board and interact with the practitioner, starting with their perception of project complexity. Helping the management to handle the complexity of a given project will here start with the understanding of how the practitioners perceive project complexity because this is the "mental map" they use to navigate the complexity of the given project.

Hindsight versus foresight

The majority of research literature about project complexity deploys a postmortem perspective, meaning an approach where the researched projects are assessed as finalized objects, where all the changes have already happened, and the outcome of the projects are known. In this case, the construct captures the entire project lifecycle and returns one measure of the complexity of a given project. This hindsight perspective is here labeled the ex-post assessment of project complexity.

In contrast tothis, some papers deploy an approach which focuses on how project complexity changes throughout the project. In the literature review of this cappa, examples of such papers will be given. The complexity construct here will be different since the remainder of the project is unknown (or even unknowable). The construct will assess the current project complexity. Other research papers take on the challenge of assessing the complexity at project initiation, which here is labeled the ex-ante assessment of project complexity.

As mentioned in the introduction, de Rezende and Blackwell (2019) raise the question of how the importance of the dimensions of project complexity change over the lifetime of a project. In other words, we do not know how the project complexity changes in-between the ex-ante and the post-ante assessment.

A minority of the research literature is devoted to the ex-ante assessment of project complexity, where only the initial information about the project is available. Ex-ante assessments are by nature merely assumptions about the given project – in the best case qualified by knowledge about the statistical mean and deviation of similar past projects.

While practitioners can learn much about project management from the hindsight offered by direct experience of past projects, their main focus will be on their foresight about the project at hand. When talking about hindsight and foresight it is important to notice 'which projects' we are talking about. To avoid confusion, the following must be kept in mind: The ex-ante assessment of *a given current* project can be qualified by the ex-post assessments of *other projects from the past* (preferably similar projects). The given project can – after closure – be subject to an ex-post assessment of complexity, but by this point it is too late to affect the decision making in the given project in any way.

Following the statement from Vidal and Marle (2008) that a project manager cannot deal with the whole reality and complexity of the project, 'Knowing where you are' is a particular problem for a project manager, which is highlighted by the hindsight/foresight dichotomy. In hindsight, when the

project has evolved and revealed its 'true complexities', it is much easier to determine a better course of action than the one followed based on foresight.

Since complexity drives radical complexity (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007b), it seems clear that ex-ante and ex-post are ontologically distinct constructs concerning project complexity, where 'ex-ante project complexity' is based on assumptions about the future in contrast to 'ex-post project complexity', which is based on observations of finalized projects. Assumptions will only equal observations when there is no unpredictability. However, the research literature seems to treat the two constructs as if they are alike. At least in the literature review, no justification was found of the assumption that 'ex-ante project complexity' equals 'ex-post project complexity.' Nor was any discussion of ex-ante versus ex-post found. If the two constructs are dissimilar, this too is a problem when helping practitioner.

Engaging practitioners in the research

In the eyes of a practitioner, complexity is dealt with one decision at a time (Brockmann & 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. Many decisions are made with the first decision of initiation until the last decision of project closure (whether the project is 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 the face of high uncertainty due to complexity. There is a double-sided cause and effect relationship between complexity and decision-making.

The decisions will, like the unpredictability, disappear into the fabric of the project history and are easily forgotten when research takes a hindsight approach. To counter this, the help from research needs to come through action research of some kind.

Decision-making is done based on perceived complexity because this is what the project manager can deal with – according to a previous quote of 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" (H. R. Maylor, Turner, & Murray-Webster, 2013, p. 46). The lived experience of a project exists in-between the ex-ante and ex-post assessment of the project. This is coined 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 carried out ex-ante or ex-post, but the 'lived experience' exists anyway. Similar to the expression 'the lived experience', ex-ante perceived project complexity can be labeled 'the expected project complexity' and ex-post perceived project complexity can be labeled 'the remembered project complexity.' All three expressions point to the subjective perception of project complexity.

Concluding on the problem

To conclude there are multiple problems to address with research-based help for practitioners handling complexity. In short, the ex-post descriptive research approach might embrace a different worldview to the one deployed by practitioners, who are limited by the perceived project complexity and are more concerned with a forward-looking perspective on the given project.

There is still much to find out about how practitioners perceive project complexity when trying to develop information systems for handling complexity. It is presumed that research-based help to

practitioners can best be provided through a collaborative effort. Just as practitioners cannot comprehend descriptive project complexity (in the words of Vidal, as quoted previously), we must assume that researchers cannot comprehend the challenges faced by the project managers of decision-making in face of on the perceived project complexity.

These problems form the basis of the research questions set out in section 3.7.

2.3. Area of concern

According to Table 1, the "area of concern" is the body of knowledge that relates to the problem. When searching "project complexity" in scientific search engines a very large body of research presents itself. Not only are there many research papers addressing project complexity; the papers are also highly diverse in their aims, methods, and worldview.

After several failed attempts at categorization, I finally succeeded in shedding some light on the area of concern. An categorization of the literature was based on a typology, which in itself is a complex theory (Doty & Glick, 1994). The developed typology has the 'intention of the research' as an independent variable, and the dependent variable in the typology is the relationship between the concept project complexity and perspective on project success. Using this typology, five ideal types of research on project complexity were identified (M. F. Mikkelsen, 2020a). The five ideal types are: 1) Positivistic modeling based on descriptive project complexity as the independent variable providing a fixed measure of the complexity devoted to finding law-like relations between project complexity and other constructs. 2) Complexity theory, where the descriptive project complexity explains the emerging nature of the project based on attractors and similar concepts from complexity theory. 3) Ontological frameworks where descriptive project complexity captures the entirety of the complex nature of projects in static or dynamic dimensions (often with high levels of abstraction). 4) Managerial frameworks addressing the managerial challenges of handling the project's complexity. 5) Emancipative investigation where perceived project complexity sets the context for a study of the complexities of a temporary organization perceived as a project.

While this categorization is not perfect, it proved helpful in the current research project. Identifying the independent variable (intention of the research) and dependent variable (the relation between project complexity and project success) helped the development of an understanding of the research literature in light of the formulated problem. To a practitioner, the chief reason for handling complexity is presumed to be to improve the chances of success. In principle, if it was not for the pursuit of success, the complexity of a project would not be a problem – it would only be circumstantial in the eyes of practitioners.

2.4. Conceptual framing – dependent on the area of concern

Conceptual framing provides a structure – like a lens – for data collection and analysis. As mentioned in Table 1, the topics of the conceptual framing can be divided into dependent and independent parts of the area of concern. According to table 2, the conceptual framing can include existing as well as developed.

2.4.1. Rethinking Project Management

Rethinking Project Management (RPM) began in 2004 as a UK Government-funded research network when a group of project management researchers came together to develop a research agenda (Cicmil, Williams, Thomas, & Hodgson, 2006). RPM identified project complexity as the first of five

directions recommended for future research in project management (Winter & Smith, 2006). Their purpose was to encourage academia to catch up with practice: "We argue that while a great deal is written about traditional project management we know very little about the 'actuality' of project-based working and management" (Cicmil et al., 2006). RPM has influenced research on project management in several areas over the years (Walker & Lloyd-Walker, 2016). As depicted in Figure 2, RPM does not reject classical project management, but rather expands the understanding needed for managing projects. Rethinking Project Management remains a vital research stream today (Svejvig & Andersen, 2015).

In their theoretical investigation of project complexity, Daniel and Daniel (2018) argue for a similar dualism of project management. With the labels theory of regulation and theory of emergence, they convey a differentiation similar to the CPM versus RPM in figure 2. The paper concludes that "The next challenge of project management science should be to generate a theory of emergence, just as a theory of regulation" (Daniel & Daniel, 2018, p. 194).

Handling risk might in practical project management work have some overlap with handling complexity. From a conceptual point of view, risk management is included in the Classical Project Management in Figure 2. Indeed, a whole chapter of the PMBOK (Project Management Institute, 2017) is devoted to handling risk. Project complexity is not one of the ten knowledge areas mentioned in A Guide to the Project Management Body of Knowledge (PMBOK) (Project Management Institute, 2017). The PMBOK represents "classical project management" as outlined in Figure 2. Given that this research project has RPM as a lens, topic of risk management is therefore not included in the scope of handling project complexity in the research.

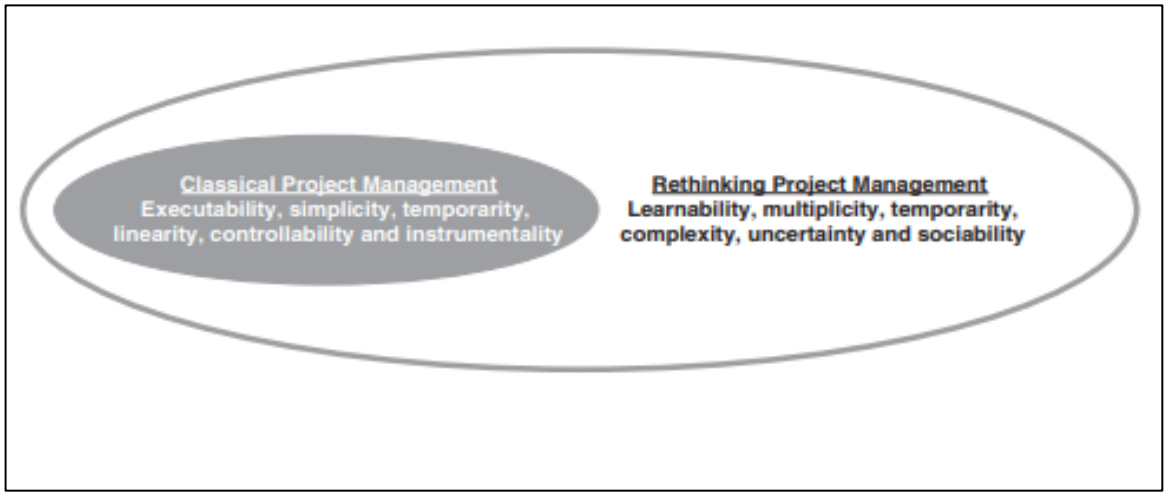


Figure 2:Important features of the classical and rethinking project management concepts (Svejvig & Andersen, 2015).

One inference of the definition from Vidal et al. (2011) stated previously is that if the project has low complexity, it poses less of a challenge to project management; hence the project is made manageable by applying the common body of knowledge of project management, e.g. the PMBOK.

2.4.2. Development of chronological perspective as a framing concept

Getting a better grip on the hindsight/foresight problem mentioned previously resulted in the development of a conceptual framing based on a chronological perspective.

Together with the dichotomy of perceived and descriptive project complexity from the area of concern, the chronological perspective forms a matrix of perspective on project complexity which became a mainstay in the research.

2.5. Conceptual framing – independent of the area of concern.

Among the many possible conceptual framings from outside the area of concern, only a few have been investigated and even fewer will be mentioned here. The explorative nature of this research project and the time limits force a selective approach. The selected concepts include: the affordance theory, the Cynefin framework, the concept of project success, the stakeholder landscape, and the concept of an outside view. Here the choices of the concepts are motivated, in a later section the concepts will be explained further.

Researching the navigation of complexity in this project included the use of an information system in the form of "IT-enabled navigation of project complexity." Among the information system theories investigated, the affordance theory best complements the research question.

Coming from an area of strategic decision making, the Cynefin framework (Snowden & Boone, 2007) offers support for the management of project complexity. The Cynefin framework exemplifies the System-of-system (SoS) perspective. The dichotomy of complicated versus complex systems is a central concept in the Cynefin framework, and this concept seems very relevant to the management of project complexity. However, the framework has thus far received very little attention in project management research. Among the few related papers are papers on project decision-making (Basha, 2017) and portfolio management (Shalbafan, Leigh, Pollack, & Sankaran, 2018). Vollmar et al. (2017) see the framework as a potentially important new tool for project managers. In light of this, the framework is positioned as a framing concept rather than being included in the literature review.

Given that the aim of this research is to aid in the handling of project complexity in order to achieve success, it includes "project success" among the framing concepts. Positivistic research has demonstrated a weak correlation between the constructs of complexity and project success. However, the literature review in this study demonstrated that the relationship between the two concepts is much more complex than assumed in positivistic research (M. F. Mikkelsen, 2020a).

Much project complexity derives from stakeholders (Aaltonen, 2011). To have a structured perspective on the project stakeholders, this study includes the concept of stakeholder landscape as a framing concept.

Since the introduction of bounded rationality (Herbert A Simon, 1972), the impediments of human decision-making have been the subject of much research. The concept of "delusional optimism" (Lovallo & Kahneman, 2003) is thus very relevant to the conceptual framing of a study on 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 concepts mentioned above in this section will be further explained in the coming section on conceptual framing.

2.6. Method

In the context of engaged scholarship, Action Design Research (ADR) is a very useful methodology (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011), and this project applied it to the research. ADR is often used in Information Systems research but is less well known in Project Management research (M. F. Mikkelsen, Venable, & Aaltonen, 2021b). Section 4.3 elaborates further on the use of ADR in this project.

Early in this project, a large national survey was carried out. The result helped to design an artifact giving affordance to project managers in navigating project complexity. The ADR project then developed a dashboard for the decision support systems (DSS) in a series of workshops open to all interested practitioners of project management. The resulting conceptual artifact was then implemented in an ICT platform based on the wisdom of crowds as a design principle. In that process, an engineering company, Atkins Denmark, was the recipient organization, where a prototype was developed and evaluated as an artifact for the "IT-enabled management of project complexity."

This research was driven by the design of artifacts, hence it is of methodological importance to realize "that the artifact itself has some representational power: an artifact can assist with the communication of the design principles in a theory" and "design principles and theory can be extracted from observation and inference from already instantiated artifacts" (Gregor & Jones, 2007).

2.7. Research question

Starting with a broad interest in researching the handling of complexity in the pursuit of project success, the exploratory process ended with the following final two-part research question:

1) What kind of information is needed for handling project complexity and *2) How can an information system be developed to provide affordance for project complexity management?*

where handling refers to managerial challenges in navigating the project to success, and where navigation includes assessment, monitoring, understanding, and decision making.

To answer the first part of the research question, two sub-questions arose:

1a) What is project complexity according to the research literature?
1b) How do practitioners perceive project complexity?

The second part of the research question is very broad, so some limitations were necessary.

2a) "What is project complexity management?" – Here the focus was on theorizing the concept around the managerial response to different levels of complexity in the project.
2b) "How can an IS be developed?" – The answer to this question is limited to the use of the Action Design Research methodology in a single case study. "Developed" is limited to conceptualizing and prototyping an implementation on an existing ICT platform, thereby giving affordance to the management of projects when navigating project complexity.

The answers to the RQs are divided among multiple papers, as explained in the next section.

2.8. Contributions

The community to which this contribution is addressed is the RPM research stream mentioned in paragraph 2.4.1 (conceptual framing). The outlets for this community are, among others, the *International Journal of Project Management in Business* (*IJPMiB*) and the *Journal of Modern Project Management* (*JMPM*). The most important conferences are IRNOP and the EURAM. This

Ph.D. thesis is based on a series of papers. The contributions are therefore distributed in the seven articles already published (or submitted to journals) and supplemented with this cappa.

For the practitioners of project management, the overall practical contribution of this project is a framework for the selection of a suitable managerial strategy for handling project complexity. This framework was implemented as a prototype on an ICT platform, demonstrating the affordance to project managers and decisions makers when the information is based on an outside view of the given project. In other words, it provides IT-enabled management of project complexity. The system provides early warnings of issues arising from the complexity of the given project. The seven journal papers provide the overall contribution in the following way.

Contributions from the already published (or submitted) papers:

Paper #1 (M. F. Mikkelsen, 2020a) takes stock of the area of concern through a literature review and identifies five ideal types of research on project complexity. The independent variable of the typology was the intention of the research, and the dependent variable is its relation to a perspective on project success. The paper demonstrates how research on project complexity has evolved to become very complex in itself. The paper provides an answer to research question 1a: project complexity is a multifaceted term, and the construct is highly influenced by the intention of the research.

Paper #2 (M. F. Mikkelsen, 2020b) takes on the challenge of defining *perceived* project complexity. The concept has been like an "elephant-in-the-room," where most research focused primarily on *descriptive* project complexity. This paper goes on to demonstrate how perception is contextual depending mostly on the project role of the perceiver. This contribution is novel. It is also important because it demonstrates the need for an *outside view* as mentioned under conceptual framing. management. The outside view is a primary design principle in the information system developed in this project. Besides this, paper #2 answers research question 1b. There is no uniform perception of project complexity among practitioners although the structural complexity and socio-political dimensions weigh the most on average.

Paper #3 (M. F. Mikkelsen & Marnewick, 2020) demonstrates how the research publications in the area of concern can be based on inaccurate presumptions about the world, a finding that aligns with the thinking behind the Rethinking Project Management initiative. Two out of three survey participants hold project managers responsible for the realization of project benefits. This expectation adds additional complexity to the practical role of a project manager, an aspect that had not been addressed by earlier research. This insight is important when designing an information system for project complexity management because benefits realization aspects need to be included. This paper contributes to answering research question 2a by highlighting further complexity of project management that needs to be handled by the project manager.

Paper #4 (M. F. Mikkelsen et al., 2020) indicates that decision-making stakeholders often suffer from unrealistic expectations about what is achievable within the project budget and timeframe. Survey participants reported that unrealistic expectations among decision-makers are the most important factor in stakeholder complexity. This insight is also important when designing an IS for project complexity management. These findings support the idea that decision-makers suffer from delusional optimism (Lovallo & Kahneman, 2003), a concept used as a primary design principle in the ADR project. This paper contributes to answering research question 2a by addressing the fact that handling complexity is very much about improving project decision making.

Paper #5 (Paper under review) proposes a *theory of the lived experience of project complexity*. The theory is based on mechanisms (critical realism) instead of the current dimensional frameworks dominating the research. The prescriptive theory provides theoretical backing for the design of "IT-enabled project complexity management." The theory prescribes that the managerial decision strategy must be selected based on the current level of project complexity. The theory rejects the thinking that project complexity can be based on a single matrix of project complexity; the actualization of the generative mechanisms involved is too contextual. Instead, early detection and an outside view should

be applied. This paper helps answer research question 2a by formulating a theory of project complexity management.

Paper #6 (M. F. Mikkelsen et al., 2021b) demonstrates how the "Action Design Research" (ADR) methodology can be used in the development of an artifact for the navigation of project complexity. The artifact provides recommendations for selecting a suitable managerial strategy for handling the current complexity of a given project. The artifact is an important contribution in itself as is the further development of the ADR project. The ADR methodology is developed in IS research, and the paper discusses the potential use of ADR in project management research. This paper contributes to answering research questions 2b.

Paper #7 (M. F. Mikkelsen, Venable, & Aaltonen, 2021a), submitted in October 2020. This paper reports on the implementation of the artifact discussed in Paper #6. The artifact was implemented on an ICT platform, which is a system for the capture and aggregation of survey results. The design employs the outside view principle mentioned in Paper #2 and Paper #4. The evaluation demonstrated that the design is useful for the "early detection" recommended in Paper #5 and provides affordance for navigating project complexity in the pursuit of success. The paper reports on the resistance to change among project managers, evidently due to their misperception of the affordance offered by the artifact. Paper #7 answers the two overarching research questions 1 and 2, and in particular 2b.

Publishing in the mentioned journals give one point each in the Danish Bibliometric Research Indicator (BFI) system; hence the Ph.D. project has a current total of five approved BFI points and the potential for two additional points from those still under review. Each paper will appear in a later section of this cappa, with a summary in Section 5 and the full-length papers attached as appendices in Section 9.

The seven papers (five journal papers and two submitted papers) partially answer the stated research questions. While the papers explain different aspects of the overall contribution this cappa provides a more comprehensive answer to the research questions. Each paper contributes knowledge on its own, and the cappa focuses more on the research methodology used across the papers.

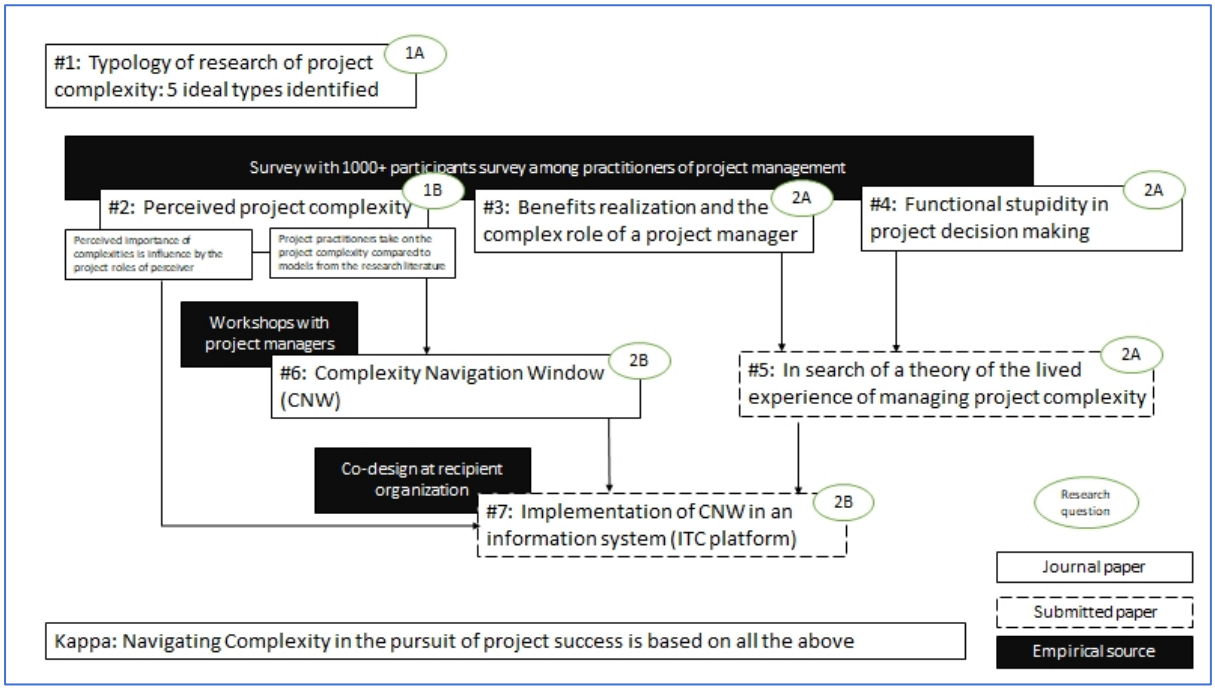


Figure 3: Flow chart of the contributions made in the student's work.

Description of the relationships between the seven papers depicted in figure 3:

- Paper #1 gives an overview of the research literature published in the area studied. By identifying five ideal types of research on project complexity, the paper offers a foundation for positioning the work of the student within this paradigm.
- #2->#6: Paper #2 is the first work in this study. Having the practitioners take on the research on project complexity was the important baseline for the workshops, that led to the Complexity Navigation Window, documented in paper #6.
- #2->#7: Paper #2 reports that the importance of complexities is influenced by the project roles of the perceiver – an observation that was not found in the literature review. This finding influenced the design of the information system intended to provide support in the management of project complexity, documented in paper #7.
- #3->#5: Paper #3 is an exemplification of false presumptions in research on project management. The reality confronting project managers has high diversity, and this needs to be considered when forming a Theory of Project Complexity Management. A proposal for such a theory is given in paper #5.
- #4->#5: Paper #4 discusses functional stupidity based on the fact that practitioners of project management (not just the project managers) report that the unrealistic expectations of project decision-makers are the most important factor in stakeholder complexity. This finding provided much inspiration for the proposed theory in paper #5.
- #5->#7: The theory of lived experience project complexity is based on the thinking, that generative mechanisms are the course of unpredictable events, which results in the complex behavior of projects. The actualization of generative mechanisms in projects can be monitored by the information system developed by the research project. By giving early warning of the emergent behavior of the project system, the information system provides affordance to the project managers navigating the complexity of the given project.

3. Background/Literature review

This section presents a review of the literature on the area of concern. There are several ways to present a literature review in serial form. This thesis presents some common definitions of project complexity first, done in 3.1, and proceeds with a historical overview of the mainstays in sections 3.2 to 3.4. Following this, a dive into various definitions of project complexity from the literature is presented in 3.5. Finally, a consideration of different strands of thinking in the research of project complexity is offered in 3.6.

3.1. Common definitions of Project Complexity

Since Baccarini (1996) proposed a definition of project complexity, which was later re-labeled as structured complexity, there has been an ongoing ontological debate among scholars. Many papers conclude that there is no common definition. Examples of concluding remarks include: “There is no commonly accepted definition” (Chapman, 2016); “Despite the many existing studies on project complexity, there is no universal agreement on the definition of project complexity” (Zhu & Mostafavi, 2017); and “However, there still was no commonly accepted definition of project complexity, despite a large number proposed. Each author had a different perspective on defining project complexity” (Dao, Kermanshachi, Shane, Anderson, & Hare, 2016).

After a study of the definitions of project complexity in the research literature, the above-mentioned conclusions seem exaggerated. These four recent definitions illustrate the variation in the definitions, where the first is adopted in this cappa.

1. “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” (Marle & Vidal, 2016);
2. “Project complexity is the degree of interrelatedness between project attributes and interfaces, and their consequential impact on predictability and functionality” (Kermanshachi, Dao, Shane, & Anderson, 2016);
3. “[P]roject complexity [is] an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with effect on the project objectives” (Bakhshi, 2016);
4. “A high level of complexity in a project implies the existence of more dependencies and difficulties in implementing and managing the project” (Zhu & Mostafavi, 2017).

Other definitions state what constitutes a complex project, rather than what project complexity is. One study “defined a complex project as one that demonstrates a number of characteristics to a degree, or level of severity, that makes it extremely difficult to predict project outcomes, to control or manage projects” (Remington, Zolin, & Turner, 2009). Definitions of project complexity and definitions of complex projects very often use the same wording.

For comparison, a typical definition of “general” complexity in social science is: “The level of complexity depends on the character of the system, its environment, and the nature of interactions between them" (Cambel, 1993, p. 4). This definition is very similar to those of project complexity but lacks an emphasis on consequences for management.

3.2. The early research on Project Complexity

Baccarini (1996) found that the term ‘complexity’ was used in the research literature on project management without precision. He stated that project complexity “[consists] of many varied interrelated parts” (Baccarini, 1996, p. 201) and argued that it can be operationalized in terms of differentiation and interdependency and found that it can be managed by integration. Baccarini (1996) also noted that there is both an organizational and a technological aspect to the concept. A few years later Williams (1999) concluded 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, Williams labels Baccarini's definition, structural complexity, and added uncertainty to the definition of project complexity. William argues his case based on Turner and Cochrane (1993), although they did not focus on project complexity.

In a paper about IS project complexity, Xia and Lee (2004) define it using a 2-by-2 matrix based on (Baccarini, 1996), (Turner & Cochrane, 1993) and (T. M. 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. Xia and Lee (2004) define structural complexity as "variety, multiplicity, and differentiation of project elements; and interdependency, interaction, coordination and integration of project elements." They define dynamic complexity as "uncertainty, ambiguity, variability, and dynamism, which are caused by changes in organizational and technological project environments" (Xia & Lee, 2004, p. 55).

3.3. A spark from Rethinking Project Management in 2006

The conceptual development of project complexity picked up speed around the introduction of the "Rethinking Project Management" initiative (Cicmil et al., 2006) which set out to research the actuality of projects. A structured review by (Luo, He, Jaselskis, & Xie, 2017) presented a variety of models and frameworks of project complexity published in the period from 1996 to 2016. Figure 4 presents a compressed version of their timeline. One particularly interesting aspect of Figure 4, not mentioned by Luo et al. (2017), is the noteworthy 'spark' of diversification that occurred in the middle of the period.

The blue dotted line in the year 2006 visualizes this spark. This line coincides historically with the

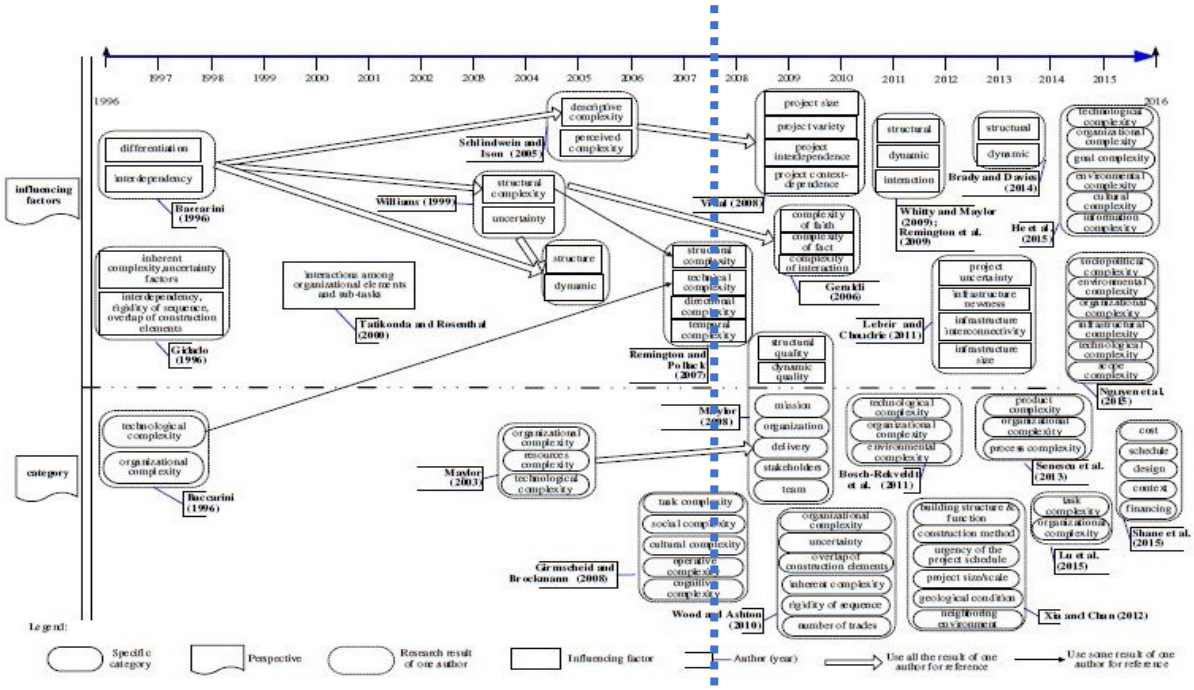


Figure 4: Historical analysis of project complexity influencing factors and categories, 1996-2016 (Luo et al. 2017). The author added the dotted line at 2006.

RPM initiative. The question of whether the RPM research network predicted this diversification or pushed the development forward is beyond the scope of this literature review. However, it is reasonable to speak of a post-RPM era of project complexity research. Figure 4 illustrates that the

diversification of research on project complexity has been around for 'only' a decade. The implication is that further diversification of research on project complexity will occur since the field has likely not yet reached its final state.

3.4. The post-RPM era of project complexity

The use of Complexity Theory was introduced after the introduction of RPM, with the work of (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007a) figuring as a renowned example. The focus here is on radical unpredictability. The potential of Complexity Theory looked promising from the beginning, 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, etc.; hence little research has followed this path.

Geraldi 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 attributed to (Baccarini, 1996), (T. M. Williams, 1999), and (Xia & Lee, 2004) in order of appearance. However, Xia and Lee (2004) argued that uncertainty is a part of dynamic complexity, as mentioned in 4.1.1. The pace dimension was identified by T. Williams (2005) and the socio-political dimension was identified by H. Maylor, Vidgen, and Carver (2008).

Of the five dimensions identified by Geraldi et al. (2011), the pace dimension seem to stands out. This is mainly because it is the only one of them that is directly decision driven. (The project deadline is defined by a decision made by the project owner or top management, etc. – hopefully after consulting the project manager, team, and other stakeholders.) The four other dimensions have more indirect relations to project decisions. Afterall, in the end, all attributes of project are based on decision.

Going back to the reference source of the pace-dimension, it can be argued that 'pace' is a contributing factor for overrun – not for complexity: "Thus, we have identified the three factors which come together to cause extreme overruns when projects are managed conventionally: structural complexity; uncertainty, and a tight time-constraint" (T. Williams, 2005, p. 503).

The other source of the pace dimension, mentioned by (Geraldi et al., 2011), is the Dimond Framework by (Shenhar & Dvir, 2007b). This is called the NTCP model and uses four bases to analyze projects: Novelty, Technology, Complexity, and Pace. Once again, pace is on the same abstraction level as complexity – not a part of the complexity.

Subsequent research literature has typically not included the pace dimension. One comprehensive literature review – comparable to that of Geraldi et al. (2011) and published five years later – found eight dimensions, and revised the labeling: Structural complexity, Uncertainty, Emergence, Autonomy, Connectivity, Diversity, Socio-political, and Element of context (Bakhshi, 2016). While there is much overlap between the two frameworks, the pace dimension was excluded in the latter.

Pace has also been positioned as a part of the dimension of structural complexity, since it has been argued that "Structural complexity is associated with size, variety, breadth of scope, the level of interdependence of people or tasks, or the pace of the work." (H. R. Maylor et al., 2013, p. 46)

Pace was reintroduced as a dimension of its own in a recent modification of the framework of (Geraldi et al., 2011) done by (de Rezende & Blackwell, 2019), where the dimensions suggested were structural complexity, uncertainty, pace, dynamic, novelty, and institutional.

The above gives a vivid picture of the evolving discussion of which dimensions to include in a descriptive framework/models of project complexity as well as the hierarchy of sub-dimensions.

In the research stream devoted to finding law-like relations between project complexity and other constructs, e.g. papers like (Bjorvatn & Wald, 2018), (Bjorvatn & Wald, 2018), (Luo, He, Xie, Yang, & Wu, 2016), (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Qureshi & Kang, 2015), and (Lu, Luo, Wang, Le, & Shi, 2015), the construct of project complexity often takes a more narrow version of dimensions than the framework mentioned previously. Some authors go back to the Baccarinian definition (structural complexity), while others use a watered-down version of a framework. The differences between the search for lawlike relations and the ontological investigations are discussed in (M. F. Mikkelsen, 2020a).

One model for the assessment of project complexity is presented in (Bosch-Rekveldt et al., 2011), where the authors developed a questionnaire to assess project complexity on three dimensions: Technological, Organizational, and Environmental. The latter is an addition to the thinking presented in the papers (Baccarini, 1996) and (Xia & Lee, 2004) mentioned previously. The first part of the questionnaire of the TOE model is presented in appendix A.

Among other tools for assessment that are worth mentioning is the Complexity Assessment Tool (CAT) (H. R. Maylor et al., 2013), where the three dimensions are structural complexity, socio-political, and emergence. CAT is placed in appendix B.

Emergence is often associated with the complexity theory, which has been presented in the research stream of project complexity (Cooke-Davies et al., 2007b). Where emergency is in complexity theory is related to unpredictability, the notion may have a twist in CAT, where unpredictability is not included. Instead, it is stated, that "Emergent complexity comprises uncertainty and change. […] We identify emergent complexity as a challenge caused by a potential or actual change in either a structural or socio-political element" (H. R. Maylor et al., 2013, p. 47).

As depicted in appendix B, the first indicator of the structural complexity is "The vision and benefits for the work can be clearly articulated". Articulation clarity is often associated with ambiguity, an indicator identified as dynamic complexity by (Xia & Lee, 2004) as mentioned previously. This too is an example of the shifting dimensions and indicators in the research literature.

Summing up, it can be argued that some common ground exists in research regarding dimensions of project complexity. Most scholars agree on two aspects: 1) Structural complexity (the Baccarinial definition) is included in project complexity. 2) This structural complexity cannot stand alone, and there is some 'residual dimension' (or dimensions). The disagreements revolve around the content of the 'residual part' of project complexity. The disagreements among scholars are mostly about the division of the dynamic side of project complexity, where suggested sub-dimensions include uncertainty, sociopolitical, emergence, and change, along with many other proposed sub-dimensions.

It is rare to find models of project complexity developed in cooperation with practitioners. One example is the MODeST complexity model based on grounded research (H. Maylor et al., 2008), where the dimensions are Mission, Organization, 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 do. This is a point worth noting when the aim is to help practitioners.

Focusing on the lived experience and how to respond to project complexity, H. 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.

The literature review found only a few papers that explicitly addressed the shifting conditions through the project lifetime. One example is (Daniel & Daniel, 2018) and another is (Zhu & Mostafavi, 2017)

paper, which presents the Complexity and Emergent Property Congruence (CEPC) framework depicted in Figure 5.

In this framework, the emergent properties are the absorptive, adaptive, and restorative capacity of the project. Use of the dimension "detailed complexity" mentioned in Figure 5 corresponds to what is elsewhere labeled structural complexity. The dynamic complexity is the time-dependent component. The source of this concept is "engineering design and manufacturing" (ElMaraghy, ElMaraghy, Tomiyama, & Monostori, 2012).

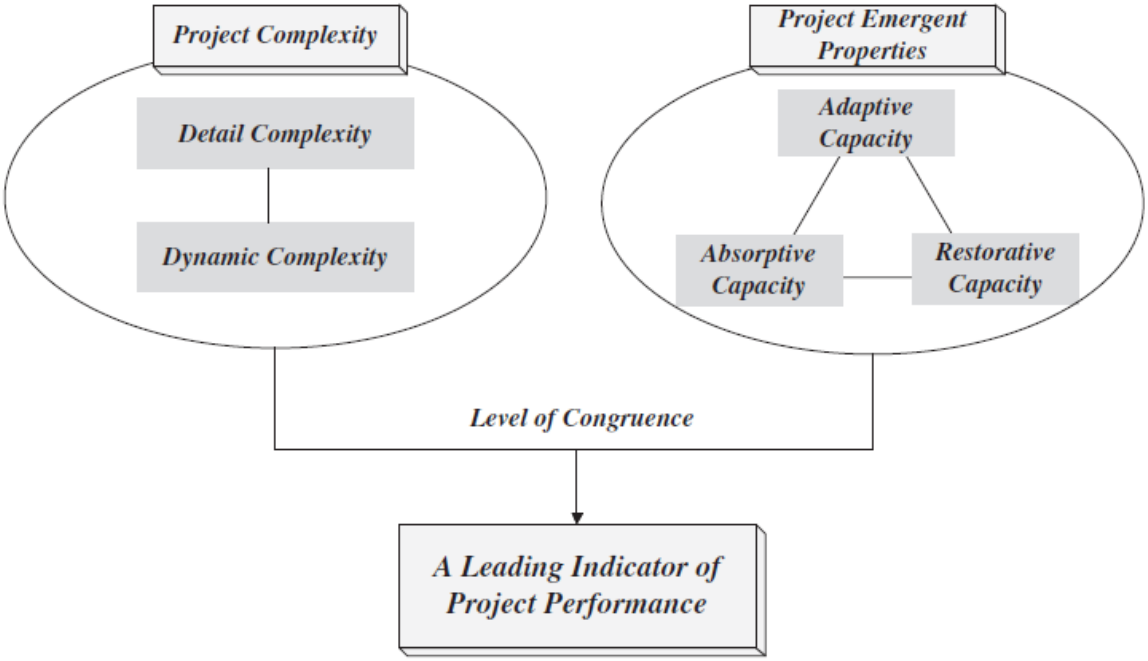


Figure 5: Complexity and Emergent Property Congruence (CEPC) framework.

3.5. System of the system perspective in project complexity

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). While there is a great deal of literature on the PMI perspective, and some research on complexity theory, there are only a few cases of literature on the SoS approach. Bakhshi et al. provide only one example, the Cynefin framework (Snowden & Boone, 2007), as an implementation of the SoS school of thinking. 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 et al. (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.

The unique affordance of SoS theory is the radical different system properties distinguish one type of system to another. The intention is to "[gain] a better understanding of the range of complexity types" (Ireland, Rapaport, & Omarova, 2012, p. 248). The main point of SoS is that the project can be

divided into different systems which are stratified by different levels of complexity. Each level calls for a unique managerial effort. Running water, as a metaphor, can explain the power of the SoS approach. In the laminar stream of water, the system behaves in a certain and predictable way. Changes in circumstances can make the stream turbulent, and as a result the system behaves differently and much more unpredictably. The logic of the laminar stream is, that system is the sum of its parts. The logic of the turbulent stream is, that the system flips to emergence, where the flow cannot be expressed by the sum of its parts. This combined perspective of systems is referred to as a system of systems (SoS).

Although promoted by Bakhshi et al. (2016) as a part of project complexity, the elaboration on the Cynefin framework is postponed to the section on framing concepts independent of the area in focus. The reason for this is that the utility of the Cynefin framework lies in strategic decision making and therefore is very different from the project complexity in the research literature.

The Cynefin framework does not fit into the mainstream research on project complexity. As one researcher wrote about the Cynefin framework, "Concluding in a critical manner, the classification made by the authors is too simplified, the model being centered primarily through the perspective of leadership and not on identifying the factors that lead to complexity" (Popescu, 2016, p. 596).This "critical" evaluation is a vivid illustration of the gulf separating descriptive research on project complexity with its focus on factors (drivers, dimensions, indicators, etc.) and the prescriptive research guiding project leadership and decision-making.

3.6. Types of theory in research on project complexity

Research of Information Systems provides a theoretical foundation that in the eye of the author exceeds what is found in the research of project management. Gregor (2006) has provided a useful taxonomy of theory types, depicted in Table 3 below. This is a useful lens for taking stock of project complexity research.

A Taxonomy of Theory Types in Information Systems Research	
Theory Type	**Distinguishing Attributes**
I. Analysis	Says what is. The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made.
II. Explanation	Says what is, how, why, when, and where. The theory provides explanations but does not aim to predict with any precision. There are no testable propositions.
III. Prediction	Says what is and what will be. The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations.
IV. Explanation and prediction (EP)	Says what is, how, why, when, where, and what will be. Provides predictions and has both testable propositions and causal explanations.
V. Design and action	Says how to do something. The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact.

Table 3: A lens for taking stock of project complexity research.

Based on this taxonomy the following observation can be made about the literature on project complexity. As the literature review of this thesis demonstrates, most of the research tries to capture what project complexity is, which falls under theory type I, according to Gregor (2006).
A smaller fraction of papers pursues complexity theory as an explanation of why projects with higher complexity are more difficult to manage, hence these papers can be classified as type II.
The investigation of law-like relations, e.g. the correlation between project complexity and project management success, can be classified as type III, since this is an attempt to predict the probability of meeting the triple constraint with project complexity as the independent variable.

The review of the literature on project complexity of this thesis did not find any papers with a clear classification as type IV.
Theory of type V addresses how to manage project complexity, the prescriptive theories of managing project complexity.

Based on the attributes of types depicted in Table 6, one might presume a natural development from type I to V. The sequence of type II and III can be switched seamlessly. Type IV should build on I, II, and III, and lead to type V. In the literature of project complexity some papers are seen to include all types of theory. One such paper is by (Cooke-Davies et al., 2007b), where the complexity of projects is explained (type I) based on the butterfly effect, strange attractors, etc. (type II), and makes predictions on radical project unpredictability (type III), and gives a set of recommendations for managerial behavior in complex projects (type V). Even though the recommended behavior in the paper derives more from common sense than from an explanation of complexity and project unpredictability, the paper is a good read and demonstrates how the type V theory can be built theoretically on type IV.

In contrast to this, a methodology like Design Science Research (DSR) aims to provide type V theory without building on the theory of type IV. The 'trick' of DSR is to design something, and then provide a rigorous evaluation to justify the contribution, which in turn could lead to new theories of type I to IV. The same kind of dualism is known from science and technology, where science might inspire new technology as well as the other way around, where new technology (without a scientific explanation/prediction) sparks scientific breakthroughs, with the science of thermodynamics and the technology of steam engines being classical cases in point. The philosophical foundation for the design approach to theory building can be found in the work of Dewey and James, often labeled pragmatism. Pragmatism can be seen as a third tradition of science, where the two 'real scientific traditions' are realism and constructivism. More on this will follow in the section on methodology.

Following Table 2, the purpose of the background section of an engaged scholarship paper is to articulate the opportunity to contribute. Based on the preceding review of the literature, there are many opportunities for contributions relevant to practitioners of project management as well as to other researchers.

Using the five types of theory as a lens on the literature on project complexity highlights yet another central point: most research has been more about analysis, explanation, and prediction of project complexity (types I – IV) and less about how to manage complexity (type V).

3.7. Complexity related literature review

Based on the literature review, the point referred to in sub-chapter 3.1 made by Geraldi et al. (2011) seems to be valid today: Research still needs to shift toward helping practitioners and their organizations to manage complexity, i.e. more prescriptive theory of type V is requested. Further, as Morcov et al. (2020) point out, we need research-based tools for measurement developed in cooperation with practitioners, and we need a better understanding of how project complexity changes over the lifecycle of a project, as mentioned by de Rezende and Blackwell (2019).

The research literature on project complexity is difficult to capture in a literature review which aims to provide an overview. With inspiration from the work of Gregor (2006) and (Doty & Glick, 1994), the student developed a typology of the research on project complexity and identified five ideal types of research where the independent variable was the intention of the research (M. F. Mikkelsen, 2020a). This provided the student with an overview; however, as will be demonstrated in the next section on conceptual framings, a 3x2 matrix categorizing perspectives on project complexity is more helpful in answering the research questions.

4. Conceptual framing

In engaged scholarship, conceptual framing helps structure the collection and analysis of data from the real world to answer research questions (Mathiassen, 2017). According to the suggestions of table 2, the conceptual framing is dividing into two types: The dependent on and the independent of the area of concern.

4.1. Conceptual framing *dependent* on the area of concern

The conceptual framing dependent on the area of concern is an extension of the literature review on project complexity, but with a focus on developing framing concepts. The result here is a 3x2 matrix of perspectives on project complexity. The first categorization of the matrix is the chronological perspectives, divided into ex-ante, transitions, and ex-post. The second categorization is the dichotomy of perceived and descriptive project complexity.

4.1.1. Perceived versus descriptive project complexity

In the research literature, perceived project complexity is very different from descriptive (objective) project complexity. The subjective notion of project complexity (as something other than "real" project complexity) is often referred to as perceived project complexity.

The work of Baccarini (1996) presents reflections on subjective perceptive versus objective approaches. Baccarini considers the use of perceived project complexity but rejects it because "this meaning of complexity has a subjective connotation implying difficulty in understanding and dealing with an object" and because it has an "unreliable basis for research analysis" (Baccarini, 1996, p. 202). Much interpretive research has contested this line of thinking, but this approach has nonetheless influenced research on project complexity.

The dichotomy of perceived and descriptive project complexity also appears in research on complexity in general, where (Schlindwein & Ison, 2004) state that "Complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself" and go on to explain that "In contrast to 'descriptive complexity,' the epistemological assumptions of 'perceived complexity' are based on the assumption that reality results from the distinctions made by an observer."

Building on (Schlindwein & Ison, 2004), the term "perceived project complexity" was coined by Vidal and Marle (2008). Their paper provides 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 mentioned previously, perceived project complexity is relevant to understanding practitioners' handling of 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."

Floricel, Michela, and Piperca (2016) use 'intrinsic' versus 'representative' as a similar dichotomy to address both structural and dynamic complexity, producing a 2x2 matrix of four different perspectives on project complexity.

An alternative to the 2x2 matrix is shown in figure 6; here it is only in the descriptive perspective that the differentiation of structural and dynamic complexity is relevant.

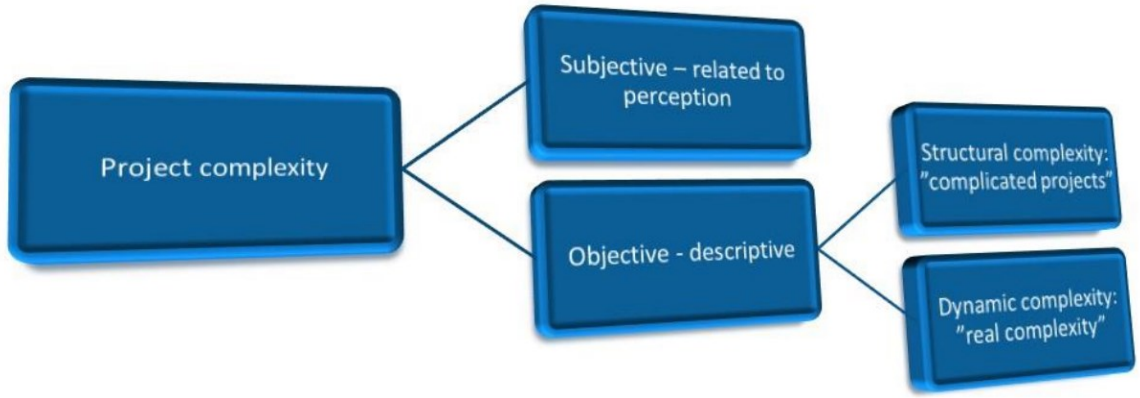


Figure 6: A common example of a breakdown of the concept of project complexity in research (Morcov et al., 2020).

4.1.2. ***Chronological perspectives on project complexity***

Section 2.3 introduced the concept of hindsight and foresight perspectives on projects along with the ex-ante and ex-post assessment of project complexity. The following section is a further elaboration on this perspective, here labeled the 'chronological perspective.'

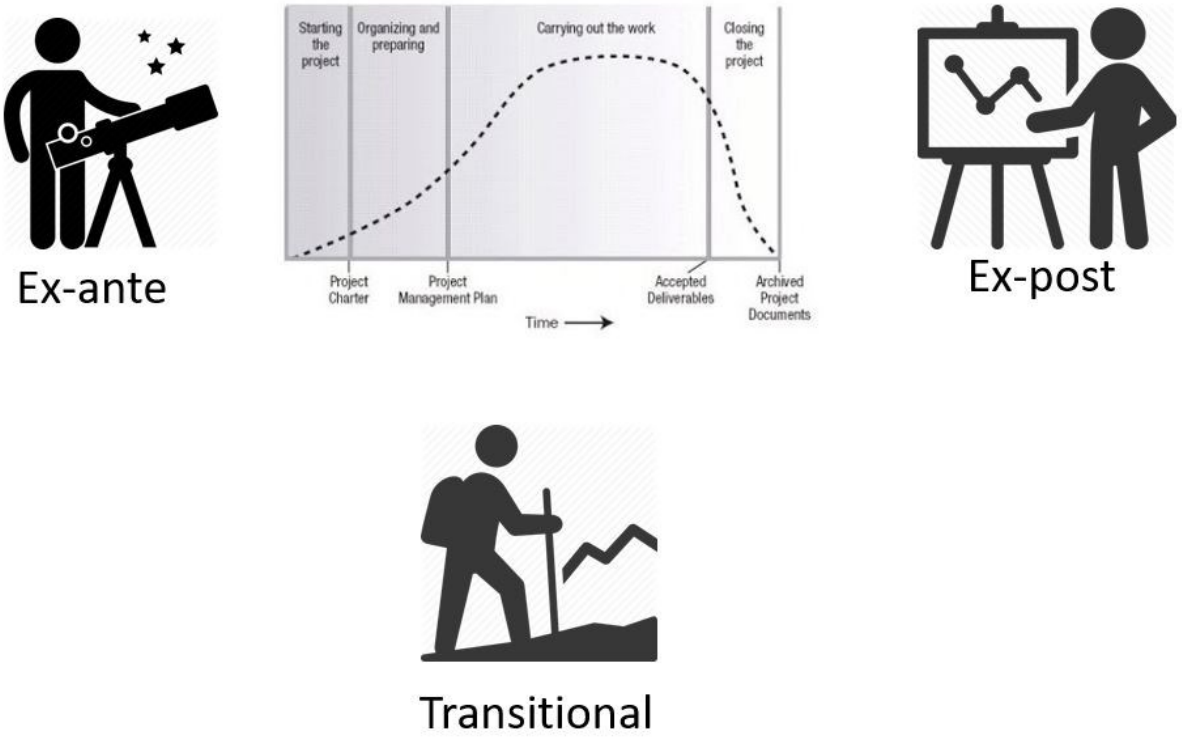


Figure 7: The three chronological perspectives on project complexity.

The chronological perspectives describe the viewpoint of the project based on the observers position on the timeline. Logically, the observations can be made before, after, or during the project. These three chronological perspectives are coined ex-ante, ex-post, and transitional. Ex-ante, meaning before the event, is a concept known from the Keynesian expectances theory (Keynes, 1937). Ex-ante and ex-post have been used in project evaluation (Samset & Christensen, 2017), but the dichotomy is perhaps more known in evaluation methods, e.g. FEDS (J. Venable, Pries-Heje, & Baskerville, 2016). The transitional perspective captures the lived experience of projects, and concerns the period between the ex-ante and ex-post timepoints. All three chronological perspectives will be explained in the following section; however, the focus of the investigation will be on the study of the transitional perspective on project complexity.

Ex-post perspective explained

Ex-post means "after the event," and in this perspective, the complexity of the project is assessed after project closure, when everything is known about the project. All the changes have already taken place, the fluctuating circumstances can be laid out on a timeline, the uncertainties can be assessed without any "uncertainty of the uncertainty," and the social-political situations can be evaluated since all conflict has been played out and hidden agendas have been revealed. There are no longer any unknown unknowns. This perspective is a post-mortem view, where the project's features and results are known objects accessible to research. This perspective entails an objectification of the project, and the complexity is a fixed construct that can be quantified, often as an array. Even though not all data are available, a researcher can assess the entirety of the project from its initiation to its conclusion. The researcher might detect a high degree of uncertainty in the project, but unpredictability is not an issue. This perspective is the most common approach in the research on project complexity.

Research that takes the ex-post perspective has the advantage that all is knowable (at least in principle) since by the time the research starts the project has ended. All the answers in the previously mentioned assessment tool will no longer be mostly guesswork. Not only can we detect which requirements changed, but also how much they changed, when they changed, and to some degree why they changed. In terms of theory, this can produce a far better explanation of why the project was *difficult to understand, foresee and keep under control* (see the definition of project complexity given in the introduction). Further, the benefits of researching projects as finalized objects give a solid basis for the comparison of projects and searching for law-like relations.

Ex-ante perspective explained

The ex-ante perspective is a view on the project at the time of the project initiation – or even before initiation. Here is a kind of chicken-and-egg problem. The question is, how much do we need to know about a given project before the ex-ante complexity can be assessed? The project decision-makers should have an ex-ante assessment of the complexity as part of their decision on initiating the project. But before the project is decided upon there is really no project to assess. Since the Project Charter in PMBOK (Project Management Institute, 2017) nor the Project Initiation Document in PRINCE2 (OGC, 2009) has assessment of project complexity this remains an open question.

As an example of an ex-ante assessment, the IPMA (International Project Management Association) approach involves making an ex-ante assessment before engaging the project manager. The assessment classifies the project in complexity level A, B, C, or D. These levels give recommendation on which IPMA certification level the project manager selected for the job should hold. (Explained in more details on https://www.ipma.world/individuals/certification/complexity/)

From a theoretical point of view the ex-ante perspective is making prediction about the project complexity based on initial information about the project. Hence, the ex-ante project complexity assessment will be based on assumptions, and these assumptions might be drawn from the

participants' experience from other projects in the past or drawn from a broader knowledge base relevant to the given project – perhaps even based on researched projections.

Comparing ex-ante and ex-post

In social science, information about the future cannot be predicted based on information about the past. Social science does not operate like Newton's laws; at best we can compare the prediction of project complexity to throwing crooked dice. While the dice is still rolling, the 'events' are only given as a probability distribution. After the roll, the 'events' are now observable manifestations. The same event will only happen again by change. Some outcomes are more likely than others, but the more crooked the dice is, the less is known about the probabilities of the different outcomes. In this metaphor, the degree of crookedness resembles the degree of complexity. Based on this allegory, it can be argued that the construct of project complexity is different when seen from the two perspectives, ex-ante and ex-post.

Since ex-ante project complexity for the most part is based on assumptions and expectations (probabilities), and ex-post project complexity are based on observations and realizations (manifestations), arguments can be made that ontologically they are two distinct constructs. Even if the same indicators were used, the ex-ante and ex-post measurements of those indicators could only be the same if there was full predictability of the project. But all projects are by nature unpredictable, and complex projects are radically unpredictable (Cooke-Davies et al., 2007a). The discussion of this does however not fit the focus of this paper.

The research streams of the two perspectives can benefit very much from each other. The ex-post research stream produces knowledge of projects in general, and herby informs the ex-ante perspective of a given project. Researching the ex-ante perspective of a given project and comparing this to the result of the same project in an ex-post perspective can provide very useful information on how the perception of the complexity of a given project can change during the project life cycle.

One example of an ex-post perspective on projects supporting the ex-ante perspective on a given project is known from 'Reference Class Forecasting' (Bent Flyvbjerg, 2008). In the method, historical data of the cost, duration, and benefit of projects are organized in project classes to utilize an increased precision of the estimation. In other words, the method deploys an ex-post perspective on statistical data of a class to improve the ex-ante estimation of a given new project from the same class. The principle of a method like RCF is like the tide raising all boats. Of course, information of the average of the project class is important for project management, there is mush more knowledge about the given project, that needs to be included for successful handling of the complexity. Project statistics can only provide limited help when the focus is on the lived experience of a single given project.

Adding to the above, complex projects can be seen as a process of "connecting the dots" (Curşeu, Janssen, & Raab, 2012), where learning is essential. Realizing the unsupported assumption of the project is easier in hindsight than foresight, hence this information will become more often in the transitional than the ex-ante perspective.

Similarly, delusional optimism (Lovallo & Kahneman, 2003), leading to unrealistic expectations of what is possible within the budget and timeframe, will not reveal itself in an ex-ante perspective – if it could, this would be deemed functional stupidity (Alvesson & Spicer, 2012). In the transitional perspective, where the project evolves in the unfolding universe, the actors find out which of the assumptions turned out to be bad or sound assumptions and realize whether the initial approved triple constraints (ion triangle) are realistic or not.

The transitional perspective explained

The perspective of the project between project initiation and termination is neither an ex-ante nor an ex-post perspective. The perspective expresses the complexity of the unfolding project from initiation

until project closure, when the ex-post perspective of the project complexity can be applied. It can be called the ex-temporal perspective, but to express the unfolding and intrinsic dynamics of this perspective, it is here coined 'the transitional perspective.'

The transitional perspective is different from the ex-ante perspective, not only because the two dimensions are defined differently, but due to the increasing knowledge of the behavior of the project system that the former affords. Assessment of project complexity in the initiation phase is mainly based on assumption, and as the project unfolds, this assumption will gradually be substituted by observations on the indicators.

The transitional perspective succeeds the ex-ante perspective. The ongoing assessments made in the transitional perspective can be done using tools developed for the ex-ante evaluation. However, some of the questions from the initial phase need to change to make sense in the later phases of the project lifecycle. Likewise, in the termination phase of a project, it can be said that the ex-post perspective can overlap with the transitional perspective when it comes to the choice of tools and frameworks.

Some indicators can for obvious reasons first be determined in the transitional perspective. Hidden agendas in the socio-political dimension (Geraldi, 2011) are an example of this. A hidden agenda cannot be known (by others) until it has been revealed. If it is known that stakeholders have competing agendas for the project, these are not hidden agendas, but only conflicting interests. Likewise, a low level of trust (Remington, 2016) can be difficult to assess beforehand, but once revealed, it is obvious to see.

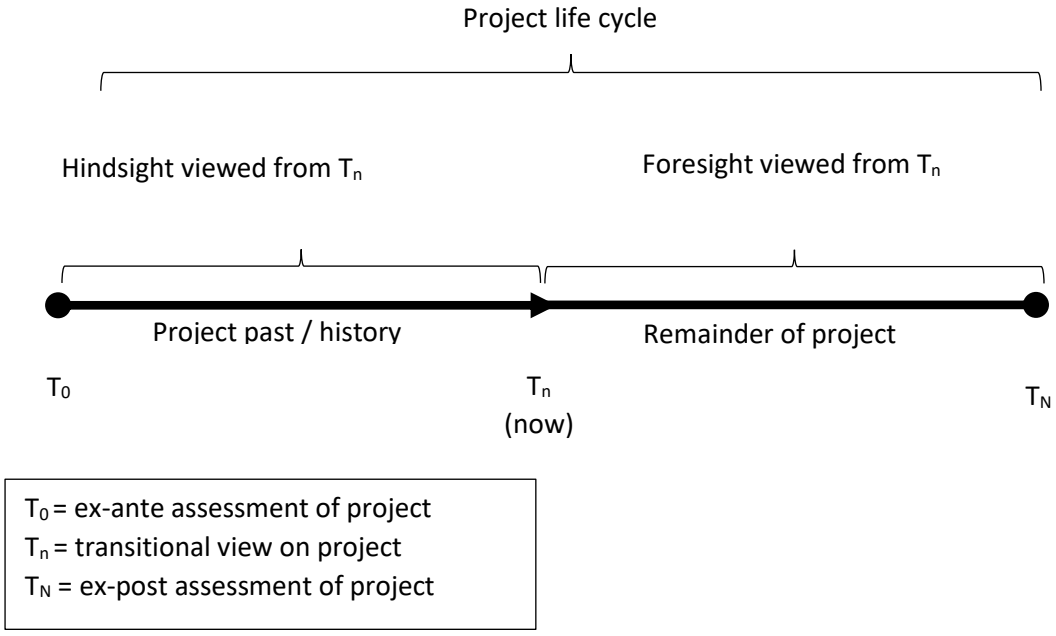


Figure 8: Depiction of the chronological perspective.

In the transitional perspective, the practitioners have a partial project history, as illustrated in Figure 4. At any given time, T_n, in the transition from the initiation (T_0) till project closure (T_N), the project is divided into two parts: the project past (until now) and the remainder of the project.

Based on figure 4 the difference between the ex-ante and the transitional perspective can be explained by the fact that the transitional perspective – in contrast to the ex-ante perspective – is informed by some of the history of the given project.

Summing up the 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.

The majority of the research papers on project complexity use the ex-post perspective, a minority of papers employ an ex-ante perspective, and only a few papers have investigated the transitional perspective. This distinction makes this thesis stand out in the context of relevant ongoing work in the specific area studied. Examples will be given later in this section.

The focus of the investigation will be on the transitional perspective.

Hindsight/foresight misconceptions in project complexity research

With the chronological perspective provide a lens for detecting misconceptions. 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 the framework in an ex-ante way. While this may not prevent the framework from being useable for practitioners, the above is still a relevant misconception.

Another example comes from the TOE model (Bosch-Rekveldt et al., 2011), The model has three dimensions of project complexity: technical, organizational, and environmental. The dimensions are assessed using 50 indication questions (Bosch-Rekveldt 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.

4.1.3. Matrix of perspectives on project complexity

Combining the dichotomy of perceived and descriptive complexity with the chronological perspective developed in 2.5.2 gives a 3x2 matrix as depicted in Table 2.

The indicator used to differentiate between descriptive versus perceptive 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. *One measure* 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. *Multiple (subjective) interpretations* of the complexity of a given project, because the complexity exists in the eyes of the beholder*s*, i.e. project manager and project stakeholders.	The multiple expectations about the dynamics of project complexity.	The lived experience of the dynamics of project complexity.	Multiple interpretations of the history of the given project.

Table 4: Matrix of perspectives on project complexity (conceptual framing).

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

Table 5 displays samples of literature on project complexity positioned in the 3x2 matrix depicted in Table 2 from the conceptual framing section. The correct position of each paper can be debated and is here only used to give an illustration of the concept of the 3x2 matrix.

	Ex-ante perspective	Transitional perspective	Ex-post perspective

Descriptive project complexity.	(Geraldi et al., 2011), (Bosch-Rekveldt 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 et al., 2013)	(H. Maylor et al., 2008), (H. Maylor & Turner, 2017), and (Ahern, Leavy, & Byrne, 2014)	(Davies, Dodgson, & Gann, 2016), (Floricel et al., 2016), and (Davies & Mackenzie, 2014)

Table 5: Examples of the research literature positioned in the matrix of perspectives on project complexity.

The following section will present arguments for the selected positioning of some of the examples of research literature in Table 5.

Geraldi et al. (2011) state that their framework is descriptive. The intended application is for "Business case development. Strategic choice. Process choice, Managerial capacity, Managerial competencies, and problem identification" (Geraldi et al., 2011, p. 983+984). Based on this the framework is categorized as an example of the ex-ante perspective.

De Rezende and Blackwell (2019) build on Geraldi et al. (2011) and present a similar, but slightly different assessment tool where the dimensions are: Structural complexity, Uncertainty, Pace, Novelty, Dynamic, Social-political, and Institutional. The authors of the paper stress that the tool is not for measurement, but rather for dialogue about the projects and programs; hence it is positioned as shown in Table 5. In principle, the tool could be used with a transitional perspective, and the authors of the paper open the way to this, which can be seen in the following call for further research: "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 & Blackwell, 2019, p. 139). Given that the utility is ex-ante, the paper is positioned as shown in Table 5.

Tools for assessing project complexity are found frequently in handbooks and tools like PMBOK (PMI, 2014). Here the indicators of complexity are questions like the following: "Are the requirements likely to change?", "Is senior management fully committed?", "Will the supplier be able to meet the commitments?", and "Is the client prepared to accept deliverables?". Based on these examples of questions from the assessment tool, the tool is a combination of the ex-ante and the transitional perspective. In table 4, the tool is placed under the latter category, but this positioning can be questioned. The reason for categorizing the tool as descriptive is the observation that the result of use is one single measure of the complexity.

The Complexity Assessment Tool (CAT) is a research-based tool for the assessment of project complexity (H. R. Maylor et al., 2013). The questionnaire used for the tool is illustrated in Appendix C. This assessment tool has three areas of complexity: the structural, the sociopolitical, and the emergent. The tool asks 22 quantitative questions to be answered by the project manager (or project decision-maker) to clarify the structural complexity, and 11 to clarify the social-political complexity. The assessment of emergence is based on a succeeding question "Do you expect this situation to remain stable?" for each of the 22 questions.

All of these questions can be answered in the initial phase of the project. The emerging complexity is assessed based on the expectation of changes to the 33 answers given. Since the wording is "Do you expect this situation to remain stable?" – without asking if the situation has already changed – the chronological perspective is assumed to be ex-ante.

4.1.5. Levels of descriptive project complexity

So far, it has been assumed that perceived and descriptive project complexity can be seen as a dichotomy, following the two definitions from (Vidal, Marle, & Bocquet, 2007). In the following, this presumption will be investigated and a more nuanced approach will be presented.

The dichotomy of perceived and descriptive project complexity is related to the two scientific traditions, often labeled interpretivism and realism. Realism assumes knowledge exists 'out there' regardless of the observer. Realism is the search for truth, whereas interpretivism seeks understanding. In the interpretivist (constructivist) worldview, knowledge and the observer cannot be separated. In other words, there is always a subjective element to knowledge.

While these two traditions are archetypes, a foundation for a pragmatic middle ground also exists. Building on Weick (1984), Orlikowski and Baroudi (1991) state that the "difference between the weak and the strong constructionist positions has implications for how interpretive research relates to research conducted in the positivist mode. From the viewpoint of weak constructionism, interpretivist research is understood to complement positivist research, that is, by generating hypotheses for further investigation, and by filling-in the knowledge gaps that positivist research cannot attend to, such as the contextual exigencies, the meaning systems, and the interaction of various components of a system" (Orlikowski & Baroudi, 1991).

The ontology of perceived versus descriptive perspective could be based on Immanuel Kant's distinction between how something appears and the thing in itself. However, the strict objectivity in the thinking of Kant would be more relevant in natural science than in social science. In the descriptive models of project complexity, objectivity is more like an intersubjective agreement based on the thinking of Carl Popper. The metrics will eventually rely on 'human popes' for the quantification of indicators and dimensions. There is hardly one single measure of projects that can be objectively determined. Unfortunately, papers on descriptive project complexity seldom account for their worldview.

When it comes to the epistemology of perceived versus descriptive project complexity, there are gray areas that need to be considered. The above theoretical considerations are in Table 4 converted into a more practical categorization of the realm between the objective descriptive and subjective perceptive project complexity. One way to carry out a classification is to define three levels of distance to the pure objective project complexity. Table 4 depicts the degree of perceived project complexity as a matter of distance away from descriptive project complexity.

Distance from the ideal descriptive	Explanation of the level along with examples of research
Level 0	Descriptive project complexity with objective measures based on a construct of dimensions with objectively calculated weights of each dimension.
Level 1a	Perceived weight of the dimensions of project complexity. For example, like the Delphi method (Vidal et al., 2011).
Level 1b	Perceived indication of the dimension of project complexity. One example is (Bosch-Rekveldt, Bakker, & Hertogh, 2018). Here, the participants are 'human probes' used for assessing indicators of complexity leading to a calculation the project complexity.

Level 1c	Perceive project complexity as a whole, as an assessment without scientifically constructed dimensions. Assuming the perceiver holds the same mental model of project complexity. An example is (Sohi, Hertogh, Bosch-Rekveldt, & Blom, 2016).
Level 2	Presumption of multiple perceptions of complexity, but with one common construct of complexity. In other words, there is only one metric for measuring, but the measures made are subjective. This is the worldview in papers like (de Rezende & Blackwell, 2019) and (H. R. Maylor et al., 2013).
Level 3	The construct of project complexity is subjective. There is no common understanding of project complexity, hence the observers give different weights to the dimensions of project complexity. There are indications that the perceived importance of dimensions is influenced by the project role of the stakeholder and to some degree also by factors like sector, project type, project experience, etc. (M. F. Mikkelsen, 2020b).

Table 6: Levels of perceived project complexity.

Table 6 is a further development of the discussion on mental models of perceived project complexity (M. F. Mikkelsen, 2020b), where the main contribution is the indication of the correlation between the perceived importance of dimensions of project complexity and the project role. The inference of this work is that perceived project complexity needs to be considered from the viewpoint of multiple stakeholder types because they do not only perceive the given project differently, but they also perceive the concept of project complexity differently.

Table 6 could have been used to further differentiate table 4; however, this would not add to the overview or the conceptual understanding, and it would make argumentation for the positioning in Table 5 even more difficult.

4.2. Conceptual framing *independent* of the area of concern

In this section, the following concepts will be presented: The affordance theory, the Cynefin framework, concepts of project success, and the stakeholder landscape. Finally, and perhaps most importantly, the concept of the outside view is presented.

4.2.1. Affordance theory

When introducing an information system (IS) as a part of the solution, the conceptual framing must include IS theory. The IS success concept (DeLone & McLean, 1992, 2003) is included in the overarching conceptual framing. In this concept, success with information systems is broken down into three components: information quality, systems quality, and user satisfaction. These components lead first to individual impact, then organizational impact.

The IS success concept from DeLone and McLean is not strong seen from the perception perspective, so affordance theory was used to the implementation of the ADR project. The original tenets of affordance theory (Gibson, 1977) declare that a goal-directed actor perceives an object in the environment in terms of how it can be used, that is what it "affords" the actor in terms of action possibilities for meeting the actor's goal. In this case, the object is the artifact, and in affordance theory, the artifact is therefore not viewed as a set of characteristics or features that are inherent in the artifact nor is the artifact independent of the actor's perception of it.

Over the years, affordance theory has evolved to include the concepts ofaffordances perception and affordances actualization before realizing the affordances effect is realized (Pozzi et al, 2014). See Figure 9.

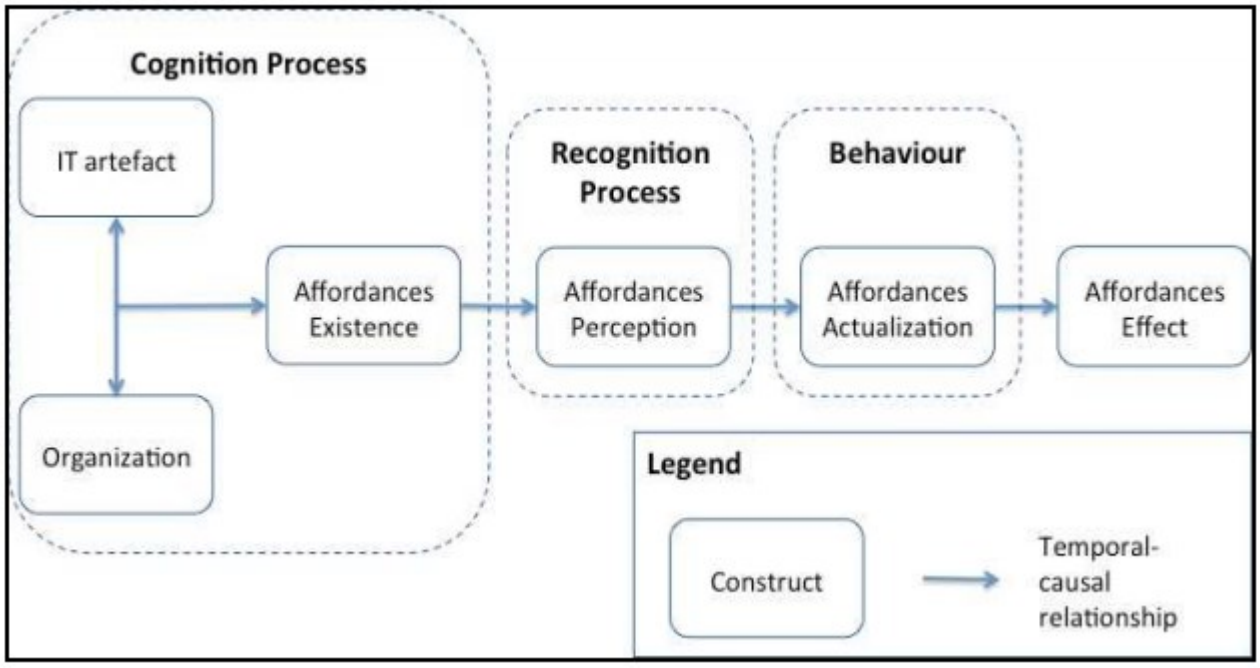


Figure 9: Affordance theory in the evolved version as presented by Pozzi, Pigni, and Vitari (2014)

The temporal-causal relationship in Figure 9 depicts the creation of affordance as a cognition, where affordance perception is a recognition process. With the focus on behavior as an intermediate preceding the effect, the affordance theory opens a broader perspective on organizational change.

Several factors can influence actualization. Pozzi et al. (2014) mention the following aspects: 1) effort necessary for action to take place, 2) cognitive load on actors, 3) goals of actor, 4) organizational and environmental structure and demands, 5) willingness to change behavior and 6) organization's level of skill or knowledge.

Most importantly, the actualization depends on the perception of affordance, as depicted in Figure 9. In this ADR project, there were some profound examples of how affordance misperception prevented the actualization of affordance. Where the intended affordance was the navigation of project complexity, the artifact might have been misperceived as a 'satisfaction measurement' with could be used in undesired manners of the manager of project managers and perhaps also HR.

4.2.2. Cynefin framework

As Figure 10 illustrates, the Cynefin framework outlines five system domains, identified as obvious, complicated, complex, chaotic, and disorder (each described below). A central feature of this framework is that different decision-making approaches are needed depending on what domain the current situation belongs to. Cynefin is a Welsh word that can be translated as "multiple belongings". In the Cynefin framework, each domain is categorized by the level of system complexity.

The framework was developed for situational strategic decision-making, not for project management. However, because a project can be considered an extended series of situations facing the managers, the Cynefin framework is applicable.

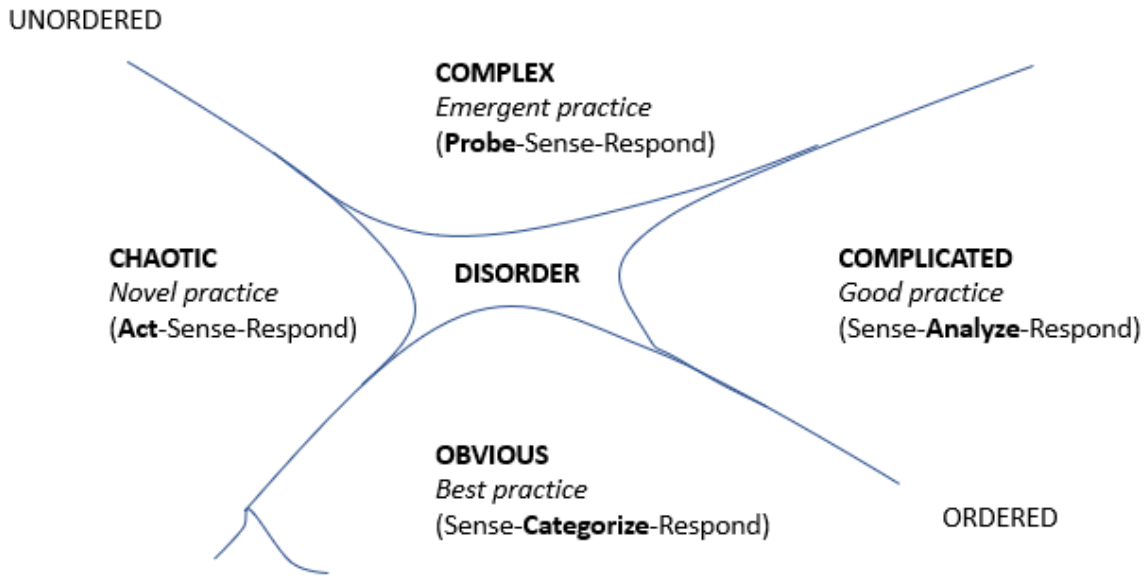


Figure 10: Cynefin framework

1. In the *Obvious* domain, systems are causal, causes and effects are obvious to all, and there exists a best practice to follow. (Obvious was labeled 'Simple' in an earlier version of the Cynefin framework)
2. In the *Complicated* domain, there are also direct connections between cause and effect in the systems, but an analysis is necessary to reveal the causality. More options are available, and they are multifaceted. Therefore, there is no single right answer.
3. In the *Complex* domain, causes and effects in the systems are loosely coupled, and they can only be seen in hindsight. This condition suggests emergent practice, where managers discover useable paths as they progress.
4. In the *Chaotic* domain, the systems, according to the Cynefin framework's use of the term chaotic, are random. Because results are random, the things managers need to do, cannot be based on experience.
5. The *Disorder* domain applies when it is unclear to which of the other four domains the situation belongs (Snowden & Boone, 2007).

Reproductions of the Cynefin framework often depict a window with four domains and exclude the very important 'disorder' domain. In an interview with the student, the author of Cynefin framework, David Snowden, stressed the problem that decision-makers are in the fifth domain most of the time.

The Cynefin framework is referred to in many project management handbooks, like (Hermano & Martín-Cruz, 2019) and (Pirozzi, 2018), and also in the methodology PRINCE2 Agile (AXELOS, 2015). However, the framework has thus far received very little attention in project management research. Among the few are papers on project decision-making (Basha, 2017) and portfolio management (Shalbafan et al., 2018). Vollmar et al. (2017) see the framework as a potentially important new tool for project managers.

Figure 11 depicts the latest update of the Cynefin framework, which includes some interesting changes. Most noteworthy is a change of "disorder" to "aporetic", labeling more suited for the confused perception of the situation and also a domain to re-enter after realizing the system has become chaotic.

Regardless of the aha-feeling many feel when confronted with the Cynefin framework, there is a need for a rigorous evaluation of the actual benefit of deploying the framework during projects. No such evaluation literature review did not find them.

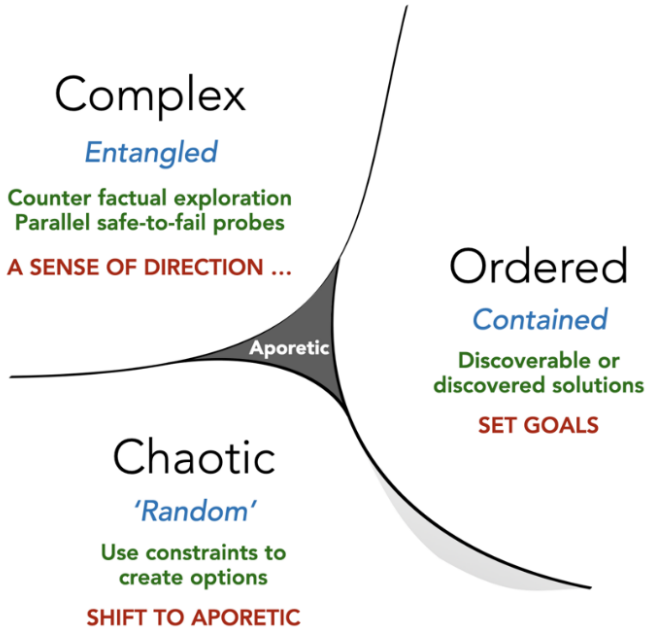


Figure 11: An updated version of the Cynefin framework (https://www.cognitive-edge.com/cynefin-st-davids-day-2021-1-of-3/)

The use of the Cynefin framework as conceptual framing in this thesis can be formulated as follows: The dynamic of the system is fundamentally different depending on the degree of complexity. Each domain calls for a very different managerial response. The central problem for the decision-maker is to realize which domain a given situation, or project, belongs to.

The information system developed in this research project addresses this problem by engaging the stakeholder by surveying their perceptions of the complexity of the given project.

4.2.3. Concepts of project success

The research literature reports correlations between project complexity and project success. One found that a strong relationship between project complexity and project success is augmented by the standardized coefficient value of −0.254 between them. (Luo, He, Xie, Yang, & Wu, 2017). Bjornvatn & Wald (2018) has "established empirically the relationships between project complexity and project management performance in terms of unscheduled delays and overspending" (Bjorvatn & Wald, 2018, p. 886). Both papers are based on positivistic research with "narrow" constructs of complexity and success. It is more aligned with the common terminology, to state that there is evidence of a correlation between structured complexity and project management success, where the latter is labeled 'efficiency' by some as explained below.

Project success is a matter of both efficiency and effectiveness (Baccarini, 1999). Efficiency is a matter of achieving project completion while minimizing the resources used (e.g., time and money). Effectiveness is a matter of realizing benefits to the stakeholders (Serrador & Turner, 2015). A literature review on project success by the student (M. Mikkelsen, 2018b), but not included in this cappa, documented that most definitions of project success aling with the above dichotomy, although the effectiveness dimensions can be debated. (This conference paper is not included in this thesis because the discussion of complexity in that paper was not fully developed).

In the literature, there are various versions of the construct of effectiveness:

1) A business focused interpretation of effectiveness includes the following: Impact on customer (customer benefits in the delivery of end products and meeting customer needs), Business Success (project benefits in commercial value and market share), and Preparation for the future (creating new technological and operational infrastructure and market opportunities) (Shenhar, Dvir, Levy, & Maltz, 2001).

2) A more developed understanding of the effectiveness dimension includes environment performance, client satisfaction, employee satisfaction, probability, learning, and development (Silva, Warnakulasooriya, & Arachchige, 2016).

3) A holistic version includes the above and also products and deliverables: criteria to judge the technical requirements and qualities of the products or deliverables resulting from the project; Business: criteria to judge the benefits and returns (or losses) of the project to the stakeholders; and Context and externalities: criteria to judge the project based on compliance with the contextual circumstances and externalities that affect it, such as the political situation, regime, and climate. The project team or organization has little or no control over these externalities. (Howsawi, Eager, Bagia, & Niebecker, 2014)

Regardless of the range of the effectiveness dimension of project success, there exists a common understanding, that it is all about the stakeholders – making a project successful in their eyes – as the following three quotations make clear: “A degree of conceptual and definitional ambiguity surrounds project success. Further, evaluations of project success are necessarily perceptual and (inter)subjectively constructed” (McLeod, Doolin, & MacDonell, 2012). “Project success is a multidimensional construct where project stakeholders can select a number of project success criteria, they believe are important to judge on success” (Joslin & Müller, 2016). “The perceived success also depends on the perspective of various stakeholders and project roles, and thus indeed lies in the ‘eye of the beholder’” (Neves, Borgman, & Heier, 2017).

In summary, structural complexity is correlated to efficiency, but there is not a documented relationship between project complexity and project success (defined as a combination of efficiency and effectiveness).

The work of the student indicates that the relationship between project complexity and success might be much more complex. (M. F. Mikkelsen, 2020a). The paper identified five ideal types of research on project complexity, each with its distinct type of relationship to the concept of project success.

4.2.4. Stakeholder landscape

If project success is to be defined from the stakeholder’s perspective, a deeper understanding of the stakeholder might be needed. Therefore, the stakeholder landscape is a part of the conceptual framing of this study.

The typical project management approach for stakeholders is to engage in “stakeholder management,” which involves aligning stakeholders with the project objectives and reducing their “resistance to

changes" among the project stakeholders. The first step is to combine a stakeholder analysis with a communication plan. The stakeholder analysis determines how the stakeholders are likely to be influenced by the project and its results, as well as how the stakeholders can influence the project. While the information on these topics can be collected based on interviews with the stakeholders, the basic approach is very much "inside out," meaning that it views the project through the eyes of project management.

Projects are essentially networks of different stakeholders with diverse backgrounds, resources, and objectives that must be aligned for the project to create value and deliver benefits (Manning, 2017). Although there is convincing evidence of the role and influence of different types of project stakeholder environments on project complexity (Aaltonen & Kujala, 2016), the most prominent contingency models for project management (Shenhar & Dvir, 2007a) tend to focus on the effects of task complexity and internal and technical factors, thus downplaying influences from the stakeholder environment (Geraldi et al., 2011). Stakeholders are primary driver of project complexity and particularly its organizational element. Understanding and mastering the project's stakeholder environments and landscapes are therefore crucial for the successful management of project complexity throughout the project lifecycle.

The project stakeholder landscape has been characterized as consisting of four key dimensions, including complexity (element and relationship complexity), uncertainty, dynamism, and the institutional context (Aaltonen & Kujala, 2016). Stakeholder complexity refers to the relationship complexity and considers stakeholders as the elements of the stakeholder system. The uncertainty element, in turn, includes the idea that the state of the project's stakeholder landscape is emergent and the interactions between project stakeholders are more or less unpredictable. For project managers this uncertainty creates a situation in which there is a gap between the amount of information required for decision-making and what is actually available concerning stakeholders. Dynamism is related to the characteristic and propensity of the project stakeholder system to change, while institutional context refers to the complexity of the institutional stakeholder environment in which the project is navigates (Aaltonen & Kujala, 2016).

The management of stakeholder landscapes with different degrees of project complexity has been addressed in a limited fashion. Research has acknowledged, however, that the management style, orientation, and interpretation processes of project managers may significantly affect how they approach and deal with project stakeholders and the complexity they produce (Aaltonen, 2011). While some project managers are outward-looking, reflective, and constantly analyze project stakeholder environment as well as enact proactive management approaches and try to learn, others are more inward-oriented and inclined to view stakeholder environments as unanalyzable (Aaltonen, 2011). Furthermore, the adaptive capacity of the actors (described as the capacity to adapt to the changes in stakeholder context and be able to learn) has been identified as a key element in managing complexity produced by the stakeholders (Giezen, Bertolini, & Salet, 2015).

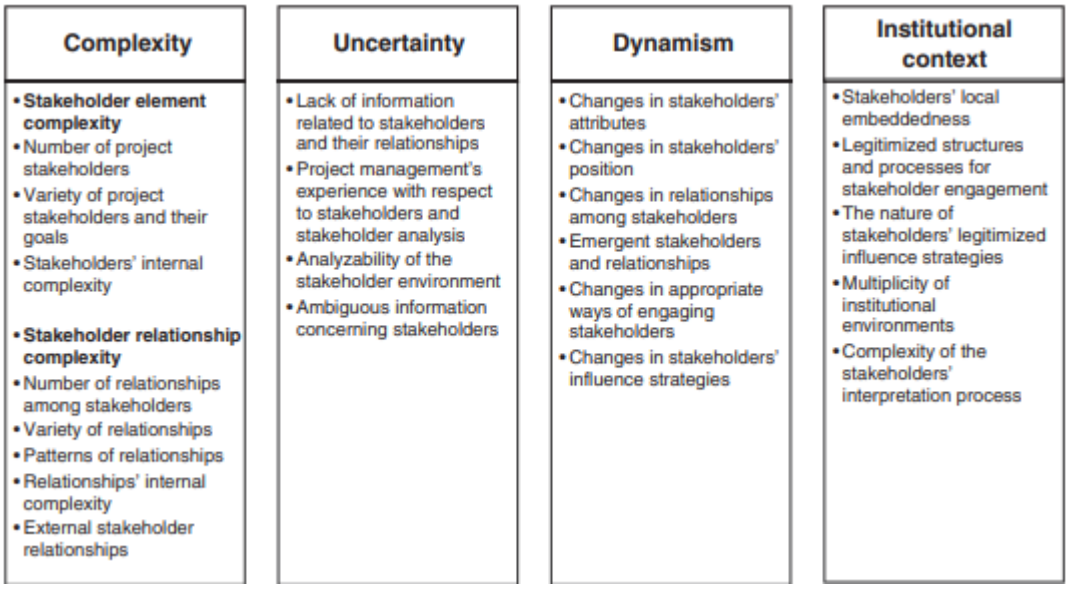


Figure 12: Key dimensions of project stakeholder landscapes (Aaltonen & Kujala, 2016)

4.2.5. Outside view

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.

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 out side view concept requires the decision-maker to consider a external information source instead of solely his/her inside view, with its baises, i.e. delusions of success (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."

A possible danger in seeking information through the wisdom of crowds based on stakeholders is that of "groupthink" (Janis, 1972). Groupthink occurs when a group of individuals aims to reach a consensus on a controversial topic. Groupthink can occur during group decision-making when group cohesiveness is high (Janis, 2008). The use of an information system with the response are collected

individually - rather than having issues discussed within groups – the groupthink risk is mitigated. The information system aggregates the data and presents these on a dashboard in a DSS.

Perceived project complexity versus outside view

The outside view is not the same as the perceived project complexity. The former is about getting a supplement to the inside view. The inside view is when the decision-maker only relies on his/her biased perspective on the situation and the alternatives. The inside view must not be mistaken for a perceived perspective. The perceived project complexity forms a dichotomy together with the descriptive project complexity. In other words, the inside view is always perceived but the outside view can be perceived or descriptive. The exemplify this, the method 'Reference Class Forecasting' (RCF) is an example of a descriptive application of the outside view. RCF uses objective data on historical projects to improve the accuracy of estimation of cost and benefits.

For clarity, the difference between outside view and perceived project complexity is here explained by an example of the use of CAT (H. R. Maylor et al., 2013): When the project manager answers the 2 x 32 questions in the questionnaire, the result is the perceived project complexity of the given project, and it is based on the mangers inside view of the attributes of the project.

However, if project manager asked a client (or another stakeholder not managing the project) to answer the same questionnaire, the result would still be the perceived project complexity of the given project, but it would be based on an outside view, and hence would provide a relevant supplementary perspective.

Concluding the example, it should be stated, that CAT method does not include the outside view, instead it relies on the inside view of project management (not only the project manager), as the paper state: "In use, the benefits of the CAT arise not directly from the questionnaire but the subsequent conversations between managers involved in the project." (H. R. Maylor et al., 2013, p. 49).

In addition, it is worth mentioning, that a project manager from another project can provide an outside view on a project that is not their own. In this case, the outside view is related to the well-known concept of peer-review.

As has been reported in paper #2, stakeholders with different roles tend to perceive the complexity differently, because they ascribe different levels of importance to the different dimensions of complexities. Therefore, there is a need for an outside view from several different project roles. However, it is not determined how many roles the setup of outside view should contain. For practical purposes, this can be determined by the managers of a given project. One recommendation is to let the structural complexity and the importance of the project guide this decision.

The decision concerns both how many people are invited to give an outside view and how many different project roles to include in the group. A rule of thumb is, the more outside viewer engaged, the higher diversity on roles should be attained. Many outside viewers with the same project role can lead to redundancy in data. In figure 13, this is illustrated. Again, no clear guidance can be provided since the effect might be different for different project roles. . E.g. due to project management training, project managers might see projects more alike than end-users from different departments.

Number of project roles involved (i.e. project manager, steering committee, end-user, etc.							
	Etc.	Not applicable					
	5						
	4						
	3						
	2						
	1						Higher risk of redundancy
		1	2	3	4	5	Etc.
		Number of persons giving outside view to the project					

Figure 13. Recommended number of persons given outside view versus the number of project roles covered – developed by the student.

The outside view and the system of system (SoS) approach

The System of System (SoS) approach is a classification of system thinking into a system itself. "System thinking, if anything, should be carried out systematically" (Ackoff, 1971, p. 671). In the classification of systems, the decision-maker views the problem in its context. There are at least two different courses of action, where there is doubt of the outcome. Each of the 'course of action's belongs to a system. (Jackson & Keys, 1984).

When using the Cynefin framework as a lens, the paradigm of the PM-BOK (Project Management Institute, 2017) can be classified as belonging to the Complicated domain. The modus operandi "sense-analyze-respond" of the complicated domain in the Cynefin framework captures the essence of the PM-BOK. The system perspective of the complicated domain is rational, and the managerial approach is a matter of governing the constraints as illustrated in Figure 14.

The complicated domain is the realm of experts. A project manager with proper training is an expert in managing projects. Given the decision-maker is a trained project manager, the default choice would be to see the project as a complicated system.

Helping the project manager obtain an outside view, might lead to a change in their perception of the given problem (or entire project), they may then perceived it as complex instead of complicated – when this is appropriated.

The presumption here is that it is beneficial to the project that the project manager gets sound input to decide or re-decide the choice of system for problem-solving. In the words of the Cynefin framework, such the chosen course of action be 'sense-analyze-respond' (complicated system thinking) or 'probe-sense-respond'' (complex system thinking).

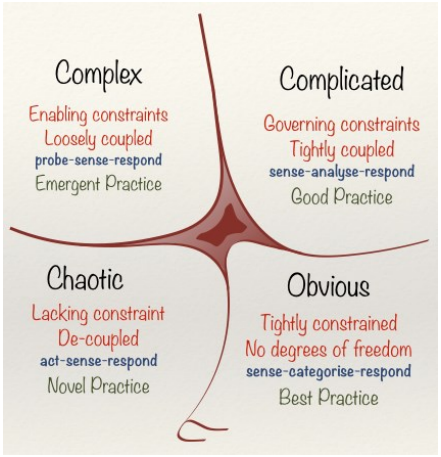


Figure 14: Cynefin framework - https://www.cognitive-edge.com/

Again, to contrast this approach with the RCF mentioned previously, the outside view deployed in RCF is to get a more accurate estimation of the cost and benefits of a given project based on similar historical projects. The RCF is concerned with cost/benefit data on projects. In contrast, the thinking here is a case of having an inside/outside view on the system level, and not having it on the data level, as the RCF does.

On a meta-level, the following can be observed: having an information system that provides an outside view to inspire a more reflective choice regarding what kind of system thinking to deploy on the project is itself a matter of deploying a specific kind of system thinking. According to Cynefin classification, this would be a complex approach since the 'probe-sense-respond' approach is deployed.

Based on Cynefin framework, the RCF can be classified as belonging to the complicated domain. The RCF method is making a 'good practice' of estimations even better.

The outside view aims to get a better grip of the 'pro-jection' of the future by balancing out the inside view of the project management.

5. Methodology

This Ph.D. project was initiated as a Design Science Research (DSR) project. However, halfway through, the methodology changed slightly and became more participatory, hence the methodology changed to Action Design Research (ADR). Both DSR and ADR will be explained in this section In the early stages of this Ph.D. study, the opportunity arose of participating in a large Danish survey of project management practitioners.

5.1. A questionnaire among practitioners

Sending a questionnaire to a large number of practitioners is a good way to qualify the problem in the real world and investigate the perceived project complexity. Using a survey to capture the real-world experiences of project managers is a common approach; one example is Fortune, White, Jugdev, and Walker (2011).

The survey was developed in collabroation between a Danish university and an international consulting company based in Denmark. The questionnaire was distributed among project managers and some project stakeholders across all sectors in Denmark. The database used for this survey contained 9,619 individuals with "project" in their job titles. Given that Denmark has 5.7 million citizens, this number is noteworthy. A total of 1,064 respondents completed the survey, resulting in a response rate of 10%. The majority of respondents (two-thirds) had the job title of "project manager," and there is thus a lower number of respondents holding other project roles.

Among many other questions, the questionnaire asked practitioners how they perceived project complexity based on a finite set of characteristics to choose from. Their answers serve as a proxy for their commonly held perceptions. The survey produced unordered categorical data. While such data are not necessarily ideal for statistical analysis, the form of the results reflected a trade-off between statistical prerequisites and flexibility in the questionnaire to allow practitioners to "express" their perceptions of project complexity. The complexity perceived by the individual could then be analyzed against many other factors, such as roles, project type, sector, and more.

5.2. Design Science Research (DSR)

When a research question begins "how can," the research endeavor often becomes a matter of design. This paper's research questions focuses on creating a new purposeful artifact to address a general problem. Design Science Research (DSR) (Hevner, March, Park, & Ram, 2004) offers a suitable solution. DSR has been developed largely within Information Systems research. However, the approach applies to all applied disciplines, including business and management (John R. Venable, 2010). For example, it has been applied in management studies by such researchers as van Aken (van Aken, 2004, 2005) and Romme (Romme, 2003; Romme & Endenberg, 2006). DSR projects typically undertake four main activities: problem diagnosis, purposeful artifact invention, purposeful artifact evaluation, and design theorizing (Venable, 2006)

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

Gregor and Hevner (2013) describe a contribution matrix to highlight the types 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 e knowledge is well-developed and well-established. Domain maturity (also high vs low) concerns whether the domain for

the application of the technology (in this case management of project complexity) is matured. The research reported in this thesis 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.

In DSR the design and the evaluation are equally important. Research papers on the methodology of DSR include many contributions on design, design principles, etc., but less on evaluation. The three cycles of DSR (Hevner, 2007) can be used to clarify the term "evaluation." See Figure 16.

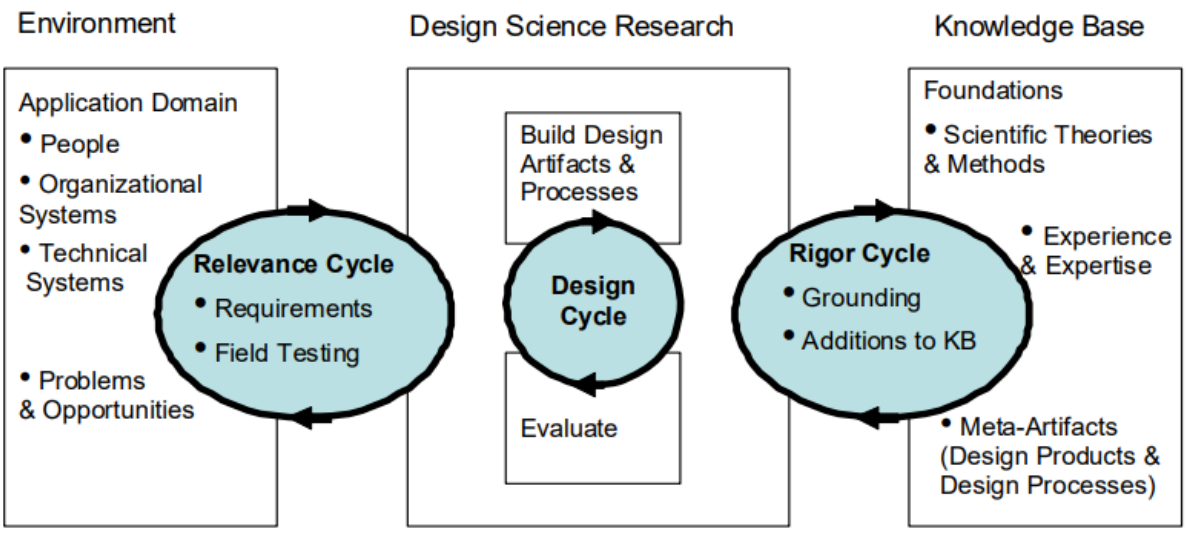


Figure 16: Three Design Science Research Cycles (Hevner, 2007)

The center of Figure 16 illustrates the fundamental design cycle of a DSR project as the iterative process of design and evaluation. This process is often referred to as formative evaluation (J. Venable et al., 2016).

5.3. Evaluation in DSR

(Cleven, Gubler, & Hüner, 2009) lay out a framework for evaluation in DSR by demonstrating that all scientific traditions, methodologies, and techniques are available for the evaluation process. The paper was on the other hand very sparse on how to evaluate practice.

The Framework for Evaluation in Design Science (FEDS) (J. Venable et al., 2016) offered more help. The purposeful artifact developed in this research (a conceptual framework and visual representation for a DSS) is heavily socio-technical, i.e., there will likely be different subjective perceptions of its clarity and utility for supporting a 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 to evaluate the subjective individual and organizational feasibility of the purposeful artifact before investing heavily in detailed development.

This strategy recommends early formative usability evaluations and a quick transition to more naturalistic (with real users, a real or at least realistic artifact, and real problem situations), rather than artificial, evaluations. Naturalistic evaluations better support the evaluation of effectiveness in real situations than the evaluation of efficacy.

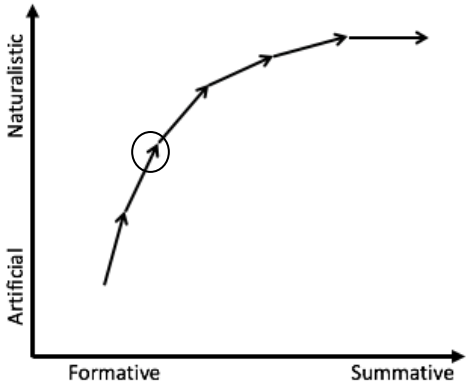


Figure 17: The Human Risk and Effectiveness evaluation strategy from the FEDS evaluation framework. Circle indicates the current state.

According to FEDS, the assessment of project goals and risks, the Human Risk & Effectiveness (a.k.a. human usability) strategy was the relevant strategy for this work (see Figure 17). It focuses early on formative (rather than summative) evaluations but moves quickly toward more naturalistic (instead of artificial) evaluations, which here means going from workshop to evaluation in actual projects. Following this strategy, a series of formative evaluations would confirm (or disconfirm) that the artifact was heading in a suitable design direction, identify any significant usability problems, and contribute to more precise instruction and clarification of the artifact. The formative evaluations were conducted in a workshop setting, which is close to naturalistic for the participants, although not quite a real situation (where practitioners would use the artifact independently in their project to help them with guiding recommendations for actual situations).

While FEDS provided the overall strategy, choosing the method of evaluation benefited from the categorization work of Peffers, Rothenberger, Tuunanen, and Vaezi (2012), in which the authors categorized seven different evaluation methods in design science.

Logical Argument	An argument with face validity.
Expert Evaluation	Assessment of an artifact by one or more experts (e.g., Delphi study).
Technical Experiment	A performance evaluation of an algorithm implementation using real-world data, synthetic data, or no data, designed to evaluate the technical performance, rather than its performance in relation to the real world.
Subject-based Experiment	A test involving subjects to evaluate whether an assertion is true.
Action Research	Use of an artifact in a real-world situation as part of a research intervention, evaluating its effect on the real-world situation.
Prototype Case Study	Implementation of an artifact aimed at demonstrating the utility or suitability of the artifact.
Illustrative Scenario	Application of an artifact to a real-world situation, evaluating its effect on the real-world situation.

Table 6: Seven different evaluation methods in design science (Peffers et al., 2012).

Based on the alternatives presented in Table 3, the evaluation of this Ph.D. project is mostly in the realm of "action research" and "prototype case study." As a result, this engaged scholarship project began with a methodology of DSR in general but transitioned to the ADR methodology more specifically.

5.4. Changing from DSR to ADR

Action Design Research (ADR) is a research method and approach that combines DSR with Action Research (AR) (Avison, Lau, Myers, & Nielsen, 1999; Baskerville & Wood-Harper, 1996; Iivari & Venable, 2009). From an outsider's perspective, the change from DSR to ADR might seem like a minor change in the methodology, but for the scholar doing the research, this change merits some elaboration.

In management information systems, Action Research (AR) has long been considered a promising but low-level research approach (Järvinen, 2007). However, when dealing with real-world problems, the approach has direct relevance because researchers are working with practitioners to solve the problem. Influenced by AR, the ADR process is more one of co-design, while the design approach in DSR is more researcher-driven. The difference between ADR and DSR is still a subject of debate (Collatto, Dresch, Lacerda, & Bentz, 2018). ADR is considered to be one of five different genres of DSR; the others are IS design theory, Design science research methodology, Design-oriented IS research, and Explanatory design theory (Peffers, Tuunanen, & Niehaves, 2018).

John R Venable, Pries-Heje, and Baskerville (2017) propose a framework for choosing from among six different DSR methodologies: 1) Systems Development Research Methodology, 2) DSR Process Model, 3) Design Science Research Methodology, 4) Action Design Research, 5) Soft Design Science Methodology, and 6) Participatory Action Design Research. Methodologies 1-3 follow an objective paradigm and methodologies 4-6 follow a subjective paradigm while working with one or more specific clients. Of the latter three, ADR distinguishes itself by a design process that focuses on a theory-ingrained artifact.

5.5. Action Design Research (ADR)

In ADR, as in AR more generally, 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 18.

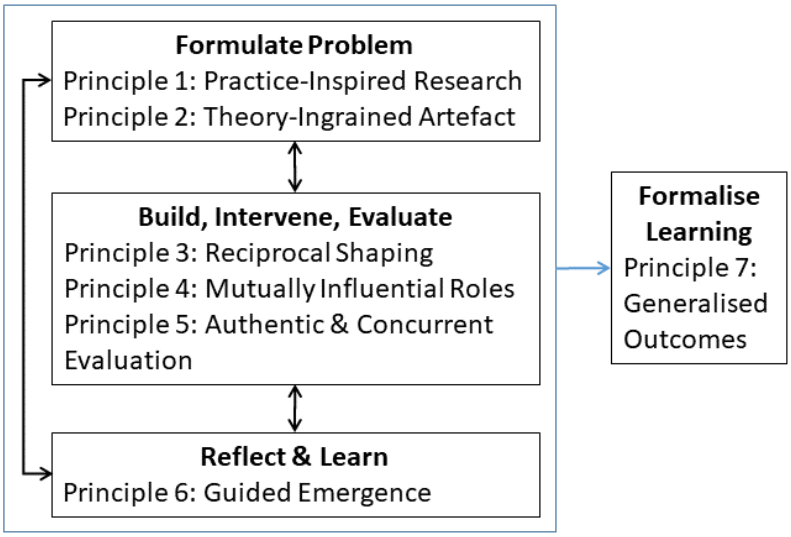


Figure 18: Action Design Research activities and principles (Sein et al., 2011)

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.

Similarly, ADR Principles 3, 4, 5, and 6 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.

5.6. The outcome of the ADR project

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.

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.

(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. Flyvbergs 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 Flyvberg (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. Results

This section presents highlights from the papers listed in Section 2.8. The section provides a synthesizes of the five journal papers and two submitted papers. The section gives priority to the logical flow instead of than a summary of each paper separately. 6.1 present the attempt to get et grip on the diverse school of thoughts in project complexity. 6.2 presents the findings from the national survey of practitioners and focuses on how these results inform the overall ADR process. From here on, the results are presented in the order of the iterative ADR process. 6.3 present the designed artifact for navigation. 6.4 present the implementation of the artifact on an ICT platform. 6.5 present the evaluation of the implementation. 6.6 elaborate on the learning as the final part of the ADR process (see figure 18) in the methodology section. Finally, 6.7 conclude with presenting the latest work on a theory of complexity management.

6.1. Getting a grip on the project complexity research literature

As demonstrated in the literature review, project complexity research publications are difficult to get a firm grip of. Many attempts have made, one found its way to get published (M. F. Mikkelsen, 2020a). Highlights from that paper is given her.

The concept of project complexity has evolved substantially since discussions of the topic began. Research a decade ago sparked diversification in this field. The multiplicity of concepts makes it increasingly challenging to utilize the overall research on project complexity. This paper takes stock of the literature and presents a typology of five ideal types of research in project complexity. The typology contributes a much-needed overview for researchers who are new to the topic. The complexity of projects is an important aspect of research in rethinking project management, and the typology has the potential of forming a theory of project complexity to support this research.

The objective of the paper is to make sense of what appears to be a disjointed mass of research on project complexity. This paper takes stock of recent research on project complexity and contributes to clarifying the differences in research by identifying five research types, thereby lending support to overall research on project complexity. The benefit of this differentiation is the identification of the uniqueness and presumptions of each type.

The quest to make sense of the diversity of research on project complexity requires some kind of classification, in which "sensemaking is a motivated, continuous effort to understand connections … in order to anticipate their trajectories and act effectively" (Klein, Moon, & Hoffman, 2006, p. 71). Classification is a way of making sense of the world, and this activity produces a set of "boxes" with the following properties: "1) They are consistent, unique classificatory principles in operation, 2) The categories are mutually exclusive, 3) The system is complete" (Bowker & Star, 2000, p. 10). The second property indicates that Bowker and Star consider categories to be the result of classification. These prerequisites are too strict to utilize in the differentiation of research on project complexity.

Typologies are not the same as classifications (Doty & Glick, 1994). Typologies have been used in research on project management, and "unlike classification systems, typologies are not about sorting entities into mutually exclusive, exhaustive groups. Instead, typologies are conceptually derived interrelated sets of ideal types that explain a dependent variable" (Niknazar & Bourgault, 2017, p. 194).

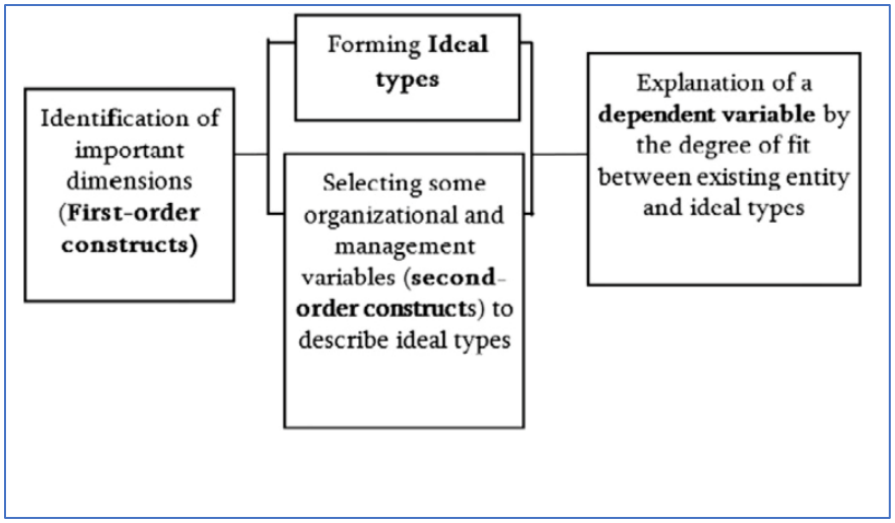


Figure 19: Development of a typology used for theory building (Doty & Glick, 1994).

Typologies are complex theories, and "ideal types are complex constructs that can be used to represent holistic configurations of multiple unidimensional constructs" (Doty & Glick, 1994, p. 233). A typology comprises a set of ideal types, and "ideal types are multivariate profiles of entities summarized by specific variables known as second-order factors/constructs. Simply put, a combination of second-order constructs is used to describe the holistic configuration of each ideal type" (Niknazar & Bourgault, 2017, p. 195). Figure 14 illustrates the steps in the process of developing a typology.

First-order construct	**Ideal type**	**Second-order construct explaining the ideal type**	**Dependent variable**
Search for prediction based on law-like relations	1 Positivistic modeling	Descriptive project complexity as the independent variables providing a fixed measure of the complexity throughout the project lifecycle.	Correlation between simplified constructs
Search for explanations of the unpredictable behavior of projects	2 Complexity theory	Descriptive project complexity explaining the emerging nature of the project based on attractors and similar concepts from complexity theory.	Relationship not relevant, hence undefinable
Search for comprehensive descriptions of project complexity	3 Ontological frameworks	Descriptive project complexity capturing the wholeness of the complex nature of projects in static or dynamic dimensions (often with high levels of abstraction).	Implicit systemic proposition
Designing prescriptive theory for handling project complexity	4 Managerial frameworks	Perceived project complexity addressing the managerial challenges of handling the project's complexity.	Overlapping and intertwined concepts
Understanding project cases – without the intention of generalization	5 Emancipative investigations	Perceived project complexity setting the context for a study of the complexities of a temporary organization perceived as a project.	Integrated based on interpretations

Table 7: Typology with five ideal types of research on project complexity

The purpose of Table 5 is to make sense of the diversification of research on project complexity. The posited research questions have been answered through the development of a typology as a way of accounting for the diversity of research on project complexity. The typology suggests five research intentions: law-like relations for prediction, complexity theoretical explanations, ontological frameworks for description, managerial frameworks for prescription, and investigations for understanding without the intent of generalization. With the second-order construct, the typology explains each of the types. The dependent variable of the typology illustrates how each ideal type corresponds to a specific relationship between the complexity and success of projects. These unique relations have been labeled correlational, irrelevant, implicit, intertwined, and integrated.

Doty and Glick (1994) argue that typologies meet at least three key criteria that all theories must have: 1) the constructs are identified; 2) the relationships among these constructs are specified, and 3) these relationships must be falsifiable through empirical examination. The presented typology meets all three criteria, although more research is necessary to attempt falsifying and thereby potentially strengthen the theory.

6.2. Results from the questionnaire

The work included a large survey among practitioners. This is documented in three papers: (M. F. Mikkelsen, 2020b), (M. F. Mikkelsen & Marnewick, 2020), and (M. F. Mikkelsen et al., 2020).

Of these, the first mentioned is the most important. This paper discusses the differentiation of concepts of perceived project complexity and provides a framework for a survey of the topic. The contribution of the paper is an increased understanding of practitioners' perceptions of project complexity as a concept very different from the descriptive frameworks that have been the focal point for research in project complexity thus far. Project complexity might be in the eye of the beholder, but the findings indicate that their eyes are very much influenced by their project role. In the review process, one of the two reviewers wrote: "The paper has a great potential to bring a significant contribution to the understanding of project complexity and how it is perceived by different stakeholders." The other reviewer called it a "great paper" and recommended it for the best paper award.

In Figure 20 a histogram indicates how practitioners perceive project complexity when given eleven characteristics to choose from. The practitioners are divided into their project roles (selected by themselves from predefined roles on a list in the survey). The legend of the characteristics is displayed in Table 7.

The results demonstrate how the practitioners give most importance to the dimension 'number and interaction of elements' - the definition from (Baccarini, 1996) – followed by the political, diversity, and unpredictability. The practitioners gave little weight to many other characteristics found in the research literature.

This finding holds similarities to a model from the research literature: The CAT model (H. Maylor & Turner, 2017; H. R. Maylor et al., 2013), with the dimensions: 1) Structured complexity, 2) socio-political, and 3) emergence. The conversion is 'Element' into structured complexity, 'Political' and 'Diversity' into socio-political, and 'Predition' into emergence.

Another result, that is not found elsewhere in the literature, is the influence the project role has on the perceived importance of the dimensions. There are significant differences. For example, do the steering committee members place much higher importance on the political aspect of project complexity than other project roles do.

One inference of this is, that understanding the complexity of projects as it is perceived by stakeholders needs to encounter many project roles to get the full picture – or at least a fuller picture, since a full picture might not be feasible.

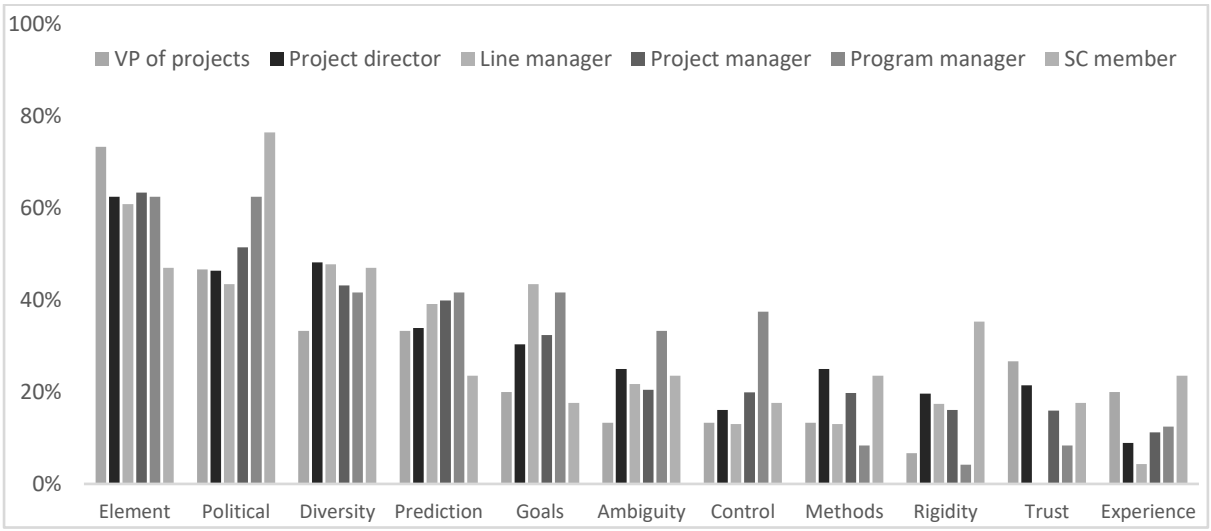


Figure 20: Perception of the importance of eleven characteristics of project complexity by project role (M. F. Mikkelsen, 2020b)

The eleven characteristics selected for the evaluation of relevance by the practitioners are displayed in Table 8 below. The survey was conducted at the beginning of the Ph.D. project. In retrospect, other characteristics might have given a better overview of the research. However, the purpose of the survey was to give the practitioner 'a voice', and the selected options to choose from served that purpose. There is no reason to presume, that the construct of the descriptive equals the perceived project complexity. Not such arguments have been found in the literature. Based on definitions from Vidal and Marle (2008), the contrary is presumed to be the case

1: (Element) The project consists of many varied interrelated elements
2: (Political) Political aspects influence the project and decisions
3: (Diversity) High diversity and difference within stakeholder groups
4: (Difficulty) The project is difficult to predict even with complete initial information
5: (Goals) High degree of uncertainty in project goals and outcome
6: (Ambiguity) High degree of ambiguity in and around the project
7: (Control) The project is difficult to manage and keep under control
8: (Method) High degree of uncertainty in methods and tools
9: (Rigid) Rigid project setup, decision-making, and organizational structures
10: (Trust) Low level of trust among parties in and around projects
11: (Experience) Project management with low experience and/or formal power

Table 8: Legend of the eleven project complexity characteristic

Another important finding from the survey, is the practitioners take on the sources of project stakeholder complexity. Findings from the survey indicate that "*unrealistic expectations of what is possible within the allocated budget and timeframe among decision-making stakeholders"* were the most important factors that perceived to contribute to project complexity. One-third of survey participants gave this statement the highest ranking of the six options. (M. F. Mikkelsen et al., 2020).

This paper also offered speculations about organizational stupidity (Alvesson & Spicer, 2012) as an overlooked factor of complexity. The findings on the unrealistic expectations of decisions makers also support the "Delusions of optimism" interpretation (Lovallo & Kahneman, 2003), from which the "outside view" design principle was taken.

The questionnaire also provided an example of how project management research contains questionable assumptions about the responsibilities of project managers in practice, in this case, their responsibility for benefits realization (M. F. Mikkelsen & Marnewick, 2020). The allocation of this responsibility is an overlooked issue in research, which makes the role of project management even more complex. The situation that Cicmil et al. described as motivation for Rethinking Project Management still exists: "We argue that while a great deal is written about traditional project management we know very little about the 'actuality' of project-based working and management." (Cicmil et al., 2006, p. 675)

Besides contributing with the above-mentioned insights, the national questionnaire also gave an important view of project management practitioners' understanding of project complexity in general. This information has great value as background when engaging with smaller, less represented groups of project managers and projects in the following ADR project.

6.3. Designing an artifact for navigation

The artifact for navigation of complexity built in the ADR process is documented in the journal paper (M. F. Mikkelsen et al., 2021b) in a special issue on Action Research. The first version of the paper was accepted for the Americas' Conference on Information Systems (AMCIS) conference (M. Mikkelsen, 2018a) and the second version for the European Academy of Management (EURAM) 2019 (M. F. Mikkelsen, and Venable, John, 2019), where the paper was honored as "best track paper."

The artifact developed in the work was named Complexity Navigation Window (CNW) and is depicted in Figure 20. The interaction was conducted as semi-structured workshops with 16 experienced project managers from 15 different companies who responded to an open invitation to contribute to research by participation in educational workshops. Following ADR Principle 2, the design of the purposeful artifact was based on the literature on project complexity and complexity frameworks in general. The theory-ingrained artifact encompassed four unique strategies as responses to four different domains of complexity. After the design of the CNW, the main reflection (activity 3 in ADR) for the researcher was the participant's difficulty in estimating the level of stakeholder disagreement and the level of unpredictability of the project. Going back to the problem formulating (activity 1 in ADR), the situation had to be reassessed.

During the workshops, the author showed the following clip to the participants when introducing the topic of complexity: https://www.youtube.com/watch?v=N7oz366X0-8&t=9s. In the video, David Snowden, the author of the Cynefin framework, explains the framework in only 8 minutes. The participants almost always understood to the level where they could engage in meaningful discussions on the five domains and relate the framework to their experiences in their projects.

The CNW can be seen as a supplementary tool for determining whether a given situation falls into the domain of the complicated or the complex in the Cynefin framework. However, even with the supplementary tool, the practitioners found that the determination of the situation (and the following choice of managerial approach) was difficult. In other words, the practitioners in the workshop allow themselves the be in the aporetic state (see 4.2.2.) not knowing with of the four strategies would be the best way forward.

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 21: The Complexity Navigation Window (CNW).

6.4. Implementation of CNW in an information system

The next build was designed to help the practitioners overcoming the challenge of assessing the situation at hand, i.e. the current complexity of the project. 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.

Serendipity can play a major factor in discovery (Roberts, 1989), which the following event of the ADR project is a case in point. The above realization came simultaneously with a meeting with a good friend, who explained his involvement in a small Danish start-up called Benelizer. This company had recently launched an ICT platform to conduct surveys with inbuild disaggregation regularly among multiple participants on projects. The system was designed to monitor benefit realization, and the dashboard of this ICT platform had some resemblance to the CNW matrix. The core questionnaire engine of the ICT platform was useful for the ADR process. Appendixes D, E, and F provide some screenshots from the ICT platform. After a few meetings with Benelizer, they agreed to provide this research project with a free license to the system for research purposes.

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. All of the project managers seemed eager to participate; however, they made many excuses for not taking the final step to use the artifact. Only 2 of 8 projects proceeded through to the evaluation, but the project provided enough empirical data to conclude.

Paper #7 given an account of the evaluations on the prototype. The highlight from this is as follows: eight project managers form Atkins Denmark was selected to participate in the ADR project. All participated enthusiastically in the design of a common survey to be given to a set of stakeholders for each project. However, only two of the eight got to the implementation of the prototype. The remaining six refrained from selecting stakeholders. The reasons for not actualizing the affordance were varied. Two project managers had 'valid' reasons, but the remaining four had what could be

labeled as procrastination. In the interview afterward, there were indications of seeing the system as a "satisfaction survey' and concern about the use of the data in the organization. This gives reason to suspect a hidden resistance to change based on a misperception of affordance.

The two projects that did implement the prototype are here labeled A and B. Project A was a medium-sized project and very well managed. The manager praised the information system, but the management of the project was not challenging, so the appraisal is given on a thin basis. Project B was a complex project and the use of the information give a very interesting case story. In short, the system provided the affordance of early warning of important changes in the stakeholder landscape. But the project manager was 'too busy' doing other things, that he did not find time to consult the system, hence overlooked a trend that eventually led to the replacement of the project manager.

Appendix E contains a screenshot from the system, where the change in the stakeholder landscape is evident holding in mind, that the stakeholder 'turning red' in the continuous survey, was part of the top management in Atkins Denmark. Appendix E displays a ranking of stakeholder's perception of the project based on qualitative responses to the questions of the survey. As it is shown, the project manager has a very positive outlook on the project. This finding confirms the presumption of the delusion of success, discussed previously, highlighting the relevance of having an outside view based on project complexity. The same pattern was found in project A, where the project manager also was among the most positive.

This finding was shared with the project managers as a reflection after the trial period. Therefore the experiment cannot tell where information about the pattern in the survey data would influence the delusion of success among the project managers when answering the survey in the future.

6.5. Evaluation of the prototype

Actions speak louder than words. When evaluating any artifact for relevance, the ultimate test is the desire to continue using the artifact after the evaluation period has ended.

Praising an information system developed in the evaluation phase of an ADR project is one thing, but it counts for much more when managers use the developed information system at full scale in the organization after the ADR project has ended. Not only does this lead to a profound "score" in a summative evaluation, but it also ensures that all the learning (explicit as well as tacit) in the hosting organization finds a use.

Based on their evaluation, the recipient organization has decided to scale the implemented system. The assessment of the complexity of the project is still in the background, but the agenda is fueled by the realization of the importance of early warnings and the competence development of the project managers. The latter is based on the following thinking: a current performance review from all stakeholders (internal and external) on the project is a vital feedback mechanism to enable project managers to identify where to improve project setup and their competencies.

Williams et al. (2012) have also studied early warning signs in complex projects (T. Williams, Jonny Klakegg, Walker, Andersen, & Morten Magnussen, 2012). One important aspect of this research is the impact of changes during setup, early project stages, and execution. This thinking is very much aligned with the presumption, that an ongoing current assessment of complexity is necessary for successful navigation.

Even though we can declare this ADR project a success for the hosting organization, this thesis still needs to elaborate on the scientific assessment of the ADR project. At its center, ADR is more focused on collaboration. The outcome was more "learning" than "evaluation."

Much “made sense” in the conversation when the researcher and practitioners met, however, this understanding is very hard to turn into contributions in a scientific matter. As the saying goes; You can understand, more than you can express, and you can express more than you can write. Much is lost in the transaction from human insights to research papers.

6.6. Formalized learnings

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. 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 what information project managers and decision-makers believe they need when navigating complexity.

As mentioned in the methodology section, Sein 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 client 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 the management of project 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 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.

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 & Tukel, 1996) which is dedicated to finding the prerequisites for project success. The subject has not received much attention in recent years. This topic investigates the factors prerequisite to achieving project success, and the factors are closely related to the dimensions debated in the research on project complexity.

The research questions on "how to navigate project complexity in the pursuit of success" 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 the related CSF 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.

Concluding on the question heading this paragraph, the project manager focused more on achieving project success than assessing the current level of project complexity. Assessing project complexity might be seen as a slippery steppingstone for getting to the other side. Their selection of indicators from the question bank can be seen as an attempt to 'jump to conclusion' (the project success) not to assess the project complexity.

6.7. The troubled child

In a family of seven, there might often be a troubled child. This is for sure the case of the seven papers included in this cappa. The aim is to contribute with a theoretical foundation for the project complexity as is might be perceived of a project manager throughout the life cycle of the project. A both ambitious and difficult aim to pursuit. The paper has gone through several major revision and rejections. The paper has finally been approved and is in press at Journal of Modern Project Management.

In the current state it includes an earlier version of the matrix of perspectives on project complexity, which is also covered in this cappa.

	Ex-ante perspective	**Transitional perspective**	**Ex-post perspective**
Descriptive project complexity. Information of the complexity exists 'out there' - independent of an observer.	Descriptive tools for assessment of the complexity of the project ahead.	Complexity Theory and abstract framework of project complexity.	Projects as finalized objects, e.g. for researching low-like relations of project complexity.
Perceived project complexity. The complexity exists in the eyes of the beholder(s), i.e. project manager or project stakeholder.	Frameworks for predictions based on a mutual understanding of the complexity of the project.	The lived experience of managing the dynamics of project complexity.	Retrospective (emancipative or interpretive) research of complexities in and around the projects

Table 8: Matrix of perspectives on project complexity

More importantly, the paper presents a theory of project complexity management based on the stratification of reality with inspiration from (Sayer, 1999) and (R Bhaskar, 1998).

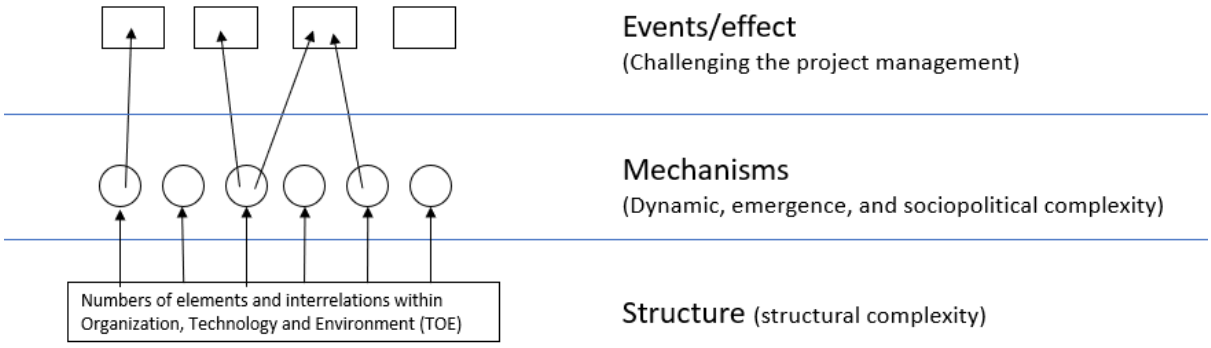


Figure 22: Stratification of project complexity in three layers

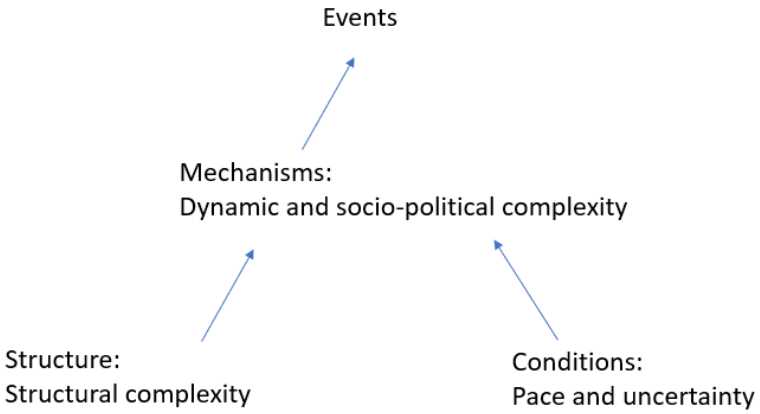


Figure 23: The five dimensions of Geraldi et al. (2011) with Sayer (2008) as a lens

Further, the paper gives examples on how the mechanisms can be a tool in research of project complexity.

1: Explication of events/effects	**2: Explication of structure and context**	**3: Retroduction: Identify the mechanisms**
Un-expected stakeholder behavior	Many stakeholders together with a low level of trust	Hidden agenda (Geraldi et al., 2011)
Resistance to change	Several organizational units involved the projects benefits realization efforts	Unactualized Top management support (H. R. Maylor et al., 2013)
Change in project goals	Powerful stakeholders with divergent interests and available time for power jogging	Power struggles (H. Maylor et al., 2008)
Radical unpredictability	Interrelations among elements with more than one equilibrium	Tipping point (Cooke-Davies et al., 2007a)
Decision making based on unrealistic expectations	Interrelations giving support to functional stupidity and high levels of delusional success bias	Stupidity (M. F. Mikkelsen et al., 2020)

Table 9: Theoretical examples mechanism of project complexity

7. Discussion

The discussion section is divided into three parts. Part one is answering the research questions, part two contains a positioning of the students' work in the context of the field, and part three discusses the use of Action Design Research in the context of project management in general and for research on project complexity.

7.1. RQ1: What kind of information is needed for handling project complexity

The first research questions asked: What kind of information is needed for handling project complexity, where handling refers to managerial challenges navigating the project to success, where navigation includes assessment, monitoring, understanding, and decision making.

Based on the developed conceptual framing provided in this study and the results documented in previous sections of the cappa, handling of project complexity in the pursuit of success can be diversified into four levels of needed information.

1) Information to counter the delusion of success
2) Information to pursuit the project success
3) Information to select the managerial project approach
4) Information to respond to the given project situation

In the following, each of the four levels will be addressed.

Add 1: The work of Kahneman on the delusion of success has been presented as a framing concept. The relevance of the concept has been supported by this study in two ways. Firstly, results from the questionnaire among practitioners indicated, that “unrealistic expectations among decision-makers” is a very present complexity in projects. This is documented in journal paper #3. Secondly, the data collected by the information system indicated that the project managers perceive the given project as far less challenging than project stakeholders do on average. This is documented in paper #7.

Kahneman suggests the use of outside view to counter the biased inside view. In our case, the inside view is held by the project manager and secondly by the project decision-maker.

One method of producing an outside view to help decision-makers and project managers is the Reference Class Forecasting (RCF) mentioned previously. In the terminology of the chronological perspective developed in this study, the RCF generates knowledge based on the ex-post perspective of similar projects and provides ex-ante adjustment of estimations of cost and benefit of the given project. While the RCF can be helpful as an outside view in the context of handling project complexity, it is presumed that a stakeholder-based outside view on the current project will provide better information for navigation of the complexity of the given project.

A prototype of an information system has been set up to implement on outside view from stakeholders. The evaluation of this prototype indicates that such an information system is a relevant affordance for the project manager navigating project complexity. Here a transitional perspective on project complexity has been applied. The evaluation demonstrates that the transitional perspective is very different for both the ex-ante and the ex-post perspective.

Add 2: This study has investigated the concept of project success. The literature ….. project success exists in the eyes of the stakeholder and is likely to change throughout the project life cycle, from project initiation to project benefits realization.

The questionnaire conducted in the study shed light on the complexity for project managers regarding benefits realization. In contrast towhat is assumed by project management research, the responsibility of benefits realization can be placed on the project manager – according to the practitioners of project

management, including steering committee members, heads of projects, project managers, and other project stakeholders. The inference is that a project manager faces a much more complex stakeholder landscape than often assumed.

Add 3: The Cynefin framework, presented in this study as a framing concept, give affordance for selecting a managerial approach according to the complexity of the situation. Must profound is the borderline between the complicated and the complex system domain. A similar differentiation is found in the concept of CPM and RPM (see Figure 2).

According to the Cynefin framework, the managerial approach when the system is complex should be to conduct multiple parallel experiments. This should not be mistaken for the agile approach, where the sprint (experiments) are serial. The multiple parallel experiments can be seen as a kind of explorative research. When project complexity is defined based on the managerial challenge – see definitions in section 3.1 – the recommendation from Cynefin framework results in an interesting conundrum when applied to a project, that is assessed as complex. If all project stakeholders truly accept the premise that the project is complex, hence multiple parallel experiments should be conducted, then the managerial challenge vanishes! It is not challenging for a project manager to conduct experiments. Searching the literature on project complexity this conundrum has not been presented yet. One concept that comes close is 'reduce' in the approach of 'Understand-reduce-respond' (H. Maylor & Turner, 2017), however, this might be stretching that terminology too far.

The CNW presented in paper #6 (see figure 20) provides four options for managerial approaches: 1) Regulation, 2) Interative, 3) Negotiations, and 4) Experimental approach to the project. The CNW can be seen as a diversification of the Cynefin borderline between complicated and complex, where the approach 2 and 3 is a way of staying on the border.

Add 4: Information for responding to the situation within the managerial approach selected.

7.1.1. RQ1a: What is project complexity according to the research literature?

Section 3.1 sheds light on a commonly accepted definition of project complexity, however, the literature review did not find a commonly accepted model of project complexity. Many dimensional models have been suggested. It is hard to come up with any attributions of a project, that has not been suggested as an indicator of complexity at some point in the research stream of project complexity. The investigation is therefore inconclusive on which model of project complexity to use.

The literature study identified some frameworks useable for the navigation of project complexity, in the context of an engaged scholarship research project, three models have been found relevant, representative, and practically usable: the Technical, Organizational, and Environment (TOE) model, the Project Complexity Dialog (PCD) framework, and the Complexity Assessment Tool (CAT), as displayed in Appendixes A, B, and C.

7.1.2. RQ1b: How do the practitioners perceive project complexity?

This project answered this question based on the responses to a national questionnaire from over one thousand project management practitioners in Denmark. Paper #2 documented this survey and presented a model of perceived project complexity. The survey indicated differences in the importance of dimensions. On average, the most selected dimensions were, in order of importance: 1) interaction of elements, followed by 2) political aspects, 3) diversity of stakeholders, and 4)

unpredictability. The importance of dimensions differed depending on the sector, and the project type and size. This result indicates that no universal model of project complexity applies. The importance differed most depending on the role of the perceiver in the project, indicating that project complexity exists in the eye of the beholder, offering a limited basis for generalization because of the subjective nature. Generalization is previously addressed including references to (Sein et al., 2011), (Bent Flyvbjerg, 2006a), and (Ruddin, 2006).

These conclusions have important implications for the kind of information needed for handling project complexity, because complexity is not only about the project, but also very much about the stakeholders. The inference of Paper #2 is that one cannot navigate project complexity without considering the perceptions of multiple project stakeholders.

Regarding the four dimensions mentioned above, two elaborations can be made. The first is based on complexity theory in general. This theory states that many interrelated elements lead to unpredictability. The first and fourth dimensions are therefore related because 1) many interrelated elements lead to 4) unpredictability, according to the complexity theory. The second is based on the argument that 2) political aspects are a matter of diversity between parties, and hence is very related to 3) the diversity of stakeholders. With these two elaborations, the four dimensions can be aggregated into unpredictability and diversity, similar to the "unpredictability-diversity-matrix" named the Complexity Navigation Window (Paper #6), an artifact design with inspiration from the Cynefin framework (Snowden & Boone, 2007).

Paper #3 documented that in practice, the project manager is held responsible for benefits realization by one of three project stakeholders. This finding stands in contrast to the general presumption in research as documented in Paper #3. Not only does this situation make the project management role even more complex, but it will also make the topic one for which monitoring information is needed. The project managers need to determine the degree of such expectations among stakeholders and monitor prerequisite indicators for benefits realization. The monitoring may include indicators of resistance to change and/or indicators of organizational capabilities. The capability factor is not included in the common models of project complexity (see examples in Appendixes A, B, and C), but an inspiration for this approach can be found in program management.

Paper #4 indicated that the most important driver of stakeholder complexity according to practitioners is the unrealistic expectations of decision-makers. In their minds, the project decision-makers might believe they are being realistic. Therefore, project managers also need information that can counter the unrealistic expectations of decision-makers. This may be doubly difficult because the project managers themselves may also suffer from "delusional optimism.". The literature on project complexity seldom address the role of decision-maker as source of complexity, but based on the findings this might be an interesting topic to investigate further.

The the survey indicated that project type and sector need to be taken into account. The information therefore must also come from persons having multiple project roles because the role influences the perception of complexity. Projects also need to make tactical decisions about information flow to counter delusional optimism, which makes the decision-maker unrealistic and also deludes the project manager. The information also needs to be adjusted to the expectations of central stakeholders and over time, both to avoid information overflow and to include information about benefits realizations in later parts of the project in the cases, when such realizations are part of the responsibilities of the project manager.

The study proposed a conceptual framing of chronological perspectives, dividing the observation of the project into ex-ante, transitional, and ex-post perspectives. The majority of research uses the ex-post perspective. When initiation a new project, the ex-ante perspective on project complexity needs to be deployed. When navigating a given project, the managers need to deploy a transitional perspective.

In the transitional perspective, the managerial challenge from the definition can be seen as a situational or an accumulated (over the project life cycle) challenge. This will provide two distinct ways of understanding project complexity.

To explain the difference of the situation versus the accumulated view, an analogy might be helpful. Effect (measured in kW) and energy (measured in kWh) are two distinct concepts that often get confused – mostly by people outside the energy sector. The equation, Effect x Time = Energy, explains the relation. Or put differently, Energy equals Effect integrated from start to finish.

Based on this analogy, the following question can be posed: Is project complexity most similar to the concept of energy or the concept of effect? The ex-post project complexity, seeing the project post-mortem, realizing the entirety of the managerial challenges of the entire project from start to finish, the energy analogy is most relevant. The ex-ante project complexity is also like the energy analogy although it is only the expected energy. The situation of the transitional perspective can be discussed based on the depiction in Figure 8.

To practitioners, living the experience of the project complexity, it will (probably) make the most sense to see the challenge as the current effect. Before the project and after closure, this is no managerial challenge in the eyes of a practitioner. In the future, one might expect to use energy, but as of now, one can relax, if there is no current challenge. The same goes for energy consumed in the past.

When examining the problem from the point of indicators of project complexity the difficulty increase. Here exemplified with two question-indicator based on the handbook "Navigating Complexity: A Practice Guide" (PMI, 2014).

The question "Does the project lack top management support?" is most relevant as a matter of effect, since the support can be lacking in a short time, for a longer period, or throughout the project life span. The during is important here, and the effect analogy is most meaningful.

"Will the requirements change?". This question addresses an event without duration, but clearly, it is a challenge to project management. Therefore the energy analogy is most meaningful here.

In practice, there might not be a problem for practitioners handling the data based on this question, but information-wise they are different. This problem has not been solved yet.

7.2. RQ2: How can an information system be developed to provide affordance for project complexity management?

This research question was spilt in two. First sub question addressed the concept of project complexity management and the section question address how to develop the information system.

7.3. What is project complexity management?

The cappa has adapted the definition of project complexity: "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" (Marle & Vidal, 2016). Based on this definition, project complexity management is the managerial response to these challenges.

The study has submitted paper #5, revised after several submissions, in an attempt to theorize the lived experience of managing project complexity. The proposed theory is inspired by the mechanism explained by (Roy Bhaskar, 2013; Sayer, 1999).

The theory supports a transitional perspective on projects. The transitional perspective sees the project as a "lived experience" and makes the practitioner the focal point. This perspective is important when developing prescriptive knowledge to guide the project manager in the navigation of project complexity.

7.4. How can an information system be developed

The second sub-question asked: How can an IS be developed, where "developed" is limited to conceptualizing and prototyping an implementation on an existing ICT platform, thereby giving affordance to the management of projects when navigating project complexity.

The second sub-question concerns the development of information systems. Paper #6 documents the use of ADR to develop a dashboard for navigating project complexity. While the artifact developed made sense to the practitioners, the process also demonstrated the need for information on an ongoing basis to position the project. This realization led to the implementation of the dashboard on an IT platform with the functionality to support a design principle of outside view based on the concept of the wisdom of crowds.

Paper #7 documented the ADR process of designing, implementing, and evaluating the deployment of the dashboard on the IT platform. 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.

During the ADR project, there was resistance to deploying the information system among the project managers, as Paper #7 documents. Only two of the eight project managers conducted summative evaluations of the information system. 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 useable in a research endeavor 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 endeavor with many agendas.

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?*

This cornerstone of the information system acknowledges the following:

- 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.

- The saying “Everybody knows something, but nobody knows everything” might prove very relevant in the understanding of project complexity and the navigation thereof.
- 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 need 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.

7.5. Contextualizing the work in the project complexity research

This section is “A critical discussion of the work of other researchers in the field, as well as a comparison between their own findings, such that the student’s work is seen in the context of the relevant on-going work in the specific area studied” as requested in the list of requirements for ITU for a paper-based thesis.

There is a large amount of research literature on project complexity. To simplify placing this study in the context of relevant ongoing work in the specific area studied, the project identified five ideal types of research on project complexity, including 1) Positivistic modeling, 2) Complexity theory, 3) Ontological framework, 4) Managerial framework, and 5) Emancipative investigation (M. F. Mikkelsen, 2020a). A comparison of the five ideal types of research led to an additional diversifier: the chronological perspective as a unit of analysis.

7.5.1. Positivistic modeling

The ideal research type ‘positivistic modeling’ is the search for prediction base on low-like relations. This study is based on perceived project complexity, which is far from the positivistic approach. In the positivistic approach, the project is often seen as an object with fixed complexity. This study presumes that project complexity is a lived experience. Because of this perspective, there is very little research to which this study may be compared in this ideal type of research in project complexity.

The positivistic approach assumes a linear relationship between the indicators of complexity and the dependent variable, for example, project management success (Bjorvatn & Wald, 2018). Dimensions can be assigned weight within a positivistic view (Bosch-Rekveldt et al., 2011; Vidal et al., 2011). The theory of complexity management proposed by this study rejects these linear relationships.

Baccarini (1996) recommended an operationalization of project complexity into differentiation and interrelation of elements. Much positivistic research uses this approach, and some law-like relations have been found. However, the correlations found are weak. Baccarini (1996) hoped to remove subjectivity from the equation, but all of the positivistic research in project complexity does have a large subjective component. Some papers directly use the perceived complexity in the dependent variable, while others use it indirectly via indicators of the level of dimensions. The latter is the case when calibrating the weight of the dimensions of project complexity against each other (Bosch-Rekveldt et al., 2011; Vidal et al., 2011). They also “measure” the complexity dimensions by use of indicators that are very often based on subjective judgments. This practice is documented in work on perceived complexity (M. F. Mikkelsen, 2020b). That paper provided an understanding of the perceived project complexity and documented that perceptions are influenced by the perceiver’s project role, the project type, sector, etc. Researchers investigating weights of dimension in the positivistic model of project complexity have overlooked, that this aspect influences the perception. One researcher wrote the following about their observations: “They started to share their experience on complexity factors and realized that the difference with the a priori ranking they had done was

mainly due to some communication and psychological barriers they had" (Vidal et al., 2011, p. 724). Here, the positivistic researchers dismissed perceived complexity as "mental barriers."

This study has demonstrated that the importance of different characteristics of project complexity is systematically divergent in different sectors, project types, and company sizes. The literature review found not a single paper taking these differences into account when presenting weights of dimensions in the positivistic study of descriptive models of project complexity. The calculation of weights, therefore, needs to be reassessed based on the new knowledge.

7.5.2. Complexity theory

The ideal research type "complexity theory" is the search for an explanation of the unpredictable behavior of projects. Complexity theory entered the social sciences via authors such as Byrne, who went to the extreme to declare that "Positivism is dead" (Byrne, 2002, p. 37). The introduction of complexity theory to research on project management came with great expectations, even coining the new phrase "project management second-order" (Saynisch, 2010). The theory has not found a solid foothold in the field of project management measured by the number of publications since its introduction.

Several authors have introduced complexity theory in their research on project management. One paper by Cooke-Davies et al. (2007), stands out based on the number of references. That paper gave a compelling explanation of complexity theory with butterfly effects, strange attractors, fractals, complex adaptive systems, the edge of chaos, and similar drivers of radical unpredictability.

This study has some relation to complexity theory through the same focus on unpredictability. The Project Complexity Management theory is based on generative mechanisms from critical realism, not on complexity theory. However, the contextual actualization and interconnectedness of the generative mechanisms can result in a stream of events in and around the project, which might as well be explained by butterfly effects, strange attractors, and other elements of complexity theory.

Cooke-Davies et al. (2007) used complexity theory to advocate four abilities for the management of complexity: Human Action, Radical Unpredictability, Anxiety, and Inseparability of Thinking and Action. The first is the ability of practitioners to engage in the processes of conversation and power relating, and reflexivity in thinking. The second is the sensitivity to qualities of conversational life to create a scope for novelty and change to emerge. The third is adequate management of anxiety in coping with unpredictability and paradox of outcomes. The fourth concerns ethical and moral concerns about actions, both intuitive and logical, taken while "thinking on one's feet" and simultaneously "knowing" and "not knowing," "being" and "not being" in control.

While the above-mentioned abilities certainly are very important in complex projects, one could argue that these are traits of any successful project manager. By use of the negation test, there might not be any projects – simple or complex – where those traits were not rendered successfully. It is hard to imagine any project, where the managers should refrain from using the above-mentioned abilities.

As an explanation for the radical unpredictability, the complexity theory approach is very helpful. The theory explains why a given project might behave very differently from similar projects, hence challenge the project management. While the complexity theory is not used directly, it has supported the work with conceptual thinking and has been an important inspiration for paper #5.

7.5.3. Ontological framework

The ideal research type "'ontological framework'" is the search for a comprehensive description of project complexity. This perspective is by far the most used in the research on project complexity. Naturally, the frameworks produced by this part of the field have been used for inspiration for parts of this study.

The ontological ideal type of research does not necessarily copy the linearity assumptions used by positivistic research, nor does it reject them. Dimensions, drivers, indicators are presented without consideration of how they challenge the management of projects (see the common definitions of project complexity in Section 4.1.3). The dimensional frameworks are presented in most cases without any explanation of the weight of the dimensions proposed for the framework, nor do they note any speculation of interconnectedness among dimensions. This neglect renders most models and frameworks useless in a practical context. The research often claims they are helping practitioners, but they are not helping to the extent claimed.

In the theory of project complexity management proposed by this study, the focus on how the actualizations of the generative mechanisms are contextualized and how they might interplay with each other make explicit the presumptions of relations between complexity and the challenges for management.

This study has also documented how differently the practitioners perceive the importance of the dimensions. The ontological framework served as inspiration for the contribution of eleven proposed characteristics of project complexity. They cannot be regarded as equally important. Only a handful of dimensions are commonly accepted as important. Adding to this discovery, this study has also revealed patterns in the perceived weight of the dimensions.

This work also demonstrated pitfalls with ontological frameworks in practical use. Among these is that the perceived importance of dimension depends very much on the project role of the perceiver (i.e. steering committee members do not prioritize dimensions of project complexity the same way as project managers do). These perceptions also vary for the sector and type of project (i.e. practitioners of IT projects perceive complexity very differently than practitioners in the construction sector).

7.5.4. Managerial framework

The ideal research type "managerial framework" is designing a prescriptive theory for handling project complexity. While the three ideal types covered so far mostly focused on project complexity alone, this type also focuses on project complexity management.

This ideal type is a suitable category for this study; however, most other work in this category proceeds from an inside view (Lovallo & Kahneman, 2003). The criticism of this approach is that it is insufficient for the navigation of project complexity, and this study, therefore, includes the outside view as a design principle.

This study on perceived project complexity belongs to this ideal type of research based on the categorization developed in (M. F. Mikkelsen, 2020a). The development of the Complexity Navigation Window artifact is also positioned in the managerial framework research type.

The work with a prototype of an information system is not included in this category. The use of the design principle of the outside view on project complexity is a novelty. The literature review found not a single case of project complexity assessment with an outside view based on the wisdom of crowds. All of the studies and tools for assessments are based on a combination of objective measures (e.g., number of elements) and indicators assessed by the project management (e.g., the social-political situation).

7.5.5. Emancipative investigation

The ideal research type "emancipative investigation" seeks to understand project cases without the intention of generalization. This ideal research type is the most elusive among the five but also the most suited category for parts of this study. The part of the engaged scholarship in which the prototype for the "IT-enabled project complexity management" was developed involved only one client company and two project cases. The conclusions can therefore not be generalized. The organizational learning might be unique to the particular client organization. However, like all studies in the category of emancipative investigations, the study can inspire further research.

Research within the managerial approach to project complexity often argues that stakeholders are an important aspect of project complexity, with the underlying understanding that the stakeholders are causing challenges to project management by their disagreements, conflicting ideas, resistance to change, etc. This study flipped that argument to make stakeholders a part of the solution, by participating in the steady stream of outside perceptions of the project, leading to early detection of problems. The steady stream of outside perception makes it possible for the project manager to recognize delusional optimism bias. As the finding revealed, the project managers constantly rate the project better than do the stakeholders.

7.5.6. Summing up the contextualization of the study

Based on the categorization developed in the ideal types of research on project complexity presented in Paper #1, the first part of this study (the survey and the CNW artifact) can be categorized as belonging to the third ideal type, "Managerial framework." The work developing a prototype of an information system belongs more to the fifth ideal type, "Emancipative investigation."

Three aspects make this study stand out from the context of the relevant ongoing work in the specific area studied:

1. Investigate perceived complexity (Paper #2), while the majority of research engaged in descriptive complexity.
2. Research the transitional perspective of project complexity (Papers #5 and #6). Most others use the ex-post perspective, and a few employ the ex-ante perspective.
3. Include the outside view (Paper #7), which has not been found anywhere in the literature, where the argument for this view can be found in Papers #2 and #3.

The Ph.D. project has therefore broken considerable new ground, though much further research is needed, as explained in the conclusion.

7.6. ADR methodology for research on project complexity and project management

ADR helps the researcher to stay on track when investigating a real-world problem. The beginning of this ADR project made many assumptions about the navigation of complexity. The interaction with practitioners has steered the project in unexpected directions, but work with practitioners is not without its frustrations. The procrastination of the project managers in deploying the prototype they had co-designed is one example. Nevertheless, their procrastination led to insights on the misperceptions of affordance and the understanding of the need for integration of ADR with organizational change theory.

The iterative open-ended approach in ADR is familiar to project management. The use of ADR 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 artifact by the stakeholders. In this study, the direction of the development changed in ways that could not have been expected. This research project started with project complexity and did not target the area of "IT-enabled Project Management," but the path taken in the ADR took the project there.

The balance between being an "unpaid consultant" to the recipient organization and being a researcher has to be addressed when conducting an ADR project. A division of roles among more people would have been helpful. Practical advice for future ADR would be to ask the recipient to hire an actual consultant to help the organization in its participation in the ADR project. Perhaps even two consultants would be necessary, one for the organizational change effort and one for the technical challenges. The borderline between research and consultancy is well defined in (H. Maylor et al., 2016). An assessment of this study based on element parameters (H. Maylor et al., 2016, p. 271) indicates that the collaboration with the client turned into consultancy in only a few cases.

All of the project managers attended many meetings about the artifact (affordance), where they engaged in discussions (perception), but only a few afterward used the artifact (actualization) and thereby demonstrated an effect. It is important to recognize the difference between perception and actualization.

"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 descriptive knowledge on project complexity but limited research on prescriptive knowledge, there is a demand for much abductive research. The portion of knowledge with an empirical basis is limited. Often the foundation of such studies is Delphi methods for adjustment of dimensions, such as (Bosch-Rekveldt et al., 2011) and (Vidal et al., 2011). On the other end, there are examples of grounded-theory-based research using workshops, like that of (H. R. Maylor et al., 2013). ADR provides 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 radically different "thing" (like the Complexity Navigation Window) "out there" to be tried and tested by practitioners and to learn from the collaboration. The 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 researchers from different paradigms as they attempt to advance knowledge" (Johnson & Onwuegbuzie, 2004, p. 16).

Based on the case study of the prototype, ADR is appropriate for research on project complexity management, particularly where new means for improving project management effectiveness and solving project management problems are needed.

Geraldi and Söderlund (2018) identify three types of research in project management: traditional positivist, interpretive, and emancipatory. This division is based on the work of (Habermas, 2015). The research methods for the first are empirical-analytic, the second hermeneutic, and the third critical science. Action research is aligned with critical science, but where does ADR (and DSR) fit into this schema?

ADR (and DSR) has the design of an artifact as a signifying activity. This approach is based on the philosophy of pragmatism of John Dewey and others, and it builds on the science of the artificial (Herbert A Simon, 1996). Having design as an element in research gives the opportunity of breaking free of the shackles of past knowledge and lessons from the past (Sarasvathy, 2003).

An analogy can be made to the duality of science and technology. While much new technology is developed by advances in science, there are examples of inventions in technology that drive scientific progress. This reversal is also the case with design. ADR uses theory-ingrained artifacts but the liberty in design can lead to new and unexpected scientific discoveries.

The design approach in ADR, as well as DSR, can be viewed as a fourth type (or paradigm) for research in project management. This conclusion is in line with those of Venable (2013). Unlike the other three research types/paradigms, which seek to develop theories based on the current state of the world for understanding and/or prediction (cf. types II, III, and IV of theory in Gregor 2006), DSR seeks to invent, design, and/or develop new purposeful artifacts and relevant knowledge about them (cf. type V theory in Gregor 2006: Theory for Design and Action). DSR's focus on the invention (thereby adding things that do not yet exist in the world) is absent from the three kinds of project management research proposed in Geraldi and Söderlund (2018), so this study proposes extending their classification with a fourth project management type: Design Science Research.

Söderlund (2011) distinguished seven schools of research in project management: (1) Optimization School, (2) Factor School, (3) Contingency School, (4) Behavior School, (5) Governance School, (6) Relationship School, and (7) Decision School. Of these schools, Optimization and Governance are most similar to DSR in that they both seek prescriptive knowledge about what actions practitioners should (or could) take. The Contingency and Decision Schools are also related in that DSR seeks to identify knowledge about the circumstances (contingencies) in which a newly developed purposeful artifact has utility for achieving its purpose, as well as decision guidance based on that new knowledge (cf. type V theory for design and action in Gregor 2006). Taking this research as a specific example, it seeks to Optimize project management in the face of complexity by recommending an approach to Govern the management of complexity and deal with the Contingencies of different degrees and kinds of complexity, so that Decisions can be made concerning appropriate action. DSR distinguishes itself from all of the other schools with its specific focus on inventing new purposeful artifacts (and evaluating their utility, efficacy, effectiveness, and efficiency). Therefore, this study proposes extending the classification proposed in Söderlund (2011) by adding Design Science Research as an eighth school (perhaps as the "Design-Oriented School" or "Artifact Invention School") of research in project management.

8. Conclusions and perspectives for further research

(To help the reading, the concepts highlighted with italics are explained further in the conceptual framing and the notation (#...) refers to the seven papers published by the student.)

An engaged scholarship project using Action Design Research (ADR) was conducted to answer the following research questions: 1) What kind of information is needed for handling project complexity and 2) How can an information system be developed to provide affordance for project complexity management?

The research questions are based on multiple calls for research in project management research literature focusing on helping practitioners to handle the complexity of projects. To verify that the aim of the research is based on a real-world problem, a large survey was conducted among practitioners, with the results showing that handling complexity is an increasingly important challenge for project managers.

The research literature on project complexity is in itself complex; however, it can be broken down based on the intention behind the research (#1). The study identified five ideal types of research on project complexity, each with a unique relation to the concept of *project success*. On the question of what information is needed for navigating project complexity, the research literature is not conclusive.

A large survey conducted as part of the research demonstrated that project type and sectors should be taken into account. More importantly, the information needs to come from multiple project roles, because role influences the perception of complexity. Project managers need to tactically consider information flow to counter the unrealistic expectations of project decision-makers.

By developing a matrix of perspectives on project complexity the study categorized six unique perspectives. The matrix consists of a chronological perspective, which divides project observations into ex-ante, transitional, and ex-post perspectives. The other axis is the dichotomy of perceived and descriptive project complexity. The study then focused on the transitional perspective of perceived project complexity, also called the lived experience of project complexity. The study also theorized the 'lived experience' (#5).

The ADR project first designed and evaluated an artifact giving affordance to navigating project complexity by recommending a managerial strategy determined by the level of project complexity. The artifact is labeled the Complexity Navigation Window (#6). The ADR project then implemented the CNW as a prototype of an information system for monitoring project complexity in a transitional perspective based on continuously updated input from stakeholders obtained in a survey of relevant questions adjusted to the current state of the project. This information system is a case of "IT-enabled complexity management."

The developed information system gives affordance to navigating the perceived project complexity. The chief design principle was the *outside view* together with the *Cynefin framework*. The outside view can counter the inside view of decision-makers resulting in unrealistic expectations, og even stupidity (#4).

When setting up the information system for a given project, the selection of the stakeholders offering an outside view should be based on the stakeholder landscape, keeping in mind that the role of the stakeholder will influence their perceived project complexity (#2). Further, the stakeholders should be selected to cover the diversity of perspectives on project success. Additionally, it should be clarified whether benefits realization is part of the complexity that needs to be handled by the project manager (#3). The affordance of this information is the outside view and the early detection of change (#7). To actualize the affordances, the project managers should consult the Complexity Navigation Window (#6) frequently. The setup of questionnaires can be based on the question bank developed with inspiration from researched tools used for the assessment of project complexity. See Appendices A, B, and C.

Using ADR, the project developed an information system using the *outside view* of projects with a *transitiona*l perspective to give navigation *affordance* to project leadership, this study stands out in ongoing international research on project complexity.

In design research, as ADR is based on, evaluation of the artifact is paramount. Following FEDS the ADR project proceed fast to the naturalistic domain, where the artifact was evaluated in situ. This highlighted impediments of evaluation in workshops. The naturalistic evaluation of the information system revealed how project manager may say and intent one thing on workshop but act differently in real-life project situation. The difference of what they say and what they do is not only caveat to workshop-based evaluation, it puts addition pressure of the ADR methodology in terms of handling resistance to changes.

8.1. Recommended future research

The proposed theory of project complexity management needs further development, more generative mechanisms need to be identified, and the contextual actualization of mechanisms needs further investigation.

To further the understanding of IT-enabled complexity management, the following future research is recommended:

- The framework for early detection in the navigation of complexity needs further development.
- Summative evaluation of the information system using the outside view needs to be conducted in more organizations and sectors.
- The potential of benefits in 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 could be investigated. ADR is the process of the research, while AT is the process of the artifact. The two theories might be integrated on a conceptual level in future research.

The relationship between project success and the transitional perspective on project complexity is a subject worthy of future research. This can be a part of the suggested theorization of project complexity management as a lived experience.

Further, there is potential for cross-fertilization between ADR and the theory of organizational change and related topics. The topic of “misperceptions” of the intended affordances needs further investigation and might lead to further development of Affordance Theory.

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10. Appendices

Appendix A: The TOE model.

The TOE model (Bosch-Rekveldt et al., 2011) has 50 questions for the project manager categorized into the dimensions of Technical, Organizational, and Environment. The TOE model is often used for positivistic research (in a watered-down version), where the measure of project complexity is assumed to be objective. However, an examination of the questions reveals that many of them are highly subjective and dependent on the perception of the respondent (often the project manager).

Table 4
TOE framework (50 elements in total).

TOE	Sub-ordering	ID	Source L/E/B[1]	Elements defined	Explanation
T	Goals	TG1	L	Number of goals	What is the number of strategic project goals?
T	Goals	TG2	B	Goal alignment	Are the project goals aligned?
T	Goals	TG3	B	Clarity of goals	Are the project goals clear amongst the project team?
T	Scope	TS1	B	Scope largeness	What is the largeness of the scope, e.g. the number of official deliverables involved in the project?
T	Scope	TS2	B	Uncertainties in scope	Are there uncertainties in the scope?
T	Scope	TS3	E	Quality requirements	Are there strict quality requirements regarding the project deliverables?
T	Tasks	TT1	B	Number of tasks	What is the number of tasks involved?
T	Tasks	TT2	B	Variety of tasks	Does the project have a variety of tasks (e.g. different types of tasks)?
T	Tasks	TT3	B	Dependencies between tasks	What is the number and nature of dependencies between the tasks?
T	Tasks	TT4	B	Uncertainty in methods	Are there uncertainties in the technical methods to be applied?
T	Tasks	TT5	B	Interrelations between technical Processes	To what extent do technical processes in this project have interrelations with existing processes?
T	Tasks	TT6	B	Conflicting norms and standards	Are there conflicting design standards and country specific norms involved in the project?
T	Experience	TE1	B	Newness of technology (world-wide)	Did the project make use of new technology, e.g. non-proven technology (technology which is new in the world, not only new to the company!)?
T	Experience	TE2	B	Experience with technology	Do the involved parties have experience with the technology involved?
T	Risk	TR1	B	Technical risks	Do you consider the project being high risk (number, probability and/or impact of) in terms of technical risks?
O	Size	OS1	L	Project duration	What is the planned duration of the project?
O	Size	OS2	B	Compatibility of different project management methods and tools	Do you expect compatibility issues regarding project management methodology or project management tools?
O	Size	OS3	B	Size in CAPEX	What is the estimated CAPEX of the project?
O	Size	OS4	B	Size in Engineering hours	What is the (expected) amount of engineering hours in the project?
O	Size	OS5	B	Size of project team	How many persons are within the project team?
O	Size	OS6	E	Size of site area	What is the size of the site area in square meters?
O	Size	OS7	B	Number of locations	How many site locations are involved in the project, including contractor sites?
O	Resources	ORE1		B	Project drive Is there strong project drive (cost, quality, schedule)?
O	Resources	ORE2	B	Resource and skills availability	Are the resources (materials, personnel) and skills required in the project, available?
O	Resources	ORE3	B	Experience with parties involved	Do you have experience with the parties involved in the project (JV partner, contractor, supplier, etc.)?
O	Resources	ORE4	E	HSSE awareness	Are involved parties aware of health, safety, security and environment (HSSE) importance?
O	Resources	ORE5	B	Interfaces between different disciplines	Are there interfaces between different disciplines involved in the project (mechanical, electrical, chemical, civil, finance, legal, communication, accounting, etc.) that could lead to interface problems?
O	Resources	ORE6	B	Number of financial resources	How many financial resources does the project have (e.g. own investment, bank investment, JV-parties, subsidies, etc.)?
O	Resources	ORE7	B	Contract types	Are there different main contract types involved?
O	Project team	OP1	B	Number of different nationalities	What is the number of different nationalities involved in the project team?
O	Project team	OP2	B	Number of different languages	How many different languages were used in the project for work or work related communication?
O	Project team	OP3	B	Cooperation JV partner	Do you cooperate with a JV partner in the project?
O	Project team	OP4	B	Overlapping office hours	How many overlapping office hours does the project have because of different time zones involved?
O	Trust	OT1	B	Trust in project team	Do you trust the project team members (incl JV partner if applicable)
O	Trust	OT2	B	Trust in contractor	Do you trust the contractor(s)?
O	Risk	OR1	B	Organizational risks	Do you consider the project being high risk (number, probability a nd/or impact of) in terms of organizational risks?
E	Stakeholders	ES1	B	Number of stakeholders	What is the number of stakeholders (all parties (internal and external) around the table, pm = 1, project team = 1, NGOs, suppliers, contractors, governments)?
E	Stakeholders	ES2	B	Variety of stakeholders' perspectives	Do different stakeholders have different perspectives?
E	Stakeholders	ES3	B	Dependencies on other stakeholders	What is the number and nature of dependencies on other stakeholders?
E	Stakeholders	ES4	B	Political influence	Does the political situation influence the project?
E	Stakeholders	ES5	B	Company internal support	Is there internal support (management support) for the project?
E	Stakeholders	ES6	B	Required local content	What is the required local content?
E	Location	EL1	E	Interference with existing site	Do you expect interference with the current site or the current use of the (foreseen) project location?
E	Location	EL2	E	Weather conditions	Do you expect unstable and/or extreme weather conditions; could they potentially influence the project progress?
E	Location	EL3	E	Remoteness of location	How remote is the location?

(continued on next page)

Appendix B: Complexity Assessment Tool (CAT)

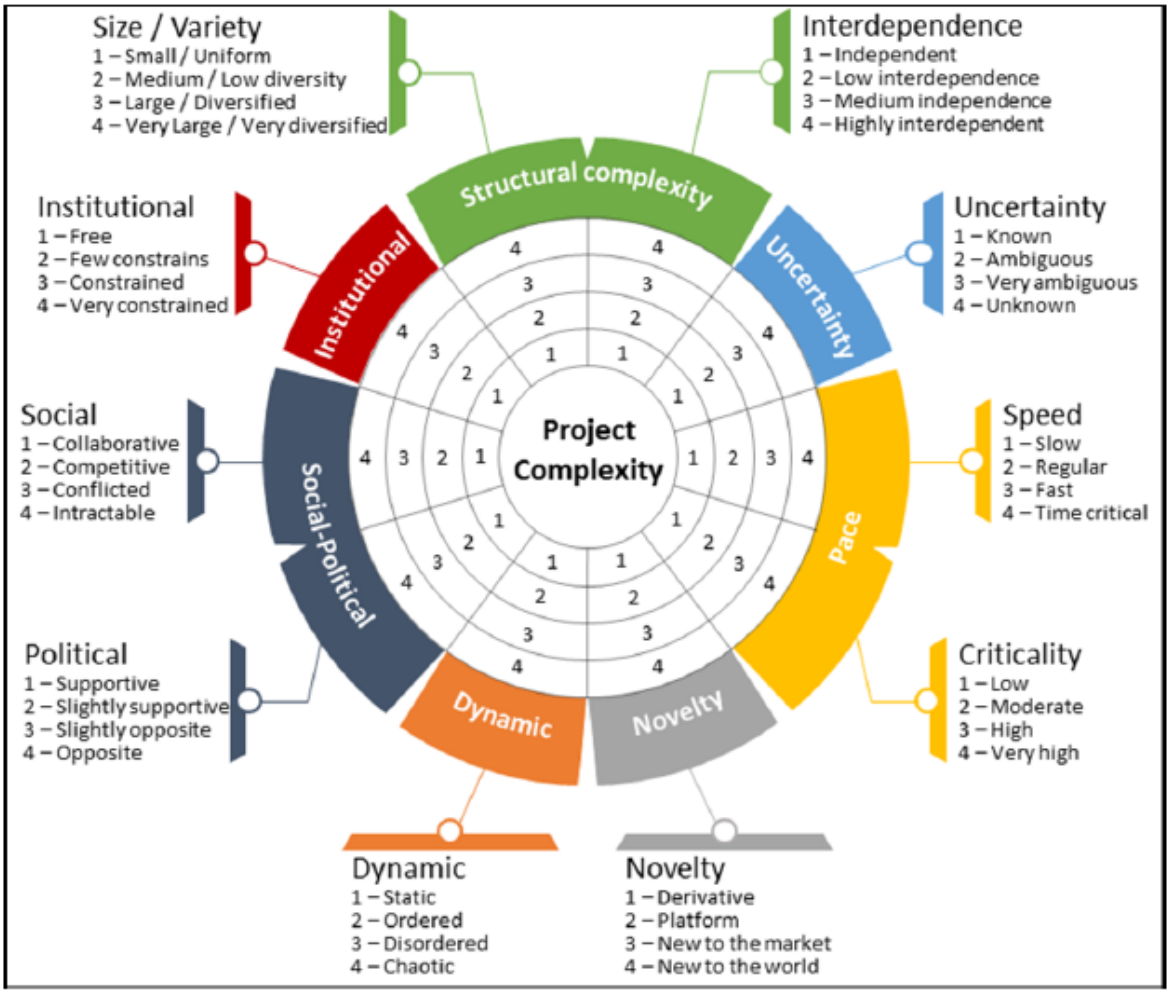
The CAT model (H. R. Maylor et al., 2013) is designed as an assessment tool with three dimensions and thirty-two specific questions to score project complexity. The CAT is also meant for dialog between the involved managers. “In use, the benefits of the CAT arise not directly from the questionnaire but the subsequent conversations between managers involved in the project.” (H. R. Maylor et al., 2013, p. 49)

The Complexity Assessment Tool

	Areas of complexity • Structural Complexity (1–21) • Sociopolitical Complexity (22–32) • Emergent Complexity (defined by expectations for stability)	Do you agree with this statement? (Y/N)	Do you expect this situation to remain stable (i.e., NOT to change)? (Y/N)
Structural Complexity			
1	The vision and benefits for the work can be clearly articulated.		
2	Success measures for the work can be defined in agreement with the client.		
3	The technology is familiar to us.		
4	The commercial arrangements are familiar to us.		
5	The scope can be well defined.		
6	Acceptance criteria for quality and regulatory requirements can be well defined.		
7	A schedule and resource plan can be well defined.		
8	The supply chain is in place.		
9	Lines of responsibility for tasks and deliverables can be defined.		
10	Accurate, timely, and comprehensive data reporting is possible.		
11	Existing management tools can support the work.		
12	Sufficient people with the right skills are available.		
13	Managers have adequate control of human resources (i.e., direct reporting).		
14	Key people are wholly allocated to the work.		
15	Integration across multiple technical disciplines is not required.		
16	The budget is sufficient for the task.		
17	The budget can be used flexibly.		
18	The work will be carried out in a single country/time zone/language/currency.		
19	The work is independent of other projects and business-as-usual operations.		
20	The pace is achievable.		
21	Resources (e.g., test facilities, equipment) will be available when needed.		
Sociopolitical Complexity			
22	The work has clear sponsorship consistent with its importance.		
23	The business case for the work is clear.		
24	The goals for the work align with the organization’s strategy.		
25	Your own senior management supports the work.		
26	Team members are motivated and function well as a team.		
27	Managers are experienced in this kind of work.		
28	The work involves no significant organizational/cultural change.		
29	The work will be unaffected by significant organizational/cultural change.		
30	The external stakeholders (i.e., not immediate team members) are aligned, supportive, and committed to the project and have sufficient time for the work.		
31	The external stakeholders (i.e., not immediate team members) have a realistic, shared understanding of the implications of the work.		
32	The core team has the authority to make decisions.		

Appendix C: Project complexity dialog framework (PCD framework)

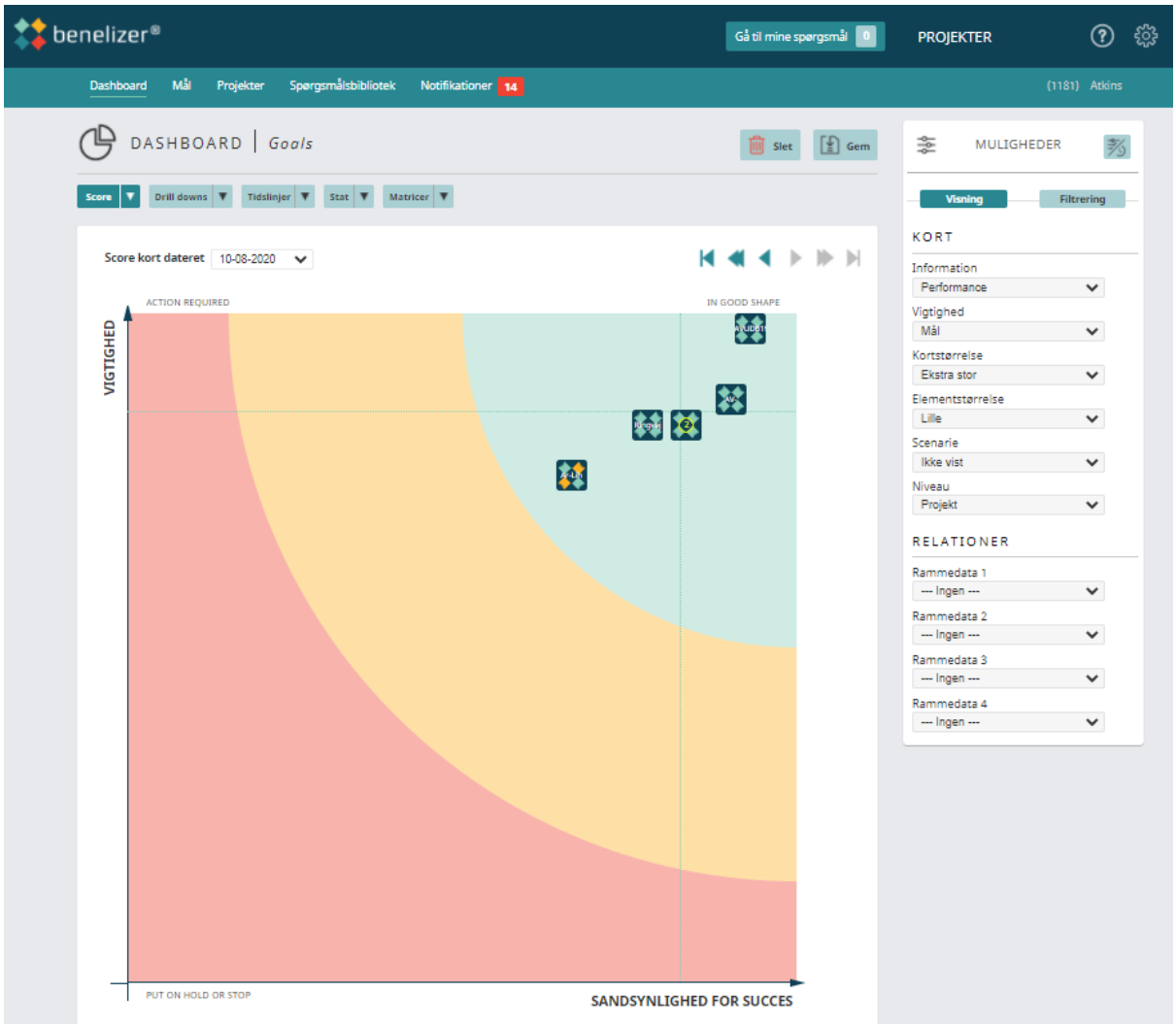
The following diagram is a recently published example of a multi-dimensional framework for project complexity (de Rezende & Blackwell, 2019). The paper stresses, that this framework is for dialog – not for measuring project complexity, hence the framework is descriptive and has here been labeled the PCD framework.



Appendix D: Implementation in Benelizer – Map

The dashboard of the IT platform is "born" with a dashboard displaying "importance" against "probability of success." Depending on the question asked and aggregated (with unique weights for each question), the real dimensions will differ. The divergence of the stakeholders can be found in the "drill-downs." See Appendix E.

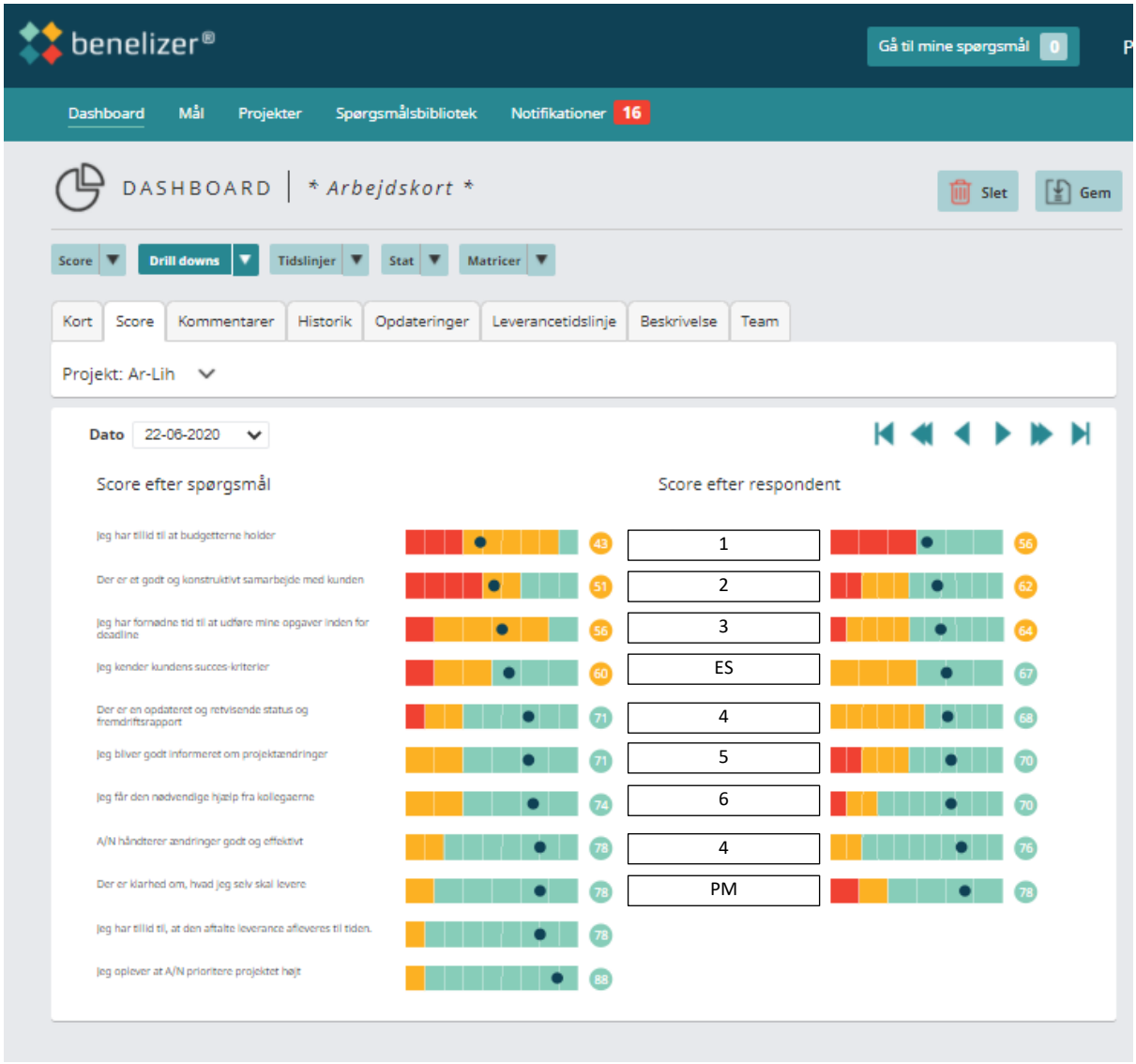
In the screenshot below, more than two projects (mentioned in Paper #7) are depicted. The others include the new project from the scaling up of the implementation.



Appendix E: 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



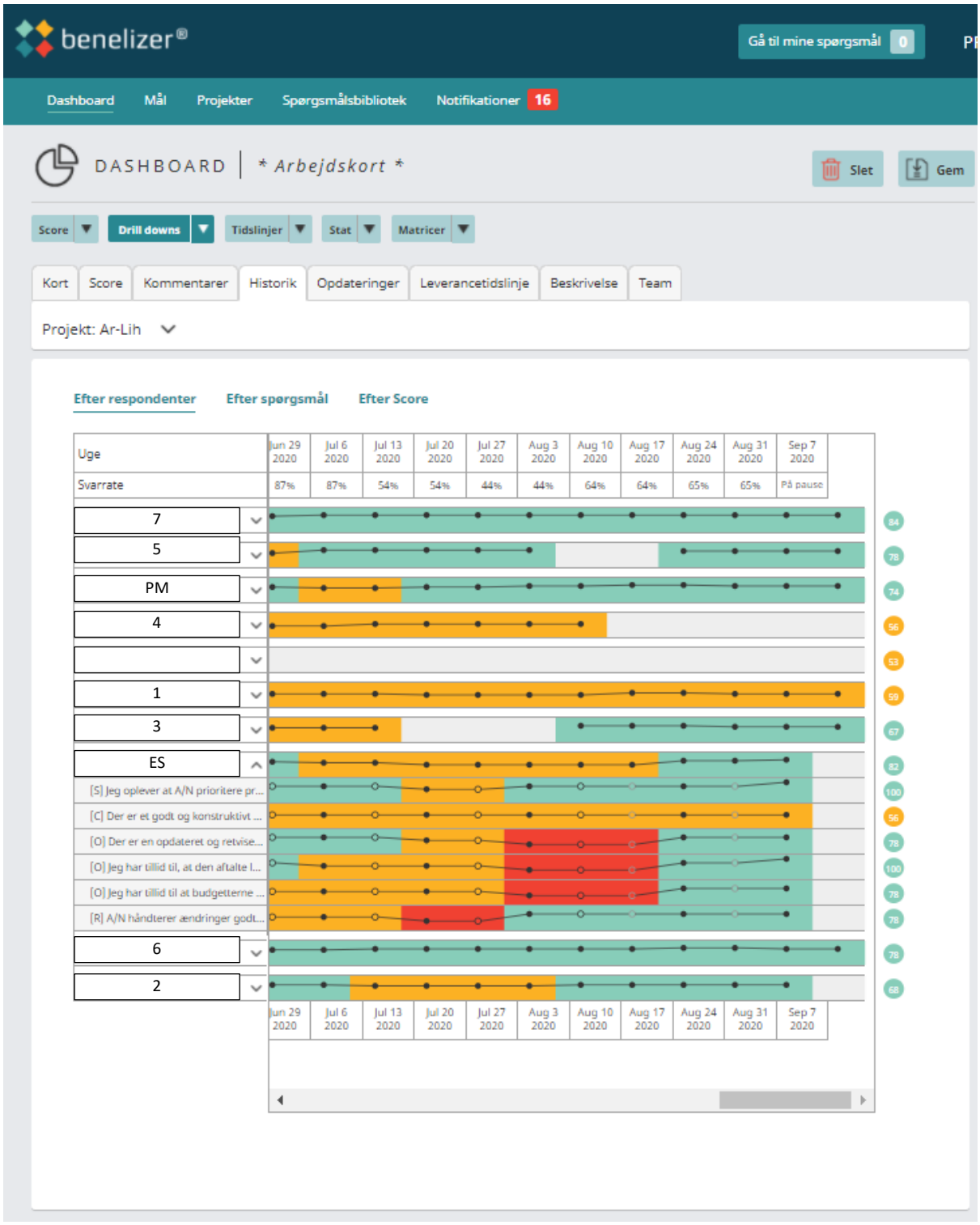
Appendix F: Implementation in Benelizer – Historic view of responses

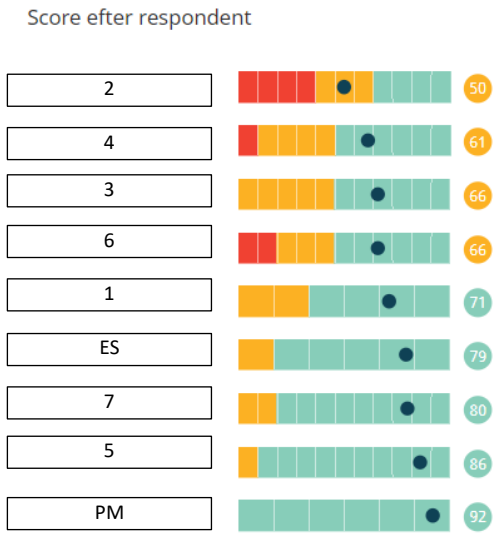
The historical drill-down in the IT platform shows the rating from each stakeholder in each time-period (Weeks). The executive, mentioned in Paper #7, is here displayed to show the specific ratings on each question posed to that stakeholder. If the project manager had followed the monitoring of stakeholders' 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.

Project Manager = PM. Executive stakeholder = ES. Other stakeholders labeled 1, 2, 3 etc

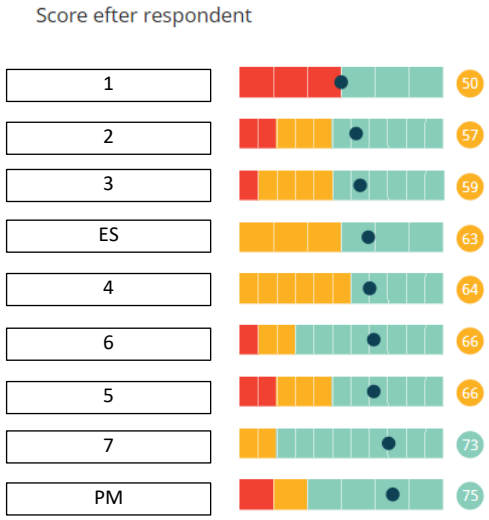
Project Manager = PM. Executive stakeholder = ES. Other stakeholders labeled 1, 2, 3 etc

25th of November 2019:

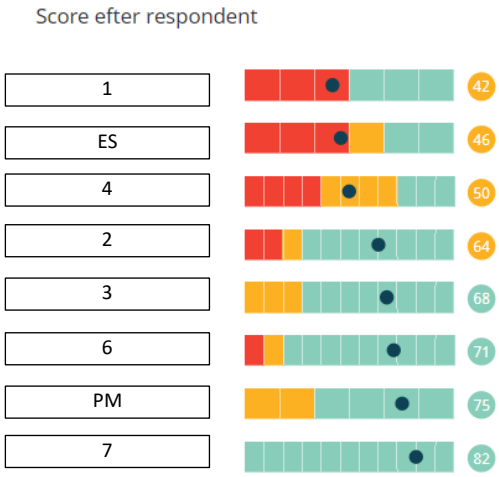


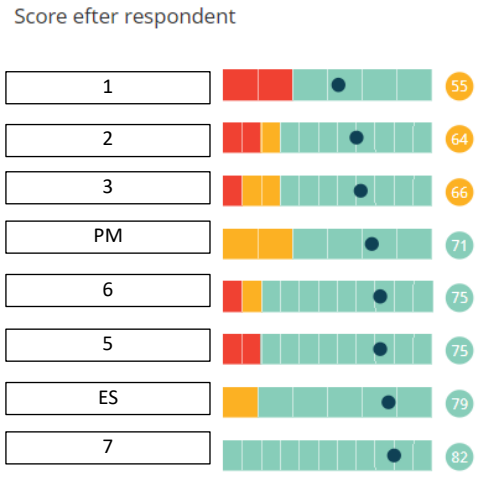


10th of August 2020 (under the storm)



9th of September 2020 (after the storm)





11. Included papers

The included seven papers displayed in table 10. The full-length papers follower hereafter.

Title	Journal	Author(s)	Shares of work
1. The complex project complexity - Identification of five ideal research types	*Journal of Modern Project Management*	Mogens Frank Mikkelsen	MFM=100%
2. Perceived project complexity: A survey among practitioners of project management	*International Journal of Managing Projects in Business*	Mogens Frank Mikkelsen	MFM=100%
3. Investigation of the institutionalizing responsibility of project managers for project benefits realization	*Journal of Modern Project Management*	Mogens Frank Mikkelsen and Carl Marnewick	MFM=60% CM=40%
4. On Stupidity in Project Management - A critical reflection of PM in a VUCA world	*Journal of Modern Project Management*	Mogens Frank Mikkelsen, Louis Klein, and Carl Marnewick	MFM=60% LK=25% CM=15%
5. The lived experience of managing the dynamics of project complexity	In press at *Journal of Modern Project Management*	Mogens Frank Mikkelsen	MFM=100%
6. Researching Navigation of Project Complexity - Using Action Design Research	Special issue of *International Journal of Managing Projects in Business*	Mogens Frank Mikkelsen, John Venable, and Kirsi Aaltonen	MFM=70% JV=20% KA=10%
7. IT enabled management of project complexity – An Action Design Research *(Extended abstract resulted in invitation to special review of IJMPiB)*	In review at *International Journal of Managing Projects in Business*	Mogens Frank Mikkelsen and Kirsi Aaltonen	MFM=90% KA=10%

Table 10: Papers included in the thesis. The shares of work are based on co-author statements.

The complex project complexity
Identification of five ideal research types

Mogens Frank Mikkelsen
IT University of Copenhagen, Denmark

Abstract: The concept of project complexity has evolved tremendously since topic discussions were initiated. A diversification was sparked a decade ago. The multiplicity of concepts makes it increasingly challenging to utilize the overall research stream of project complexity. This paper takes stock and presents a typology with five ideal types of research in project complexity. This demonstrates an overarching relationship between the type of research of project complexity and the inherent perspective on project success. The typology contributes a much-needed overview for researchers who are new to the overall topic of project complexity. The complexity of projects is an important aspect of research of rethinking of project management, and the typology has the potential of forming a theory of project complexity supporting this research.

Keywords: Ideal types, project complexity, project success

1. Introduction

Project complexity is a fascinating research area in which there are many shoulders to stand on and many viewpoints to consider. While there is much disagreement in research on the concept of project complexity, there is one thing that many papers agree upon: “There is no commonly accepted definition” (Chapman, 2016). Many studies on project complexity delve into the topic echoing this common mantra; for example (Dao, Kermanshachi, Shane, Anderson, & Hare, 2016), (Luo, He, Jaselskis, & Xie, 2017), and (Zhu & Mostafavi, 2017). The absence of a common definition of project complexity is a symptom of an underlying diversity of the research that requires attention. Theory development should not simplify complexity; it should aim at complexifying theories (Tsoukas, 2017). This statement serves as a fine starting point.
Research on project complexity has come a long way in the two decades since the appearance of the paper (Baccarini, 1996) that by many is considered to be the starting point of the research stream on project complexity. The concept is central to the development of research in project management (Cicmil, Williams, Thomas, & Hodgson, 2006) and was the first of six items on the agenda for Rethinking Project Management (RPM), which began as a UK Government-funded research network (Winter & Smith, 2006); later, RPM became a movement, according to (Svejvig & Andersen, 2015).

A recent paper concluded that its research has “established empirically the relationships between project complexity and project management performance in terms of unscheduled delays and overspending” (Bjorvatn & Wald, 2018, p. 886). While this is good news, it also illustrates one specific view of project complexity; a firm narrow perspective. Another recent paper argues for further development of the framework of project complexity, introducing institutional complexity as a new dimension for the practitioner the build there understanding of project on. (de Rezende &

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Blackwell, 2019). Research papers often refer to project complexity as a uniform concept, which is a contestable simplification. This paper will demonstrate that project complexity is a concept with high plasticity in which the purpose of the research shapes the concept of project complexity in a systematic way.

This paper takes stock of recent research on project complexity and contributes to clarifying the differences in research by identifying five research mainstays, thereby lending chief support to the overall research on project complexity. The benefit of this differentiation is the identification of the uniqueness and presumptions of each type. A typology differentiates but has the potential to unite diversity into a bigger picture, hence a rigorous classification gives credence to an integrated perspective needed to rethink project management. Moreover, the contribution of the paper is an indication of how these five ideal types of research promote a distinct relationship with the concept of project success.

Compared to project complexity, the concept of project success has a high level of consensus, although there is some diversity in the definitions. Project success can be divided into efficiency and effectiveness (Baccarini, 1999). Efficiency is about meeting specifications within time and budget, which is equal to project management performance (Mir & Pinnington, 2014) and to process success (McLeod, Doolin, & MacDonell, 2012). Project effectiveness is a more debated topic. One suggestion among many is a number of divisions: organizational benefits, project impact, stakeholder satisfaction, and future potential. (Joslin & Müller, 2015). Further elaboration of these divisions will be conducted as this paper progress, including an explanation of the identified types of research on project complexity.

This paper is to take a meta-perspective of the research on project complexity and should not be confused with a structured literature review. The goal is to demonstrate how the research perspective influences the concept of project complexity and how this relates to the understanding of projects. The paper poses the following research questions: What is the state of art in researching project complexity, and how can diversity be classified into ideal types of research?
In the pursuit of this question, the ideal types are related to perspectives on project success in order to investigate how the perspectives (on project complexity and success respectively) are related.

The rest of the paper is structured as follows. Section 2 is a literature review of the various studies on project complexity. Section 3 presents the methodology of the paper. Section 4 presents a typology of research on project complexity, and section 5 elaborates on each of the five ideal types. Section 6 discusses the paper's contribution, and section 7 presents the conclusion and suggestions for further research.

2. Literature review

Surveying the research literature on the topic of project complexity begins with an overview of the timeline. The literature sections of most studies on project complexity reference (Baccarini, 1996) as their initial paper. Here, it was proposed that project complexity should be defined as "consisting of many varied interrelated parts", which was later referred to as structural complexity. There is both an organizational and a technological component to project complexity, which can be operationalized in terms of differentiation and interdependency (Baccarini, 1996).

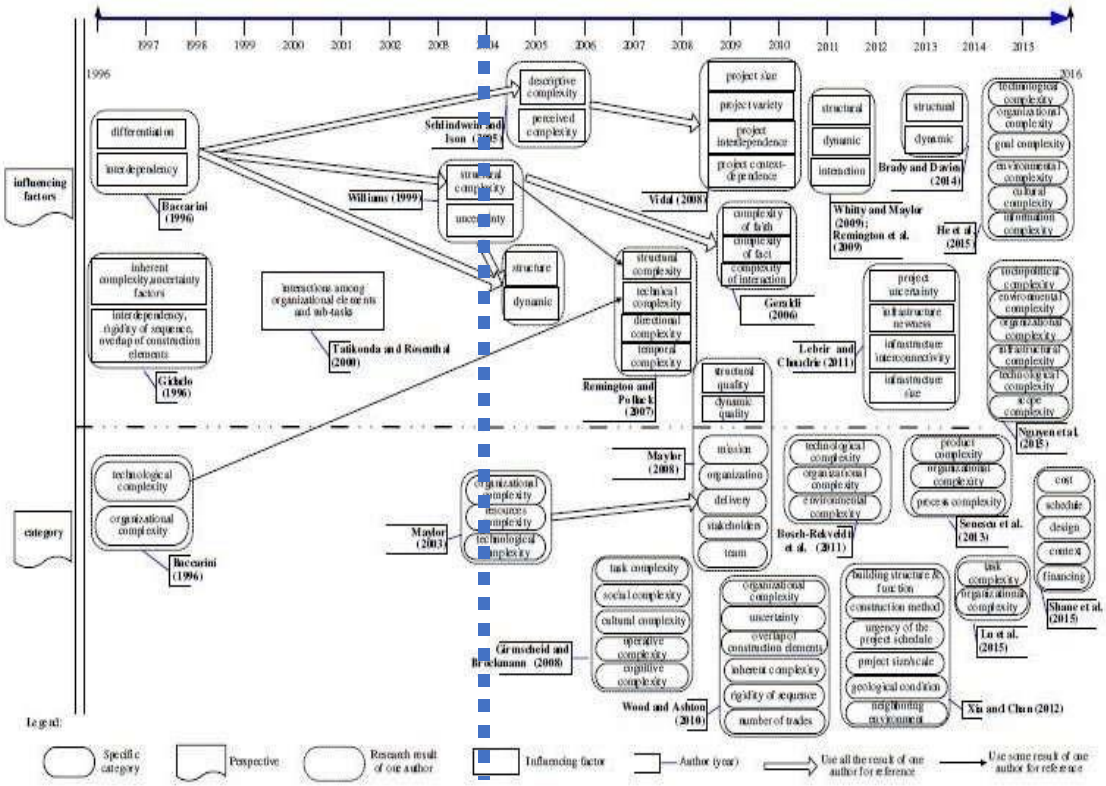

Figure 1: Miniature copy of historical ('96-'16) timeline on project complexity (Lou et al. 2017). The vertical dotted line at year 2006 was added by the author.

In 2004-2006, a network of researchers devised the concept "Rethinking Project Management" (RPM) (Winter & Smith, 2006). The research topic "project complexity" was at the top of the list of five recommended directions for research in project management. In hindsight, there are indications of a post-RPM era in the research on project complexity.

A structured review (Luo et al., 2017) presented the contributions of influential factors and categories in project complexity, from the period 1996 to 2016. A miniature of this graph is shown in **Figure 1**. The strength of this historical presentation is that the middle of the period has a visible 'spark' of diversification that coincides with the RPM initiative. Whether the RPM research network saw this diversification coming or pushed the development forward is beyond the scope of this literature review. However, it is reasonable to speak about a post-RPM era of project complexity research. This illustrates that the diversification of research in project complexity has 'only' been around for a decade. The implication is that we may anticipate further diversification of research of project complexity since we cannot expect it to have grown into its final state yet.

Before the 'spark', an early diversification is identified with the response from Williams (1999) to (Baccarini, 1996), including the argument for adding uncertainty as a dimension of project complexity with the following definition: "Project complexity can be characterized by two dimensions, each of which has two subdimensions: structural complexity (number of elements and interdependence of elements) and uncertainty (uncertainty in goals and uncertainty in methods)" (T. M. Williams, 1999). Retrospectively, this was a crossroads at which some scholars pursued the

operationalization proposed by Baccarini, while others took up the broader approach taken by Williams and looked for related dimensions to include in the concept of project complexity. Uncertainty as a dimension of project complexity is still the topic of active debate post-RPM, as exemplified by (Padalkar & Gopinath, 2016).

In the footsteps of Williams's diversification, Remington and Pollack (2008) argued for four project complexity dimensions: structural, technical, directorial, and temporal. Later, a systematic literature review concluded that the concept of project complexity had evolved to encompass new dimensions: structural complexity, uncertainty, dynamic, pace, and sociopolitical dimension (Geraldi, Maylor, & Williams, 2011). Five years later, another structured literature review was conducted, showing further development and reflecting the diversification mentioned above. According to this work, the concept of project complexity has expanded to the dimensions: emergence, autonomy, belonging, connectivity, diversity, size, and the element of context (Bakhshi, Ireland, & Gorod, 2016).

However, the operationalization path led to further studies on project complexity. Some focused on a few variables, while others identified many, as for example (Kian Manesh Rad, 2016), with 51 project complexity indicators. Another paper (Dao et al., 2016) divided the concept of project complexity into 11 categories, with 35 complexity attributes and, in total, 101 indicators. One paper reported that 128 project complexity factors had been identified as a result of a literature review covering the period 1990 to 2015 (Bakhshi et al., 2016).

Analytical Hierarchy Process (AHP) is one of the preferred methods of operationalization. AHP belongs to the multicriteria decision methodologies. For calibration of the multidimensional models, the AHP is used to estimate the weight of the dimensions, often in combination with the Delphi method and taking input from practitioners' evaluations of the suggested dimensions. An example is (Vidal, Marle, & Bocquet, 2011). Another favorite method is Structural Equation Modeling (SEM), as in the case of (Qureshi & Kang, 2015) and (Bueno & Gallego, 2017).

In the search for explanations of project complexity, complexity theory becomes evident. While there has been important work on complexity theory in project complexity prior to RPM, of which (Jaafari, 2003) is a prime example, the use of complexity theory in project management has gained momentum with studies such as (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007).

Research on levels of project complexity is orthogonal to the previously mentioned dimensions of project complexity. In its simplest form, the duality of being a complex project or not comprises two levels of complexity. The differentiation of the project in two categories; complicated versus complex is mentioned in (Whitty & Maylor, 2009). A more elaborated version of this idea is found in the sense-making Cynefin framework (Snowden & Boone, 2007), which includes four domains: simple, complicated, complex and chaotic. Bakhshi et al. (2016) use Cynefin as an example of system-of-systems (SoS), as one three schools of thought on project complexity they identified. The other two schools of thought are the PMI-view and the complexity theoretical view. More recent papers on the foundation of complexity theory have contributed stratification concepts, in which project complexity is divided into levels; see (Kiridena & Sense, 2016) and (Daniel & Daniel, 2018). Based on these two papers, the complexity theory and the SoS school of thought have merged.

Another important diversification is perceived project complexity, about which it is said that "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" (Vidal & Marle, 2008, p. 1096). Among research into perceived project complexity, we find examples such as a model called "MODeST" (H. Maylor, Vidgen, & Carver, 2008), with the following dimensions: mission, organization, delivery, stakeholder, team. This model is developed in workshops with practitioners of project management. Another example is based on ground theory and is a division of the overall complexity into task, social and cultural complexity (Brockmann & Girmscheid, 2007). The TOE framework (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011) began as a framework based on perceived project complexity but was later presented as a more descriptive model, as applied by (Qureshi & Kang, 2015).

The use of case studies – as opposed to generalizations – is yet another differentiation in understanding project complexity. One prime example of case studies includes papers on megaprojects. In some studies, the project complexity of the mega-project is conducted using the same models, as in (Kian, Sun, & Bosché, 2016). To other authors, mega-projects are a separate species altogether, i.e., whereas the mega-projects are complex, they are simple per definition (Flyvbjerg, 2014); however, this has been questioned in (Pollack, Biesenthal, Sankaran, & Clegg, 2018).

As a final remark on the literature review, although much research has been conducted on and much has been written about project complexity, there remains no overarching theory. Whether this is discouraging or energizing is a matter of personal opinion.

3. Methodology

The quest to make sense of the diversity of research on project complexity requires some kind of classification, wherein "Sensemaking is a motivated, continuous effort to understand connections (…) in order to anticipate their trajectories and act effectively" (Klein, Moon, & Hoffman, 2006, p. 71). Classification is a way of making sense of the world, and this produces a set of 'boxes' with the following properties: "1) They are consistent, unique classificatory principles in operation, 2) The categories are mutually exclusive, 3) The system is complete" (Bowker & Star, 2000, p. 10). From the second property, it follows that Bowker and Star consider categories to be the result of classification. These prerequisites are too strict to utilize in differentiation of the research on project complexity.

A less categorical classification can be found in 'schools of thought', with has been used to classify project complexity (Bakhshi et al., 2016); however "schools" are generally associated with one or more charismatic founders (Swales, 2014), which is not applicable to all types of research on project complexity.

Another option is the use of genres as classification, wherein "genres of research are overarching categories for different ways of approaching research. Each genre lends itself to studying particular kinds of topics and includes a range of commonly used methods of data collection, analysis, and representation" (Leavy, 2014, p. 3). Genres of research are seen, for example, in research on

education (Bennett, 2001; Borko, Liston, & Whitcomb, 2007) or on information systems (Rowe, 2012). Genres can be attributed to a journal, such as the European Journal of Information Systems (Te'eni, Rowe, Ågerfalk, & Lee, 2015) and also methodologies, such as 'Design Science Research' (Peffers, Tuunanen, & Niehaves, 2018). However, genres are less rigorous and are therefore less suited for our quest.

In between the firm categories and the looser genres, we find the concept of typology. Typologies are not the same as classifications (Doty & Glick, 1994). Typologies have been used in research on project management, wherein it was pointed out that "unlike classification systems, typologies are not about sorting entities into mutually exclusive, exhaustive groups. Instead, typologies are conceptually derived interrelated sets of ideal types that explain a dependent variable" (Niknazar & Bourgault, 2017, p. 194). Typologies are complex theories, and the "Ideal types are complex constructs that can be used to represent holistic configurations of multiple unidimensional constructs" (Doty & Glick, 1994, p. 233). A typology comprises a set of ideal types, and "Ideal types are multivariate profiles of entities summarized by specific variables known as second-order factors/constructs. Simply put, a combination of second-order constructs is used to describe the holistic configuration of each ideal type" (Niknazar & Bourgault, 2017, p. 195). The steps in the process of developing a typology are illustrated in **Figure 2**.

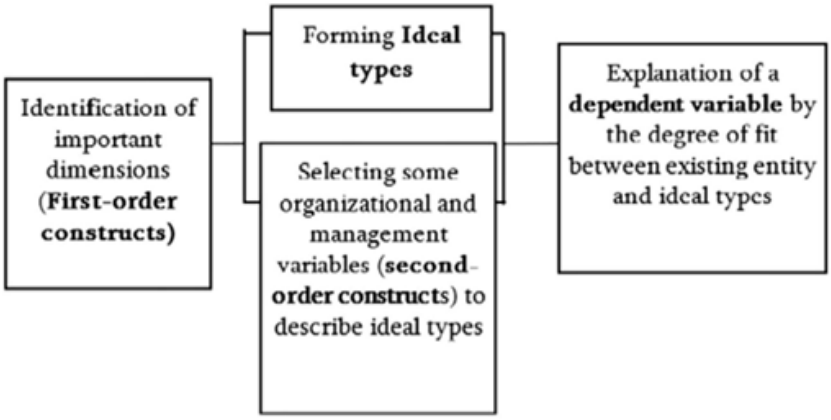

Figure 2: (Niknazar & Bourgault, 2017)

4 Theoretical foundation – the first-order construct of the typology

The presentation in the following can give an impression of a deductive process leading to the typology of research on project complexity, but this is only a retrospective perspective, since the process leading up to this point was very pragmatic, in the sense that "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).

The process of identification of the important dimensions, the first-order construct, has roots in many levels of worldviews, both ontological and epistemological. As pointed out by Doty (1994), a typology is a complex theory. The dimension is 'the intention with the research'. While the ideal types are numbered and have a clear structure, they are not an ordered category variable. The ideal types of the dimension have been coined as follows: 1) positivistic construct, 2) complexity theory, 3) ontological framework, 4) managerial framework, and 5) emancipative investigation. The diversification of the five types will follow in the coming sections.

The diversity of intentions has long roots in science, starting with the two fundamental traditions in science, realism, and constructivism, where the former searches the generalizable truth and the latter a contextual understanding. Ideal types 1-3 are mostly realist, and type 5 is mostly constructivist. The third "tradition", the pragmatist approach (Dewey, 1916), accounts for how-to-knowledge; "Truth is what works" is the motto of pragmatism. The ideal type 4 is very much aligned with the pragmatist approach.

Bhaskar (2013) presents a stratification of reality, wherein mechanisms work 'behind the scenes' and cause events, which again lead to experiences. This stratification determines three domains, i.e., the real, the actual and the empirical, as illustrated in **Table 1**. The writings of Bhaskar have become an important foundation for critical realism, distancing itself from all other types of dashes of realism. The three domains in Bhaskar's stratification of reality can be approximated to the ideal types as follows: ideal type 1 relates to the empirical domain, ideal type 3 relates to the actual domain, and ideal type 2 relates to the real domain.

	Domain of Real	*Domain of Actual*	*Domain of Empirical*
Mechanisms	√		
Events	√	√	
Experiences	√	√	√

Table 1: Stratification of reality (Bhaskar, 2013, p. 2)

Neuman (2013) divided social science into five types. Of these, the so-called critical social science and feminism are not relevant here. The other three are explained in **Table 2**. In positioning this with the ideal type, type 1 relates to A, types 3 and 4 relate to B, and type 5 relates to C (see Table 2).

	A: Positivism	B: Interpretive	C: Postmodern
Reason for research	To discover natural laws so people can predict and control events	To understand and describe meaningful social action	To express the subjective self, to be playful and to entertain and stimulate
Nature of social reality	Stable preexisting patterns or order that can be discovered	Fluid definitions of a situation created by human interaction	Chaotic and fluid without real patterns or master plan

Table 2: Three types of research extracted from a more comprehensive table explaining social science (Neuman, 2013, p. 121)

The ideal types 3 and 4 can be positioned in Table 2 as borderline between columns A and B. This is also related to the stratification by Bhaskar (2013), as explained previously. An important difference is who is doing the interpretation: the researcher or the practitioner? The interpretation in the realist approach of ideal types 3 and 4 are considered by Sayer (1999): in the realist approach, the interpretation is based on scholarly knowledge. Similar thinking is found in the quote "Critical realism combines a realist ontology with an interpretive epistemology" (Munkvold & Bygstad, 2016). This approach stands in contrast to interpretivism, which builds an understanding of the interpretations of practitioners. This distinction is related to the differentiation of descriptive and perceived project complexity (Vidal & Marle, 2008): 1) "descriptive complexity considers complexity as an intrinsic property of a system, a vision which incited researchers to try to quantify or measure complexity", and 2) "perceived complexity considers complexity as subjective since the complexity of a system is improperly understood through the perception of an observer". Deduced from this, the ideal types 1, 2, and 3 use the former, whereas 4 and 5 use the latter.

Shifting to another angle, the purpose of research can be divided into description, explanation, and prediction (Hanna, 1969). The contextual understanding achieved by the interpretive approach is not covered by these three, nor is the pragmatic approach. The latter gain some momentum via a typology of theory by Gregor (2006), who states four primary goals of theory: 1) analysis and description, 2) explanation, 3) prediction and 4) prescription. The fourth is labeled 'design theory' and "says how to do something. The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for construction of an artifact" (Gregor, 2006, p. 618).

An additional differentiator holds ideal type 5 apart from ideal types 1 to 4, where generalizability is a common nominator. Ideal type 5 refrains from generalizations of the contributed contextual understanding of the investigated case(s).

5. Typology of research in project complexity

Based on the differentiation in section 4 and the literature review in section 3, the typology presented in the paper is illustrated in **Table 3**. In this typology the first-order construct is the intention of the research, the second-order construct is the concept of project complexity and the dependent variable is the relation to project success. The second-order construct and the dependent variable will be further elaborated later in this section.

First-order construct	Ideal type	Second-order construct explaining the ideal type	Dependent variable

Search for prediction based on law-like relations	1 Positivistic modeling	Descriptive project complexity as the independent variable providing a fixed measure of the complexity throughout the project lifecycle.	Correlation between simplified constructs
Search for an explanation of the unpredictable behavior of projects	2 Complexity theory	Descriptive project complexity explaining the emerging nature of the project based on attractors and similar concepts from complexity theory.	Relationship not relevant, hence undefinable
Search for a comprehensive description of project complexity	3 Ontological framework	Descriptive project complexity capturing the wholeness of the complex nature of projects in static or dynamic dimensions (often with high abstraction).	Implicit systemic proposition
Designing prescriptive theory for handling project complexity	4 Managerial framework	Perceived project complexity addressing the managerial challenges of handling the project's complexity.	Overlapping and intertwined concepts
Understanding project cases – without the intention of generalization	5 Emancipative investigation	Perceived project complexity setting the context for a study of the complexities of a temporary organization perceived as a project.	Integrated based on interpretations

Table 3: Typology with five ideal types of research on project complexity

In this section, the typology will be described as one ideal type at a time. The next five paragraphs cover the steps depicted in **Figure 1**. First, forming the ideal types. Second, describing the ideal type by second-order constructs. A third part contains examples as a further description of the type. Lastly, part four explains the fit of ideal types with the dependent variable, which herein is the relationship between the concept of project complexity of the ideal type and the concept of project performance.

5.1: Positivistic model

5.1.1 Forming the ideal type

The intention for the ideal type 1 is to search for law-like relations conducted using a positivistic approach. Even though studies based on this often use the term 'explain', the intention of the ideal type is interpreted as being more prediction than explanation because law-like relations between

constructs can be used for predictions such as 'If the project complexity is X, the project success rate can be expected to be Y'.

5.1.2 Second-order construct

The typical layout of a type 1 paper often includes a literature review with a high diversity of project complexity and then transforms this input into a much simpler construct using measurable independent variables and a dependent variable concerning, for example, team performance, project leadership, project success, etc.

Projects are seen as deterministic entities unchanged by the environment (the owning organization and the world around it). The complexity of the project is based on a set of simplifying assumptions, which is beneficial to the statistic model of project complexity and the dependent variable selected for the study. One basic assumption is that project complexity exits independent of the observer (the realist worldview). A further assumption is that project complexity can be measured using one variable (or a set of variables), which does not change over the project lifetime. The inference here is that the project complexity is knowable at project initiation, as opposed to only known retrospectively. Further, the environment (if included in the model) has a fixed influence on the project. However, (Lu, Luo, Wang, Le, & Shi, 2015) is an example of ideal type 1 with dynamic variables that is an exception to the rule. There is nothing in the positivistic worldview that rejects the possibility of having dynamic measures of project complexity; therefore, this simplification is more a matter of epistemology rather than of ontology.

5.1.3 Exemplification of ideal type 1

Adding to the papers mentioned in the literature review on operationalization, the ideal type 1 can be exemplified by (He, Luo, Hu, & Chan, 2015) and (Nguyen, Nguyen, Le-Hoai, & Dang, 2015) using fuzzy AHP to develop a computational model for measuring. The search for law-like relations may involve learning (Eriksson, Larsson, & Pesämaa, 2017), working methods such as lean and agile methods (Sohi, Hertogh, Bosch-Rekveldt, & Blom, 2016), and project leadership and performance against the concept of project complexity (Müller, Geraldi, & Turner, 2012). In meeting project objectives and overall satisfaction, the former is measured by project closure and the latter by one given timestamp, not taking into account that satisfaction might decrease or increase as time progresses. Floricel et al. (2016) identify a negative statistical association between technical complexity and schedule and budget performance in projects. Lastly, as mentioned in the introduction, (Bjorvatn & Wald, 2018) have established empirical relationships between project complexity and project management performance in terms of unscheduled delays and overspending.

5.1.4: Ideal type 1's relationship to project success

The concept of project complexity is reduced to a fixed measure for the project spanning the entire lifecycle. The same reductionism is used for project success. As one example of measuring project complexity against project success, the project's success was directly reflected by eight project targets, namely, time, cost, quality, health and safety, environmental performance, participants'

satisfaction, user satisfaction, and commercial value (Luo, He, Xie, Yang, & Wu, 2016), thereby including both efficiency and effectiveness. However, each of the targets measured is a fixed variable without regard for the changing of this measure over time, which is often the case with stakeholders. It is also independent of the differences in the importance of stakeholders.

Based on these simplifications, many studies have demonstrated a correlation between the concept of project complexity and the concept of project success. Sometimes project efficiency (delivering specification on time and within budget) is held as a proxy of project success. The assumed causality is that project complexity reduces the probability of project performance. The next four paragraphs, covering the other ideal type, will deepen this understanding and to some extent even contradict the study's conclusions.

5.2 Complexity theoretical type

5.2.1 Forming the ideal type

Ideal type 2 deploys complexity theory to explain the complexity of projects. The papers are motivated by 'exploration' and 'investigation'. Here, the intention is not to define and measure but to understand the inner workings of projects in their environments.
Complexity theory originated as a formal science and has successfully explained many phenomena in natural science. Complexity theory entered the social sciences via authors such as Byrne, who goes to the extreme and declares that "Positivism is dead" (Byrne, 2002, p. 37). Hence, there is a dramatic contrast between type 1 and type 2, where the latter modifies the former. The introduction of complexity theory into project management seems to hold many promises, as one paper shows by coining a new phrase: "project management second-order" (Saynisch, 2010).

5.2.2 Second-order construct

In contrast to ideal type 1, the view of the project in ideal type 2 is anything but deterministic. The explanation for the unpredictability is based on constructs such as strange attractors, emergence, butterfly effects, self-organizing, etc. (Cooke-Davies et al., 2007), whereas complexity theory is defined as "the study of how order, structure, pattern, and novelty arise from extremely complicated, apparently chaotic systems and conversely, how complex behavior and structure emerges from simple underlying rules" (Cooke-Davies et al., 2007, p. 52). A commonality of the secondary constructs is the reduced operationalizability of the variables. In type 2, the emergence (unpredictable) is contrasted with one fixed measure of project complexity, as described in ideal type 1.
The project as complex adaptive systems (CAS) is a concept made popular in studies by (Holland, 1992) and (Dooley, 1997). As mentioned in the literature review, recent papers based on complexity theory have argued for stratification in levels of complexity of the projects. A paper on profiling project complexity suggests the following notions: A) complicated systems, B) complex systems and C) complex adaptive systems (Kiridena & Sense, 2016). Another example is a three-level model: 1) algorithmic, 2) stochastic and 3) non-deterministic (Daniel & Daniel, 2018).

Uncertainty can be seen as a factor of unpredictability, and in the debate on this issue, one paper concludes that "While our finding may appear to align with complexity-theoretic concepts of a strong interrelationship between complexity and uncertainty, we argue that such confounding represents the intermingling of varying ontological and epistemological preferences within the community of project management scholars rather than a broad adherence to complexity theory" (Padalkar & Gopinath, 2016). Based on this, the uncertainty dimension is more relevant in the ideal types to be presented later.

5.2.3 Exemplification of ideal type 2

One of the first examples of the use of complexity theory in project management was (Jaafari, 2003) and it was popularized by (Cooke-Davies et al. 2007). Some early papers related project complexity to CAS (Innes & Booher, 1999), but as with the rest of the papers on complexity theory and projects, papers employing CAS have increased significantly in the post-RPM era. Currently, CAS is often seen in project management papers because "projects are socially constructed entities and so can be described as complex adaptive systems" (Whitty & Maylor, 2009). One important characteristic is that complex adaptive systems have the capability to learn (Holland, 2006). Perhaps the concept of CAS is most widespread in agile circles, since "Projects that employ agile methodologies are complex adaptive systems (CAS)" (Augustine, Payne, Sencindiver, & Woodcock, 2005).

5.2.4: Type 2's relationship with project success

Complexity theory is not concerned with success as such. A paper on innovation ecosystems (Jucevičius & Grumadaitė, 2014) made the case for the differentiation of system thinking and complexity theory as follows: 1) "Systems theory and system thinking are concerned with defining the ideal future state of the system and trying to close the gap", and 2) "Complexity theory has no ambition of predicting the future or defining the 'ideal' state of the system – it is more about describing the present and seeing what can be changed." Based on this, the relationship in type 2 between project complexity and success is not relevant, hence undefinable.

5.3: Ontological framework

5.3.1 Forming the ideal type

The common underlying question in research of this type is: What is project complexity? Therefore, the ideal type is termed 'ontological'. The use of 'framework' is a way to differentiate it from type 1, where the term 'model' would be more appropriate. The terms 'model' versus 'framework' are not used consistently in papers but might serve as an indicator. Words such as 'explore' and 'investigate' are often a part of the motivational paragraph in papers belonging to type 3. The same is seen in type 2, but type 3 does not use complexity theory as a foundation.

5.3.2: Second-order construct

In type 3, projects are seen as systems. Based on system thinking, the papers of this ideal type create frameworks, often with high-level variables. Ideal type 3 is concerned with dimensions, factors, or drivers. These are often presented without consideration for later measurement or assessment of other functional aspects of the resulting frameworks.

Type 3 is somewhat positioned between type 1 and type 2 but also counter to both. The secondary constructs in type 3 are characterized by being dimensions (as opposed to type 2) but are also often difficult to measure (as opposed to type 1). Contrary to type 1, type 3 includes uncertainty. The contribution from the ideal type 3 often serves as inspiration for ideal type 1 papers. This creates a gray zone between these two types; however, a classificatory principle clears up the gray zone, i.e., if the paper does not explicitly mention how to measure the dimensions, it belongs to ideal type 3.

The ideal type 3 is more realistic than interpretivist. As Sayer argued, in the realist view, only scholarly interpretation counts. We find this exemplified in the following quotation about the development of a complexity framework: “They started to share their experience on complexity factors and realized that the difference with the a priori ranking they had done was mainly due to some communication and psychological barriers they had” (Vidal et al. 2011, p. 724). An interpretive approach would not have dismissed the so-called “barriers” but instead would have investigated the individual perception of complexity leading to the difference in a priori ranking.

In contrast to type 1, type 3 does not assume fixed variables, although the presumption of the changeability of the variables (dimensions) is often not directly articulated in papers of type 3. The dimension of ‘change’ is often a part in the ensemble and so is the dimension of ‘uncertainty’.

5.3.3 Exemplification of ideal type 3

The frameworks in (Geraldi et al., 2011) and (Bakhshi et al., 2016) previously mentioned in the introduction are prime examples of type 3. A third example is (Xia & Lee, 2004), who divide complexity into structural and dynamic complexity. Another paper presents the complexity dimensions as structural, technical, directorial and temporal (Remington & Pollack, 2008). The definition of project complexity by Williams (1999), presented in the literature review, conforms with ideal type 3, and here the uncertainty of the goals is a part of the complexity.

5.3.4: The dependent variable for type 3

In papers regarding type 3, one can often read between the lines that the reason for the selection of the dimension is to improve our understanding of the success or failure of a project. The highly abstract dimension in the frameworks of ideal type 3 is difficult to operationalize. No correlational relationship, as seen in type 1, is found in this type. Whereas type 2 had complexity theory as a foundation, type 3 is based on system thinking. There are three requirements of system thinking: purpose, elements, and interconnections (Arnold & Wade, 2015). In other words, the desired future state is part of system thinking and is therefore related to project success. Thus, the relationship of ideal type 3 to success is therefore labeled ‘implicit systemic proposition’.

5.4: Managerial frameworks

5.4.1 Forming the ideal type

In the managerial framework ideal type, the focus is on the management of the project and removes of "what is project complexity" into "what to do with project complexity". While types 1, 2 and 3 have focus on the complexity of the project, type 4 focuses on how to handle it. This is the prescriptive knowledge of project complexity. This is often based on pragmatism (Dewey, 1916) or a pragmatic approach to research (Morgan, 2007). The purpose is not to describe, explain, or to predict but instead to prescribe a solution to a given problem (i.e., project complexity). This resembles design theory, based on design principles such as "If you want to achieve Y in situation Z, then something like action X will help" (Aken, 2004).

5.4.2 Second-order construct

The ideal type 4 focuses more on management than on the project itself. The distinction between the project and project management has been promoted by many authors. Morris argues further, that the overall management of projects can be divided into three levels: 1) the core of the project, where the work is done, 2) the Project Management level, and 3) the institutional level, i.e., the context of the project. (Morris, 2013). The managerial genre includes both levels 2 and 3. Papers of this type sometimes use the expression 'project management complexity'. This type could also be called 'complex project management', as some papers have chosen to call them (Ahern, Leavy, & Byrne, 2014).

A standard of project management competence was proposed (CCPM) but did not receive a warm welcome from (Whitty & Maylor, 2007); then again, this paper can be classified as belonging to the complexity theory, which might explain some of the reasons for its cool reception. From the perspective of the complexity theory of project complexity, the CCPM is not grounded in theory. However, from a pragmatic worldview, the CCPM has merits especially in regard to qualifications for project managers.

In this ideal type, perceived project complexity predominates over the descriptive view, based on the definitions provided by Vidal and Merle (2008). Another factor that distinguishes type 4 from the first three types is frequent references to PMBOK (Project Management Institute, 2017) from the Project Management Institute (PMI), and sometimes also to PRINCE2 (OGC, 2009). Using references such as these is not 'comme il faut' in types 1 to 3.

One paper, which we have classified as type 2, ends with a concluding remark on the need for a paradigm shift from "defining complexity and its characteristics to developing responses to project complexities" (Geraldi et al., 2011). Whereas Geraldi et al. speak of a paradigm shift, we think more in terms of different coexisting ideal types of research.

Geraldi (2011) laid the foundation for later development of the work into a tool (H. R. Maylor, Turner, & Murray-Webster, 2013) whereby management can assess the complexity of a given

project. This assessment is interpretive, and therefore very different from the positivistic approach in type 1. It is also very different from types 2 and 3, where no metrics are given.

5.4.3 Exemplification of ideal type 4

An example of prescriptive work is how to find early warnings in complex projects (T. Williams, Jonny Klakegg, Walker, Andersen, & Morten Magnussen, 2012). An example of identifying managerial strategies for handling project complexity using a Delphi questionnaire is seen in (Kermanshachi, Dao, Shane, & Anderson, 2016). The TOE framework (Bosch-Rekveldt et al., 2011) was initiated as a perceived approach to engaging practitioners. The framework was later used to conduct research of a more descriptive character, which is an example of the framework not being tied to one ideal type alone.

Since the managerial approach interests practitioners, scholars also use the book media for writings on managing project complexity, as for example (Pryke & Smyth, 2012). However, some project management books are more on the border of type 2. Hass (2008) profiles projects according to levels of complexity: 1) independent, 2) moderately complex, and 3) highly complex. However, the book is positioned as type 4 because of the second half of the book; the intention of the work is focused on how to handle project complexity. The same consideration applies to a book by Remington, who employs an adapted version of the Cynefin framework, and based on this devotes her attention to leadership as a way of handling project complexity (Remington, 2016).

5.4.4: Relationship to project success

The following two definitions illustrate how project complexity can focus on the managerial aspect: “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” (Marle & Vidal, 2016), and “A high level of complexity in a project implies the existence of more dependencies and difficulties in implementing and managing the project” (Zhu & Mostafavi, 2017). Here, the effect of project complexity is included in the definition of project complexity. Since management is about achieving success, the two concepts become intertwined.

One paper discusses the separation of project complexity from the severity of managing the project (Remington, Zolin, & Turner, 2009). This is relevant for ideal types 1 to 3, but in ideal type 4, the point is that the severity and the complexity are seen as one and the same. Furthermore, the causality can be somewhat backward compared to ideal type 1. Hass (2008) argues that having business success as part of the project objectives causes the project to be complex. A similar view is found in (Mikkelsen, 2018), where the more project success is oriented toward project effectiveness, the more complex the project becomes from a managerial perspective.

The relationship between project success and project complexity, when project management is included in the latter, is no longer separable. The relationship is therefore labeled ‘overlapping and intertwined’

5.5 – Emancipative investigation

5.5.1 Forming the ideal type

A project often lends itself to a good story worth telling. Case studies are important, not only for theory building but also for human learning and understanding (Flyvbjerg, 2007). However, not all case studies are ideal type 5. When dealing with cases, we must always answer the question "What is this a case of?" (Lund, 2014). It could be a case of a complex project where special themes are investigated or a case of an interesting project study that contributes to an understanding of project complexity. Ideal type 5 is the emancipative investigation of project cases in search of an understanding of the complexity of the case without the intention of generalizing findings.

5.5.2 Second-order construct

A contextual limited understand of a single case is often based on interpretive research. There is a focus on the lived experience of projects. Both ideal types 4 and 5 are of the interpretive type and will often have the management of projects as their unit of analysis.

Generally, papers of ideal type 5 are case stories, although many case studies also fit into the previous types. There are many prominent case stories that do not fit into the types mentioned thus far. That is the reason for this category. The expression "pink elephants" is taken from (Geraldi & Söderlund, 2016), where three categories of general research projects are classified as follows: 1) any projects (projects are seen as similar and comparable), 2) specific types of projects, and project contexts, and 3) 'pink elephants' with prominent ethical, theoretical and/or practical value/uniqueness. Research on the third category "follows emancipatory knowledge interests, and helps project practitioners to question work practices, and instigates them to change it" (Geraldi and Søderlund 2016). The authors based their paper on Habermas's three ways of knowing: technical (positivistic science), practical (interpretive research) and emancipatory (critical social science) knowledge (Tinning 1992), which is a trio in which essence corresponds well with the divisions in **Table 1**, i.e., positivist, interpretivism and postmodernist. Case stories in research are sometimes not given enough credit.

5.5.3 Exemplification of ideal type 5

Prime examples of cases stories about mega-projects used to investigate complexity include papers on the London Olympics (Davies & Mackenzie, 2014) and London Heathrow Terminal 5 (Davies, Dodgson, & Gann, 2016). A comparison of two mega-projects can be found in (Van Marrewijk, Clegg, Pitsis, & Veenswijk, 2008). However, a study of mega-projects might be positioned in one of the ideal types. Examples include (He et al., 2015), which fits into type 1, and (Lessard, Sakhrani, & Miller, 2014), a fine case of type 3, and (Giezen, 2012), which should go into the managerial type 4.

Pink elephants come in many sizes and forms and some might be more gray than pink. The topic might investigate problem-solving in a complex project (Bowman & Crawford, 2017) or the governance of collaboration (Chakkol, Selviaridis, & Finne, 2018). Or, papers might use the theory

of project complexity in combination with project managerial themes, such as risk, when explaining the nature of risk in complex projects (T. Williams, 2017) or related topics, e.g., stress (Jepson, Kirytopoulos, & London, 2017). Another type of case story is investigation projects or project-related topics where project complexity is used as a lens. These will often be on the borderline of the ontological or the managerial ideal types. In some cases, a paper may even position itself as a case study to avoid epistemological and methodological discussions.

5.5.4: Type 5's relationship with project success

As with type 4, project success is difficult to observe separately for the concept of project complexity. "The perceived success also depends on the perspective of various stakeholders and project roles, and thus indeed lies in the 'eye of the beholder'" (Neves et al. 2017). The absence of generalization makes is possible to see beyond the somewhat artificial borders of the project in the lived experience of the participants. The temporary organization can emerge in the permanent organization to the extent where the cost of the project cannot be clarified, and the benefit of the project is an unrepeatable part of the permanent organization. Here, the concept of project success as an isolated concept reduces its meaning. Since ideal type five is not bounded by generalization, project success can be investigated longitudinally and can further include the complexity of multiple stakeholders with respect to benefit realization, a diverse understanding of stakeholder and project success, as found in (Davis, 2017); hence, the interrelation between project complexity and success is labeled as being integrated.

6 Discussion

The parable of the elephant and the blind men, who conceptualize the animal based on the part of the elephant they are touching, is well suited for research on project complexity. Each ideal type makes sense, but no single one portrays the full picture. This paper began with the realization that there is no common definition, and based on the typology presented we can give five different versions of definitions: 1) project complexity is a fixed variable measuring the varied interrelated parts of the project; 2) project complexity is the unpredictable based on the emergent nature of the project; 3) project complexity is a set of static or dynamic dimensions capturing the wholeness of the project; 4) project complexity is the aspect of a project that makes it difficult manage; or, lastly, 5) project complexity is in the eye of the beholder.

In the discussion of the typology displayed in Table 3, we can ask the following editorial questions (Southgate, 1993): Is it new? Is it true? Is it interesting? The first question is easy since it is new. Many have classified the dimensions of project complexity, but the literature review did not find any at the level of research on project complexity, although two papers were on this path: (Bakhshi et al., 2016) and (Zhu & Mostafavi, 2017). The next two paragraphs discuss the matter of trueness from a pragmatic point of view and make an interesting contribution to the paper. In section 6.1, the truthfulness of the typology will be argued using a pragmatic approach, where the reasoning is as follows: what works is true. (May, 2011).

6.1 Trying out the typology

What is the truth is still up for discussion and is an ongoing debate between different traditions of science. One viewpoint is, that "Truth is neither absolute nor purely conventional and relative, but a matter of practical adequacy" (Sayer, 1999, p. 57). This paper has presented the five ideal types with rigor and illustrated their usefulness by explaining the dependent variable and illustrated the five different relationships between complexity and success.

Based on **Table 3**, a pragmatic set of questions has been formulated to conduct a simple trial; trying out the strength of the ideal type as attractors (in a complexity theory sense of the word) - not like categories for sorting research papers on project complexity. The questions seen as proxies for ideal types are as follows: 1) Does the paper document a correlation to prove law-like relations between constructs? 2) Does the paper use concepts from complexity theory, such as emergence, attractors, or the like? 3) Does the paper present a framework with a set of dimensions hard to operationalize? 4) Does the paper prescribe managerial approaches to handling project complexity? or 5) Does the paper refrain from generalizing the findings from a case study of a complex project?

Going through a test set of papers, the majority of them had a positive response to only one of the five questions mentioned above. A minority responded positively to more than one of the questions, but still only one dominated the others. In some cases, it was difficult to determine. One example was a paper entitled "The nature of risk in complex projects" (T. Williams, 2017). The final judgment was to identify this paper as a type 2, since the interaction of many risks was used as an explanation similar to other concepts of complexity theory. Another conundrum was the use of 'perceived project complexity' (Sohi et al., 2016), where the paper was clearly an ideal type 1. This lead to the realization that 'perceived' might refer to the use of humans as probing devices, rather than the notion put forth by (Vidal, 2008). Often there was a paragraph arguing for the paper's contribution to managing projects or something similar; hence, it aspired to ideal type 4. However, if there were no arguments about how the contributions were directly beneficial to the managers of projects, the statements were disregarded. All in all, this indicates the high usability of the typology. However, the real test of the typology is whether the researcher adopts it, in which case it will become true, not only based on a pragmatic reasoning about truth but also according to the well-known dictum by Thomas: "What people believe to be true is true in its consequences" (Nias, 1987). When people believe in a typology, it becomes true in its consequences.

6.2 Contributions of the typology

"To classify is human" (Bowker & Star, 2000), meaning that classification is of natural interest to humans, hence a contribution in itself. However, we do not close with that statement alone. To be truly interesting, the classifying typology should provide some kind of usability for future research.

The typology can be considered a theory in itself (Doty & Glick, 1994). This typology holds that the intention of research in project complexity shapes the concept of project complexity, and through this determines the relationship between complexity and the success of the project. Danial and Daniel (2018) divided project complexity into regulation and emergence, concluding that there is a need for developing theory for the latter. Further, there is the notion that "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). If this all-inclusive approach to general complexity should apply to project complexity as well, there is a need for a research approach capturing all five perspectives from the ideal types of research on project complexity. This would crossover into classical traditions of science merging the positivistic approach with the postmodern, according to (Neuman, 2013). However difficult this might be achievable, according to Orlikowske and Baroundi: "From the viewpoint of weak constructionism, interpretive research is understood to complement positivist research, that is, by generating hypotheses for further investigation, and by filling in the knowledge gaps that positivist research cannot attend to, such as the contextual exigencies, the meaning systems, and the interaction of various components of a system" (Orlikowski & Baroudi, 1991). On this basis, it seems possible to have an inclusive perspective of the diversities in typology by integrating them into a bigger picture. An inclusive perspective is also found in RPM, where classical project management becomes an integrated part of the new paradigm (Svejvig & Andersen, 2015, fig 1).

7. Conclusion

This paper set out to make sense of the diversification of research on project complexity. The posited research question has been answered through the development of a typology, as a way of accounting for the diversity of research on project complexity. The typology suggests five research intentions: law-like relations for prediction, complexity theoretical explanation, ontological framework for description, a managerial framework for prescription, and investing for understanding without the intent of generalization. With the second-order construct, the typology the paper explains each of the types. The dependent variable of the typology illustrates how each ideal type corresponds to a specific relationship between the complexity and success of projects. These unique relations have been labeled correlational, irrelevant, implicit, intertwined, and integrated.

Doty and Glick (1994) argue that typologies meet at least three key criteria that all theories must have: 1) the constructs are identified; 2) the relationships among these constructs are specified, and 3) these relationships must be falsifiable subject to empirical examination. The presented typology has all three, although more research is needed to attempt falsifying and hereby potentially strengthen the theory.

Further, there is a need for research in an integrative framework based on weak constructivism (Orlikowski & Baroudi, 1991) to investigate the opportunity of a theory on project complexity, including contributions from all five ideal types of research. By being conscious of the differentiators, an integrative approach is feasible and therefore may elicit further rethinking of project management.

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Perceived project complexity: a survey among practitioners of project management

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Abstract

Purpose – Project complexity has been comprehensively investigated over the last two decades, resulting in many descriptive frameworks and models. The common layout is a multidimensional construct. While the perception of the complexity of projects is essential for a managerial approach, only scant research has been conducted into how practitioners perceive project complexity. The purpose of the paper is to fill this gap.

Design/methodology/approach – This paper is a quantitative study based on a large survey among managers of projects with more than 1,000 participants. The questionnaire is designed based on a review of research literature on project complexity.

Findings – The findings indicate that practitioners' mental models are concentrated on only a few dimensions of the many found in descriptive models. Further, the findings indicate that the mental models are much influenced by the project role of the perceiver and less so by the type of project and sector.

Originality/value – This paper discusses the differentiation of concepts of perceived project complexity and provides a framework for a survey of the topic. The contribution of the paper is an increased understanding of practitioners' perceptions of project complexity as a concept very different from the descriptive frameworks that have been the focal point for research in project complexity thus far. The project complexity might be in the eye of the beholder; however, the findings indicate that the eyes are very much influenced by the project role of the beholder.

Keywords Perceived project complexity, Descriptive project complexity, Mental models, Survey of characteristics of project complexity

Paper type Research paper

1. Introduction

Research of the characteristics of project complexity has been undertaken for over a quarter of a century, and many frameworks and models have been investigated. In a structured review of project complexity, the authors argued 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 *et al.*, 2011, p. 986). The literature study revealed only very few contributions, hence the request for more research stands unanswered even today. Of the few that followed up on Geraldi *et al.*'s request for more research, one paper developed a model of project complexity based on the common view of practitioners. Here, one conclusion was that "Complexity is a subjective notion, reflecting the lived experience of the people involved" (Maylor *et al.*, 2013). This paper takes on the challenge of contributing to closing the gap by focusing on perceived project complexity.

According to most, the starting point into the research of project complexity is the work of Baccarini (1996). The paper presented reflections on the subjective perceptive versus an objective approach. The former was dismissed because it has an "unreliable basis for research analysis" (Baccarini, 1996, p. 202). This line of thinking has been contested by the interpretive research. However, the objective approach has dominated the research, and one might speculate whether the perceived project complexity has become the proverbial elephant in the room.

The subjective notion of project complexity (as something other than the "real" project complexity) is often referred to as perceived project complexity. The term was coined by

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Vidal and Marle (2008). Their paper provides the following definitions: (1) "descriptive complexity considers complexity as an intrinsic property of a system, a vision which incited researchers to try to quantify or measure complexity," and (2) "perceived complexity considers complexity as subjective, since the complexity of a system is improperly understood through the perception of an observer" (Vidal and Marle, 2008).

The dichotomy of perceived and descriptive project complexity is also found in research on complexity in general, where one paper states that "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), and goes on to explain that "In contrast to '*descriptive complexity*', the epistemological assumptions of '*perceived complexity*' are based on the assumption that reality results from the distinctions made by an observer" (Schlindwein and Ison, 2004).

Vidal and Marle (2008) stated that "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". From this quote follows an interesting question: which aspects of "the whole reality" (the descriptive project complexity), are included in project managers' perceptions? That is the first research question of this paper; we cannot proceed with Geraldi *et al.*' request without first answering this research question.

According to Saks and Johns (2005), there are three components to perception: the perceiver, the target and the situation. They further argue that "The situation greatly influences perception because different situations may call for additional information about the target." If it turns out that the subjective perception is based on patterns within the situation, this may impact the research on descriptive project complexity. In our case, the "situation" will be investigated as the two important explaining factors: type of project and the project role as held by the perceiver. The aim of this research is to investigate the influences of these factors on the perception of project complexity. The relevance here is an indication of the generalizability of the overall findings from the abovementioned research question.

The remainder of this paper is structured as follows: First, Section 2 explains the methodology, whereafter Section 3 presents the literature study on project complexity. Section 4 theorizes perceived project complexity, and, following this, Section 5 presents a framework for investigation. Section 6 presents the empirical findings, and a discussion of the findings can be found in Section 7. Finally, Section 8 presents the conclusion.

2. Methodology

This research investigates perceived project complexity by means of a large survey among practitioners in Denmark. We distributed a questionnaire among project managers in different sectors. The survey was developed as a collaboration between a Danish university and an international consulting company based in Denmark. The database used for the survey contained 9,619 individuals with "project" in their title. Given that Denmark has 5.7m citizens, this number is noteworthy. A total of 1,064 respondents completed the survey, giving a response rate of 10%. The majority of respondents had the job title "project manager," and there is thus a lower number of respondents holding other practitioner roles.

The opportunity to participate in the survey posed some considerations. If a quantitative approach was selected, we would risk imposing our mental model too heavily on the survey participants. With a qualitative approach we could ask open questions and ask participants to contribute with essays on project complexity. However, this was not an option given the constraints of the research opportunity at hand. The compromise was to select a set of options based on the literature and ask the survey participants to choose any number of these, which would function as a proxy of their mental model of project complexity. The quantitative data would be of unordered binary category data type, which is not well suited for statistical analysis. Accordingly, compromises had to be made.

In our survey, we asked practitioners how they perceived the construct based on a finite set of characteristics in order to select from the results of the research of the second question. The answer is seen as a proxy of their commonly held perception. The result of the survey is unordered categorical data. While this is not necessarily the best choice for statistical analysis, the decision was made as a trade-off between statistical prerequisites and flexibilities in the questionnaire for the benefit of the practitioners being able to "express" their perception of project complexity. However, the so-called expression was limited to a selection between 11 pre-defined characteristics of project complexity.

We undertook a literature review with the keywords "project" and "complexity" and limited the search to materials published after the year 2015, which at the time yielded 200+ titles. Based on the seeming relevance of title and the journal (giving priority to PMJ, IJPM and IJMPB) a smaller sample was selected for the reading of abstracts, and from there an even smaller sample for the study. During the study, we continually added to the database of papers based on the findings of interesting references in the sample. Our analysis revealed different schools of thought. To characterize the concept of project complexity, we found a number of relevant characteristics suitable for investigating the perceptions of project complexity among practitioners of project management.

This survey, which had previously been performed several times with an interval of 3–4 years, contains a large array of questions on the current state of project management. Each time, new themes have been investigated along with the longitudinal element of the survey.

A quantitative approach was adopted to determine the relationship between project complexity and stakeholders' perceptions of project complexity. The questions pertaining to stakeholder complexity formed part of a larger longitudinal survey focusing on project management. The adoption of a quantitative approach allowed the researchers to quantify the problem through the generation of numerical data which quantifies the opinions and behaviors. Because it is difficult to engage with organizations in their entirety, the survey was undertaken at the individual level. Therefore, individuals involved in the broader discipline of project management were the units of analysis. Individuals were targeted using snowball sampling as a nonprobability sampling technique. The aim of the nonprobability sampling approach was to secure a representative sample.

Table 1 provides an overview of the respondents' role and the industries that they represent. The purpose of the results in Table 1 is to understand the survey sample, to show that they are representative and to provide context for the results. Project management is the most prevalent role among the participants, not surprisingly given the subject of the survey. The pharmaceutical industry in Denmark is large, which is also reflected in the large number of survey participants from this sector, as can be seen in Table 1.

Denmark is a small country with many smaller companies, however the number of participants shown in Table 2 do not match the distribution of employees on organizations/companies in Denmark.

Based on Tables 1–3, the participants of the survey are widely distributed according to sector, roles, company size and years of experience. The dataset is not representative of the population of Denmark, nor should it be in a specific survey concerning project management. "People working with projects" is not an easily statistically identifiable population, however the participants of the survey can be assumed to have a reasonable representation. The participants have a Danish cultural background and are willing to spend time completing surveys, though these factors are not assumed to lead to biases in the results as such, though the results might be different in a worldwide survey.

Table 1.
Cross-tabulation between industry and role

	Project manager	Project coordinator	Head of project management	Line manager	Program manager	Program director	Project participant	Steering committee	Other	Total
Agriculture and fisheries	5	0	0	0	0	0	2	0	0	*7*
Construction industry	51	2	13	2	0	2	3	2	4	*79*
Energy and water supply	67	4	1	4	1	0	12	2	2	*93*
Manufacturing	95	12	5	2	4	3	22	3	4	*150*
Information and technology	92	7	7	6	7	1	4	0	7	*131*
Pharmaceutical	110	12	11	3	2	4	26	2	2	*172*
Public administration	98	6	4	1	4	0	5	5	0	*123*
Commerce	11	1	0	0	0	1	2	0	1	*16*
Utility	22	2	1	0	0	0	2	0	0	*27*
Other	181	10	14	5	6	4	31	3	12	*266*
Total	*732*	*56*	*56*	*23*	*24*	*15*	*109*	*17*	*32*	

3. Literature review of project complexity

3.1 Defining project complexity

Baccarini was the first to propose a definition of project complexity as "consisting of many varied interrelated parts" (Baccarini, 1996). For comparison, "general" complexity is defined as follows: "The level of complexity depends on the character of the system, its environment, and the nature of interactions between them" (Cambel, 1993, p. 4). Since Baccarini's proposed definition, there has been an ongoing ontological debate among scholars. Many papers conclude that there is no common definition. Some examples of the concluding remarks are: "There is no commonly accepted definition" (Chapman, 2016), "Despite the many existing studies on project complexity, there is no universal agreement on the definition of project complexity" (Zhu and Mostafavi, 2017), and "However, there still was no commonly accepted definition of project complexity, despite a large number proposed. Each author had a different perspective on defining project complexity" (Dao *et al.*, 2016).

To illustrate the variation in definitions, four examples are here qouted: (1) "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" (Marle and Vidal, 2016); (2) "Project complexity is the degree of interrelatedness between project attributes and interfaces, and their consequential impact on predictability and functionality" (Kermanshachi *et al.*, 2016); (3) "Define project complexity as an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with effect on the project objectives" (Bakhshi, 2016); and (4) "A high level of complexity in a project implies the existence of more dependencies and difficulties in implementing and managing the project" (Zhu and Mostafavi, 2017). Based on these four examples, the disagreement of definition seems somewhat overstated. This paper therefore proposes the following definition: *"Project complexity is the interrelatedness of elements causing an emergent nature of the project and challenging the project management"*.This definition is applied in this paper.

3.2 Descriptive models of project complexity

While it can be argued that there is a commonly accepted definition of project complexity, there is a large diversity of models of project complexity. This diversity can be illustrated by the variety of selected dimensions in the different models. In 1999, William gave a response to Baccainici's 1996 model of project complexity, which encompassed the varied interrelated

Organization/company size	Number of participants
1–100	168
101–250	94
251–500	60
501–1,000	122
1,000+	620

Table 2. Number of participants for different company sizes

Years of experience with project work	Number of participants
0–2	68
3–6	223
7–10	232
10+	541

Table 3. Number of participants in categories of experience with project works

organizational and technological parts of the project. William termed this the structural complexity (a phrase adopted by many scholars) and argued that uncertainty was another important dimension of project complexity. "Project complexity can be characterized by two dimensions, each of which has two sub-dimensions: Structural uncertainty (number of elements and interdependence of elements) and Uncertainty (uncertainty in goals and uncertainty in methods)" (Williams, 1999). The inclusion of uncertainty is still contested. Xia and Lee (2004) argued that instead of uncertainty, the dimension ought to be dynamic, and they proposed a 2 × 2 matrix with organization/technology and structural/dynamic. A systematic literature review concluded that project complexity has evolved to encompass five dimensions: structural complexity, uncertainty, dynamic, pace and socio-political (Geraldi *et al.*, 2011). Another structured review performed five years later showed further evolvement and expanded the understanding to eight dimensions: Structural complexity, uncertainty, emergence, autonomy, connectivity, diversity, socio-political and element of context (Bakhshi *et al.*, 2016).

3.3 Schools of thought

Bakhshi *et al.* (2016) identified three schools of thought in research on project complexity: (1) complexity theory, (2) System-of-systems and (3) PMI view.

The first, the "complexity theory" school of thought, is based on the work of Cooke-Davies *et al.* (2007), among others, and includes recent work such as that undertaken by Cicmil *et al.* (2017) and Okwir *et al.* (2018). Complexity is a mathematical concept which has inspired social science (Byrne, 2002) and later project management. Some authors on complexity in social science are eager to "take over" and abruptly declare that "Positivism is dead" (Byrne, 2002, p. 37). The main point in complexity theory is that emergence leads to unpredictability in the project, which is therefore difficult to manage and lead (Cooke-Davies *et al.*, 2007).

The second, the "system-of-systems", is based on the work of Ireland *et al.* (2012). Bakhshi exemplifies this school by referencing the sense-making framework Cynefin (Snowden and Boone, 2007). The main point is that the project can be divided into different systems which are stratified by different levels of complexity. Recent contributions include Kiridena and Sense (2016), where complicated systems, complex systems and complex adaptive systems are used as stratification, and Daniel and Daniel (2018) who introduce three levels, algorithmic, stochastic and nondeterministic.

The third perspective, the PMI view, is too diverse to be considered one school. The PMI view can be divided into the following: (1) the discussion of what project complexity entails; (2) the positivist research focused on measurements of project complexity investigation of law-like relations to other constructs, such as project performance and (3) the research focused on the management of the complexity of projects.

The first stream of research comprises the models mentioned in Section 2.2. From this developed another measurable research stream variable instead of the abstract metricless dimensions. The approach is positivistic and often applies multicriteria decision methods (MCDM) such as analytic hierarchical process (APH), as in Vidal *et al.* 2007 (He *et al.*, 2015), (Nguyen *et al.*, 2015). The research objective can be measuring the project against project success (Zhu and Mostafavi, 2017), structural equation modeling against performance (Bjorvatn and Wald, 2018), learning (Eriksson *et al.*, 2017), project leadership and performance against the concept of project complexity (Müller *et al.*, 2012), as well as working methodologies such as lean and agile (Sohi *et al.*, 2016).

Building on the work of Bakhshi *et al.* (2016) and others, Mikkelsen (2020) identified five ideal types of research on project complexity as follows: (1) positivistic modeling; (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.

The managerial stream of research is related to the rethinking of project management networks.

Researching project complexity was singled out as one of the six directions of rethinking project management (Winter and Smith, 2006). From these networks, a somewhat controversial statement was made: "while a great deal is written about traditional project management, we know very little about the "actuality" of project-based working and management" (Cicmil *et al.*, 2006). In a structured literature review a decade later, the rethinking of project management is now regarded as a movement (Svejvig and Andersen, 2015), and there is still much to research in project complexity. The managerial approach is the methodology closest to the perceived project complexity.

3.4 Research on perceived project complexity

At present, the volume of literature researching "perceived complexity" utilizing this approach is limited. One of the exceptions is the development of the project complexity model MODeST, which is presented as "an investigation into project managers' perceptions of managerial complexity" (Maylor *et al.*, 2008). The methodology here encompasses workshops with practitioners, where concepts were generated and subsequently classified. Interestingly, the five dimensions (mission, organization, deliverables, stakeholders and team) differ from the more mainstream project complexity dimensions mentioned in Section 2.2 The model is close to the project management depiction of a project, disregarding dimensions such as unpredictability, ambiguity and social-political.

Based on grounded theory, (Brockmann and Girmscheid, 2007) present the following model: overall complexity (manifoldness, interrelatedness, consequential impact of a decision field) along with task complexity, social complexity and culture complexity. This model focuses on the understanding rather than measuring of project complexity, as one might in an interpretive study. Another approach to the perceived project complexity based on interpretive research is via causality mapping (Ackermann and Alexander, 2016).

Besides the research papers mentioned above, surveys are an important window into perceived project complexity. One such is the PMI's *Navigating Complexity* (Cooke-Davies, 2013), where the highest ranking (58%) of the characteristic of project complexity was "Multiple stakeholders." Following this, in second place (48%) was "Ambiguity of project features, resources, phases, etc." and "Significant political/authority influences" (35%) was third.

4. Theorizing perceived project complexity

Where the former section focused on the literature on project complexity, this section will focus on its perception. Starting on a general note, "Perception is the complex sequence of processes by which we take the information received from our senses and then organize and interpret it, which in turn allows us to see and hear the world around us as meaningful, recognizable objects and events with clear locations in space and time" (Pomerantz, 2006). While it is a very specific definition, it makes it clear the perception is a subjective view of the world. Perception and a mental model are related concepts because an individual's mental model reflects their perception of reality (Brunswik, 1956). Once established, the mental model becomes a provider of perception. Mental models serve three crucial purposes: "They help people to describe, explain, and predict events in their environment" (Mathieu *et al.*, 2000). Mathieu defines a mental model as a "mechanism whereby humans generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states", and further, that "mental models are organized knowledge frameworks that allow individuals to describe, explain, and predict behavior" (Mathieu *et al.*, 2000).

Interaction between perception and mental models works in two ways. The mental model is the result of life-long perceptions of the world around us, and new perceptions are informed by the current mental model. The mental model operates as a lens, focusing more on what is believed to be important and filters out what is believed not to be. In the context of projects, the inference of this is that we perceive a given project though our mental model of projects, which is the result of lifelong perceptions of our experience with projects.

Following this, the perceived project complexity can be seen from two overall perspectives:

A) The complexity of a given project as in the eyes of the beholder,

B) The concept of complexity of any project as the mental model.

Asking "what is the complexity of a given project" (the A-perspective), conforms to a realist worldview where there is one answer, although we might disagree on what the answer is for the given project. As mentioned in the introduction, Vidal and Marle (2008) present perceived and descriptive project complexity as a dichotomy. In practice, however, the descriptive and the perceived project complexity will be less dualistic than their paper claims. Only structural project complexity can be assessed objectively, and all other dimensions of project complexity are based on more subjective assessments. Based on the practical approached found in the research literature, there is two kinds of assessment used in the A-perspective:

A1: Direct categorization of the complexity of a given project. An example of this can be seen in Molokken-Ostvold and Furulund (2007) paper, where practitioners are asked to rate the complexity on a scale from low to high. This is like a human instrument of measuring project complexity and is a natural choice when the perceived project complexity is the independent variable in the research. Another example is the work of Sohi *et al.* (2016), who apply the TOE framework (Bosch-Rekveldt *et al.*, 2011).

A2: Indirect indication of the complexity of a given project. This approach involves asking questions related to the indicators of the dimensions of project complexity, deriving from the descriptive project complexity used in the particular research. This is the most frequent approach found in the research literature. The TOE framework can also be used in this manner, as seen in (Bosch-Rekveldt *et al.*, 2018).

A1+A2: Interaction of the perspectives. The combination of A1 and A2 can be of use when validating a weighted multidimensional model of project complexity as is seen in (Vidal *et al.*, 2011). The model to be validated was developed with HAHP and Delphi. The Delphi method made use of the B-perspective for the so-called "experts" (without providing information on what qualified that classification). The B-perspective was, as mentioned earlier, applied in the development of MODeST (Maylor *et al.*, 2008), where the researchers engaged practitioners. In a similar manner, the subcategories of the TOE framework (Bosch-Rekveldt *et al.*, 2011) were developed using the B-perspective, though as mentions above is now applied to the A-perspective.

The B-perspective conforms to a constructive worldview without a single truth "out-there" to be found. In other words, it is what is referred to in the first part of the quote from (Schlindwein and Ison, 2004): "Complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself." Finding out more about the metal models behind the "eye of the beholder" requires a framework for investigation, as will be elaborated in the next section.

5. Framework for investigation

The research question is an investigation of the subjective worldviews on project complexity: what kind of mental models do the practitioners hold? When we ask how practitioners perceive project complexity, we do not ask only in a specific case of a given project but rather

in a more general manner. In other words, the question concerns the mental model, not the assessment in a single case.

The design of a set of selectable characteristics of project complexity for participants to choose from was based on the literature study presented in the previous section. The design principles were selected from among the most frequently used definitions of project complexity. This was supplemented with the findings from the survey *Navigating Complexity*. The two chosen additions are primarily based on watercooler conversations with practitioners attending workshops on the topic of project management. In Table 4 the selected project complexity characteristics (PCC) are presented.

When survey participants are given the option to select any number of these PCCs, we believe this to be a relevant and sound first indication of their mental model of project complexity. This is by no means an exhaustive investigation as many more layers of mental models could be examined.

6. Empirical results

Here we present the distribution of roles based on the participants' self-reported role, based on selections from predefined categories. The 1,064 participants were divided as follows, in order of numbers: project manager (732); project participant (129); roject coordinator (56); project director (36); program manager (24); line manager (23); steering committee members (17) and VP of projects (15).

As displayed in Figure 1, the most important PCC is "1: The project consists of many varied interrelated elements," because this was selected by two out of every three survey participants. Second is "2: Political aspects influence the project and decisions," selected by half of the participants. From here the sequence declines in a long tail, with from 42% to 10% of the participants selecting these PCCs. Given these results none of the proposed PCCs can be deemed irrelevant.

Figure 2 presents the results divided by different kinds of projects. The survey participants were allowed to indicate a maximum of three kinds of projects, and the participants selected 1.8 on average.

Figure 3 displays the distribution division of the survey participants' self-reported project role.

Comparing Figures 1–3, the influence of project role on the mental model of project complexity is higher than the influence of project type and sector. The general picture is that there are many differences between the mental models based on the role of the practitioners.

As Schindwein and Ison's (2004) quote (Schlindwein and Ison, 2004) presented in the introduction states, complexity exists in the eye of the beholder. Our findings, presented in Figure 3, support this in the realm of projects. When compared to Figures 1 and 2, we can add the following: the beholder is more influenced by his/her project role than by the type of project or sector.

6.1 Relations among the PCC

It is important to determine whether there are interrelations between the dimensions. The data on the dimensions of project complexity can be sorted into binary categories. Therefore, it does not make sense to calculate the relation between the dimensions using linear regression. Instead, Table 6 uses Pearson's χ^2 coefficient (Kuhn, 1973; Sun *et al.*, 2007) to calculate the relation between the 11 characteristics of complexity.

Table 6 shows that there are only minor interrelations between the elements. Interestingly, the majority of relations are of positive value, and only few and low negative values have been calculated. Nearly all detected relations are between PCCs in the long tail, from numbers 6 to 11, where the coefficient is around 20% or lower.

Characteristic of project complexity	Argumentation for including this as a selectable option in the survey
The project consists of many varied interrelated elements	This PCC is a direct quote from the definition (Baccarini, 1996, p. 201) Most later scholars refer to this as the structural complexity, but the use of this term would probably cause many misinterpretations among the practitioners
High degree of uncertainty in project goals and outcome High degree of uncertainty in methods and tools	The uncertainty dimension is mentioned by many but was introduced by Williams with the rationale that "Project complexity can be characterized by two dimensions, each of which has two sub-dimensions: Structural uncertainty (number of elements and interdependence of elements) and Uncertainty (uncertainty in goals and uncertainty in methods)" (Williams, 1999). Uncertainty is also included in the structured reviews by Geraldi *et al.* (2011) and later by Bakhshi (2016). We wanted to test where practitioners considered a difference in goals and ends with regard to uncertainty Because the uncertainty of goals and methods might be perceived as two different concepts, Williams' definition was divided into two selectable PCCs
The project is difficult to predict even with complete initial information The project is difficult to manage and keep under control	The definition from Vidal *et al.* (2011), (project complexity is the property of a project which makes it difficult to understand, foresee and keep its overall behavior under control, even when given reasonably complete information about the project system), is, in fact, both a cause (unpredictability) and an effect (difficult to manage) Therefore, it is divided into two PCCs in order to measure whether practitioners focus most on the cause or the effect
High degree of ambiguity in and around the project	In a PMI pulse survey (Cooke-Davies, 2013), the notion of ambiguity as a project complexity characteristic came in at third place. Ambiguity is also mentioned by Pich *et al.* (2002), Cicmil and Marshall (2005), Remington *et al.* (2009), Nguyen *et al.* (2015), and Marle and Vidal (2016)
Political aspects influence the project and decisions	The political aspect is mentioned in one version or another in many papers. A dimension termed "social-political" is mentioned in the structured literature review by Geraldi *et al.* (2011) and that of Bakhshi (2016). However, the term "socio-political" is not sufficiently concrete to be used in a survey, and therefore the notion of "political aspects influencing the decisions" is here used instead
High diversity and difference within stakeholder groups	This element on the list is formulated with inspiration from the large survey "Navigating Complexity" (Cooke-Davies, 2013), where the highest scoring (58%) characteristic of project complexity was "Multiple stakeholders"; however, the term seemed too short a notion and is reformulated as here displayed
Low level of trust among parties in and around projects	In the book *Leading Complex Projects*, project complexity is defined as "uncertainty, ambiguity and decreasing levels of trust" (Remington, 2016). Trust is also mentioned in the complexity models of Qureshi and Kang (2015), Lu *et al.* (2015) and Kian Manesh Rad (2016)]. Level of trust also relates to "transparency, multiplicity of reference and empathy" as is a part of the interaction complexity (Geraldi and Adlbrecht, 2007)

Table 4.
Project complexity characteristics (PCC) along with explanations for this selection of options in the survey

(*continued*)

Characteristic of project complexity	Argumentation for including this as a selectable option in the survey
Rigid project setup, decision-making, and organizational structures	This option was included based on internal complexity (Ramasesh and Browning, 2014) and was translated into more practically-oriented wording. Project setup is known to complicate matters (Williams, 2016). Furthermore, we know that decisions in projects are complex and multifaceted (Stingl and Geraldi, 2017)
Project management with low experience and formal power	Project management itself is frequently mentioned as a dimension. The relation between the project manager's competencies and project complexity has been explored in Müller *et al.* (2012). However, it is difficult to distinguish dimensions of complexity from severity (Remington *et al.*, 2009)

Table 4.

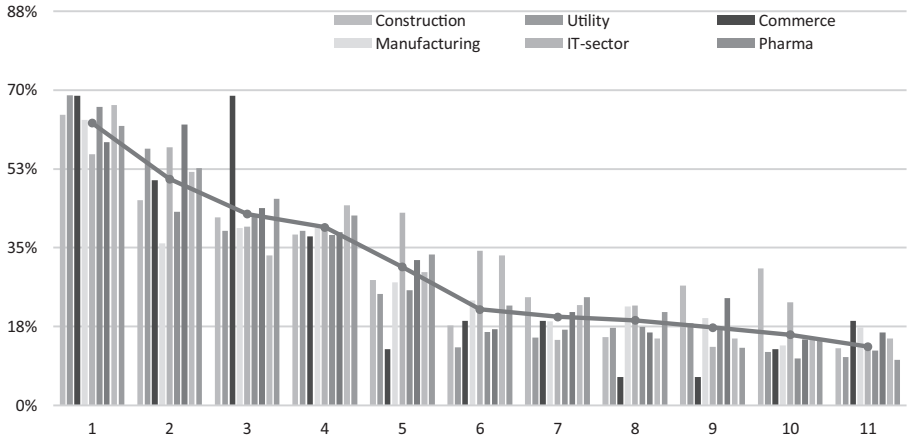

Figure 1.
Distribution PCC (mentioned in Table 5) divided by sectors

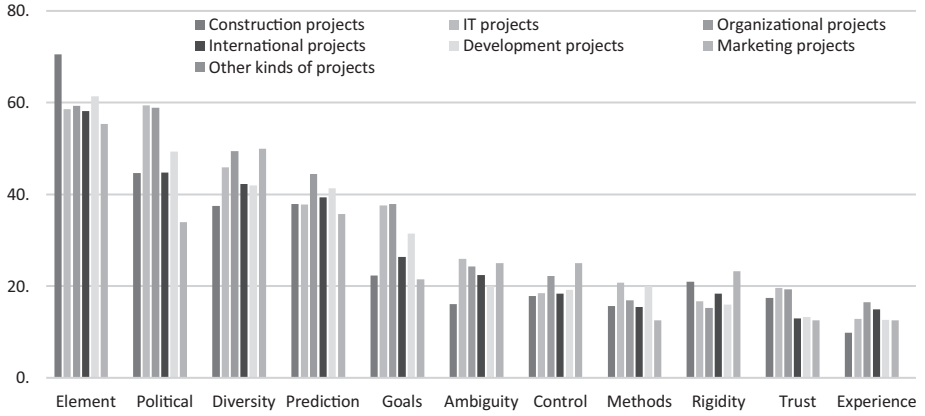

Figure 2.
Distribution of PCC (mentioned in Table 5) divided by the project type on which the survey participants reported working

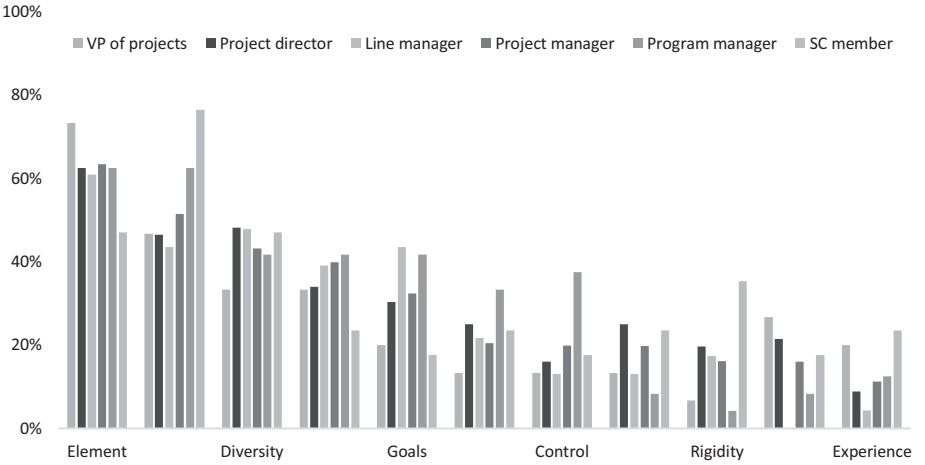

Figure 3.
Distribution of PCC (mentioned in Table 5) divided by the reported project role of the survey participants

Table 5.
Overview of project complexity characteristic

Project complexity characteristics (PCC)
1: (Element) The project consists of many varied interrelated elements
2: (Political) Political aspects influence the project and decisions
3: (Diversity) High diversity and difference within stakeholder groups
4: (Difficulty) The project is difficult to predict even with complete initial information
5: (Goals) High degree of uncertainty in project goals and outcome
6: (Ambiguity) High degree of ambiguity in and around the project
7: (Control) The project is difficult to manage and keep under control
8: (Method) High degree of uncertainty in methods and tools
9: (Rigid) Rigid project setup, decision-making, and organizational structures
10: (Trust) Low level of trust among parties in and around projects
11: (Experience) Project management with low experience and/or formal power

Table 6.
Relations between the 11 elements of project complexity. The cells present Pearson's χ^2 coefficient

	1	2	3	4	5	6	7	8	9	10	11
1	1.00	−0.12	−0.04	−0.05	−0.08	−0.09	0.01	−0.02	−0.08	0.00	−0.07
2		1.00	0.17	0.05	0.02	0.21	0.06	0.09	−0.09	0.05	0.15
3			1.00	0.01	0.01	0.09	0.00	0.05	−0.02	0.07	0.06
4				1.00	0.04	0.10	0.07	0.05	0.02	0.11	0.09
5					1.00	0.04	0.02	0.03	0.06	0.00	0.14
6						1.00	0.10	0.16	0.03	0.02	0.24
7							1.00	0.22	0.10	−0.03	0.15
8								1.00	0.06	−0.08	0.13
9									1.00	−0.09	0.12
10										1.00	−0.03
11											1.00

It is noteworthy that PCC1 is practically unrelated to all other PCCs in this study. Not only do almost two out of three practitioners perceive PCC1 as project complexity, but they also do so regardless of how they otherwise perceive the project complexity.

The strongest relationship was found between an uninspired/powerless project management and high ambiguity (11–6). There is no way of ascertaining the causality

direction (if any), but it is easy to imagine how these project managers may find it extremely challenging to deal with project ambiguity.

The second strongest relationship is between the difficulty to manage and uncertainty in methods (PCC7 and PCC8). A relationship exists between political aspect and high ambiguity (PCC2 and PCC6): While these numbers are not high, it is still interesting that ambiguity is seen regarding the political aspect and weak project management when the participants selected among the options. A special analysis revealed that, of those who only made a selection of one characteristic, their selection was PCC2 7% of the time. The inference is that the political aspect is often selected as a "kicker" to something else.

7. Discussion

The common perception of project complexity among the participants of our survey is centered around four characteristics, with a long tail consisting of the other seven proposed characteristics. Of the four, the most selected characteristic, with two-thirds of participants selecting it, is the notion that project complexity is when "The project consists of many varied interrelated elements." This is Baccarini's (1996) original definition.

In second place, half of the participants find that the "Political aspects influence the project and decisions" is a characteristic of project complexity.

The finding is that practitioners' mental models are very different in nature. Other project roles have distinct patterns in their model of project complexity. Three roles stand out:

(1) Steering committee members. The profile of the steering committee members' mental model of project complexity differs considerably from the average in the majority of characteristics. First, they have a very political focus on project complexity. Second, they score low on structural complexity and unpredictability. Third, compared to others they score very high on rigid project setup, and, finally, they are those who most commonly blame inexperience and lack of power of project management. The root cause of this might be that the steering committee members are struggling with highly complex decision-making.

(2) Project VPs. Regarding the two most selected characteristics of project complexity, project VP's are in direct opposition to the average steering committees member as they indicate a strong focus on structural complexity and a weak one on political aspects. One in four project VPs consider the low level of trust to be an issue of project complexity. The reason for this perspective on project complexity is assumed to do with the situation for a project VP: they are often the end-station for blame on projects not finishing on time or within the scope and budget.

(3) Program managers also have a distinct profile. They differ the most from the average profile, with a high score on PCC5, 6 and 7, which are, respectively, goal uncertainty, ambiguity and difficulty of control. The reasoning for this perspective might be found in their role-specific schooling, such as Managing Successful Programmes (MSN), (AXELOS, 2011), where other roles depend more on Project Management Body of Knowledge (PMBOK), (Project Management Institute, 2017). The difference between MSN and PMBOK might explain the program managers' perspective. Adding to this may be the role they play in the organization, giving them a more broad perspective of the organization.

There is a need for additional research to determine whether the two indicated mental models are truly distinct. If this is the case, the finding could be of inspiration for further development in the research of descriptive project complexity. One way forward could be to branch into two strands: emergence and divergence. This thinking is inspired by the uncertainty–

disagreement matrix attributed to Stacey by Zimmerman *et al.* (1998). Emergence is the concept of unpredictability based on the interconnected variants and changeable elements based on complexity theory, and divergence is the socio-political arena of multiple stakeholders and politically influence-based behavioral science.

The practitioners' take on project complexity might also contribute to the never-ending discussion of the fundamental understanding in research of descriptive project complexity. Many competing contributing descriptive models of project complexity have been presented over the past two decades. Researchers disagree on some very fundamental aspects of project complexity. The overarching picture is highly diverse. As one example, Williams (1999) states that uncertainty is a central aspect of complexity. However, other project complexity researchers adhere to the thinking that uncertainty and complexity are two distinct concepts, for example (Little, 2005) and (Pich *et al.*, 2002). It would be interesting to know whether practitioners are more aligned regarding the scope of project complexity, and, if so, could this be used to anchor the commonly accepted descriptive model?

In an often cited paper on the measurement of project complexity, we found an interplay between descriptive and perceived complexity, as the paper discusses the participants in a test of a model of project complexity: "They started to share their experience on complexity factors and realized that the difference with the *a priori* ranking they had done was mainly due to some communication and psychological barriers they had" (Vidal *et al.*, 2011, p. 724). The authors refrained from investigating the reason for the differences in ranking, but then dismissed them, as if they were only measurement errors. However, the so-called communication and psychological barriers are a natural part of human perception. The managerial challenge of this becomes very real in practice because most projects do not have a researcher present who can facilitate a shared understanding.

The paper brings us a small step of the way to "help practitioners," in Geraldi's words quoted in the introduction of this paper. The findings of this paper can benefit most practitioners; however, the following recommendations are provided with the project manager in mind. The term stakeholder is here used in the broad sense, as in everybody involved, influencing, and influenced by the project.

First, project complexity is in the eye of the beholder, and it is perceived very differently. Stakeholders hold very different mental models of the concept and are likely to focus on different characteristics (PCCs) as the most important. In other words, one should keep in mind that the realist worldview, with only one measure for the complexity of a given project, does not suffice. Assessments made with state-of-the-art frameworks cannot stand alone. A social constructive worldview needs to be taken into account when addressing project complexity in order to grasp the whole picture.

Second, while project complexity might be in the eye of the beholder, the findings indicate that the "eyes" are very much influenced by the project role of the "beholder". A helpful heuristic can be to expect certain patterns in the perceived complexity of stakeholders based on their role in the given project. Distinct mental models can found in the roles of project VPs, steering committee members and among program managers, in particular where there are disagreements on the social-political dimension.

Finally, when communicating with various stakeholders it might be wise to avoid the debate of whether the project is to be based on complexity in general. If you only speak of project complexity as a general concept you are bound to miscommunicate with the stakeholders, due to their conflicting mental models. Instead, you could address the specific project complexity characteristics, e.g. the element interrelatedness, the social-political challenges, the unpredictability etc. (as displayed in Table 5).

Much research on descriptive project complexity has been identifying dimensions for the framework in a "one-size-fits-all" approach. The findings in this paper indicate the importance for dimensions for different sectors and project types. As one example from

Figure 2, PCC1 (elements) seems to matter much more for the practitioners' construction projects than PCC2 (politics), however in IT and organizational projects PCC1 and PCC2 seem to have equal importance. Further, PCC5 (goals) is highly important for practitioners of IT and organizational projects but not so much for practitioners of construction projects. More examples can be extracted from Figure 2. When comparing Figures 1 and 2, the findings indicate that differences due to sector are less than differences due to project types. Here the commerce sector is regarded as on outlier of little importance. Differences in project type should be afforded more attention in future research on project complexity.

De Rezende and Blackwell (2019) have developed a framework for project complexity with the intention of analyzing and discussing (instead of measuring) the given project, and advocate that "a future research agenda can also focus on how the importance of each dimension changes over the life cycle of a project" (De Rezende and Blackwell, 2019, p. 139). We argue that not only is the change over the project life cycle important, but the inclusion of many perspectives from different project roles is equally important.

The findings in this paper further indicate that the differences based on different project types exceeded by differences based on practitioner's project roles when it comes to perceived project complexity. Different dimensions of complexity are of different importance to different project roles. The situation for a practitioner is messy, and the inference here might be that in order to navigate the complexity of a given project, there is a need to include the perspectives of many individuals holding different roles within the given project. As the saying goes: nobody knows everything, but everybody knows something. The concept of "wisdom of the crowds" might prove helpful when navigating the complexity of a given project. Continually reassessing the complexity throughout the project life cycle and including the perspective of many different project roles calls for an information system where the collecting of options among stakeholders can be automated and aggregated into a dashboard. Future research in project complexity could focus on the development of such an information system. The technology for this is already available in the form of survey tools and ICT platforms. What is needed regarding research is the conceptualization, implementation and evaluation thereof. Having such an IT system can prove very beneficial not only for the project manager but also for the portfolio management given new opportunities for comparing the current stakeholder perception of the complexity of the project in the given portfolio.

8. Conclusion

Based on a large survey, a profile of the average mental model of practitioners in Denmark was established. The profile concentrated on a few of the selectable characteristics. Interestingly, the project role-based profiles demonstrated large variations from the average profile, and from this we conclude that the project role highly influenced perceivers' mental model of project complexity. The large diversities in the mental model are seen in decision-making project roles. Project complexity is not only in the eyes of the beholder but also in the eyes as influenced by the role of the beholder. The perceived project complexity is very subjective, though some patterns can be found. This paper identifies the role of the practitioner as a factor having an impact on the perception of project complexity. The results are not necessarily applicable to other countries and cultures. More research is needed to expand the understanding of project complexity as a subjective notion, reflecting the lived experience of the individuals involved.

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Investigation of the institutionalizing responsibility of project managers for project benefits realization

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Abstract: The purpose of projects is to produce benefits, but who is responsible for project benefits realization? Project management practitioner-guiding frameworks are clear on the responsibility for benefits realization. The majority of scientific papers on the topic follows the same logic. However, watercooler conversations with practitioners reveal a more nuanced project reality. The purpose of the paper is to investigate the gap between theory and practice.

Given an opportunity for collaboration with a large-scale Danish survey among practitioners of project management, we included clarification of the institutionalization of responsibility for project benefits realization. The investigation was conducted with institutional logic as a lens, and the contribution of this paper is a deeper understanding of the stakeholder diversity regarding responsibility for benefits realization and to the socio-political dimension of the complexity of project management. The findings from the survey demonstrate that one in three of the participants holds the project manager responsible for benefits realization – in contrast to the overall recommendations in guidelines and research literature. The value of the paper is the inconsistency demonstration and hereby assist the understanding of the complexity and diversity of responsibility for benefits realization.

Keywords: Benefits realization, Responsibility institutionalization, project managers responsibility

1. Introduction

Benefits realization, value creation, and project effectiveness are concepts addressing the same objective, i.e., transforming the project output into a positive outcome for stakeholders, especially the organization owning the project. This is a vast topic that offers many interesting research options, among them the question, who is responsible for benefits realization? This question has been addressed in research and also in normative frameworks of project and program management. The given recommendations are relatively clear in the guidelines and research literature. According to the Project Management Institute (2017a), the project manager plays an important role in achieving the objectives of the project. The project manager is typically involved throughout the project's life cycle but might also be "involved in follow-on activities related to realizing business benefits from the project" (Project Management Institute, 2017a, p. 51). However, the programme manager is responsible for delivering benefits associated with projects (Project Management Institute, 2017b). According to the (International Project Management Association, 2015), the project

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manager, as well as the programme manager, should be competent in benefits realization and should have knowledge about benefits realization management.

However, in discussions with practitioners within workshops on project management, the standard recommendation is often contested. Many practitioners argue that the responsibility for benefits realization often lies with the manager of the project and, furthermore, that there are many divergent opinions on the matter. This is also noted by Dalcher (2016), stating that the practice for project managers is changing, and the lines of responsibilities become less clear. Based on the confusion on the term of the program among experienced practitioners on paper concluded, "This indicates a need to agree and adopt an internally consistent set of definitions of project, program, and portfolio across the whole project management field. "(McGrath & Whitty, 2019, p. 243). This paper contributes to this request by providing a practitioner-based investigation. Further, the paper contributes to the research stream of 'rethinking of project management' (Cicmil, Williams, Thomas, & Hodgson, 2006) to the ongoing debate on future directions for research on project value creation (Laursen & Svejvig, 2016) where time impact is becoming a key issue (Per Svejvig, Joana Geraldi, & Sara Grex, 2019).

The empirical part of the study was an extensive national survey on project management in Denmark. The longitudinal part of the survey was a given, but also provided the opportunity to add additional questions on benefits realization and perceptions of project success. The approach to the dataset as a whole was explorative with an abductive approach given the basis for a future, more deductive-orientated, approach with a formal hypothesis.

Institutional logic is used as a theoretical lens since this theory accepts and deals with the ambiguity as a result of multiple and conflicting institutional logics, at the levels of analysis of society and individual roles. The institutional process is a combination of external institutional forces and internal performance pressures (Scott, 2005).

The research question is divided into two parts: 1) What is the current institutionalization of responsibility for benefits realization as perceived by practitioners of project management? 2) What are the drivers of this institutionalization?

The remainder of this paper is structured as follows: Section 2 is a literature review of the methodologies of project management and research papers on the responsibility of benefits realization in projects. Section 3 describes the research method used. Following this, section 4 presents the findings, and section 5 contains a discussion. Finally, section 6 presents the conclusion, with suggestions for further research.

2. Literature review

The literature review is presented in two parts. The first part benefits realization, with the selection criteria being reflections upon the responsibility. The second part of the literature review contains the project management practitioner guidelines.

2.2 Review of research literature

The outcome of a project is a product or service that should create benefits for the organization. The product or service is utilized by the organization, and benefits are created through the usage of the product or service (O. Zwikael & Smyrk, 2015). The process of planning and managing benefits is referred to as benefits realization management (BRM). This process already starts during the initiation phase, where the benefits are identified. The process is terminated after the product or service is delivered, and the intended benefits are realized and harvested.

There is, to a large extent, agreement on the BRM processes. **Table 1** summarizes the processes of benefits management, and it is evident that the literature agrees on the basic processes.

Table 1. Benefits management processes

(Project Management Institute, 2013)	(Ward & Daniel, 2012)	(Ashurst, 2011)	(Bradley, 2010)
Benefits identification	Identifying and structuring the benefits	Benefits planning	Set vision and objectives
Benefits analysis and planning	Planning benefits realization	Benefits delivery	Identify benefits and changes
Benefits delivery	Executing the benefits plan	Benefits review	Define initiatives
Benefits transition	Reviewing and evaluating the results	Benefits exploitation	Optimize initiatives
Benefits sustainment	Establishing potential for further benefits		Manage initiatives
			Manage performance

The bones of contention are whether BRM is part of project management or program management (Project Management Institute, 2017b) or who the responsible person is for BRM. The focus of this article is on the responsibility and accountability of BRM. Various views exist who this person should be. "Benefits are not delivered or realized by the project manager and project team, they require the actions of operations management" (Cooke-Davies, 2002, p. 187), which is echoed by (Peppard, Ward, & Daniel, 2007, p. 3) stating that "*only business managers and users can realize business benefits*". Badewi and Shehab (2016) state that the responsibility for benefits realization is placed on the business change manager. Based on ten central roles in project management, the benefit responsibility can be placed on the project owner, sponsor, investor, or program manager – but not on the project manager, according to Ofer Zwikael and Meredith (2018). O. Zwikael, Meredith, and Smyrk (2019) in a subsequent study, concluded that the product owner is accountable for BRM.

Over a period of two decades, two observations can be made. The first observation is that there is still no consensus on who responsible is for BRM. The second observation is that although there is confusion about the responsibility, there is a consensus that the project manager should not be responsible for BRM. The responsibility of the project manager is on the project's deliverable that should create benefits. Musawir, Serra, Zwikael, and Ali (2017) is of the opinion that the project managers is responsible for project management success that focuses on the triple constraint. The argument is that BRM is a separate process from project management, and it "*needs to be implemented along with another project, program, and portfolio management practices in order to ensure the complete management of project performance*" (Serra & Kunc, 2015, p. 64). Presenting BRM as a separate process from

project management is indirectly an argument that benefits realization is not the responsibility of the project manager (Badewi, 2016).

2.3. Review project management practitioners' guidelines

According to the PMI, the project manager may be involved in activities that are related to benefits realization (Project Management Institute, 2017a) but also acknowledge that the role and responsibilities vary from organization to organization. The PMI also adds that the project manager is responsible for the team delivering the benefits but that the benefits or business owner "*takes overall responsibility for monitoring and measuring benefits and ensuring they are achieved*" (Project Management Institute, 2016, p. 4). Like the project manager, the programme manager is responsible for constituting a team that are capable to deliver the benefits (Project Management Institute, 2017b). PMI's competency development framework makes it clear that benefits management is a performance competence of a programme manager, implying that the programme manager is responsible for the entire BRM process.

IPMA's Individual Competence Baseline (ICB) states that "*benefits realization is the fundamental objective of programme management*" (International Project Management Association, 2015, p. 230) implying that benefits realization is the responsibility of the program manager and thus not the responsibility of the project manager.

With regards to benefits realization, PRINCE2 states that "*at project closure, the business case is used to confirm that the project has delivered the required products and that the benefits expected can be realized in an appropriate timeframe by the business*" (Office of Government Commerce, 2009, p. 200). This implies that the project manager is responsible for delivering the product, but not for benefits realization. Regarding the specific role responsible for benefits realization, the PRINCE2 methodology has defined a stakeholder role i.e., the "Senior User" which is a member of the project board representing the customer. The incumbent of this role is responsible for "*ensuring that the products provide the expected user benefits*" (Office of Government Commerce, 2009, p. 210).

As a methodology for managing programmes, Managing Successful Programmes (MSP) is devoted to benefits realization. MSP only mentions the project manager in relation to the output, not the outcome. The responsibility of the latter is placed with the programme manager with help from change managers, hence not the project manager (Sowden, 2011).

In summary, all the consulted practitioners' frameworks of project management gave the same result as found in the scientific papers: The project manager is not responsible for the benefits realization; however, the *PMBOK guide* (P. Project Management Institute, 2017) is open to the possibility.

3. Methodology

3.1 Institutional logic

Institutional logic is defined as "a set of material practices and symbolic constructions — which constitute its organizing principles and which is available to organizations and individuals to elaborate" (Friedland & Alford, 1991, p. 248) provide a suitable lens for investigation the responsibility of benefit realization of projects. Ocasio, Thornton, and Lounsbury (2017) discuss the importance of not confusing the ideal types of the inter-institutional system with a description of the empirical observations in a study. Institutional logics were defined as "the socially constructed, historical patterns of material practices,

assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (Ocasio et al., 2017). Closer to our purpose, we have the following definition of institutional logic as the "frames of reference that condition actors' choices for sense-making, the vocabulary they use to motivate action, and their sense of self and identity" (Thornton, Ocasio, & Lounsbury, 2012).

3.2 The survey

The questions pertaining to the BRM responsibility formed part of a larger longitudinal survey focusing on the management of projects. The survey, which had previously been performed several times with an interval of 3-4 years, contains a large array of questions on the current state of project management. Each time, new themes have been investigated along with the longitudinal part of the survey. The survey was sent out using SurveyMonkey to a selection of 9 619 potential respondents. A total of 1,064 respondents completed the survey, giving a response rate of 10%. Around two-thirds of the respondents had the title of the project manager, while the remainder held another project role regarding their project, making the survey highly suitable. An assumption that the participant has chosen the most specific title/function has been applied to the dataset.

The practitioners' institutionalization of the responsibility of benefits realization was assessed with regards to where the responsibility was placed relative to the project as well as the role the responsible person holds. In both questions, the options for answer were presented to the participates as radio buttons, where all options were displayed. To avoid priming, the order of presentation of the options was presented to the participants in a randomized manner.

As an indication of the organizational maturity on benefits realization, a multiple-choice questionnaire was consistent on four levels. Furthermore, the participants were asked about the prevailing perspective of project success. There are many ways to categorize project success, where efficiency and effectiveness are often used, and the latter is often divided into two or more subcategories (Mikkelsen, 2018). As the foundation of the question, the categorization promoted in McLeod, Doolin, and MacDonell (2012) was selected. Their framework divides project success into process success, product success, and organizational success. The choice was motivated by being representative of a large section of the options and having a language suitable for practitioners.

The methodology approach was explorative and abductive. The data could be used for retrospective formulations of a hypothesis. However, this is not considered to be good practice. Instead, we present the data and make inferences on interpretation as a contribution to later inductive studies.

4. Findings

The first research question asked what the current institutionalization of responsibility for benefits realization is as perceived by practitioners of project management. The results are quite interesting, as displayed in **Table 2**.

Table 2. Benefits realisation responsibility

Categories for answers on the question of where the responsibility of benefit realisation is placed	Roles of Survey Participant									
	Project manager	Project coordinator	Head of PM	Line manager	Program manager	Program director	Project participant	Steering committee	Other	SUM
Benefits Manager	3.29%	0.09%	0.28%	0.00%	0.09%	0.00%	0.28%	0.00%	0.09%	4.12%
Project Manager	21.24%	1.50%	2.16%	0.66%	0.19%	0.66%	2.63%	0.47%	0.75%	30.26%
Project Sponsor	10.34%	0.38%	1.03%	0.09%	0.56%	0.38%	0.28%	0.47%	0.28%	13.81%
Steering Committee	17.01%	1.41%	1.03%	0.85%	1.03%	0.09%	3.76%	0.38%	0.75%	26.31%
None	7.52%	0.38%	0.47%	0.38%	0.38%	0.19%	0.66%	0.19%	0.66%	10.83%
Do not know	9.40%	1.50%	0.28%	0.19%	0.00%	0.09%	2.63%	0.09%	0.47%	14.65%
SUM	68.80%	5.26%	5.25%	2.17%	2.25%	1.41%	10.24%	1.60%	3.00%	99.98%

The results indicate that six of the nine roles are of the opinion that the project manager should be responsible for the realization of benefits. Thirty percent of the respondents are of the opinion that the project manager should be responsible for benefits realization. This includes the respondents who are fulfilling a steering committee role. The project managers themselves is of the opinion that they should be responsible for benefits realization at a rate equal to the average among all participants.

Apart from the project manager, the steering committee is also perceived to be responsible for benefits realization. Twenty-six percent of the respondents believe that the steering committee is responsible for benefits realization. Interestingly, the steering committee themselves do not believe that they should be responsible for benefits realization with a mere four steering committee respondents supporting this notion. Fourteen percent of the respondents believe that it is actually the responsibility of the project sponsor to realize the benefits, with 10% of the project managers supporting this belief. Of concern is the 25% of respondents who either do not know who should be responsible or that believe it is no one's responsibility.

Research question 2. What are the external forces and internal pressures of this institutionalization?

Table provides insight into the perceived barriers why benefits are not realized from projects. A weighted average percentage was used to rank the barriers. Respondents had to rank each of these barriers (1-5) with five the most prevalent barrier. The results indicate that the most prevalent barrier is that organizations are running too many projects. The perception is created that project managers are too busy managing these projects that they do not have time or energy to be concerned about the realization of benefits. Organizations are spending all their energy to manage these multiple projects and do not necessarily have the capacity or energy to focus on benefits realization management.

Table 3. Barriers to implementing benefits realization

Barriers	Percentage (Ranking)
Changes to needs and demands	18%
KPI	14%
Unclear responsibilities	20%
Business-as-usual	23%
Too many projects	25%

The second most prevalent barrier is that once the project is completed, the project team and organization return to a mode of business-as-usual. The most important aspect is to ensure that operations continue, and benefits realization is not perceived as business-as-usual. The realization of benefits is almost perceived as an accidental outcome. The least prevalent barrier is the changes that are a direct result of the needs and demands of the various stakeholders. Scope changes might have a negative impact on the realization of benefits as these changes differ from the original scope that was approved in the business case.
According to the respondents, the involvement of top management in the realization of benefits contribute the most to improve the realization of benefits. This is an interesting observation as the respondents also indicated that the project manager (who is not part of top management) should be accountable for benefits realization. The results in **Table 2** do not indicate the involvement of top management at all. The other two factors that will also contribute positively to the realization of benefits are the appointment of a person who will be responsible for benefits realization (21%) and the associated training of this responsible person in the management of benefits realization (21%).

Table 4. Factors that will improve benefits realization (Weighted score average)

Improvement factors	Percentage
Responsible for BR	21%
Authority of the steering committee	17%
Delegation of power	18%
Top management involvement	24%
Training	21%

Figure 1 illustrates the benefits realization practices that are implemented within organizations. Respondents could choose multiple practices that were implemented within the organization.

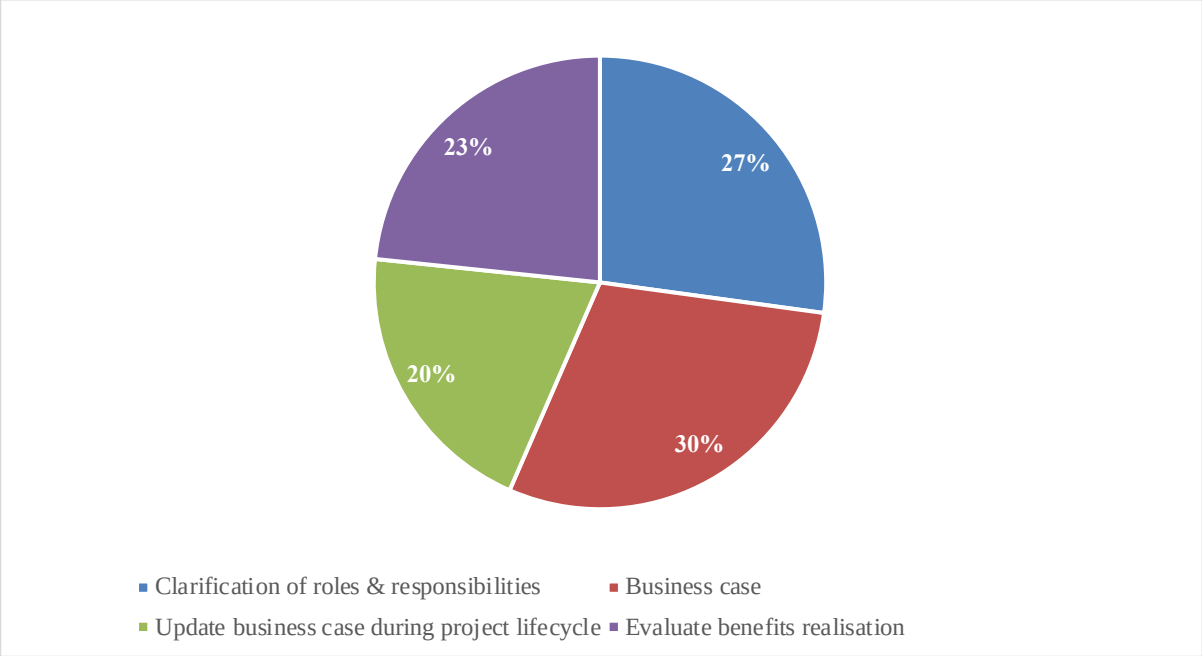

Figure 1. BR practices implemented

The results are quite disheartening. The best practices are not implemented at all to the extent that one would like. The business case is the document to list the benefits of the project and how it should be harvested once the project's deliverables are in operation (Marnewick, 2014). The results, as portrayed in Figure 1, corresponds with the research of F. Einhorn and Marnewick (2018). Their research highlights that the organizations use the business case to authorize and prioritize projects, but the business case is never used beyond the initial phases of the project (Frank Einhorn, Marnewick, & Meredith, 2019). This is also evident from the results as only 20% of the respondents state that the business is updated during the course of the project lifecycle. This has a serious impact on the realization of benefits as the project environment might change that will have an impact on the promised benefits. The other two best practices are also not implemented and correspond with the results in Table .

Figure 2 illustrates the maturity levels of benefits realization within organizations. It is evident from these results that organizations are immature with regards to benefits realization. In most of the organizations (77%), benefits realization is either rarely discussed or it is talked about, but there is no implementation of benefits realization.

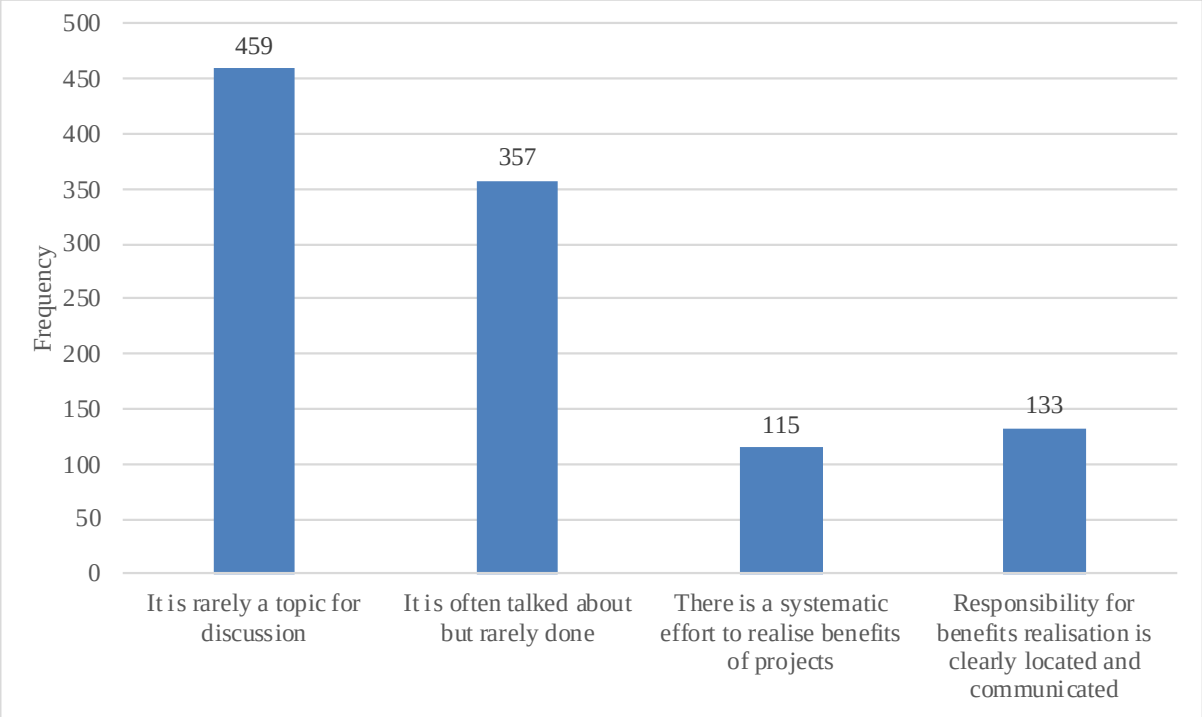

Figure 2. BR maturity levels

In relation to whether the maturity level of benefits realization is impacting the implementation level of benefits realization best practices, **Figure 3** paints an interesting story. The less mature organizations are in benefits realization, the better they are in implementing benefits realization best practices. This is counter-intuitive, and more in-depth research is needed to understand this phenomenon.

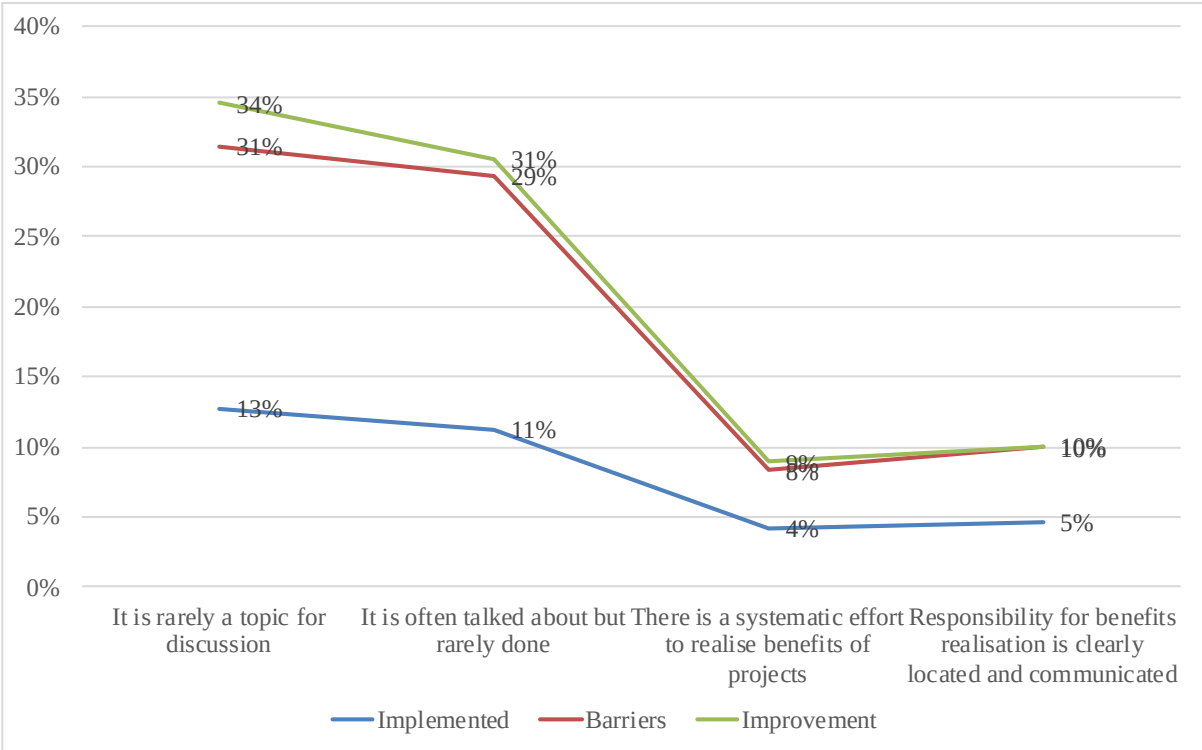

Figure 3. Maturity levels mapped against benefits realisation practices

An ANOVA was done to determine whether the different roles have a different perspective on the factors contributing to the improvement of benefits realization. The results (**Table 5**) indicate that there is no difference between various roles' perspective on what contributes to the improvement of benefits realization.

Table 5. ANOVA - Improvement

		Sum of Squares	df	Mean Square	F	Sig.
Responsible for BR	Between Groups	29.604	8	3.701	1.548	0.137
	Within Groups	2120.034	887	2.390		
	Total	2149.638	895			
Authority of Steering Committee	Between Groups	9.533	8	1.192	0.737	0.659
	Within Groups	1417.038	876	1.618		
	Total	1426.572	884			
Delegation of Power	Between Groups	7.755	8	0.969	0.697	0.695
	Within Groups	1183.653	851	1.391		
	Total	1191.408	859			
Top management involvement	Between Groups	16.396	8	2.049	1.098	0.362
	Within Groups	1702.030	912	1.866		
	Total	1718.426	920			
Training	Between Groups	7.585	8	0.948	0.490	0.864
	Within Groups	1732.724	896	1.934		
	Total	1740.309	904			

The same applies to the roles' perspective on what barriers are in place that minimizes the realization of benefits. The results in **Table 6** highlight that the roles' have the same perception as to the barriers that impede the successful realization of benefits.

Table 6. ANOVA - Barriers

		Sum of Squares	df	Mean Square	F	Sig.
Changes to needs and demands	Between Groups	13.481	8	1.685	0.866	0.545
	Within Groups	1577.518	811	1.945		
	Total	1590.999	819			
KPI	Between Groups	10.574	8	1.322	0.836	0.571

	Within Groups	1109.733	702	1.581		
	Total	1120.307	710			
Unclear Responsibilities	Between Groups	22.964	8	2.870	1.641	0.109
	Within Groups	1518.546	868	1.749		
	Total	1541.510	876			
Business as Usual	Between Groups	13.372	8	1.671	1.067	0.384
	Within Groups	1390.878	888	1.566		
	Total	1404.250	896			
Too many projects	Between Groups	29.932	8	3.741	2.147	0.029
	Within Groups	1552.534	891	1.742		
	Total	1582.466	899			

Influence form size and sector

The question used for data in **Table 7** is as follows*: Selected dimensions on company size, sectors, and project size. The selection criteria are extreme values in the distribution of responses to the question: Who is responsible for the benefits realization in your project? Columns, rows, and cells are the same, as explained in* ***Table 2.***

Table 7: Placement of responsibility of benefits realization depending on company size, sector, and project size

Categories of choice answering the question of responsibility for project benefits realization	**Average distribution**	Selected subsets of the overall dataset with large diversity form the mean				
		Company under 100 employees	Construction	IT sector	Project size < 100,000 euro	Project size over five mill euro
Project manager	**30%**	40%	52%	18%	30%	38%
Steering committee	**26%**	20%	15%	24%	26%	26%
Project sponsor	**14%**	10%	8%	21%	7%	15%
Benefit manager	**4%**	5%	1%	8%	5%	4%
Nobody	**11%**	13%	11%	15%	11%	10%
Don't know	**15%**	13%	13%	15%	22%	8%

Number of participants	***1064***	*168*	*79*	*131*	*223*	*218*

In **Table 7,** the columns are selected because of their extreme diversion from the average distribution.

Table 7 indicates a very high diversity between sectors when it comes to placing the responsibility for benefits realization onto the project manager. Construction and IT are selected because they represent the top and bottom in the range of sectors. The sector is more important than size in this topic, as shown by the two columns featuring the smallest and largest projects in the survey.

A company size under 100 employees was the most extreme of the size intervals in the dataset, meaning that size does not matter much in this context. The same is true for project size. But sectors are very influential to the nationalization of responsibility of benefits realization.

Types of projects

The question used for data in **table 8** is as follows: Types of projects engaged in (max three types) related to the distribution of responses to the question: Who is responsible for benefits realization in your project? Rows, columns, and cells are the same as in **Table 2**.

Table 8: Placement of responsibility of benefits realization depending on project type

Categories of choice answering the question of responsibility for project benefits realization	**Average distribution**	What type of project are you engaged with? (Select maximum of three)							
		Development	It projects	Organizational	Construction	Other projects	International	Marketing	Logistic
Project manager	**30%**	29%	19%	25%	45%	39%	40%	32%	28%
Steering committee	**26%**	28%	30%	31%	22%	26%	17%	25%	25%
Project sponsor	**14%**	14%	20%	19%	8%	9%	17%	5%	16%
Benefit manager	**4%**	3%	5%	5%	3%	3%	3%	2%	7%
Nobody	**11%**	9%	13%	12%	8%	10%	10%	14%	10%
Don’t know	**15%**	16%	13%	9%	14%	13%	12%	21%	14%
Number of responses	***1,064***	*489*	*444*	*243*	*224*	*202*	*201*	*56*	*69*

The diversity based on project types is similar to that found under the sectors.

Prevailing project management guiding methodology

Table 9 displays a sample of selected dimensions from the entire array of questions in the survey. The selection criteria are extreme values in the distribution of responses to the question: Who is responsible for the benefits realization in your project? Columns, rows and cells are the same as in **Table 2**.

Table 9: Placement of responsibility of benefits realization depending on project management methodology

Categories of choice answering the question of responsibility for project benefits realization	**Average distribution**	Division on prevailing project management methodology in the organization (if any)		
		IPMA	PMI	PRINCE2
Project manager	**30%**	28%	42%	20%
Steering committee	**26%**	27%	26%	29%
Project sponsor	**14%**	21%	18%	21%
Benefit manager	**4%**	4%	2%	7%
Nobody	**11%**	10%	6%	9%
Don't know	**15%**	10%	6%	14%
Number of participants	***1,064***	*254*	*115*	*302*

In regard to the prevailing organizational project management methodology, shown in the three columns to the right, there are interesting differences.

The IPMA does not seem to influence opinion on the responsibility of benefits realization to any great extent because the distribution is the average overall. The use of PMI raises the number of participants who point to the project manager, which is contrary to what one might expect. The PRINCE2 lowers the number, as expected.

5. Discussion

The findings from **Table 2** have demonstrated that, on average, 31% of the practitioners in different project roles indicate that they place the responsibility for realizing the project benefits on the project manager. This answers the first part of the research question: What is the current institutionalization of responsibility of benefits realization perceived by practitioners of project management? Here it is relevant to note the vast diversity of stakeholders on the matter. **Table 2** displays the distribution of participants' opinions on who is responsible for benefits realization. With this set of participants, the institutionalization of benefit responsibility is 30% placed 'inside' the project (on the project manager) and 44% is placed 'outside' the project (on the steering committee, sponsor of benefits manager). Inside and outside are, however, a matter of perception. Disturbingly, 26% of the participants of the survey opted for the category of 'nowhere or unknown'.

The stakeholder disagreement on the project manager as responsible for benefits realization is noteworthy. At one end of the range, only 8% of program managers point to the project manager as being responsible for benefits realization – and, at the other end, 47% to the VP of projects. The majority lie in the range of 26% to 31% holding the project manager responsible.

When this distribution is correlated with the information of the partition's title/function, as shown in Table 2, more interesting observations can be made, since the institutionalization is unevenly distributed in the organizations. Besides the aforementioned observations mention under finding, Table 2 promote discussions on the following indications.

1. The percentage of project directors and VPs of projects holding the project manager responsible for benefits realization is considerably higher than average. These are assumed to be the most organizational influential participants of the survey.

2. Program managers have a very different worldview. The percentage of program managers holding the project manager responsible is deficient (8%) in comparison to the average (30%). The institutionalization seems to be very different within this group. One explanation might be their responsibility toward projects and another the methodologies of program management.

3. The groups appearing mostly unaware of the responsibility (answering 'Don't know') are the project coordinators and project participants, at 29% and 26%, respectively. These are also the ones with the lowest rate on the response: 'Nobody is responsible". This adds up to an average group perception of: "Somebody must be responsible, but I don't know who."

4. The benefit responsibility of the sponsor is very different among the different groups of participants. Based on the distribution of the titles/functions, one interpretation might be that an 'inner circle' of project management is holding the sponsor responsible more often than the 'outer circle' of coordinators, participants, and line managers.

5. 'Benefits manager' is seemingly not a concept that is adopted by the practitioners of project management in Denmark, since this only scores 4%. Translation can have an effect since the benefits manager can be translated into two different Danish words meaning the same: 'benefit manager' and 'gevinstansvarlig.' (the former was used in the survey); however, the overall conclusion must be that the phase has not yet been institutionalized.

The second part of the research question was: "What are the drivers of this institutionalization?" The project management practitioners' guidelines recommendation of

the responsibility on a role in the permanent part of the organization – and not the project manager – seems to have some effect.

Many other factors have a documented influence, but the most interesting finding is the relation between the percentage holding the project manager responsible in the sectors on the one side and the perspective on project success on the other. Given the setup of the research, there is no indication of the causal direction between the two; however, given simple reasoning, the latter is the root cause of the former. One would place the responsibility according to what is important in the project, not the other way around. In other words, the more the sectoral perspective on project success equals the efficiency of the project, the higher the probability of holding the project manager responsible. Simply put, the focus on project efficiency over project effectiveness leads to holding the project manager responsible for benefits realization.

There are some reasons to be cautious. After all, this is only a survey, so some precautions will be addressed in this section. As in any survey, there might be a say-do problem interfering with the result. Some may say they hold the project manager responsible, but, in reality, they expect the sponsor to handle the benefits realization, and vice versa. Furthermore, some might say that the sponsor is responsible because this is the "right answer," but, in real life, they act as if the project manager is responsible.

The understanding of the term 'benefit' might not be that clear. Does benefit mean something different in the IT sector as opposed to the construction sector, for example? Here, we found a rate of 20% versus 50% respectively. Since the construction project often involves a more distinct 'handover' of the result of the project, there is reason to believe that an understanding of 'benefit' in the construction is considerably more closely related to the 'iron triangle' of the project. This could explain some of the differences between the two sectors regarding this ratio.

Moreover, the understanding of 'responsibility' may vary. There are surely many possible interpretations of the term responsibility. The different points of view of the benefits, as well as responsibility, are found in an interpretive study on project success based on 11 interviews (Davis, 2017). From the survey, we cannot tell which interpretations have been used, but due to the many respondents, there is the hope that the differences will equal out. Since each respondent selects one role over another, the diversity of interpretations does not matter to any great extent.

Furthermore, a 'priming effect' (Kahneman, 2011) might occur; the former questions might influence the perception of the next question in focus. In the survey, the former question was: "What does your organization do to succeed with project benefits realization?" The options to choose from are as follows: "1) Clarify roles and responsibilities for project benefits realization. 2) Use business case (or similar document) for the selection of the most beneficial projects, 3) Update the business case (or similar document), both during and at the end of projects, and 4) Evaluate the benefits realization to improve the process, roles and responsibilities". Based on this, the unconscious priming effect would be more relevant to the business side of the project than for the 'iron triangle.' The effect – if any – will supposedly lower the rate rather than inflate it.

Based on the above, it seems fair to assume that a significant number of respondents actually do mean that the responsibility belongs to the project manager – even if this flies in the face of the common 'wisdom' expressed in project management methodologies. Furthermore, it

can be assumed that one overarching factor is the focus on efficiency over effectiveness in the perception of project success in the sector.

The above finding is based on the means of the sectors. As **Tables 7, 8, and 9** show, the variety of other factors have an influence on which project role the responsibility of benefits realization is placed. While the specific variation is interesting and calls for clarifying causal explanations, the overarching picture is highly diversified. Based on this finding, the central recommendation to the practicing project manager might be: Ask the central stakeholders about their perception of project benefit, who is responsible, and what their perception of responsibility is. There might be some surprises and a great deal of enlightenment from this approach. The result of asking this question is likely to give different answers from the different stakeholders of a given project. Our data indicate that the project managers faced diverse expectations of taking the responsibility of benefits realization.

6. Conclusions and further research

Project management practitioner guidelines are clear on the responsibility of benefits realization. Based on discussions with practitioners, the institutionalized reality of responsibility is not only different, it is also very diversified. An explorative approach was used in a large national survey on project management. The findings are that, on average, 31% consider the project manager to be responsible for benefits realization. Both external institutional forces and internal performance pressures were found. Most influential was the role of the stakeholder and the sector of the organization; the latter also demonstrated strong relations to the perspective on project success. Further research is needed, and among the many options, the following seems highly relevant.

Firstly, it is important to identify cultural differences. The survey is conducted in a country that is characterized by very low power-distance (Hofstede, 1984). Will the same rate be found in other cultures? Secondly, the investigation was conducted with an abductive approach, and the findings can lead to many hypotheses that can be tested in a formal deductive study. Thirdly, research in prescriptive knowledge on how project managers can deal with the increasing complexity stemming from the responsibility of the project benefits realization. Finally, holding the project manager responsible for the benefits realization may be a central part of Rethinking Project Management. The purpose of the work is to contribute to the rethinking of project management (Cicmil et al., 2006), which has turned into a movement (Svejvig & Andersen, 2015). A particular Danish agenda of RPM (Svejvig & Grex, 2016) focuses on the concept of "Half-double" (Per Svejvig, Joana Geraldi, & Sara Grex, 2019) where benefits are realized early, often with the project manager as the one responsible. This might open up an entirely new perspective: Project management as a business entrepreneur (or intrapreneur when still on the payroll of an organization). Entrepreneurial project management is a concept addressed by Trokic, highlighting that "none of the research has produced frameworks or models that help lead to the development of an established theory on entrepreneurial project management as its field; particularly in portraying and discussing the use of project management techniques and tools in entrepreneurial endeavors. Subsequently, there is a significant need for further research if the gap between entrepreneurship and project management is to be bridged completely" (Trokić, 2016).

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ON STUPIDITY IN PROJECT MANAGEMENT

A CRITICAL REFLECTION OF PM IN A VUCA WORLD

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Abstract: The culprit for project failure is the complexity that is associated with a project. Unfortunately, project complexity will be part and parcel of a project especially in a VUCA world. This implies then that projects will continuously fail as the culprit is not disappearing. However, the purpose of this paper is to show how complexity at times appears like an opaque conundrum, which allows hiding whatever in it, even stupidity. The analysis of 1064 datasets from a questionnaire-based survey on stakeholder complexity reveals that project stakeholders do not treat project complexity with the necessary respect that sometimes borders stupidity. The article highlights that project stakeholders do not apply common sense when dealing with project complexity. Our journey in understanding project complexity became a learning journey into stupidity and a critical reflection on our frivolous liaison with the VUCA world.

1. INTRODUCTION

On a dark night, in the light of a streetlamp, a man was searching the ground for his keys. A bypassing man stopped to help. After a little while, the latter asked the former;

- *"Where exactly were you when you lost your keys?"*
- *"Over there," the man pointed to an area in the dark part of the street.*
- *"Oh, then why are we searching here?" the other man asked, surprised.*
- *The first man replied: "Because here, there is light."*

Much research has been done on the topic of project complexity (Klein, 2012; Cooke-Davies et al., 2007). However, in a structured review on project complexity (Geraldi, Maylor, & Williams, 2011, p. 986) argued 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". This is a road less travel by, with some exemptions like Maylor, Turner, and Murray-Webster (2013). The quest was an investigation of practitioners' perceived project complexity. At the outset, we had the indication of 'multiple stakeholders' being perceived as the essential characteristics of project complexity among practitioners (Cooke-Davies, 2011), and we decided to investigate the reasons for the stakeholder complexity in a survey among practitioners of project management. The research opportunity was a recurring Danish survey among project managers and related roles in project management.
The retrieved empirical data from the survey did not seem to make sense at first. The streetlamps did not shed light on the keys. The process leading to this paper was rather abductive until we dared to look at the data through the lens of organizational stupidity (Alvesson & Spicer, 2012). The term stupidity is rarely used in the project management discourse. However, given the explanatory power of the concept of stupidity in our research, the topic might be like the proverbial elephant in the room. Research approaches it from different sides using different terms and keeps failing to address the whole thing. Common sense has always been there calling stupidity 'stupidity'. It is about time to talk about stupidity in project management and governance in an informed way and allow to address it in PM research. We need to prevent stupidity from hiding comfortably behind complexity.
Based on a structured review (Stingl and Geraldi, 2016) offer an understanding of the current theoretical pluralism of project decision making and identified opportunities for future research within and across theoretical foundations. This paper is (also) a response to their calls for more research on project decision making.
(Stingl and Geraldi, 2016) found three categories in the literature, hence the title of their paper Errors, lies, and misunderstandings". This paper argues that stupidity is not covered by any of the three categories. The actors are not (always) acting out of any kind of self-interest; they are not optimizing, nor politicalizing, nor sense-making. Instead, sometimes their action is based on plain stupidity.

Complexity is used as a token to excuse all kinds of messy behavior in PM, so are the other siblings from the VUCA acronym: volatility, uncertainty, and ambiguity. Future PM practice needs to find ways to address these fields systematically based on innovative research. PM research needs that emancipate from the reductionist and linear research settings and embark on the research innovations from social, cultural, and political studies (Klein, 2020; Boulton et al.; 2015).

With this paper, we present our prelaminar findings and conceptualization as a contribution to future research of more deductive nature. We set out to investigate stakeholder complexity and found stupidity. The initial question was: why is 'multiple stakeholders' seen as an essential characteristic of project complexity, and the final question investigated in this paper is: how can we make sense of stupidity in project management? This might be the keys we are looking for in the dark, away from the streetlights.
The remaining parts of this paper are organized in the following sections: 2. Initial research: a stakeholder complexity survey, 3. Findings on stakeholder complexity, 4. Extended Research: a discourse exploration on stupidity, 5. Discussion: complexity vs. stupidity and finally, 6. Conclusion

2. PROJECT COMPLEXITY THROUGH THE LENS OF COMPLEXITY

We are currently living in a VUCA world—an acronym for volatility, uncertainty, complexity, and ambiguity. According to Bennett and Lemoine (2014), complexity is any situation or environment that has many interconnected parts and variables. R. B. Mason (2007) adds to this, stating that the level of complexity is based on the heterogeneity or diversity in factors such as customers, suppliers, socio-politics, and technology. Within a complex environment, the ability to understand and use the information to plan and predict becomes more difficult Bennett and Lemoine (2014); (R. B. Mason, 2007). In other words, the more complex systems become, the more difficult it is to make sense of it and to manage it.
Two approaches exist in managing complexity, i.e., algorithmic and natural complexity (Vasconcelos & Ramirez, 2011). Algorithmic complexity concerns the difficulty of solving a given, well-defined problem. Solving these problems requires finding a solution through means stated in an algorithm and institutionalized as rules. Natural complexity concerns situations in which finality is not a priori known by the actor in question. Here complexity is a measure of absent information. Complexity is a function of the degree of the actor's ignorance about the reality's working principles.
In order to make sense of complexity, the notion of complexity theory should be applied. The underlying principle of complexity theory is that in these complex systems with heterogeneous or diverse factors, these factors tend to self-organize into systems. Thus, complexity theories are concerned with the emergence of order in dynamic non-linear systems (Burnes, 2005). R. B. Mason (2007) opines that the underlying idea of complexity theory is that all the parts eventually self-organize into systems.

One way to deal with complexity is through complex adaptive systems (CAS). Complex adaptive systems (CAS) examines how interactions between the various individual and autonomous parts of a system enable the system to adapt to its environment and yield higher-level emergent behavior (Sweetman & Conboy, 2018).
One of the most important insights of complexity theory is this notion of emergence which implies that, given a sufficient degree of complexity in a particular environment, new (and to some extent unexpected) properties and behaviors emerge in that environment (M. Mason, 2008).
Project managers' training focuses on an environment of certainty. This contradicts their real-life experiences where they operate in environments with increased volatility, uncertainty, complexity, and ambiguity. Organizations that are professing decentralized and self-organizing management are more successful in managing complexity. This implies that project managers are in the ideal position to deal with complexity. Project managers do have the authority to decentralize and self-organize components within the project. Thus, making projects the ideal solution to deal with complexity.

Project complexity

(Baccarini, 1996, p. 201) proclaims that 'complex projects demand an exceptional level of management, and that the application of conventional systems developed for ordinary projects have been found to be inappropriate for complex projects.' This is further reiterated by Levin and Ward (2011), arguing that projects should be managed as complex systems. Projects per se should be seen as complex adaptive systems and managed accordingly.
Project complexity has been researched much over the last decades, starting with a definition from Baccarini (1996, p. 202) "many varied interrelated parts". This definition was contested early on by Williams, stating that "project complexity can be characterized by two dimensions, each of which has two sub-dimensions: Structural uncertainty (number of elements and interdependence of elements) and Uncertainty (uncertainty in goals and uncertainty in methods)" (Williams, 1999, p. 271). This definition contests the often-used complexity-uncertainty grid (Bennett & Lemoine, 2014) and opened for an continuous expansion of dimensions in the concept of project complexity. Many scholars prefer the narrow definition, t.ex (Besner & Hobbs, 2012). Not surprisingly, literature review often concludes like (Zhu & Mostafavi, 2017, p. 3); "Despite the many existing studies on project complexity, there is no universal agreement on the definition of project complexity."
A systematic review, based on an including the approach to the research literature, concluded that the concept of project complexity had evolved to encompass five dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political (Geraldi et al. 2011). A similar review performed five years later indicated a further development of the concept and expanded the understanding to eight dimensions: Structural complexity, Uncertainty, Emergence, Autonomy, Connectivity, Diversity, Socio-political, and Element of context (Bakhshi et al. 2016). The stream seems never-ending; a recent example of the framework (de Rezende & Blackwell, 2019) has ten different, but similar dimensions.
From a meta perspective, Bakhshi et al. (2016) identified three schools of thought on project complexity: The PMI-view, the complexity and the system of a systems view. Building on this work, a resent paper identified five ideal types of research of project complexity, indicating that each type holds a different relation to the concept of project success. The ideal types are: 1) Positivistic modeling, 2) Complexity theory, 3) Ontological framework, 4) Managerial framework and 5) Emancipative investigation. (Mikkelsen, 2020), where the first three types deploy descriptive version, and the two latter include a perceived project complexity, where "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" (Vidal & Marle, 2008). In the mind of the practitioner the multiple stakeholder is the most important characteristic of project complexity (Terry Cooke-Davies, 2013). "Variety of stakeholders' perspectives" is also found to be among the highest contributor to project complexity according to (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011).

3. RESEARCH METHODOLOGY

This survey, which had previously been performed several times with an interval of 3-4 years, contains a large array of questions on the current state of project management. Each time, new themes have been investigated along with the longitudinal part of the survey.

A quantitative approach was adopted to determine the relationship between project complexity and stakeholders' perception of project complexity. The questions pertaining to stakeholder complexity formed part of a larger longitudinal survey focusing on the management of projects. The adoption of a quantitative approach allowed the researchers to quantify the problem through the generation of numerical data that quantify the opinions and behaviors. Because it is difficult to engage with organizations in its entirety, the survey was done at an individual level. Therefore, individuals involved in the broader discipline of project management were the units of analysis. Individuals were targeted using snowball sampling as a non-probability sampling technique. The aim of the non-probability sampling approach was to get a representative sample. The survey was sent out using SurveyMonkey to a selection of 9 619 potential respondents. A total of 1 064 respondents completed the survey, giving a response rate of 10%. Table 1 provides an overview of the respondents' role and the industries that they represent. Project management is the most prevalent role in the pharmaceutical industry. The purpose of the results in **Table 1** is (i) to understand the survey sample and their organizations, (ii) to show that they are representative, and (iii) to provide context to the results.

The first section of the survey covered demographic data about the respondents: role in the organization, industry sector, types of projects that they are involved in as well as project experience. The section focusing on project complexity had six questions resulting in 40 items. The aim was to investigate the perceived cause of "multiple stakeholders" being a characteristic of project complexity. The design of the questionnaire for this purpose was based on the selection of six plausible causes for the participants to priorities in a forced prioritization. Based on the literature on stakeholders and project complexity, the topics were disagreement, expectations, ambiguity, change of needs, resisting change, and lack of communication.

There are two criteria that data must meet for credible results to be produced: data must be both valid and reliable (Field, 2018). A further distinction can be made between internal validity and external validity (generalisability). There are several ways of assessing internal validity. Logical validity is based on the subjective judgment that the measurement items relate to the stated research questions. This was addressed through the design of the questionnaire. Content validity relates to the domains being measured, and whether the scale items measure those domains. For this research, all items of the questionnaire were drawn from literature and are believed to be valid. From an external validity point of view, the data is believed to be generalizable. However, the findings might not be generalizable outside of organizations not involved in technology implementations.

There are a number of criteria for data reliability. The data must be consistent, with the same method being used to gather it, and must exhibit independence among the respondents. It must be stable, meaning that gathering more data would produce similar results, and reproducible, meaning that if the research were repeated, it would also produce similar results.

A commonly accepted way of measuring reliability is by using Cronbach's alpha test, where an alpha of 0.7 or above is considered satisfactory (Argyrous, 2011). Of the 40 items, reliability testing could only be performed on eight items due to the nature of the questions. An overall alpha value of 0.383 (8 items) resulted from the analysis and indicated that there was cause for concern about the consistency of the data.

Another requirement for many types of statistical data analysis is that the data for each rating item are normally distributed. Normality is measured by skewness and kurtosis, which are calculated for each of the rated items. The parameters skewness / standard error of skewness, and kurtosis / standard error of kurtosis are used. Ratios above 2.58 indicate that the data may not be normal (Argyrous, 2011). Based on this ratio, and inspection, ratings for the items are normally distributed. Having done reasonable checks on the data, the conclusion is that the data can be used for analysis.

4. FINDINGS ON STAKEHOLDER COMPLEXITY

With regard to identifying complexity within a project, there is a correlation between the three identified steps. There is a weak significant correlation between the identification of complexity within a project and the understanding of identified complexities. There is a moderately significant correlation between the understanding of the complexities and acting on these complexities. This implies that once complexities are identified, it is not always understood, but once it is understood, the probability of acting on these complexities increases. This is evident from the weak correlation between identifying complexities and acting on complexities (r=0.190, p=0.000). This weak correlation is an indication that not all identified complexities are acted upon. (**figure 1**)

Table 1. Cross-tabulation between industry and role

	Project manager	Project coordinator	Head of Project Management	Line manager	Program manager	Program director	Project participant	Steering committee	Other	Total
Agriculture & Fisheries	5	0	0	0	0	0	2	0	0	**7**
Construction	51	2	13	2	0	2	3	2	4	**79**
Energy & Water Supply	67	4	1	4	1	0	12	2	2	**93**
Industry	95	12	5	2	4	3	22	3	4	**150**
Information & Technology	92	7	7	6	7	1	4	0	7	**131**
Pharmaceutical	110	12	11	3	2	4	26	2	2	**172**
Public administration	98	6	4	1	4	0	5	5	0	**123**
Trade, hotel and restaurants	11	1	0	0	0	1	2	0	1	**16**
Transport, mail and telecommunications	22	2	1	0	0	0	2	0	0	**27**
Other	181	10	14	5	6	4	31	3	12	**266**
Total	**732**	**56**	**56**	**23**	**24**	**15**	**109**	**17**	**32**	

Figure 1. Correlations between complexity steps.

The question that should be asked is how good stakeholders are performing these three activities. A weighted scoring average shows that stakeholders are not that good in performing these three activities.

Activity	Identifying complexity	Understanding complexity	Acting on complexity
Average	62%	64%	63%

Table 2. Weighted average – performing complexity activities.

There is not much difference in the performance of the activities. The activities are performed at a 63% average, implying that there is a major room for improvement. This average level of performance can be attributed to various factors such as a lack of training, lack of experience or not being part of the role as a stakeholder. This phenomenon can be further investigated at a later stage through in-depth interviews.

Identifying Complexity

The first step is to identify and determine the level of complexity within a project. As per Table 2, the respondents are not good at complexity identification. Part of complexity identification is to assess the level of complexity. The results in Table 3 support the results of Table 2. Only 41% are trying to do some form of formal assessment during the initiation phase of the project. An astounding 22% rely on some sort of gut feeling to determine the project's complexity. The reality is that 59% of the respondents are going the wrong way to determine the complexity of a project.

Variable	Rank	Percentage
Formal Assessment - Initiation Phase	1	41%
Part of Risk Assessment	2	33%
No attempt	3	26%
Gut Feeling - Initiation Phase	4	22%
Determined during the execution phase	5	19%
Disagreement	6	3%
Other	7	3%

Table 3. Determining the levels of complexity.

This wrong way of going about to determine the complexity of a project has a direct impact on the way that a project will be managed. The fact that the stakeholders cannot identify a complex project, implies that they might deal with a complex project as a simple or complicated project.

Understanding of complexity

With regard to the respondent's understanding of complexity within a project environment, **Figure 2** provides some insights. Sixty-three percent of the respondents believe that complexity can be defined as a project consisting of many varied inter-related elements. Complexity is also perceived as political aspects that influence the project and decisions made within the project (50%). A project manager with low experience (13%) and a low level of trust among parties in and around the project (16%) is not perceived as descriptors of complexity.

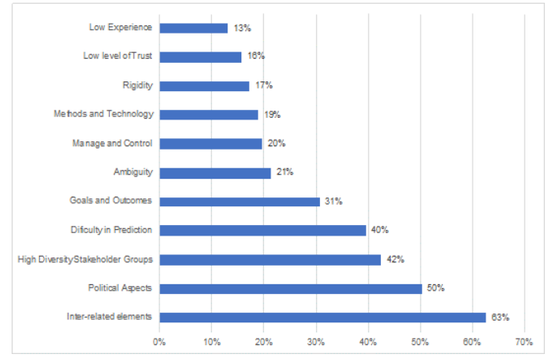

Figure 2. Ranking of complexity descriptors.

There is a moderately significant correlation between the understanding of the complexities and acting on these complexities. It is evident from Figure 2 that the respondents are using various descriptors to make sense of complexity. The spread of responses across the various descriptors indicates some confusion about what complexity is all about and how complexity should be defined. This speaks directly to the findings of Zhu and Mostafavi (2017), stating that there is no clear and succinct definition for project complexity. This confusion about what constitutes project complexity implies that the stakeholders would not necessarily recognize a complex project even when they are part of the project. They might be shining the light at the wrong place to determine whether a project is complex or nor.

Project Complexity Strategies

It is evident from the results in **Table 4** that the respondents are making use of various strategies to determine the complexity of a project. The two most popular strategies are engaging an experienced project manager (40%) and having increased meetings with the stakeholders (39%).

Engaging more frequently with project stakeholders does have its own challenges as per **Table 5**. According to the results in Table 5, stakeholders cannot be used as a reliable source of determining project complexity. The results are quite contradictory.
Some of the strategies to deal with complexity are Agile-oriented (MVP (21%) and interactive processes (17%)). Although there is evidence that Agile can reduce complexity, Agile is predominately applied in the IT industry. Engaging an experienced project manager sounds like a good strategy, but an experienced project manager does not necessarily have the experience in managing complex projects. The experienced project manager might realize sooner that a project is complex. The majority of the strategies are not that popular among the respondents. This might be an indication of their inability to manage complexity and that they are clutching at straws.

Stakeholders' influence on the complexity

Stakeholders per se, can significantly contribute to the project's complexity. According to T. Cooke-Davies (2013) 'multiple stakeholders' are the main course of project complexity. Decision-making stakeholders' unrealistic expectations of what is possible within the allocated budget and timeframe is ranked as the most important factor that contributes to project complexity. **Table 5** provides the ranking order.
The results support T. Cooke-Davies (2013) findings in that the stakeholders themselves contribute to the complexity of the project. The results highlight that stakeholders disagree among themselves about the project goal and deliverables; there are ambiguity and a constant change with regards to their needs and demands. Although the stakeholders are the cause of change, they are also perceived as the ones who are not willing to change. One of the strategies to deal with complexity is the ability to adapt or change.

Stakeholder Influence	Ranking
Unrealistic expectations	1
Reaction to poor/insufficient communication	2
Ambiguity	3
Resistance to change	4
Change in needs/demands	5
Disagreement	6

Table 5. Ranking of Stakeholders' influence on the complexity.

Complicated versus Complex

Snowden and Boone (2007) created the Cynefin framework to assist leaders (project stakeholders) in determining the prevailing operative context so that they can make appropriate choices. The two most prevailing operative contexts within a project environment are that projects are either complicated or complex. The classification of a project as either complicated or complex, determines the way and manner the project will be managed. The results in **Table 6** highlight two important aspects. Firstly, the project stakeholders sometimes distinguish between a complicated and a complex project. This might be because of the fact that they do not know themselves how to differentiate between a complicated and a complex project. Secondly, it is often the expectation of the stakeholders to 'downgrade' a complex project to a complicated project. This might be the result that complicated projects are easier to manage than complex projects. Although projects often do have significant complex parts, projects are 'downgraded' too complicated projects. This has a significant impact on the final outcome of the project.
Whenever we reach the limits of classic PM common sense comes into play. The first aspect relates to successful project managers who insist that they are successful despite PM and call on intuition. The second aspect relates to what our research shows and could out of a perspective of common sense be bluntly called stupidity. There is something awkward in the realms of PM. However, if we take the effort and doublecheck on common sense we find yet another layer of social dynamics to be discovered. In the case of PM success and experienced managers research shows that e.g. improvisation is not the banality of muddling through or simple pragmatism. Improvisation is successful improvisation if it is informed improvisation, like in jazz music. You need to master your

	Median	Implication
Distinguish between complicated and complex part of a project	2	Sometimes
Project has significant complex parts	3	Often
Decision-making stakeholders acknowledge project complexity	3	Often
External stakeholders acknowledge project complexity	2	Sometimes
Stakeholder expectation: Reduce complexity to complicated	3	Often

Table 6. Ranking of Stakeholders' influence on the complexity.

Variable	Rank	Percentage
Engaging experienced project manager	1	40%
Increase of meetings with stakeholders	2	39%
Allocation of more PM time	3	26%
Prototyping/MVP	4	21%
Interactive processes	5	17%
Planning with extra Stage Gate	6	16%
Improvisation of process	7	15%
Other	8	6%
Learning on the project	9	5%

Table 4. Strategies to deal with project complexity.

instrument to improvise successfully. You need to master PM to be successfully pragmatic and improvise (Klein et al., 2015).
We learned that this holds true for stupidity as well. It is worth to have a second, scientific look at it and not plaster it with common sense. There is a lot of research on stupidity to shed light on the matter and devise ways to escape it.

5. EXTENDED RESEARCH: A DISCOURSE EXPLORATION ON STUPIDITY

There is a lot to know about stupidity. Hence, the encounters with stupidity marked for us rather a beginning than an end. What can we know about stupidity to avoid it? The further parts of the paper explore the existing discourses on the matter to discuss first ideas for remedy and indicate the need for further research on the topic. The research literature on stupidity in the context of projects is presented in three themes: (i) stupidity in the broader context, (ii) organizational stupidity and (iii) stupidity in project management.
Although stupidity occasionally emerged as yet another excuse for semi-professional practices and ignorant conduct, it is rarely fair to blame the person. Viewed through a systems' lens individual stupidity is allegedly promoted and facilitated on two levels. On an ontological level, goal setting, role descriptions and processes facilitate, up to the level of perverse incentives, specific behaviors which may be regarded as stupid (Caplow, 1994). On an epistemological level, we are confronted with the limits of project management in its preference for linearity and complexity reduction, which create fundamental problems meeting the VUCA world (Bredillet, 2010; Whitty & Maylor, 2009).

General stupidity

The Oxford dictionary gives the following definition of stupidity: "Behaviour that shows a lack of good sense or judgment".
These definitions, as well as our everyday understanding of stupidity, address the individual rather than taking the power of context into account. Stupidity is promoted as an individual property rather than a systemic co-creation. Systems and complexity theory would argue that any kind of behavior is context-dependent. Senge (1990) elaborates the argument that the structure of social systems would predetermine the behavior and, eventually, the results. Fighting stupidity on the level of behavior is a tedious endeavor if we acknowledge the systemic power of context. Preventing stupidity, hence, is rather an activity that changes the systemic context and the systemic social structures than training people to behave smarter.
However, stupidity – or better stupid behavior – seen from a neuroscientific point of view is grounded in cognitive biases and bounded rationality. In the bestseller Thinking fast and slow biases (Kahneman, 2011) many have been exemplified. Human beings trust their lived experience and the so-called human scale. We do not have antennas for the Earth being a sphere or its trajectory revolving around the sun. We have no feeling for exponential developments or probabilities. We need to measure and calculate these facts, or we remain ignorant. Stupid behavior is then just a consequence. A bias with specific relevance for decision-makers not only in organizations and project management is the Delusion of Success (Lovallo & Kahneman, 2003). We have a tendency to underestimate costs and overestimate benefits. Any project initiated based on this bias is bound to fail. We may want to call this stupidity; however, we may learn to double-check on the biases of our gut feeling.
Bounded Rationality, as a source of stupid behavior, builds on this. It addresses the actors' inability to make completely rational decisions due to lack of time, information and the according to processing capacity (Simon, 1972). If we know that we can counterbalance human biases, we should plan for the time and resources to do so. If we do not do it, we can call it stupidity or investigate what systemic conditions keep us from doing the right thing and promote stupid behavior.

Organizational stupidity

Alvesson and Spicer (2012) address the topic of stupidity in an organizational context, labeling it functional stupidity, which is "characterized by an unwillingness or inability to mobilize three aspects of cognitive capacity: reflexivity, justification and substantive reasoning" (Alvesson & Spicer, 2012, p. 13). In developing their theory of stupidity-based theory of organization, Alvesson & Spicer (2012) investigated the concept of stupidity as the deviations from smartness, which is neither semi-rational nor purely stupid. They proposed the concept of functional stupidity, and organizations are seen as generators of functional stupidity. The concept is captured in the quote: "For us, functional stupidity is the inability and/or unwillingness to use cognitive and reflective capacities in anything other than narrow and circumspect ways. It involves a lack of reflexivity, a disinclination to require or provide justification, and avoidance of substantive reasoning. It is related to the intertwined elements of cognition, motivation and emotion." (Alvesson & Spicer, 2012, p. 16).
Among the positive outcomes of functional stupidity is that it provides a sense of certainty and purposefulness around the organizations' activities, despite the questionable basis of many of them.
In this sense, stupidity allows masking organizational paradoxes, even for a long while. However, in the long run, those organizational paradoxes will take their toll. Growing stress and dissonance indicate the necessity to address the shortcomings of the 'stupid' solution to organizational challenges. The courage to acknowledge the shortcomings may be found internally; however, critical eyes from external stakeholders sometimes serve as valuable support. This may be, in turn, a reason why managing external stakeholders is so painful as they address the obvious and point at organizational stupidity; we are not ready and prepared to face.
The concept of stupidity has not often been investigated directly, but books on the topics are quite frequently encountered in the literature review. In the book The Power of

Stupidity, the author makes a profound statement: “One of the reasons stupidity is dangerous is that it is unpredictable (Livraghi, 2009, p. 23).” This statement is echoed in the book The Stupidity Paradox (Alvesson & Spicer, 2016). Being the cause of unpredictability is also said about project complexity: “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 complete information about the project system” (Marle & Vidal, 2016). Besides form complexity and stupidity are both the source of unpredictability, there exists a kind of reciprocity between complexity and stupidity: Where complexity is a property of the perceived behavior of the project, stupidity is a property of the behavior of the perceiver. In sum, the link to the VUCA world concept becomes more and more evident. Addressing stupidity then works as a token for the organizational inability to handle volatility, uncertainty, complexity, and ambiguity.

The Stupidity Paradox identifies five sources of functional stupidity: **Leadership, Structure, Imitation, Branding, and Culture**. Hence, functional stupidity is seen as a consequence of the organisation. “We see functional stupidity as being created not through intellectual deficits but through political expediency and the operation of power” (Alvesson & Spicer, 2012, p. 42). This highlights that members of an organization become functionally stupid through a series of cultural and institutional beliefs and arrangements salient in an economy of persuasion. The concept of social complexity shines through, and is reinforced by managerial (and self-managerial) interventions (such as encouraging a narrow action orientation, the celebration of leadership, attachment to structure, a strong belief in institutions). This will discourage reflexivity, substantive reasoning and justification.
A more ‘stupidity-appreciating’ book The Power of Stupidity (Livraghi, 2009), different laws are being presented as sources of stupidity, which includes: The law of Murphy, the law of Parkinson, and the Peters principle. The book The Vitality of Stupidity (Bos, 2007) emphasizes the importance of balance between stupidity and wisdom, and here the stupidity almost becomes almost a virtue. The Basic Laws of Human Stupidity (Cipolla, 1976), gives a set of laws of which the first seems most essential to our study: Always and inevitably everyone underestimates the number of stupid individuals in circulation. These books, though thoughtfully crafted with vivid examples, are lacking scientific rigour.

Stupidity in project management literature

It is very little on stupidity in decision making in the project management literature.
Stingl and Geraldi (2017) serve as a valuable starting point to elaborate on reasons for questionable decision making, however, stupidity is not addressed explicitly. Their systematic review on behavioural decision making in projects brings forward a conceptual framework rooted in three schools of thinking: reductionist (on cognitive limitations), pluralist (on political behaviour), and contextualist (on social and organizational sensemaking). Based on these three schools of thoughts, they identified three sources of bad decisions: Errors, lies and misunderstandings. The case of stupidity in project decision making does not fall into any of these three categories.

1. **Reductionist, decision making is rational:** The steady low rate of project performance is a documented fact know by most project decision-makers. The statistics have been discussed and shared among practitioners of project management for a very long time. The reductionist approach cannot account for the irrational decision making about the triple constrictions leading to the persisting low-performance rate. When a rational decision-maker realizes that he/she has made an error during the decision-making process, he/she will correct this going forward.
2. **Pluralist, decisions are negotiations:** The agreed-upon triple constraint (scope to be reached within an agreed deadline and budget) is a result of the negotiating process. In the case of delays and/or overrun of the projects promises there will be a looser among the negotiating parties. We must assume that the participant of the negotiation process is well information, including here; informed of the persisting low-performance rate of projects in general. The pluralist approach assumes self-serving parties, hence no part willing to suffer losses.
3. **Contextualist, decisions are sensemaking processes:** Having projects that are underestimated in time and/or resources do not make sense. The contextualist approach does, therefore not explain the persisting low-performance rate. “Decision-makers do not ‘make’ decisions, but are actors constructing narratives which will shape processes of attention, prioritization and ultimately decisions.” (Stingl and Geraldi, 2017 page 125). The narratives of the persisting low-performance rate should be a part of the sensemaking process according to the conceptualistic approach, hence improving the performance rate over time.

Adding to the discussion based on the paper from Stingl and Gerladi (2017), there has been a discussion on the overrun of time and budget was due to delusion or deception. On the face of the action, it might be different to distinguish between duplicity and stupidity, since one needs to know the true intention to do so. Under political circumstances – in public office or private firms – we often find hidden agendas. Those make some actions appear to be a result of stupidity, but in fact they are not. The often-seen relocation to close down a failing public known project close to the next election day, is a case in point (Flyvbjerg et al., 2009).
A paper arguing against Flyvbjerg et al. (2009) addresses the question well: “Given duplicitous or stupid projections, project managers will not infallibly fix them – they are, after all, human. Implicitly, arguments that see the failures of megaprojects as residing in a lack of realism that deliberately misleads stakeholders about the true costs and complexity of the projects assume a norm in which large-scale organizations are characterized by rational behaviors. In projects that are not as organizationally complex, ambiguous, ambitious, political and risky, the façades of rationality may be easier to maintain. The complexity and ambiguity of megaprojects can make the maintenance of these rationality façades much more difficult (Pollack et al., 2018, p. 382).”
The current research poses a dichotomy of bad intentions (lies, deception and hidden agendas) on the one hand or in-capacity (delusion and misunderstanding) on the other hand.
Thinking deeper on the problem, we find there is a third stance. Having the ability to make better decisions, but not applying this in the given situation, without doing this out of bad intention. This equal to the characteristic of stupidity of Alvesson & Spicer (2012), as an unwillingness or inability, to mobilize one’s cognitive capacity.
We find support for our third stance in PMI pulse of the profession (PMI, 2016) where a telling picture showing: The rate of staying within initial budget and deadline is a flat curve the period of 2012 to 2016. The numbers are based on the question: “In your estimation, what percentage of the projects completed within your organization in the past 12 months?” The reported numbers on “Completed within original budget” lies in the range of 53-55% and “completed on time in the range of 49-51%. The numbers from 2017 and 2018 is within the same intervals. The issue here, is not so much the low numbers, but the steadiness of them. When you year after year have reported such number, the overspend and overrun can hardly come as a surprise. Not taking this into account for the next projects, is a kind of stupidity. As stated earlier: Repeating mistakes based on our known mental biases, can be classified as a result of stupidity.

Finally, there is the so-called conspiracy of optimism (Chapman et al., 2006; Chapman & Ward, 2003; Hirt, 1996). Especially in the public arena concerning decisions about large and mega projects the best-case scenario will be brought forward for decision. Based on those parameters the project can only perform or underperform. The odds are with the project failure, whatever the project management is ready to do. The public opinion has a clear perspective on the project performance part: stupidity!

6. DISCUSSION: COMPLEXITY VS. STUPIDITY

The scientific frame of reference taps into systems research combining theories of social systems, complexity studies, and system dynamics (Edson, 2016). In order to tease out the drivers and consequences of complexity, the methodology of causal mapping has been deployed especially looking into the works on social complexity in PM provided insights on how to decompose complexity in social systems (Klein, 2016). Useful was the TPC model which offers a combination of three perspectives: a technological (T), a political (P) and a cultural (C) perspective, highlighting that complexity resides where (micro-) political interests and cultural worldviews meet (Tichy, 1983). Overall taking complexity seriously mobilizes research into structures of iteration. This is inevitable on all levels: on the level of the system in focus as well as on the level of research design and on the level of reasoning. “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).

Causality mapping

Among others, Ackermann & Alexander (2016) have developed the concept of causal mapping, a way of conveying the perceived causal links. The map illustrated (**figure 3**) the essential causalities for stupidity in project decision making. There are detected several positive feedback loops, which might cause the stupidity to spiral out of control.
Here, we use the methodology to illustrated how stupidity could be seen in the context of project overrun and delays. If stupidicity can be defined as: “Doing the same thing again and expecting different outcome”, then our findings indicate a high degree of stupiditiy on the part of the decision-makers with the expectation on doing projects within timebound and budget. The participants of the survey indicated this to be the most characteristic among the stakeholder complexities.

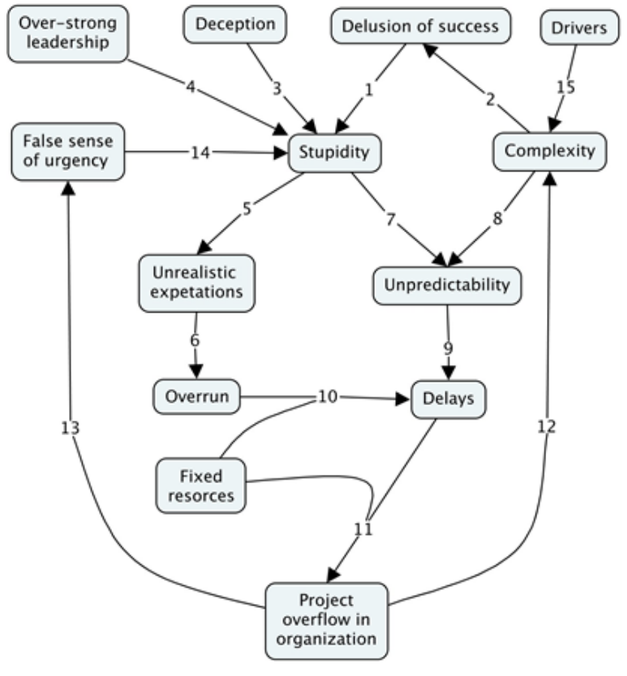

Figure 3. Ilustration causal mapping.

Arguments for the causal mapping is here presented in bullets:

1. A delusion of success (Lovallo & Kahneman, 2003) is stupidity is there is knowledge of the statistical project efficiency and effectiveness. Not countering one's own bias is an unwillingness to compensate for one's inability to mobilize aspects of cognitive capacity, and is, therefore, a part of the definition of functional stupidity in (Alvesson & Spicer, 2012)
2. The delusion of success is also the effect of the "attempt to come to grips with the complexities of a unique challenge (Lovallo & Kahneman, 2003, p. 7)",
3. Deception correspond to the unwillingness mobilize two of the three aspects of cognitive capacity: justification and substantive reasoning from the definition of functional stupidity in (Alvesson & Spicer, 2012)
4. Over-strong leadership leads to stupidity (Alvesson & Spicer, 2012)
5. The unrealistic expectation is a fact-based on our empirical finding. A consistency of this cannot be anything than stupidity.
6. Unrealistic expectations lead on average to overrun (otherwise, it would not be unrealistic).
7. Stupidity leads to unpredictability ((Alvesson & Spicer, 2016)
8. Complexity leads to unpredictability (Cooke-Davies et al., 2007) and many others
9. Unpredictability leads to delays, per definition
10. Overrun plus fixed resources lead to delays, logical
11. Delays plus fixed resources lead to project overflow in the organization, logical project overflow leads to complexity, based on the social-political dimension (and others) project overflow leads to a false sense of urgency, a false sense of urgency leads to stupidity, e.g., 'less-than-rational' decision-making approaches often appear in crisis environments (Parnell, 2017, p. 1)."
12. Give a short explanation of other drivers of complexity

<u>Stupidity in the eye of the beholder</u>

Absolute stupidity is probably less than perceived stupidity. It must be assumed that some actions might appear stupid when the intention of the decision-maker is not revealed. This could be the case of hidden agendas. Personal gain can produce decisions that might be perceived stupid, because of the unintended consequences for others. It must also be assumed that nobody deploy stupidity on purpose. Ex-ante stupidity of self is not a plausible phenomena. However, a sound self-reflection might include retrospective stupidity. The frequency of this depends on personality traits. Not all will do this, and those how do, might not publicly admit to this. The frequency can increase by feedback from others. Still, publicly announcing 'I screwed up' is mostly reserved for extreme cases, and the numbers do not reflect the many cases of screwing up.
Sensemaking is an affordance of being human, and stupidity is when it is not activated. Alvesson & Spicer (2012) point to the refrain activation of the human mental capacity of reflexivity, justification and substantive reasoning. Weick (1995) argues sensemaking in the same fashion yet arrives at 'mindfulness' which can in this context be regarded as the opposite of stupidity.
Instead of seeing the stupidity as something the stressed people accentually do - or powerful people do out of hubris - the affordance theory make us see stupidity as the default. The baseline from where we can deviate with an effort to deploy our mental capacity.
A gorilla in a suit. This picture is the caricature of an executive meeting the complexity of projects with over-simplified reaction. The project manager complains over lack of time and resources to handle the complexity of the project, and the executive order the project to be done anyway. This might be stupidity in the eyes of the project manager (and the bystanders) but it might simply be the natural reaction of the gorilla.
Using the theoretical foundation from critical realism: Reflexivity, justification and substantive reasoning are three generative mechanisms. There is a certain degree of randomness if these mechanisms are countered by other mechanisms or if they are simply not activated in the situation.

7. CONCLUSION

Our research can be seen as a classic approach to distill data from a sufficiently large survey. It came with all the limitations of quantitative research. Questionnaires and limited answering spaces depend on and re-generate a specific worldview. We can be satisfied with these limitations or, as in our case, feel challenged to reassess the results in the light of what we addressed as stupidity.
We see what we call a shift of scapegoating. Projects fail as it was often stated on the soft side, the people side. If people are stupid, we need to train them better to become smarter project managers and decision-makers, understanding soft issues and develop "soft" intelligence. If it is not our own people it is other people we like to blame, i.e., stakeholders who behave in funny ways. However, we like to call this difficult behavior complex. Complexity, however, does not only serve to describe difficulties with stakeholders, but it also became mainstream to address any large project complex to explain why it is so difficult to be successful and so likely for them to fail. So, the new scapegoat is complexity or better the entire VUCA world.
There has been a lot of research on complexity, and on uncertainty and even volatility occurred in the research papers. These have been the first steps in the right direction. The entire VUCA world needs to be readdressed and put under scrutiny. This should enlighten questions, not only project success and project manager performance. It will challenge our ideas of project management as a discipline. The days of linear and reductionist approaches are over. All areas where they work have been covered long ago. Now we see them deployed in areas that demand more than superb engineering and management by the book.
We may go as far as acknowledging PM being at home in social science. With this came ample opportunities to reassess success and performance and to finally understand the inevitability of a systemic perspective in research. Systems thinking builds on the assumption that the world is true, volatile, uncertain, complex, and ambiguous. Believing that the world was a LEGO box is the stupidity we need to overcome in PM research and practice. We need to learn from systems research more about adequate tools for systemic inquiry, linking quantitative and qualitative research in a more meaningful way. Projects are social systems, VUCA by nature, and should be met accordingly.
If stupidicity can be defined as: "Doing the same thing again and expecting a different outcome", then our findings indicate a high degree of stupiditiy on the part of the decision-makers with the expectation on doing projects within timebound and budget. The participants of the survey indicated this to be the most characteristic among the stakeholder complexities.

No further excuses accepted - stupid is as stupid does.

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The lived experience of managing the dynamics of project complexity

Abstract

Project complexity has been researched much. The majority of research on project complexity is descriptive and deploys a retrospective perspective on projects, where project are seen as final objects. The use of an ex-ante approach, use for assessment in the initial phases of projects, is less commonly seen in research but has got some attention. However, for the involved managers, the project complexity is a lived experience as the projects evolves in dynamic interactions with the stakeholders. Not much research has focused on this perspective. This paper presents a theoretical framework explaining the unpredictability of events course by project complexity. The theorizing is based on critical realism and focuses on the identification of generative mechanisms as the methodology. The paper then discusses the potential value of the proposed theory - both to the research of project complexity and for practitioners of project management.

1. Introduction

Baccarini (1996) was among the first in the search stream of project complexity. The Baccarinian definition stated that project complexity is "consisting of many varied interrelated parts". This has later been labeled 'structural complexity' by other scholars, who induced more dimensions of project complexity, like uncertainty (Williams, 1999), dynamic (Xia & Lee, 2004), socio-political dimension (Geraldi, Maylor, & Williams, 2011). These dimensional frameworks of project complexity are often descriptive. The descriptive project complexity is useful when comparing projects or search for law-like relations between project complexity and related constructs, e.g. project management success. When the purpose of the research is to understand a given project or to provide managerial guidance, the perceived project complexity need to be included, because "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" (Vidal & Marle, 2008, p. 1096). Adding to this, it has been argued, that "Complexity is a subjective notion, reflecting the lived experience of the people involved" (H. R. Maylor, Turner, & Murray-Webster, 2013). So far, not much research has focused on the project complexity as a lived experience of projects as the managers muddle through, trying the navigate the unfolding project.

Rezende and Blackwell developed the previously mentioned work of Geraldi et al. (2011) into a guiding framework for practitioners and concluded with the request of : "… 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 change over the lifecycle of a project or program." (de Rezende & Blackwell, 2019, p. 139). This paper takes on that challenge, and states the following research question: *How can the dynamics of perceived project complexity be conceptualized?*

The research unconvered an ontological problem within the mainstream models in research of project complexity. Expectations and manifestations are two different sources of information, hence there is a need of distinguishing between an ex-ante and post-ante project complexity. Resolving this matter is a vital part of the above research question. To accomplich this, the paper coins the 'transitional perspective' as the intermediate between the 'ex-ante' and 'ex-post' stream of research

of project complexity, hence this is a central part of the theorizing of the lived experience of managing the dynamics of project complexity.

The remainder of this paper is structured as follows: Section 2 presents the literature study on project complexity. Section 3 gives a theoretical background for the theorizing. Section 4 layout a foundation for the development of a theory. Section 5 discusses the identification of generative mechanisms of project complexity. Section 6 presents the conclusion

2. Literature review

The research literature on project complexity is vast and diversified. This section presents the selection of papers viewed as relevant for the endeavor of this paper. The research of project complexity does not always have a managerial perspective, often the intention is to understand the nature of projects or to build a construct for the search of law-like relations.
While there is no commonly accepted definition of project complexity, many authors (Giezen, 2012; Luo, He, Jaselskis, & Xie, 2017; Mikkelsen, 2020b) have promoted the definition proposed by Vidal et al. (2011). Their definition states that: “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, & Bocquet, 2011, p. 719). This definition focuses more on the dynamics and consequences of project complexity and refrains from the assessment of the project complexity itself.
Understanding the research literature, a short history of project complexity research is helpful. This might start with Baccarini (1996), who argues that project complexity is consisting of many varied interrelated parts, and can be defined in terms of differentiation and interdependency and that it is managed by integration. For comparison, “general” complexity can be defined as follows: “The level of complexity depends on the character of the system, its environment, and the nature of interactions between them” (Cambel, 1993, p. 4). The essential difference is, that project complexity includes the managerial aspect by definition.
Williams (1999) coined the definition from Baccarini ‘Structural complexity’ (number of elements and their interdependence) and argued for adding ‘Uncertainty’ (uncertainty in goals and uncertainty in methods) based on (Turner & Cochrane, 1993). However, the element of uncertainty as a dimension of project complexity is still the topic up for debate - exemplified by (Padalkar & Gopinath, 2016).
Williams´s concept of project complexity was developed further by Xia and Lee (2004), who took the input from the above-mentioned authors and argued for widening the concept of uncertainty into the concept labeled ‘Dynamic complexity’, defined as “uncertainty, ambiguity, variability, and dynamism, which are caused by changes in organizational and technological project environments” (Xia & Lee, 2004, p. 55). The same dichotomy of structured versus dynamic project complexity can be found in for example (H. Maylor, Vidgen, & Carver, 2008), (Floricel, Michela, & Piperca, 2016), and (Daniel & Daniel, 2018). The latter defined the difference this way: (1) structural complexity focuses on interactions producing unexpected effects that cannot be explained or deduced, and (2) dynamic complexity focuses on processes that generate unpredictable change in systems. (Daniel & Daniel, 2018).
A systematic review of the research literature so far was conducted by (Geraldi et al., 2011) summed up the development, and concluded that the concept of project complexity had evolved to encompass five dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political. A comparable review performed five years later, argued for an expansion of this understanding to encounter eight dimensions: Structural complexity, Uncertainty, Emergence,

Autonomy, Connectivity, Diversity, Socio-political, and Element of context (Bakhshi, Ireland, & Gorod, 2016).
In the development of a project complexity assessment tool, H. Maylor and Turner (2017) argued for a division in structural complexity, sociopolitical, and emergence, where the latter can be assessed as the expected change of the two former constructs. A recent paper (de Rezende & Blackwell, 2019) - also based on Geraldi (2011) - argued for an assessment framework based on the following seven dimensions: Structural complexity, Uncertainty, Dynamic, Novelty, Pace, Socio-political, and institutional.
In the research stream devoted to finding law-like relations between project complexity and other constructs, e.g. papers like (Bjorvatn & Wald, 2018), (Bjorvatn & Wald, 2018), (Luo, He, Xie, Yang, & Wu, 2016), (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011), (Qureshi & Kang, 2015), and (Lu, Luo, Wang, Le, & Shi, 2015) the construct of project complexity is often a more narrow version of dimensions than the framework mentioned previously.

Summing up, it can be argued there exists a common ground in research regarding dimensions of project complexity. There is structural complexity and this needs to be combined with 'residual dimension' (or dimensions), where there are disagreements of the content of the residual part of project complexity The disagreements among scholars is mostly about the division of the dynamic side of project complexity, where suggested sub-dimensions include uncertainty, sociopolitical, emergence, change, along with many other proposed sub-dimensions.

Based on a review of 420 different publications Bakhshi et al (2016) found three dominant schools of thought within the construct of complex projects: the PMI perspective, the System of System (SoS) perspective, and the Complexity Theory perspective. These three will be addressed in the following.
The so-called 'PMI perspective' school of thought entails by far the largest number of publications of research on project complexity. The common nominator here is the dimensional approach. The contributions are sometimes expressed as abstract frameworks and other times as measurable constructs. But the review of literature of this school holds so much diversity, that calling it one school is an over-simplification. It has been suggested to divide the literature by intention of the research (Mikkelsen, 2020a) arguing for ontological frameworks, the search of law-like relations, and a managerial focus of the research.
The second school of thought was by Bakhshi et al (2016) only exemplified by Cynefin framework (Snowden & Boone, 2007) since not much work had been done at the time of the study. But later, more contributions on the SoS-perspective have been published, including (Kiridena & Sense, 2016), where complicated systems, complex systems, and complex adaptive systems are used for categorizing the level of project complexity. A similar categorization is found in (Daniel & Daniel, 2018), here labeled regulated versus emerging system properties. Daniel and Daniel (2018) introduced three levels of complexity, labeled: algorithmic, stochastic, and non-deterministic.
The third school, the Complexity Theory, was introduced rather late in the research of project complexity. A renowned example is (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007) The protentional of perspective 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.
Reflecting on the three schools of thought, the difference can be simplified as follows: The dimensional approach provides a 'vertical sliding' of a given project assuming the same kind of

system thinking can be applied to all. Counter to this, the SoS approach provides a 'horizontal' diversification for classifying projects according to what kind of system thinking can be applied. Complexity Theory on the other hand attempt to explain the complexity of complex projects – leaving the 'complicated' project (or part of projects) to be explained by conventional systems theory.

3. Theoretical foundation

The theoretical foundation of the paper is divided into two. The first half of this section develops a map of the research on project complexity using two sets of dimensions. One concerning the observer-project relation in time and another the dichotomy of perceived versus descriptive project complexity. The second half of this section presents a perspective on critical realism useful as a foundation for a theory of the lived experience of managing project complexity.

3.1 Time perspectives on project complexity

The 'time-perspective' describes the observations of the project based on one's position on the timeline. Logically, the observations can be made before, after, or during the project. These three time-perspective are coined ex-ante, ex-post, and transitional. Ex-ante, meaning before the event, is a concept known from the Keynesian expectances theory (Keynes, 1937). Ex-ante and ex-post have been used in project evaluation (Samset & Christensen, 2017), but the dichotomy is perhaps more known in evaluation methods, e.g. FEDS (Venable, Pries-Heje, & Baskerville, 2016). The transitional perspective captivates the lived experience of projects, that is the period between the ex-ante and ex-post. All three time-perspectives will be addressed in the following.

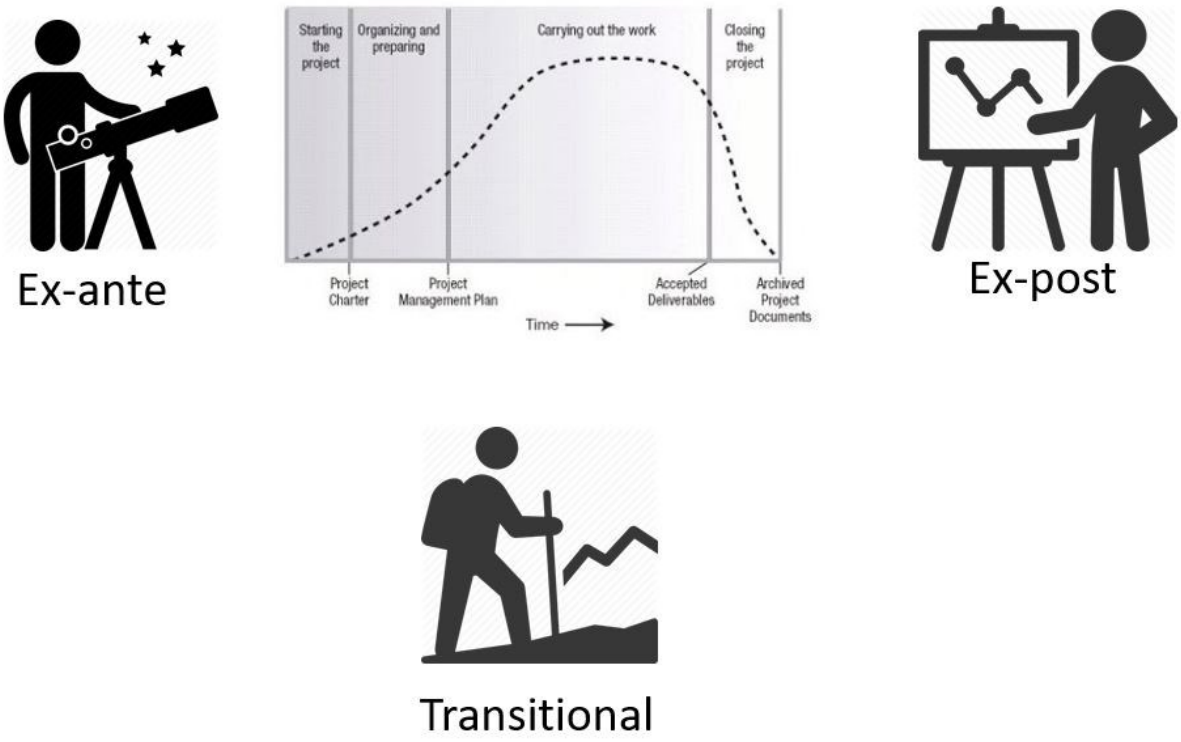

Figure 1: The three time-perspectives on project complexity

Ex-ante perspective

The ex-ante perspective on the project-based solo the initial information and assumptions. The assumption might be the participants' experience form on other projects in the past or drown from a broader knowledge relevant for the project. The ex-ante perspective on project complexity is found frequently in handbooks and tools like (PMI, 2014). Here the indicators of complexity are questions like: "Are the requirements likely to change?", "Is senior management fully committed?", "Will the supplier be able to meet the commitments?", and "Is the client prepared to accept deliverables?"

Ex-post perspective

Research in the ex-post perspective has the privilege, that all is knowable (at least in principle) since the project by then closed. All the answers in the previously mentioned assessment tool will no longer be mostly guesswork. Not only can we detect which requirements did change, but also have much they change, why, and when they change. Hence, a far better expiation can be given to why the project was *difficult to understand, foresee and keep under control* (s the definition of project complexity given in the introduction). Further, the benefits of researching projects as finalized objects give a solid basis for comparison of the projects and for searching for law-like relations.

Comparing ex-ante and ex-post

In social science, information about the future is different from information about the past. Social science does not operate like newtons laws; at best we can compare a project to trowing crooked deices. As the deice rolls, the 'events' are onlygiven as a probability distribution. After the roll, the 'events' are now observable manifestations. The same event will only happen again by change. Based on this allegory, it can be argued that the construct of project complexity is different when seen in the two perspectives, ex-ante and ex-post.

Since the ex-ante project complexity mainly is assumptions and expectations (probabilities), and the ex-post project complexity is observations and realizations (manifestations), arguments can be made, that ontologically they are two distinct constructs. Even if, the same indicators were used, the ex-ante and ex-post measurement of that indicator could only be the same if there was full predictability of the project. But projects are all by nature unpredictable, and complex projects are radically unpredictable (Cooke-Davies et al., 2007). The discussion of this does however not fit into the focus of this paper.

Papers developing frameworks for project complexity assess the dynamic dimension presuming the *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). Hence an ex-post perspective is needed. However, the utility of the framework is about the ex-ante perspective, e.g business case development, strategic choice, etc. One can not have an ex-post perspective of a given project ex-ante, such an 'omniscience' perspective does not exist.

The research streams of the two perspectives can benefit very much from each other. The ex-post produces knowledge of projects in general, and herby inform the ex-ante perspective of a given project. Researching the ex-ante perspective of a given project and comparing this to the result of the same project in an ex-post perspective, can provide very useful information on how the perception of the complexity of a given project can change during the project life cycle.

One example of Ex-post perspective of projects supporting the ex-ante perspective of a given project is known from 'Reference Class Forecasting' (Bent Flyvbjerg, 2008), here historical data of cost, duration, and benefit of projects are organized in project classes to utilize an increased precision of the estimation of a given project from the same class. While the method does not address the project complexity as such, the classification of projects could be based on indicators

complexity dimensions and indicators. The principle of a method like RCF is like the tide raising all boats. Ajusting for a historical average cost and benefit, the improve the estimation accuracy, is a good method when you are to ajust a portfolio of projects. The principle do however only litte, when the focus is on the lived experience of one given project.

The transitional perspective

The perspective of the project between project initiation and termination is neither an ex-ante nor an ex-post perspective. The perspective expresses the complexity of the unfolding project from initiation until project closure terminated and the ex-post perspective of the project complexity can be applied. It could be called the ex-temporal, but to express the unfolding and intrinsic dynamics of this perspective, it is here coined 'The transitional perspective'.

There is an overlap between the three perspectives. The transitional perspective will in the initial phase be much like the ex-ante, and much like the ex-post at the project closure. But in between the transitional perspective will differ from both the ex-ante and the ex-post perspective.

The transitional perspective is different from the ex-ante perspective, not only because the two dimensions are defined differently, but due to the increasing knowledge of the behavior of the project system. Assessment of project complexity in the initiation phase is mainly based on assumption, and as the project unfolds, the assumption will gradually be substituted by observations on the indicators.

The transitional perspective succeeds the ex-ante perspective. However, it can be argued, that the ongoing assessments made in the transitional perspective could be done using tools developed for the ex-ante evaluation. However, some of the questions from the initial phase would need to change to make sense in the later phases of the project lifecycle. Likewise, in the termination phase of a project, it can be said that the ex-post perspective can overlap with the transitional perspective when it comes to the choice of tools and frameworks.

Some indicators can for obvious reasons first be determined in the transitional perspective. Hidden agenda in the socio-political dimension (Geraldi, 2011) is an example of this. One can not know a hidden agenda, until it has been revealed. If there is information, that stakeholders have competing agendas for the project, these are not hidden agendas, only conflicting interests. Likewise, the low level of trust (Remington, 2016) can be difficult to assess on the forehand, but once revealed, it is obvious to see.

Complex projects can be seen as a process of "Connecting the dots" (Curşeu, Janssen, & Raab, 2012) where learning is essential. Realizing the unsupported assumption of the project is easier in hindsight than foresight, hence this information will come more often in the transitional than the ex-ante perspective.

Similarly, delusional optimism (Lovallo & Kahneman, 2003), leading to unrealistic expectations of what is possible within the budget and timeframe, will not reveal itself in ex-ante perspective – if it could, this would be deemed functional stupidity (Alvesson & Spicer, 2012). In the transitional perspective, where the project evolves in the unfolding universe, the actors find out which assumptions turned out as bad or sound assumptions and realize if the initial approved triple contains is realistic or not.

<u>Descriptive versus perceived project complexity</u>

Research of project complexity distinguishes between descriptive (objective) versus perceived (subjective) as illustrated in figure 2. Ontologically, the dichotomy descriptive/perceived related to the two basic traditions of science: realism versus constructivism. Realism assumes the truth to exist regardless of the observer, where constructivism is concerned with the perception made by the

observer. Epistemologically, there can arise some gray zones regarding the two traditions, since some dimensions of project complexity depend on human perception of the indicators used to determine the complexity dimension (i.e. the level of conflict in the political dimension).

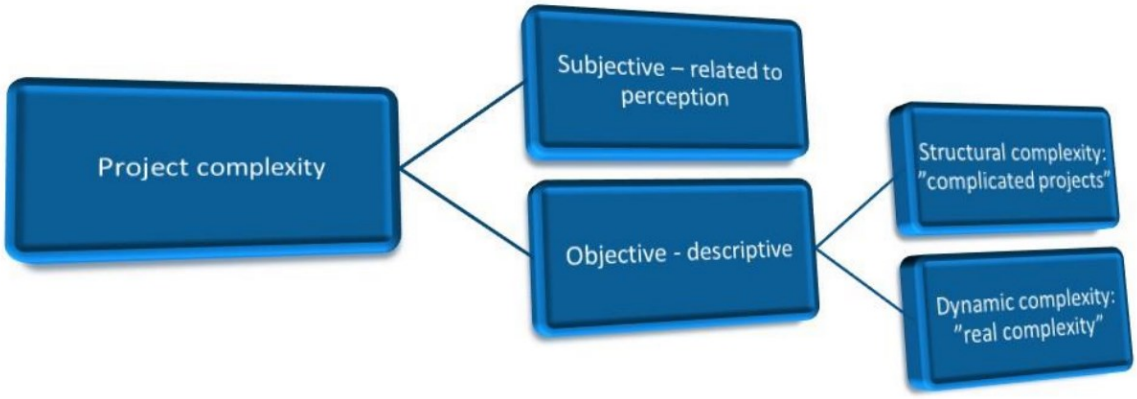

Figure 2: A common example of a breakdown of the concept of project complexity in research (Morcov, Pintelon, & Kusters, 2020, p. 13)

In descriptive project complexity, the information is 'out there' regardless of the observer - but "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" (Vidal & Marle, 2008, p. 1096). Further, the perceived complexity is not only a matter of what can be grasped, the concept of project complexity *itself* is perceived differently depending on which project role the perceiver holds (Mikkelsen, 2020b).
In a paper on human knowing, Schlindwein and Ison (2004) argue, that complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself. This quote places the complexity in the gulf between the traditions of realism and interpretivism. The paper argues that from an epistemological perspective, 'descriptive complexity' is based on the assumption of the existence of an objective reality, external and independent of us, and to which we can have privileged access, resulting in the assumption that complexity can be objectively measured. In contrast to 'descriptive complexity, the epistemological assumptions of 'perceived complexity are based on the assumption that reality results from the distinctions made by an observer" (Schlindwein & Ison, 2004).
Vidal and Marle defined the difference like this: 1) "descriptive complexity considers complexity as an intrinsic property of a system, a vision which incited researchers to try to quantify or measure complexity," and 2) "perceived complexity considers complexity as subjective since the complexity of a system is improperly understood through the perception of an observer" (Vidal & Marle, 2008).
Floricel et al. (2016) use 'intrinsic' versus 'representative' as a similar dichotomy to address both structural and dynamic complexity producing a 2x2 matrix.

Matrix of perspectives in project complexity
Combining the two perspectives gives a 3x2 matrix depicted in Table 1.

	Ex-ante perspective	**Transitional perspective**	**Ex-post perspective**

Descriptive project complexity. Information of the complexity exists 'out there' - in-depended of an observer.	Descriptive tools for assessment of the complexity of the project ahead.	Complexity Theory and abstract framework of project complexity.	Projects as finalized objects, e.g. for researching low-like relations of project complexity.
Perceived project complexity. The complexity exists in the eyes of the beholder(s), i.e. project manager or project stakeholder.	Frameworks for predictions based on a mutual understanding of the complexity of the project.	The lived experience of managing the dynamics of project complexity.	Retrospective (emancipative or interpretive) research of complexities in and around the projects

Table 1: Matrix of perspectives on project complexity

Table 2 displays samples of literature in the 3x2 matrix depicted in Table 1.

	Ex-ante perspective	Transitional perspective	Ex-post perspective
Descriptive project complexity.	(PMI, 2014) and (Bosch-Rekveldt et al., 2011)	(Cooke-Davies et al., 2007), (Zhu & Mostafavi, 2017), and (Daniel & Daniel, 2018)	(Nguyen, Nguyen, Le-Hoai, & Dang, 2015), (Qureshi & Kang, 2015), (Bjorvatn & Wald, 2018), and (Zaman, Jabbar, Nawaz, & Abbas, 2019)
Perceived project complexity.	(H. R. Maylor et al., 2013) and (de Rezende & Blackwell, 2019)	(H. Maylor et al., 2008), (Ahern, Leavy, & Byrne, 2014), and (Mikkelsen, 2020b)	(Davies, Dodgson, & Gann, 2016), (Floricel et al., 2016), and (Davies & Mackenzie, 2014)

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

3.2 Critical realism

A version of Critical Realism (CR) based on Bhaskar (R Bhaskar, 1998; Roy Bhaskar, 2013) and (Sayer, 1999, 2004) positioned CR in the gulf between the two traditions. In the words of Bygstad (2010)): Critical realism combines a realist ontology with an interpretive epistemology; although a real-world exists, our knowledge of it is socially constructed and fallible. Similar thinking is found in the paper of Mingers, Mutch, and Willcocks (2013), Critical realism can be expressed as the search for generative mechanisms based on a realist ontology, with an interpretivist epistemology, and methodological pluralism. CR is not used **as** much in research of project management but much more in research of Information systems.
Figure 3 depicts the stratification of reality by Sayer (1999, 2004). Figure 3 also illustrates different kinds of research. Using this notation, this paper is 'abstract research' analyzing project complexity

through the mechanisms and structures. Events are the observable part of reality. The mechanisms generate events but are themselves not directly observable.

The concept of 'Tipping point' is a good example of a mechanism (Easton, 2010), it has an observable effect and rests on a structure of sellers and buyers. The tipping point itself can not be observed but is an inference based on the observed events. The marked expectation is an example of conditions actualizing the mechanism. Mechanisms depend on the layer of structures. In order the generate events (or non-events) mechanisms must actualize. The actualization is contextual and can be caused by other mechanisms and/or events, and this can lead to the unpredictability of the resulting events. Mechanisms may interact with other mechanisms and hereby result in emergent behavior. Structures are the fundamental part of reality do not 'do' anything themselves, instead they give affordance to mechanisms. "Thus, structures are not deterministic, they have the potential to enable and constrain events through their inherent mechanisms" (Bygstad, Munkvold, & Volkoff, 2016, p. 2).

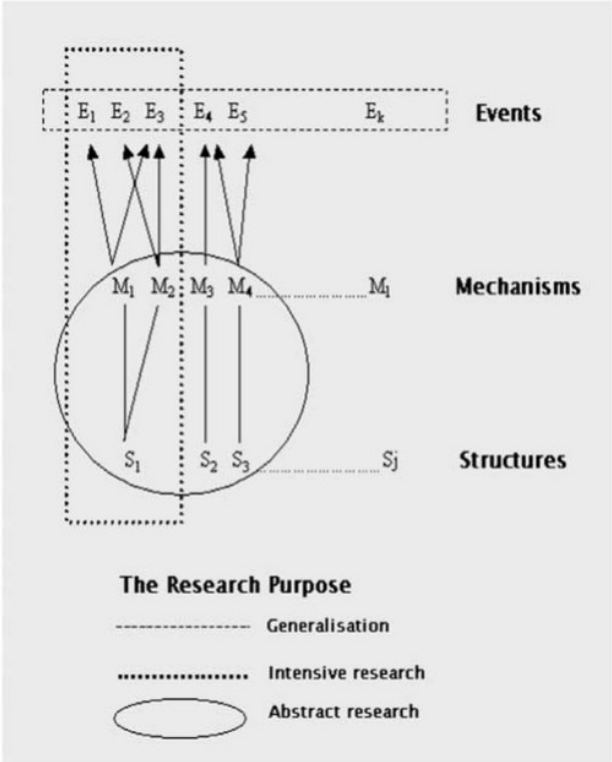

Figure 3: The layered ontology of critical realism and research strategies (Sayer, 1999).

An overview of the methodology of identifying mechanisms in Critical Realism is here provides by (Bygstad et al., 2016) building on (Wynn Jr & Williams, 2012):

(i) Explication of events: Identify the key events of the case, building on experience and abstraction. These events are outcomes, which we want to explain.

(ii) Explication of structure and context: Identify the human, social and physical entities of the case, and the relationships between them. These relationships may reveal emergent properties.

(iii) Retroduction: Identify the mechanisms (powers and tendencies) that explain the outcomes. The analysis should give logical and analytical support for the existence of the proposed mechanisms linking the structure to events.

(iv) Empirical corroboration: Ensure that proposed mechanisms have causal power and that they have better explanatory power than alternatives: Assess the explanatory power of each proposed mechanism with the empirical evidence.

(v) Triangulation and multiple methods: Use a variety of approaches to identify causal relationships and build on different sources and data types in order to explore the diversity of underlying structures and to control for bias.

4. Theory of project complexity management

The theory of the lived experience of managing the dynamic project complexity use the definition: "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 et al., 2011, p. 719). Following Bhaskar and Sayer, the theory stratified the project and its environment in three levels of reality: event, mechanism, and structure. Compared to the definition above, project behavior equals events. The project complexity can be explained as the result of actualized and interacting mechanisms resting on a structure of interrelated elements.
The proposed theory states, that the project behavior, which is difficult to understand, foresee and keep under control is generated by mechanisms in the project and its environment. To generate an effect, the mechanisms need actualization. The actualization is contextual and can depend on other mechanisms and/or **conditions**. The more mechanisms actualized the less predictable a project. The implication of this is, that the research not only should account for mechanisms in project complexity, the contextual setting of a given project must also be investigated.
As demonstrated in the literature review, there is a common acceptance of dividing project complexity into structural complexity and dynamic complexity. Building of the division, and stretching it a bit further, the argumentation is that structural complexity in project complexity equals the structural level in the stratification of critical realism. In a conceptual paper on project complexity, Kiridena and Sense (2016, p. 65) argue for the stratification of project complexity, where the structural complexity is the lower level and the dynamic aspect is the top level. There, the structural complexity is divided into technology, organization, and environment - like in the TOE-framework (Bosch-Rekveldt et al., 2011).
The proposed theory makes a presumption, that structural complexity is more fundamental than dynamic complexity, hence the structural complexity equals the structure layer in CR as it is defined by Sayer (2000). Further, the multiply dimensions that together form the dynamic complexity can be found in the mechanisms and conditions as explained by Sayers version of CR. While the dichotomy of structural complexity and dynamic complexity does not state the workings of reality like this, there is not found any argument against it either. There the presumption can be made, that mechanism of project complexity can be found in the so-called dynamic complexity.
The theory has a realist ontology of project complexity, meaning that the information of the property of the project exists ‘out there’ regardless of the observers. The challenging effect of project complexity can be found in the events. However, like the CR the theory uses an interpretive epistemology. All stakeholders (the project manager included) interact based on their perception of the given project and their individual understanding of the concept of complexity. These multiple perceptions are an intrinsic part of the ontology of project complexity.
With inspiration from Sayer's version of critical realism, the theory states that no event comes from structures directly. A mechanism needs to be actualized to generate the events, and the actualization depends on the context. Mechanisms can interact and herby generate the emergence of unexpected events in and around the projects. Events are the result of the actualized mechanisms. The unexpected and/or unwanted events that are causing the challenges for the project management (see the definition of the project complexity).

Based on the above stated, a theory of the lived experience project complexity management can be depicted as illustrated in Figure 3 depicting the stratification of project complexity in three layers.

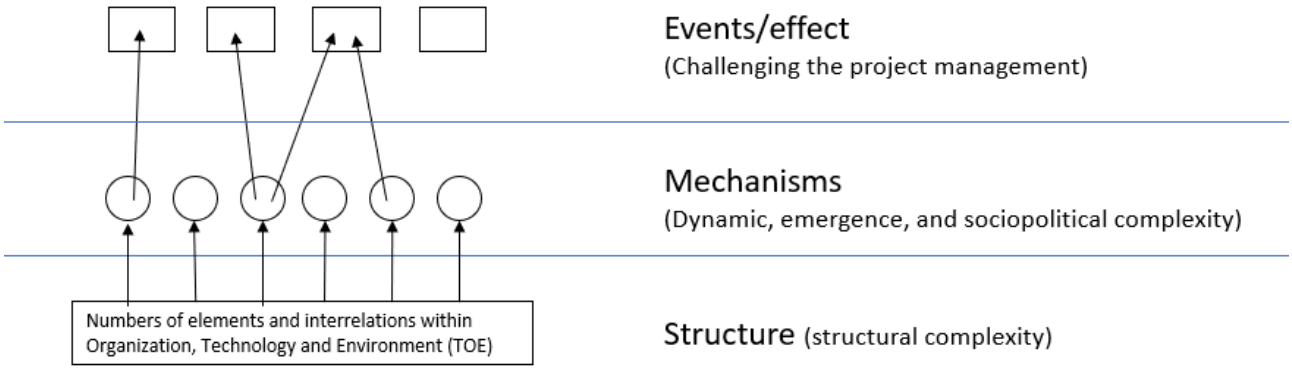

Figure 3: Stratification of project complexity in three layers

The project manager is selected during the project initiation. Here, the pre-ante perspective of project complexity applies to the given project. At the time of project initiation, the expectation of the given project is based on the perception of a similar historical project gained from an ex-post perspective of them.

The managerial challenges of project complexity are first and foremost to control events in and around the project. Since not all events are controllable, the management of project complexity should also attempt to enable or dampen the mechanism, and to investigate options for changes to the structural level. The engagement of the project manager has ended when the ex-post perspective of the given project. Throughout the project lifecycle, the project manager has lived experience of the project, including the so-called transitional perspective on the project complexity.

In the perspective of critical realism, a project can be seen as a sequence of events – some planned, others spontaneous, or random. There are also planned events, that never realized, the so-called non-events. In the environment of the project, there will be events influencing the project as well as initiated by the project. Part of the controls, project managers use to influence the project outcome, can be regarded as a mechanism. Project complexity can result from the lack of control mechanisms.

The lived experience of managing the project and its complexities is based on the perception of the events unfolding during the project lifecycle, from initiation to closure. No stakeholder – no even the project manager – has a full understanding of the mechanisms and their contextual uncertain actualizations. The structural complexity can be objectively assessed, but the causal connection explaining the events and outcome is beyond full understanding.

On determinism in the proposed theory
In research of project complexity, the positivist approach assumes linearity between the indicators of project complexity and the dependent variable, i.e. project management efficiency. Some examples are (He, Luo, Hu, & Chan, 2015) and (Bjorvatn & Wald, 2018). In (H. R. Maylor et al., 2013) and (PMI, 2014) the assessment is based on a questionnaire adding the score as an indicator of severity. One indicator can add one point no matter how extreme the given indicator is in the context of the project being assessed. In the case of descriptive frameworks for the assessment of

project complexity, like the one from (Geraldi et al., 2011) and (de Rezende & Blackwell, 2019) mentioned in the literature review, the assumption is seldom articulated.
The proposed theory assumed interactions across the dimensions posed by the framework. In other words, the dimensions could enable or constrain each other, as it would be expected from a Complexity Theory point of view (Byrne, 2002). The relations are presumed to follow the thinking in Critical Realism, stating that "Thus, structures are not deterministic, they have the potential to enable and constrain events through their inherent mechanisms" (Bygstad et al., 2016, p. 2).
The mechanisms need to be actualized to generate effects and/or events. To exemplify this, multiple stakeholders with opposed interests do not in itself do generate events, like a conflict. Between the structure of interest and the event, there needs to be actualized mechanisms for the causation to work. One of these might be information flow between stakeholders (internal or external). Another being stakeholder with contracting interests and capacity to pursuit own interest. Still, the mechanisms need to be actualized to generate events. The actualization is contextual, meaning in this case that conflict can only arise in case to supporting context. If, for example, one stakeholder might be short on the time to pursuit own interests, and then the 'conflict event will not be generated. Another example is a strong stakeholder with a hidden agenda, if the condition is that his/she is buzzy with other matters, the hidden-agenda-mechanism will not be activated.

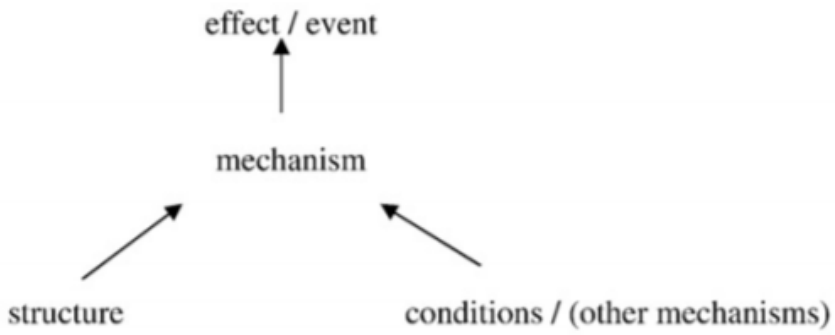

Figure 4: Critical realist view of causation (Sayer, 2008)

The proposed theory assumes enabling and constraining interactions between the dimensions (explained as structure and mechanisms) as depicted in Figure 4. The actualization of the mechanism is contextual, meaning that the conditions in or around the project must enable the mechanism. Adding to this, other mechanisms can serve as actualizing factors for the given mechanism. A low level of trust has been identified as a source of project complexity by Remington (2016). In the context of research of project management, trust seems to be more a condition than a mechanism.

5. Discussion

The paper set out to investigate how the dynamics of perceived project complexity can be conceptualized. The theoretical foundation in section 3 provided a structured view over the existing literature, that serves as a lens magnifying the area in focus: The lived experience of managing a project with all its unpredictability caused by project complexity. Section 4 proposed a theory of the dynamics of the perceived project complexity. The discussion in section 5 is sectioned into three parts. First, the proposed theory is compared to a central framework of researching project

complexity. Second, examples of mechanisms of project complexity are provided. Thirdly, consideration of the contributions is given.

5.1. Comparing dimensions of project complexity to the proposed theory

The first part of the discussion compares the proposed theory to the work of Geraldi et al. (2022). The CR view of causation in Figure 4 from Sayer (2008) sheds new light on the interaction of the five project complexity dimensions: structural complexity, uncertainty, socio-political, dynamic, and pace Geraldi et al. (2011). In the following, it will be argued that the dimensions pace and uncertainty is conditions rather than mechanism.

The pace of a project is in most cases be a reflection of market conditions or legislation. When pace is seen as a condition in the theory of project complexity management, then the pace is influencing events and effects through other mechanisms. In the framework from de Rezende and Blackwell (2019), they argue for a division of pace into speed and criticality. The given pace of a project is to a large degree a result of decisions making, often as a reaction to market needs or internal stakeholder expectations (including the decision-makers' ambitions). Due to the biased delusion of success, the decisions making regarding pace is overoptimistic leading to overrun (Bent Flyvbjerg, 2006). All else been equal, a short timeframe will challenge the project management, because more work and activities are going on at the same time. Therefore, there is less time to handle risk and fix errors and misunderstandings. A high pace can also lead to the actualization of resistance to change. There is reason to presume that the pace dimension in project complexity will have a U-shape relation to the challenge of project management. With a low pace, more changes in the project environment can happen during the project lifetime. The lack of time pressure can be a driver of complexity, since a prolonged life cycle might expose the project to external dynamics like organizational changes, changing priorities, new competition, etc, and is exposed to external risk for a longer time. As one example of this, a slow pace of the project will give more time for political influence to be actualized.

Like pace, uncertainty can hardly be seen as a mechanism within the paradigm of critical realism. The uncertainty dimension in project complexity derives from the definition given by Williams (1999), where it is defined as the uncertainty of goals and uncertainty of methods. From a critical realist point of view, uncertainty is related to the contextual actualization of the mechanisms. Using pace and uncertainty as conditional dimensions in the proposed theory of the lived experience of project complexity management, the framework of Geraldi et al (2011) can be illustrated as shown in Figure 5

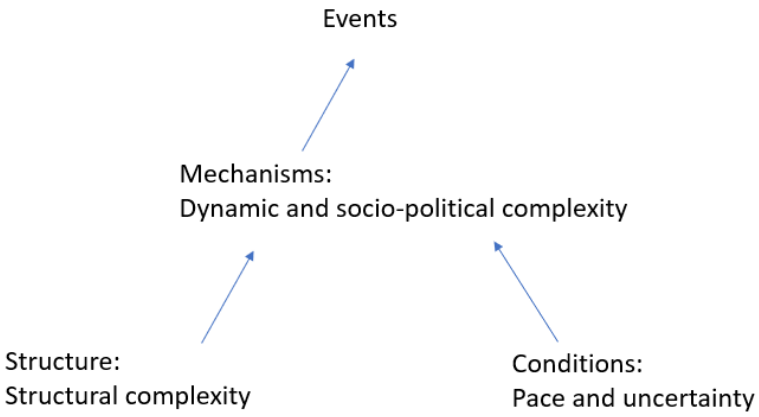

Figure 5: The five dimensions of Geraldi et al (2011) with Sayer (2008) as a lens

5.2. Exemplification of mechanisms in of project complexity

The second part of the discussion is an illustration of the search for mechanisms. To do this, some examples have been selected as displayed in Table 3. A sample of examples has been selected to demonstrate both specific and more general mechanisms. The theoretical search for mechanism has been based on 'reverse engineering', meaning the methodology order 1) Explication of events, 2) Explication of structure and context, and 3) Retroduction of mechanisms, that has been explained previously has been turned around, starting with the mechanisms found in literature where plausible structures/context has been found based on the first principle, and then probable events/effect has been assumed. The purpose of Table 3 is only to demonstrate stratifications that might be found in future research based on the proposed theory.

1: Explication of events/effects	**2: Explication of structure and context**	**3: Retroduction: Identify the mechanisms**
Un-expected stakeholder behavior	Many stakeholders together with a low level of trust	Hidden agenda (Geraldi et al., 2011)
Resistance to change	Several organizational units involved the projects benefits realization efforts	Unactualized Top management support (H. R. Maylor et al., 2013)
Change in project goals	Powerful stakeholders with divergent interests and available time for power jogging	Power struggles (H. Maylor et al., 2008)
Radical unpredictability	Interrelations among elements with more than one equilibrium	Tipping point (Cooke-Davies et al., 2007)
Decision making based on unrealistic expectations	Interrelations giving support to functional stupidity and high levels of delusional success bias	Stupidity (Mikkelsen, Marnewick, & Klein, 2020)

Table 3: Theoretical examples mechanism of project complexity

5.3. The potential benefits of the theory of project complexity

The proposed theory of project complexity management can enrich the research on project complexity by adding a better understanding of the lived experience of project complexity management. The dimensional frameworks are good for the research of project complexity in general but lack the affordance of a context-specific explanation of what is going on in the specific project. The theory of project complexity on the other hand gives rigor to the softer interpretive understanding of the working of a project. Further, the proposed theory provides a practical explanation of the radical unpredictability of projects leading to them having an emergent structure, hence the contribution might also fit into the development of a theory of emergence.

The benefit for the practitioners of project management from the theory of project complexity management derives from the focus on the unpredictability of actualization of the mechanisms, lead to a higher focus on early detection. The number one recommendation to practitioners based on the project complexity theory is: Early detection is vital to an appropriate managerial approach to handle the project complexity. Some practitioners might use the theory to take comfort in the observation, that they cannot be expected to explain the events and outcome based on the initial information about the project.

The theory also stresses the importance of a proactive mindset for the project manager. A reactive managerial response to project complexity is to wait for the events (or the lack of events) to manifest. A more pro-active managerial approach is to influence the context of mechanisms to dampen (or enhance) actualization – depending on the view of the resulting events. A pro-active approach may even influence the structural level – e.g. divide the project into smaller projects to be carried out successive or change the method and/or goals to something less uncertain.

6. Conclusion

The paper set out to theorize the lived experience of managing project complexity. Based on different perspectives regarding the time of observations versus the descriptive/perceived project complexity, a matrix of perspectives on project complexity was developed. The matrix positioned the research of lived experience of managing project complexity in the overall research literature on project complexity.

With inspiration from critical realism, a theory has been proposed. The paper then when on to discusses the utility of the theory. Particularly the recommendation for identifying the generative mechanism. While there is still much to be researched, the presented theory of project complexity holds the potential for contributing to the research of project complexity, especially the management hereof. Adding to this, the theory might prove very practical given support for the practitioner struggling with the complexity of their projects.

Future research may include the identification of mechanisms and context actualizing them. Much research is needed to excavate the mechanism of project complexity. Building on this, research of strategies for enabling or dampening the mechanisms may help practitioners of managing project complexity.

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Researching navigation of project complexity using action design research

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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 CNW 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 ADR 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). 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), but there was not then an adequate theoretical basis concerning complexity and its management on which to draw.

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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). 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). 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) 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. Amongst the different methods for conducting DSR, the research reported in this paper employs the action design research (ADR) 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 (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 focusses on developing a practical solution to aid practicing project managers in managing project complexity.

Importantly, while prior empirical literature on the management of complexity focussed 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 organisational 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 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 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 towards 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 towards 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 towards 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) 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), 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). Williams (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). 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 organisations 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.

Amongst 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 characterised 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 *et al.* (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 visualising 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 (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 amongst three schools of thought in project complexity by Bakhshi *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 whatkind of system domain (e.g. in our case, a particular project system) is at hand.

(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 do not 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 focusses on creating a new purposeful artefact to address a general problem. 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, 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).

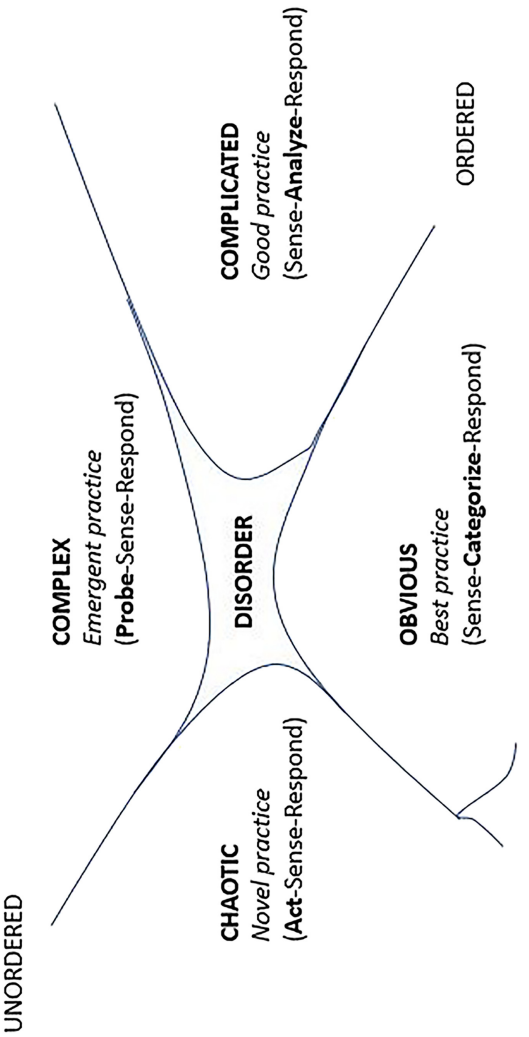

Figure 1.
Cynefin framework (adopted from Mikkelsen, 2018)

In DSR, a research opportunity arises in the environment (Hevner, 2007), e.g. a problem occurring in business practice. We found our problem amongst project managers, who struggle with handling project complexity. The end goal of this research is to develop an IS artefact as a 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 towards a desired destination (a situation that is less complex and therefore more easily manageable).

Sprague and Carlson (1982) proposed the 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 DSS 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 amongst 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 ADR (Sein *et al.*, 2011) as the DSR methodology for this research.

ADR is a research method and approach that combines DSR with AR. (Avison *et al.*, 1999; Baskerville and Wood-Harper, 1996; Iivari and Venable, 2009). In ADR, like in AR (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.

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

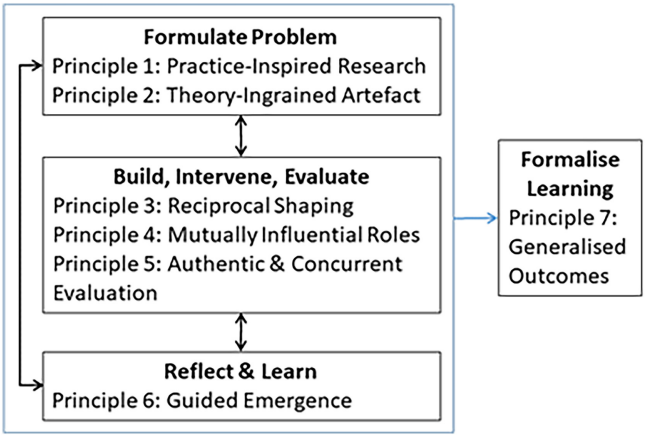

Figure 2.
Action design research activities and principles (Sein *et al.*, 2011)

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 DSS) 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 5, 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 SoSs 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 2×2 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 focusses 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 CNW 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 CNW 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 CNW, was the realisation that the 5th Cynefin domain (disorder) corresponds to the disagreement amongst 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 CNW 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 CNW. Importantly, because sub-parts of a project can be expected to be spread over more than one quadrant, different strategies may be required for different project sub-parts.

4.2 The labels of the artefact

(1) The choice of labelling 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

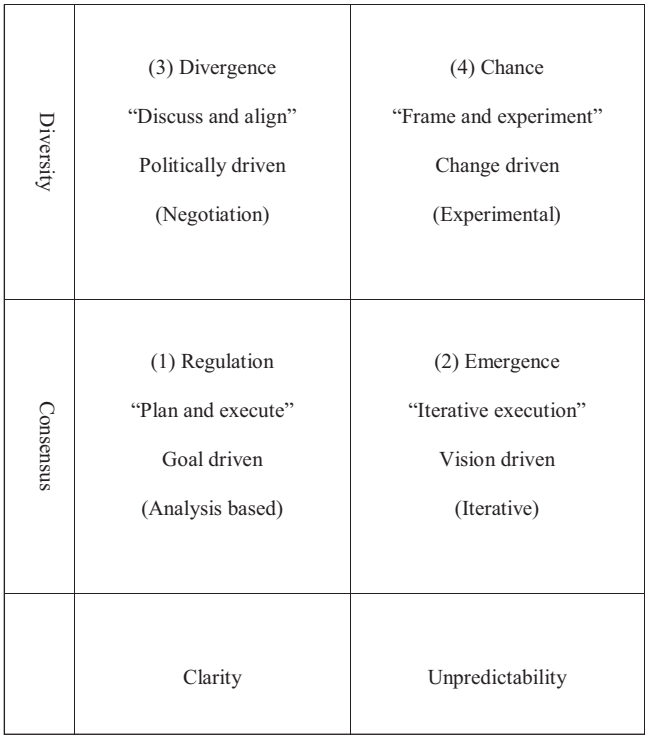

Figure 3.
The Complexity Navigation Window

strategy of its project management should be "plan and execute" and the project life cycle can be guided by the initial defined project goal.

(2) The second quadrant is labelled "emergence" with reference to the work of Daniel and Daniel (2018) as above. In the emergence quadrant, the unpredictability of a system makes it complex (as opposed to "only" complicated). The strategy of the quadrant should be iterative and the direction of the project life cycle should be guided by a vision (since an initial 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 amongst 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.

4.3 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 decision-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 CNW, where each of the four squares calls for a unique strategy.

4.3.1 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.

4.3.2 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 10 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. 1,018). 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 PRINCE2 Agile (AXELOS, 2015).

4.3.3 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 towards 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). 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 organising 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 will not 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)

4.3.4 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. 1,019), 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 breakdown structure leading to a set of experiments to be carried out, and the result which will inform the temporal problem breakdown structure and hence the situational scope of the project or sub-project.

4.3.5 An overarching strategy for quadrant hopping. Two things are important for the user of the CNW to keep in mind: (1) The division of a project in sub-project is not a fixed or given breakdown 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), then the methods for evaluation, and finally, the findings of the evaluation of the CNW.

As introduced in Section 3, this project used the FEDS (Venable *et al.*, 2016). The FEDS evaluation design process is composed 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.

Based on an assessment of project goals and risks, the relevant FEDS strategy chosen for this work is the human risk and effectiveness (a.k.a. human usability) strategy (see Figure 4): focussing early on formative (compared to summative) evaluations, but moving quickly towards 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.

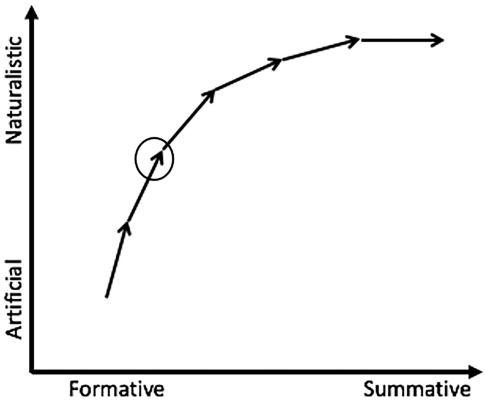

Figure 4.
The human risk and effectiveness evaluation strategy from the FEDS evaluation framework. Circle indicating the current state

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 and 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 focussed 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 was 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 SD 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.

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 SD (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

Table 1.
The result of 16 project managers evaluations of the artefact

#	Question	Average	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 dialogue with the project owner?	8.5	2.3

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.

Based on Table 2, the value of the artefact is most significant for project-setup and stakeholder management. The latter had a very low SD, 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 SD 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 organisations.

5.2 Qualitative evaluation of the Complexity Navigation Window

The flowing qualitative data are 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 CNW to illuminate exactly this problem in the collaboration between the project owner and the project manager. These comments illuminated very different worldviews amongst 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 CNW, 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 CNW. 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 amongst 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".

Table 2. The results of 16 project managers' evaluations of the artefact in the area of use

#	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	Organising	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

The borders in the CNW 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 CNW, 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 DSR 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 CNW 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 CNW 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 project 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 amongst the multiple stakeholders. A computer-based DSS 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 amongst 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 ADR 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 artefact can foster a fruitful discussion between research and practice. With ADR it becomes possible for researchers to put a radical different "thing" (like the CNW) "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 ADR 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 amongst researcher from different paradigms as they attempt to advance knowledge" (Johnson and Onwuegbuzie, 2004, p. 16).

The use of ADR 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 *et al.* (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 AR, 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 CNW, 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 CNW 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 CNW 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.

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.

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.

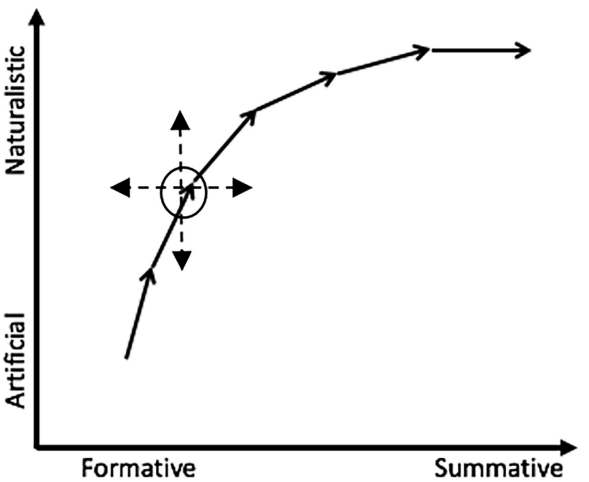

Figure 5.
The path of the evaluation strategy can be hard to predict in exploratory DSR projects

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 DSR and applies the ADR methodology, which are not often used in research on project management. The design of the CNW 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 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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IT-enabled management of project complexity - An Action Design Research project

1. Abstract

Project complexity has been researched much. The majority of publication is searching for law-like relations or development of descriptive frameworks. More prescriptive knowledge is needed to guide the 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 et al. 2021). The purpose of the paper is to investigate the research of prescriptive knowledge on the management of project complexity.

Based on a longitudinally case study, this paper use 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 recipient 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.

The findings from the research project are presented using the affordance theory (Gibson 1977) as a framing concept and give special attention the affordance perception (Pozzi, Pigni et al. 2014). 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. Due to the relevance of the information system indicated by the evaluations, the recipient organization decided to scale up the implementation.

The paper contributes on two levels. The paper presents a novel approach to researching project complexity based on engaging the stakeholder in generating a common perception of the ongoing state of the projects. The paper also contributes 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,

International Journal of Managing Projects in Business

Maylor et al. 2011). The subsequent review of research literature shows that only a few have followed up on their 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 project pursuit a contribution based on research-based practical guidance to project managers embedded in an information system.

The paper adapts the following definition of project complexity: "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. As the literature review will document, 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 "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" (Vidal and Marle 2008). There exist only a few papers on perceived complexity (Mikkelsen 2020). When it comes to helping the practitioners, the limited research on perceived project complexity is considered to be a far bigger problem than the scholarly disagreement on descriptive models.

The majority of research literature about project complexity deploys a postmortem perspective, meaning an approach where the researched projects are assessed as finalized objects, where all the changes have happened, and the outcome of the projects are known. In this case, the construct captures the entire project lifecycle and returns one value of the complexity. This hindsight perspective is here labeled the ex-post assessment of project complexity. A minority of the research literature is devoted to the ex-ante assessment of project complexity, where only the initial information about the project is available. Ex-ante assessments are by nature merely assumptions about the given project. The forsigth in the best case qualified by knowledge about the average and deviation of similar past projects. The complexity construct here will be different form the ex-post, since the remaining of the project is unknown (or even unknowable). Only very few papers has adressed the 'current complexity', the transition from ex-ante to ex-post perspective on the project, which is coined the transitional complexity – The lived experience of dealing with the percieved complexity from project initiation to closure.

Following the definition from Vidal & Marle (2008), a project manager cannot deal whit the whole reality and complexity of the project. In hindsight when the project has evolved and revealed its 'true complexities' it is much easier to determine a better course of actions than the one followed based on foresight. While practitioners can learn much about project management from the hindsight of past projects, their main focus will be on the foresight of the project at hand. When talking about hindsight and foresight it is important to notice 'of which projects' we are talking about. To avoid confusion, the following must be kept in mind: The ex-ante assessment of *a given current* project can be qualified by the ex-post assessments of *other projects from the past* (preferable similar projects). The given project can - after closure - conduct an ex-post assessment of complexity, but then it is too late

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in terms of decision making in the given project. The decisions seems to disappear into the fabric of the project history and are easily forgotten in the research by a hindsight approach. To counter this, the help from research needs to come through action research of some kind.

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. Wise 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 practitioners point of view, there is 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 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 labeled "the expected project complexity" and the ex-post perceived project complexity can be labeled 'the remembered project complexity'. All three expressions point to the subjective perception of project complexity.

To conclude there are multiple problems to address with research-based help to practitioners handling complexity. In short, the ex-post descriptive research approach might be another world view than the one deployed by practitioners, who are limited by the perceived project complexity and are more concerned whit a forward-looking perspective on the given project.

There is still much to find out about how practitioner perceives project complexity when trying to develop information systems for handling complexity. It is presumed, that research-based guidence to practitioners is best provided in a collaborative effort. Just as practitioners cannot comprehend the descriptive project complexity (in the words of Vidal), we must assume that researchers cannot comprehend the challenge faced by the project managers of decision-making based on the perceived project complexity.

Based on the problem decription above, this papers state the following: H*ow can an information system be developed to provide affordance for project complexity management 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 reaming of the paper is structured as follows: In section 3, an literature review is conducted and is presented as background. In section 4, the framing concepts are presentet and further developed. Section 5 present the methodology, section 6 results, and section 7 contains the discussion of both the

International Journal of Managing Projects in Business

resulats and the metholdogy used in the context for researching project complexity. The paper conclude with setion 8.

3. Background / literature review

Baccarini (1996) found that the term 'complexity' was used in the research literature on project management without clarity. He stated that project complexity is "consisting of many varied interrelated parts" (Baccarini 1996), and argued it could be operationalized in terms of differentiation and interdependency and found that it can be managed by integration. Baccarini (1996)also noted that there is both an organizational and a technological aspect to the concept. A few later Williams (1999) concluded 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. William argued his case based on Turner and Cochrane (1993) although they did not focus on project complexity.

In a paper about IS project complexity, Xia and Lee (2004) define it with 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. Xia and Lee (2004) define structural complexity as "variety, multiplicity, and differentiation of project elements; and interdependency, interaction, coordination and integration of project elements." They define dynamic complexity as "uncertainty, ambiguity, variability, and dynamism, which are caused by changes in organizational and technological project environments" (Xia and Lee 2004).

The use of Complexity Theory was introduced relative late in the research stream of project compleity, with (Cooke-Davies, Cicmil et al. 2007) as a renowned example. The focus here is radical unpredictability. The protentional 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.

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 and mentioned in 4.1.1. The pace dimension was identified via (Williams 2005) and the socio-political dimension was identified via (Maylor, Vidgen et al. 2008).

One model for assessment of project complexity is found in (Bosch-Rekveldt, 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. Among other tools for assessment can be mentioned the Complexity Assessment Tool (Maylor, Turner et al. 2013), where the three dimensions are structural complexity, socio-political, and emergence. More on these tools will follow in a later section of this literature review.

Summing up, it can be argued there exists some common ground in research regarding dimensions of project complexity. Most scholars agree on two aspects. 1) The structural complexity (the Baccarinial definition) is included in project complexity. 2) This structural complexity can not stand alone, there is some 'residual dimension' (or dimensions). The disagreements revolve around the content of the

International Journal of Managing Projects in Business

'residual part' of project complexity. The disagreements among scholars are mostly about the division of the dynamic side of project complexity, where suggested sub-dimensions include uncertainty, sociopolitical, emergence, change, along with many other proposed sub-dimensions.

So far the focus has been on providing an overview of the mainstay of the literature. Among the exceptions, some are worth mentioning in the context of this kappa.

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 do. This is a point worth noting, when the aim is to help practitioners.

Focusing on the lived experience and 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.

In the research literature, perceived project complexity is very different from the descriptive (objective) project complexity. The subjective notion of project complexity (as something other than the "real" project complexity) is often referred to as perceived project complexity.

The work of Baccarini (1996) presented reflections on subjective perceptive versus objective approaches. Baccarini considered perceived project complexity but rejected it because "this meaning of complexity has a subjective connotation implying difficulty in understanding and dealing with an object" and because it has an "unreliable basis for research analysis" (Baccarini 1996). Much interpretive research has contested this line of thinking, but it has influenced research on project complexity.

The dichotomy of perceived and descriptive project complexity also appears in research on complexity in general, where (Schlindwein and Ison 2004) state that "Complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself" and go on to explain that "In contrast to 'descriptive complexity,' the epistemological assumptions of 'perceived complexity are based on the assumption that reality results from the distinctions made by an observer."

Building on (Schlindwein and Ison 2004), the term perceived project complexity was coined by Vidal and Marle (2008). Their paper provides 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 mentioned previously, the perceived project complexity is relevant to understand the practitioners handling of 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."

Floricel, Michela et al. (2016) use 'intrinsic' versus 'representative' as a similar dichotomy to address both structural and dynamic complexity producing a 2x2 matrix of four different perspectives on project complexity.

An alternative depiction to the 2x2 matrix is shown in figure 1, here it is only in the descriptive perspective the differentiation of structural and dynamic complexity is relevant.

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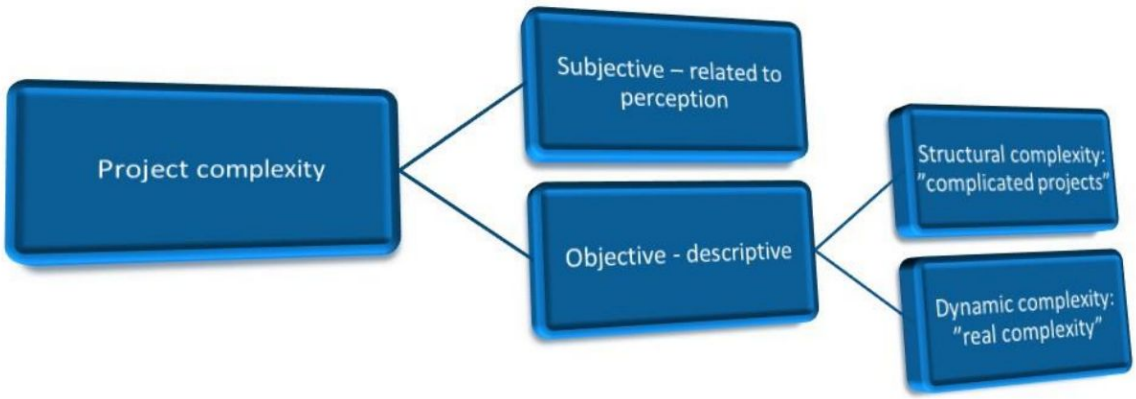

Figure 1: A common example of a breakdown of the concept of project complexity in research (Morcov, Pintelon et al. 2020)

Given the percpection is sujective, there there will be multiple perception of the complexity of a project. Based on a large survey among practititioner, 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 understande the overall perception of project complexity.

As mentioned previously, there is not much research on the perceived project complexity nor did the literature review find many papers researching the forsigth of project complexity. Some were found, that has the focus of helping practitioners navigate the project complexity. Maylor, Turner et al. (2013) developed the Complexity Assessment Tool (CAT) with contains 21 questions to assess the structural complexity, 11 questions to assess the socio-political complexity. The assess the third dimension, emergence, the tool asked is the answer given to the 32 questions was expected to change. CAT is somewhat similar to a handbook tool developed by PMI (2014) aiming to give guidance to navigate the project 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). The paper stresses, that this framework is for dialog – not for measuring project complexity, whis is the case for the two previously mentioned assessment tool.

Since complexity drives radical upredicitbilty (Cooke-Davies, Cicmil et al. 2007), it seems clear that ex-ante and ex-post would be ontologically distinct constructs concerning project complexity ‘ex-ante project complexity’ is based on assumptions about the future opposite to the ‘ex-post project complexity’ which is based on observation on finalized projects. Assumptions will only equal observations when there is no unpredictability. However, the research literature seems to trait them alike. At least in the literature review, there was not found any justification of the assumption, that ‘ex-ante project complexity’ equals ‘ex-post project complexity’. Nor has any discussion of ex-ante versus ex-post been found. If the two constructs are very dis-alike, this too is a problem, when the help to the practitioners is based on the research literature.

4. Conceptual framing

4.1.1. The chronological perspectives on project complexity

Previously was the concept of hindside and foresight perspectives of projects presented. The following section is a further elaboration on this perspective, here labeled the ‘chronological perspective’.

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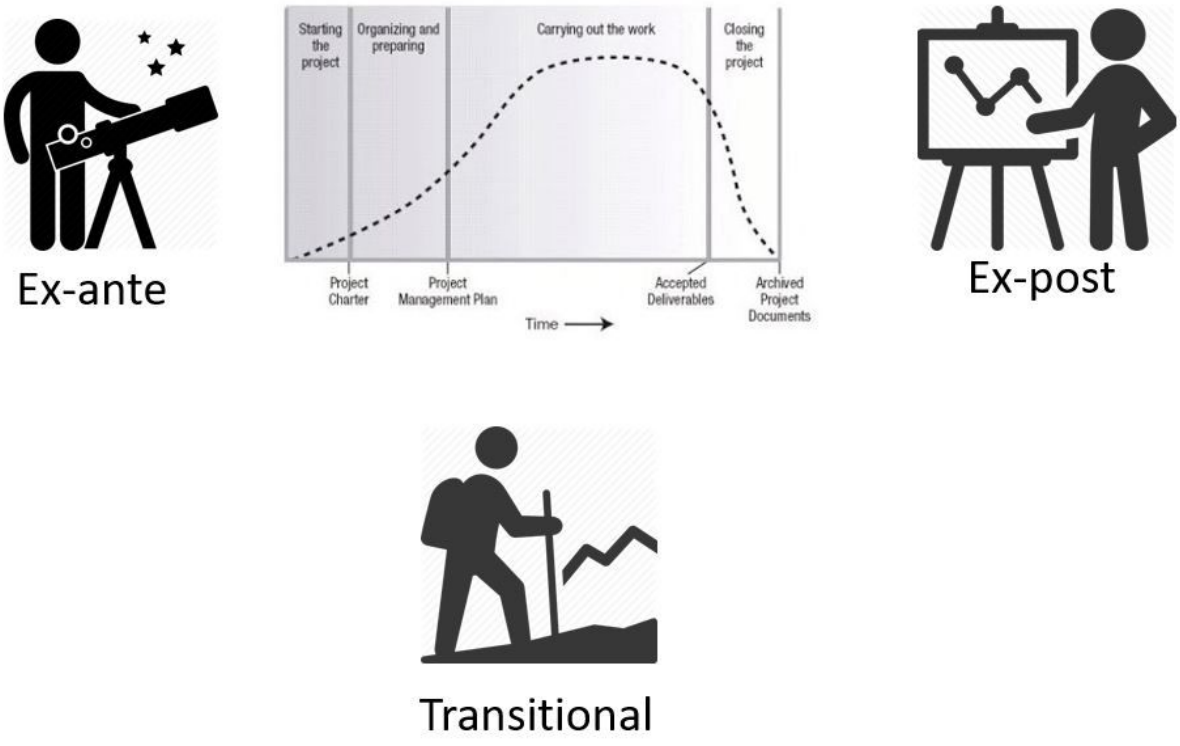

Figure 2: The three chronological perspectives on project complexity

The chronological perspective describes the point of observations of the project based on one's position on the timeline. Logically, the observations can be made before, after, or during the project. These three chronological perspectives are coined ex-ante, ex-post, and transitional. Ex-ante, meaning before the event, is a concept known from the Keynesian expectances theory (Keynes 1937). Ex-ante and ex-post have been used in project evaluation (Samset and Christensen 2017), but the dichotomy is perhaps more known in evaluation methods, e.g. FEDS (Venable, Pries-Heje et al. 2016). The transitional perspective captivates the lived experience of projects, that is the period between the ex-ante and ex-post.

The differences between the three chronological perspectives can be illustrated this way:

- 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 managerial challenging do we expect 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.

The focus of the investigation will be the transitional perspective.

Hindsight/foresight misconceptions in project complexity research

With the chronological perspective comes also more clarity and the opportunity of pointing to misconceptions of other scholars' work. In the following, two examples are presented.

Geraldi, Maylor et al. (2011) state that utility of their framework (with the dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political dimension) business case development, strategic choice, process choice, managerial capacity, managerial competencies, and problem identification. (Geraldi, Maylor et al. 2011). This application is a part of the project initiation, and therefore the framework takes an ex-ante perspective on projects.

This is however problematic because some of the dimensions are mostly ex-post or at least rather late in the project life cycle, hence deploy a transitional perspective. The framework developed by Geraldi (2011) state that the dynamic dimension express *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, Maylor et al. 2011). This information can however not be obtained from an ex-ante perspective to the project. Another problematic dimension is the social-political, where 'hidden agendas' are frequently mentioned as the source on the socio-political dimension, and hidden agendas can per definition only be known (to others) in hindsight. In the ex-ante perspective, this would simply be 'the stated interest of project stakeholders.'

In short, the Geraldi (2011) framework presume to assess (part of) the project complexity ex-post. This does not support the claimed ex-ante utility of the framework. Unless time travel is invented, this is not possible.

Another renowned model, The TOE model (Bosch-Rekveldt, Jongkind et al. 2011) has three dimensions of project complexity: Technical, organizational, and environment. The dimensions as assessed by 50 indication questions (Bosch-Rekveldt, Jongkind et al. 2011), where some are based on foresight ("Do you expect …".), some are in the present tense ("What is …." and; "Do you …".), and some in the past tense ("Did the project …".). The mixing of tense indicates that the authors have not really where in time the observations should be made.

These two examples indicate that misconception on foresight versus hindsight can occur in the literature on project complexity, however, no effort has been done to investigate the commonness of this issue. The misconceptions can be seen as a result of not researching in collaboration with practitioners, where such errors might have been detected.

4.1.2. Matrix of perspectives on project complexity

Combining the dichotomy of perceived and descriptive complexity with the chronological perspective developed in 2.5.2 gives a 3x2 matrix as depicted in Table 2.

The indicator used to differentiate between descriptive versus perceive 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.	Descriptive tools for ex-ante	Framework for assessing *the*	Projects as finalized objects,

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One measure of project complexity - the information of the complexity exists 'out there' in-depended of an observer.	assessment of *the* complexity of the given project ahead.	current project complexity throughout the project life cycle.	e.g. researching low-like relations - often on multiple projects
Perceived project complexity. *Multiple (subjective) interpretations* of the complexity of a given project, because the complexity exists in the eyes of the beholder*s*, i.e. project manager and project stakeholders.	The multiple expectations of the dynamics project complexity	The lived experience of the dynamics of project complexity.	Multiple interpretations of the history of the given project.

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

4.1.3. Affordance theory

When introducing an information system (IS) as a part of the solution, the conceptual framing must include IS theory. The IS success concept (DeLone and McLean 1992, Delone and McLean 2003) is included in the overarching conceptual framing. In this concept, success with information systems is broken down into three components: information quality, systems quality, and user satisfaction. These components lead first to individual impact, then organizational impact.

The IS success concept from DeLone and McLean is not strong on the perception perspective, so affordance theory guides the implementation of the ADR project. The original tenets of affordance theory (Gibson 1977) declare that a goal-directed actor perceives an object in the environment in terms of how it can be used, i.e. what it "affords" the actor in terms of action possibilities for meeting the actor's goal. In this case, the object is the artifact, and in affordance theory, the artifact is therefore not viewed as a set of characteristics or features that are inherent in the artifact nor is the artifact independent of the actor's perception of it.

Over the years, affordance theory has evolved to include the affordances perception and affordances actualization before realizing the affordances effect (Pozzi et al, 2014). See Figure 3.

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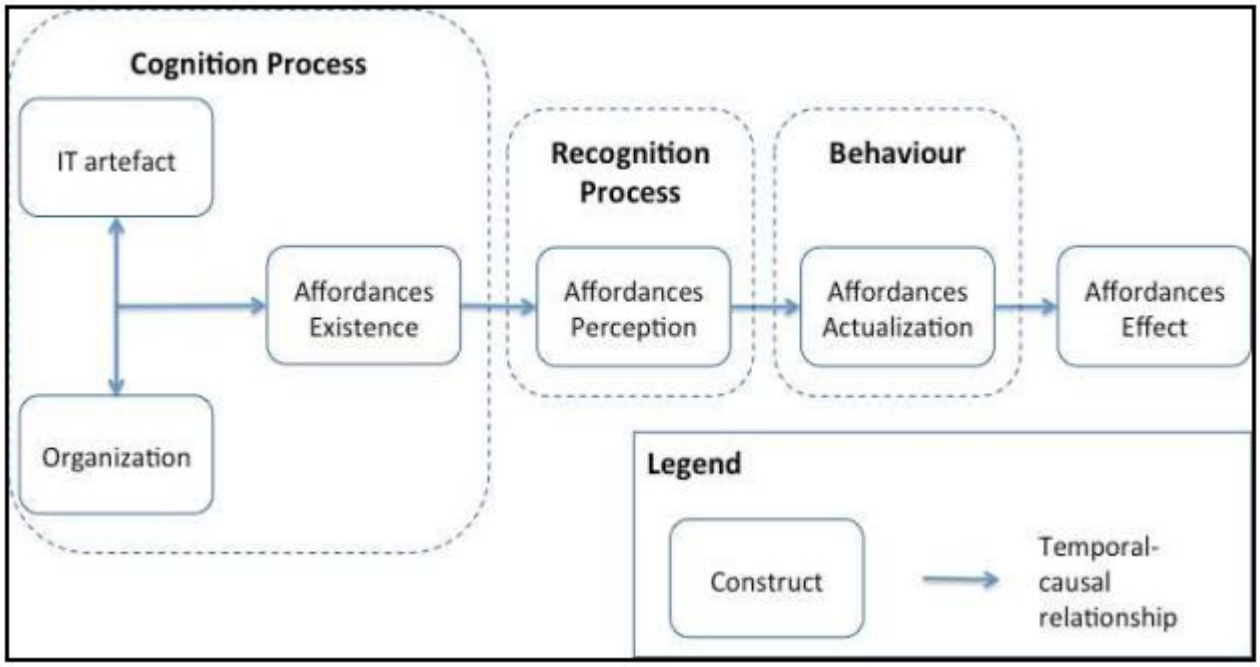

Figure 3: Affordance theory in the evolved version as presented by (Pozzi, Pigni et al. 2014)

The temporal-causal relationship in Figure 9 depicts the creation of affordance as a cognition, where affordance perception is a recognition process. With the focus on behavior as an intermediate before the effect, the affordance theory opens a broader perspective on organizational change.

Several factors can influence actualization. Pozzi et al. (2014) mention the following aspects: 1) needed effort of action, 2) cognitive load on actors, 3) goals of actor, 4) organizational and environmental structure and demands, 5) willingness to change behavior and 6) organization's level of skill or knowledge.

Most importantly, the actualization depends on the perception of affordance, as depicted in Figure 9. In this ADR project, there were some profound examples of how affordance misperception prevented the actualization of affordance. Where the intended affordance was the navigation of project complexity, the artifact might have been misperceived as a satisfaction measurement given all kinds of uncontrolled affordances to the manager of project managers and perhaps also HR.

4.1.4. Outside view

Since the introduction of bounded rationality (Simon 1972), the impediments of human decision-making have been the subject of much research. Among this research, the concept of "delusional optimism" (Lovallo and 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 and Kahneman 2003) is a mainstay design principle in the artifact developed in this ADR project. The outside view is explained in the following paragraphs.

Thinking in terms of 'Bounded rationality' (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 and 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" (Flyvbjerg 2006),

The outside view has inspired the development of an estimation technique called Reference Class Forecasting (RCF) (Flyvbjerg 2007, 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" (Flyvbjerg, Garbuio et al. 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 and 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."

A possible danger in seeking information through the wisdom of crowds based on stakeholders is that of "groupthink" (Janis 1972). Groupthink occurs when a group of individuals aims to reach a consensus on a controversial topic. Groupthink can occur during group decision-making when group cohesiveness is high (Janis 2008). The use of an information system with the response are collected individually - rather than having issues discussed within groups – the groupthink risk is mitigated. The information system aggregates the data and presents these on a dashboard in a DSS.

5. Methodology

Action Design Research (ADR) (Sein, Henfridsson et al. 2011). ADR is often used in Information Systems research but is less well known in Project Management research (Mikkelsen, Venable et al. 2021).

Atkins Denmark, an engeenerings company, accepted the invitation to become the recipient organization in the ADR project, where a prototype was developed and evaluated as an artifact for IT-enabled management of project complexity.

This research is driven by the design of artifacts, hence it is of methodological importance to realize "that the artifact itself has some representational power: an artifact can assist with the communication of the design principles in a theory" and that "design principles and theory can be extracted from observation and inference from already instantiated artifacts." (Gregor and Jones 2007).

In ADR, as in AR more generally, 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 18.

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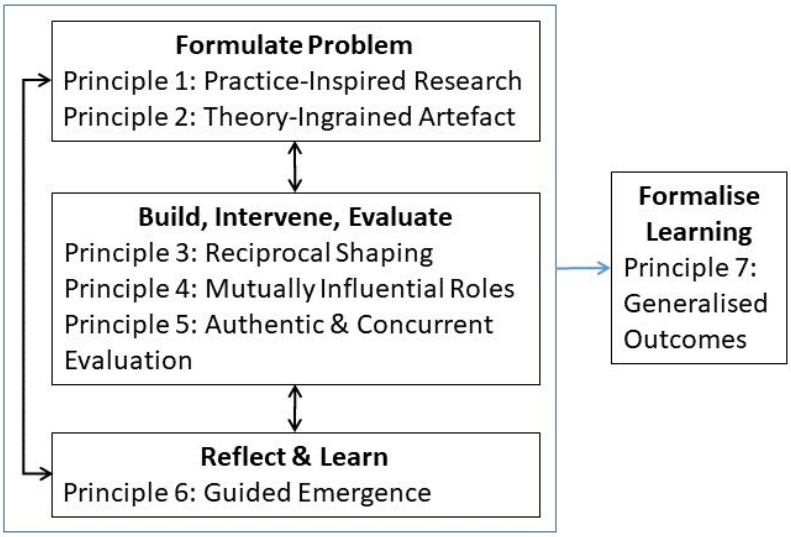

Figure 4: Action Design Research activities and principles (Sein et al., 2011)

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.

Similarly, ADR Principles 3, 4, 5, and 6 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.

An artifact for navigation of complexity (Mikkelsen, Venable et al. 2021), was selected for implementation in the ADR. The artifact was named Complexity Navigation Window (CNW) and is depicted in Figure 20. The affordance of this artifact is to guide the user to select a suitable managerial approach to the current state of the project. The four represented strategies are very different in the approach to the project.

From the evaluation of CNW it is know, that pracitioners acknowledge the importance of choosing the most suited of the four managerial approached, however find it hard to identify in which of the four quadrants the project currently belongs to. This is were an information systems might provide navigation affordance.

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)

International Journal of Managing Projects in Business

	Clarity	Unpredictability

Figure 5: The Complexity Navigation Window (CNW).

The purpose of the design was to help the practitioners overcoming the challenge of assessing the situation at hand, i.e. the current complexity of the project reported in . The primary design principle used here was "Outside view" (Lovallo and 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. The resulting concept implemented in an ICT platform is based on an outside view provided by stakeholders as a design principle.

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 2: Evaluation results of the eight involved project managers

International Journal of Managing Projects in Business

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."

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.

During the ADR project, there was resistance to deploying the information system among the project managers, Only two of the eight project managers conducted summative evaluations of the information system. However, the relevance reported by these two project managers made the client

International Journal of Managing Projects in Business

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 useable in a research endeavor 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 endeavor 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 can not talk to all stakeholder all the time, the information systems need to point to the stakeholder who the project manager most need 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.

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. 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 labeled "early detection." This affordance-labeling would have provided much better stickiness and may have corrected the misperceived affordance of "satisfaction-measure."

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.

International Journal of Managing Projects in Business

Based on 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 co-creation 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. 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 do project managers and decision-makers believe they need to handle the 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 client 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.

International Journal of Managing Projects in Business

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 Tukel 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: H*ow can an information system be developed to provide affordance for project complexity management in collaboration with practitioners?*

The ADR project identified an artifact labeled 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 cording 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 questioner developed by the

International Journal of Managing Projects in Business

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 an 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.

8.1. Recommended future research

To further the understanding of IT-enabled complexity management, the following future research is recommended:

- The framework for early detection in the navigation of complexity needs further development.
- Summative evaluation of the information system using the outside view needs to be conducted in more organizations and sectors.
- 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.

International Journal of Managing Projects in Business

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International Journal of Managing Projects in Business

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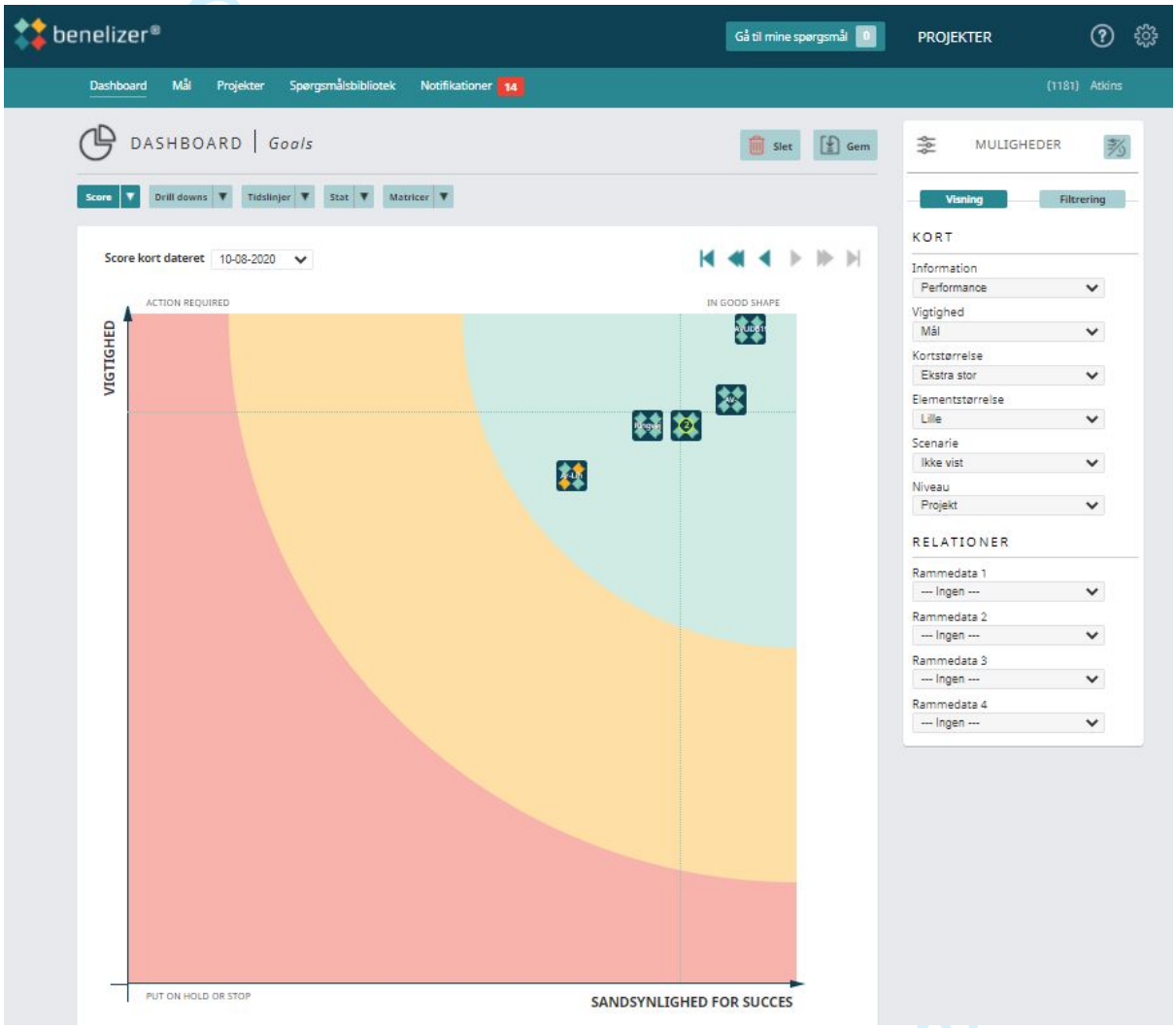
International Journal of Managing Projects in Business

Appendix A: Implementation in Benelizer – Map

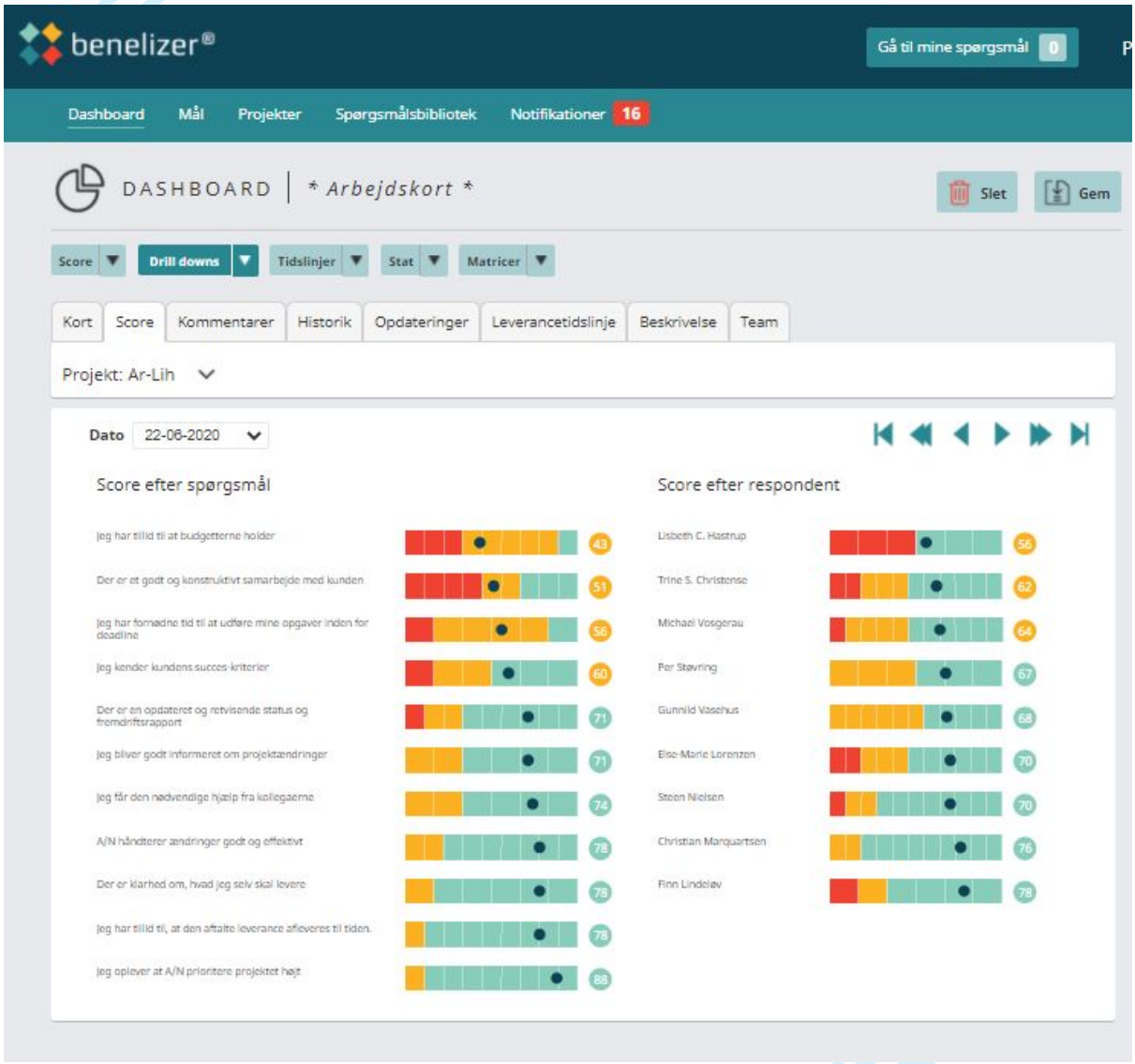
The dashboard of the IT platform is "born" with a dashboard displaying "importance" against "probability of success." Depending on the question asked and aggregated (with unique weights for each question), the real dimensions will differ. The divergence of the stakeholders can be found in the "drill-downs." See Appendix E.

In the screenshot below, more than two projects (mentioned in Paper #7) are depicted. The others include the new project from the scaling up of the implementation.



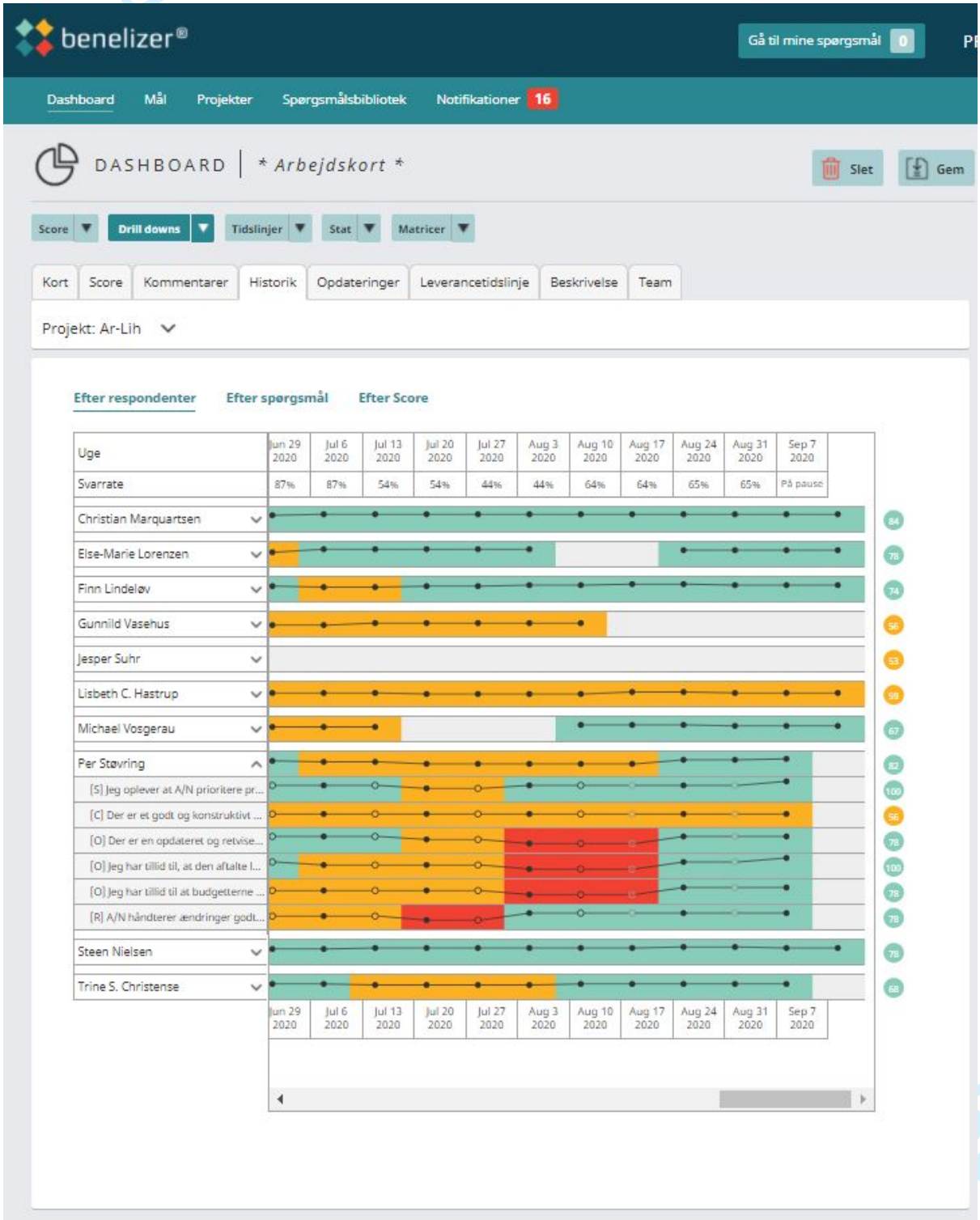
Appendix B: Implementation in Benelizer – Questions/respondents

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.



Appendix C: 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, mentioned in Paper #7, Per Støvring, 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.

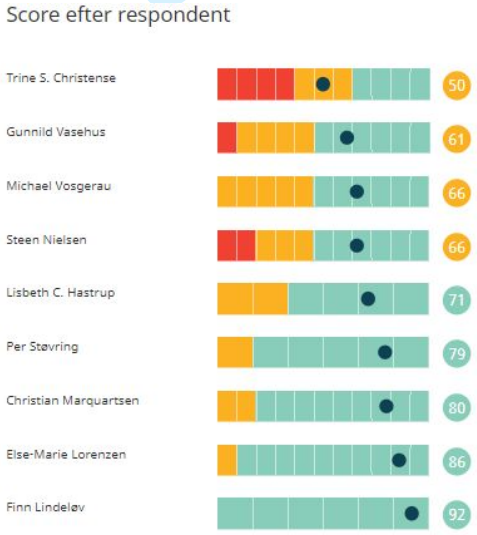


Appendix D: Implementation in Benelizer – Responses of individual stakeholders

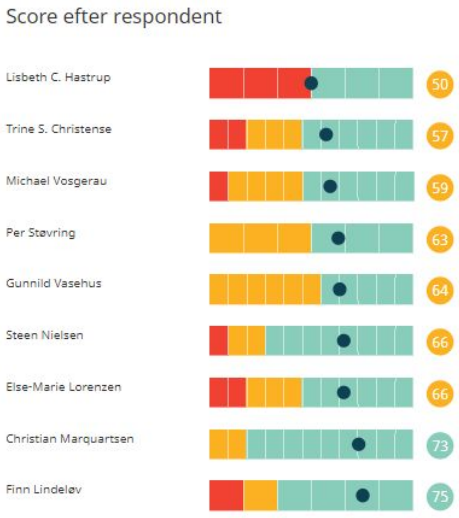
The four dates exhibit the change in perception of project complexity (the lower the rate of answers, the higher the complexity for the project manager)

Executive stakeholder = Per Støvring. Project Manager = Finn Lindeløv

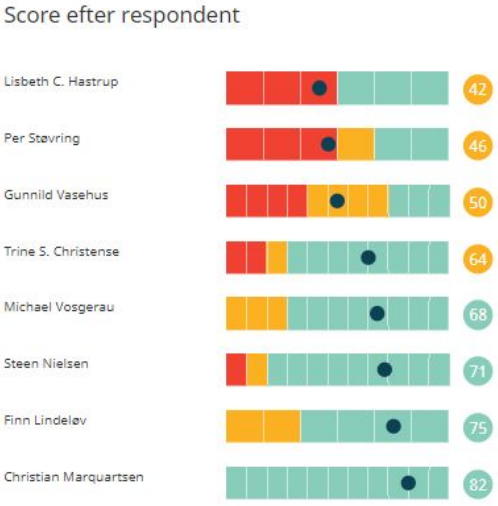
25th of November 2019:



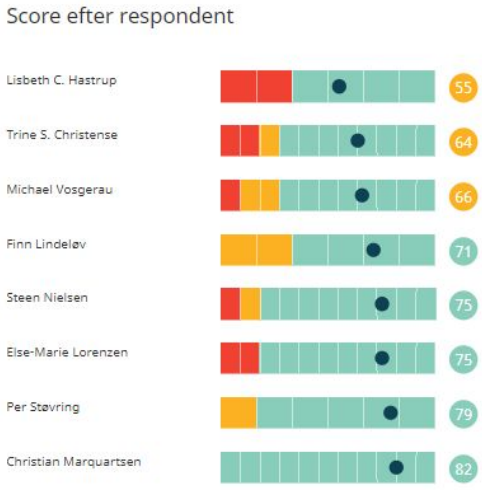
22th of June 2019 (before the storm)



10th of August 2020 (under the storm)



9th of September 2020 (after the storm)



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COLLEGE OF BUSINESS AND ECONOMICS

12 January 2021

TO WHOM IT MAY CONCERN

Statement of Co-authorship: Mogens Frank Mikkelsen

I hereby acknowledge that the following articles were co-authored with Mogens. Frank Mikkelsen.

1. Mikkelsen, M. F., Marnewick, C., & Klein, L. (2020). On stupidity in project mangement: a critical reflectioon of PM in a VUCA world. *The Journal of Modern Project Management*, 8(2), 145-157. doi:10.19255/JMPM02412.

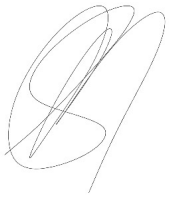
   For this article, I was responsible for section 4 that dealt with the data analysis and findings. Mogens and Prof Klein was responsible for the remainder of the article.

2. Mikkelsen, M. F., & Marnewick, C. (2020). Investigation of the institutionalizing responsibility of project managers for project benefits realization. *The Journal of Modern Project Management*, 7(4), 1-19. doi:10.19255/JMPM02213.

   For this article, I assisted with the data analysis and the overall layout of the article. My contribution to this article was about 40%.

I also acknowledge that the articles are part of the presented PhD thesis, and that I am in agreement about the scope and character of the individual contribution of Mogens' work.

Please feel free to contact me if you have any further queries.



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CO-AUTHOR STATEMENT

I have been a co-author of Mogens Frank Mikkelsen and John Venable in paper "Researching Navigation of Project Complexity - Using Action Design Research" published in International Journal of Managing Projects in Business. I have been commenting and editing the drafts of the paper particularly from the perspective of how to strengthen the stakeholder perspective in the research.

I have acted as a co-author of Mogens Frank Mikkelsen and John Venable in "IT-enabled project complexity management – A case of Action Design Research" (currently under review at International Journal of Information System and Project Management). My role has been in providing feedback and comments to the draft versions of the paper.

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14 January 2021

To whom it may concern,

I am writing this letter to summarise my contribution to a paper that I co-authored with Mr Mogens Frank Mikkelsen, which has been submitted as part of Mr Mikkelsen's PhD thesis.

I co-authored the following paper with Mr Mikkelsen.

> Mikkelsen, Mogens, John R. Venable, and Kirsi Altonen (2020), "Researching Navigation of Project Complexity Using Action Design Research", *International Journal of Managing Projects in Business*, ahead-of-print published online 12 November 2020, (DOI: 10.1108/IJMPB-02-2020-0040).

My contribution to the paper was primarily in suggesting the paper structure (following Gregor and Hevner, 2013) and editing the paper (in particular the English language expression throughout and the abstract, introduction, research methodology, discussion, and conclusion sections). The artefact design and evaluation are entirely the work of Mr Mikkelsen, although I did make some recommendations for that work.

If you have any questions, please feel free to contact me (email preferred).

Kind regards,

John Venable

Adjunct Research Fellow

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