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Challenges in Prototyping a Problem-Solving Practice

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Abstract. The purpose of this paper is to describe challenges in collaborative research in practice. The research object is a development process where a medium-sized and large manufacturer applied prototypes of a problem-solving practice on practical problems in product realization. These applications provided the manufacturers with insights into practical problems in product realization and their problem-solving capabilities. In addition, the application of the prototypes generated data for a case study about challenges in collaborative research. The findings reveal three challenges in collaborative research. The first challenge relates to scoping problems and action. The second challenge relates to practitioner's immediate outcome from applying the problem-solving practice. The third challenge addresses practitioner's commitment for change. Practitioners gained insight by applying prototypes; however, implications for practitioners emerge when mutual stakeholders have ambiguous or conflicting objectives for participating in research. Implications for research include tension between researchers and practitioners in the organization. Therefore, researchers, practitioners and consultants can benefit from considering these challenges when engaging in collaborative research.

Keywords: Problem-solving, collaborative research, product realization.

1 Introduction

Research continuously explores the possibilities for collaboration, interaction, and co-creation of knowledge with practitioners [1], [2]. Researchers [2], [3] are occupied by research quality, epistemological discussions, and whether a trade-off exists between contributions to practice and research. The challenge for researchers is delivering knowledge with practical relevance, ensuring the scientific quality of research [3], linking theory, practice, and collaboration, and capturing differences while sustaining collaboration and managing quality [4].

Research provide guidance for researchers and practitioners collaborating in research within Operations Management. Engaging in collaborative research require that practitioners develop confidence in the language and process. For researchers collaborative research require skills such as listening to, motivating and convincing people, involving various areas of competence, designing and conducting change management. The research process engage researchers and practitioners in social interaction and col-

lective inquiry into the research topic [4]. Even though collaborative research is common within Operations Management and research provide guidance, empirical case studies of the challenges in conducting collaborative research are rare.

This paper aims to describe the challenges in collaborative research in practice and contribute to the collaborative research stream within operations management. The research object is a development process where a researcher collaborate with practitioners in applying prototypes of a problem-solving practice for product realization. Practitioners in two manufacturing enterprises applied prototypes of a problem-solving practice twice before applying a final version. The mutual objective was to gain insight into practical problems in product realization while developing a problem-solving practice. Practitioners and the researcher gained insight at an early stage of the development process, which allowed them to refine the problem-solving practice. In addition, early insight gained by practitioners targeted their need for short-term gains, whereas the researcher improved applicability of the problem-solving practice.

The remainder of the paper presents the literature on collaborative research gains and prototyping a problem-solving practice. Subsequent sections describes the applied action research methodology. The empirical context is a development process of a problem-solving practice that practitioners can apply to improve product realization. The findings indicate three challenges: scoping problems and action, learning from outcome, and committing to change. Finally, the paper discuss authority relations and learning in collaborative research, and concludes by proposing future research directions.

2 Literature

2.1 Collaborative Research Gains

Collaborative research serves a dual purpose for practice and theory. For practitioners, the purpose is to generate actionable knowledge to pursuit practical solutions to issues of pressing concern to people for worthwhile human purposes [3], [5]. For research, the purpose is to generate a theoretical understanding that pertain to the academic field of management and organizational studies [4].

Collaborative research is a true partnership between researchers and members of a living system [3] grounded in a participatory worldview and growing out of a concern for the flourishing of individuals and their communities [5]. Collaboration between research and practice can be mutually beneficial as researchers gain access to real-life data and practitioners gain access to applicable knowledge [2], [4], [6], [7]. In addition, researchers and practitioners benefit from helping each other while practitioners help researchers understand practical problems and researchers help practitioners explicate learnings about the effects of their actions [4].

Practitioners claim that collaborative research creates an arena for reflection and conceptualization comprising the application of newly created knowledge to achieve competitiveness [2]–[4]. Researchers gain value by creating new knowledge and sharing findings with fellow researchers (e.g., journal papers [4]).

The process of collaborative research is a methodological approach characterized as a participatory and democratic process that reconnects action and reflection, and theory and practice [2], [5]. Further, collaborative research is an emergent and systematic inquiry process that helps design and implement appropriate management tools, and procedures in the field based on defined transformation projects [3]. As such, the practice system is a site for learning for both practitioners and researchers who needs each other to generate shared understanding, conceptualizations and interpretations [2], [4]. However, the time frame of creating value within research is a longitudinal and resource-demanding process where practitioners expect short-term gains [2], [3].

2.2 Prototyping a Problem-Solving Practice

Literature within operations management promotes conceptualizations of product realizations such as lean product and process development [8], and agile stage gate [9]. However, Benner and Tushman [10] suggested that researchers take a more problem-focused approach to developing theories on innovation and organizations. Implementing such universal programs can potentially deliver unexpected outcomes or even harm organizations [10]. Therefore, the problem-solving practice for product realization is developed through a prototyping process in collaboration with practitioners.

Developers create prototypes to gain customer or internal stakeholder feedback at an early stage of development [11]. Conventional product development applies prototyping as a practice to initiate a dialog with manufacturing concerning manufacturability and marketing about customer needs [12]. Designers in product development create prototypes of product concepts. Engineers create prototypes of the production designs, and software developers create prototypes of software for beta testing.

Collaborative prototyping acts as a boundary object across functional, hierarchical, and organizational boundaries in new product development, thus improving the overall prototyping process [13]. In addition, collaborative prototyping provides an approach to problem-solving that continuously iterates the prototype, improving functionality and usability through design changes [13]. As such, prototyping is a learning process for both users and designers [11].

This case study consider a problem-solving practice in product realization to be the product and two manufacturers to be the users applying the prototypes of problem-solving practice. Similar to prototypes of products, the objective was applying prototypes of a problem-solving practice to generate insight into improvements of product realization for practitioners and provide feedback about the problem-solving practice to the designer (the researcher in this case).

3 Research Method

A pragmatic position is taken and a practice-based perspective is applied on the research topic [14]. This paper study the challenges in collaborative research and apply action research in two manufacturing enterprises. Applying action research enabled a mutual learning process and collaborative partnership between practitioners and the researcher. Developing a problem-solving practice is a complex problem that requires a

reflective and questioning process [3]. Such a process requires actions like “finding a problem; finding a group; identify their questions, reflections, and insights; how to build their (and the researcher’s) commitments; and helping them while being open to their help” [4, p. 1682]. Breaking down the research process into smaller steps enables mutual reflection and builds creative confidence, benefiting practitioners and the researcher [4].

Following the recommendations from collaborative research [2]–[4], [6], [15], this case study takes small steps in a reflective and collaborative research process aimed at determining and designing solutions for real-life organizational problems. A problem-solving practice for product realization was designed through four action research cycles. Each cycle comprise four steps: developing a construct, planning action, taking action, and evaluating action. The first of the four action research cycles aimed to scope the activities with management representatives in two manufacturing enterprises to develop a mutual understanding of the relevant issues to address using the problem-solving practice. In the second and third action research cycle, appointed practitioners applied prototypes of the problem-solving practice to the issues within product realization. After completing each research cycle, management representatives decided application focus for the next cycle. The researcher then revised the problem-solving practice and planned the next step with the practitioners. Finally, in the fourth action research cycle, the practitioners applied a revised problem-solving practice on similar issues within product realization.

The research process implied that the researcher managed clarifying the problems in product realization, negotiating acceptance for applying prototypes of the problem-solving practice, and managing stakeholders in the research program. To paying attention to the first person voice [15], [16], the researcher kept a personal journal, observation notes and recorded research activities with participants. In addition, resúmes and transcribed interviews was shared with participants. Reflection-on-action by participants’ self-evaluation and sharing insights and reflections with management representatives provided a second person voice to the collaborative research [15], [16]. Activities in the four action research cycles generated data multiple types of data; transcribed interviews, observations at workplaces and meetings, resúmes from applying the problem-solving practice, chronicle workshops, and field data such as notes and pictures.

4 Empirical Findings

4.1 Applying Prototypes of a Problem-Solving Practice

Two manufacturers participated in the development process. Manufacturer A was a large global manufacturer delivering make-to-stock products with medium product variation and complexity in high quantities. It was essential for Manufacturer A to be flexible enough to adapt new technologies and simultaneously improve quality and lead-time to introduce new products and processes. These issues required collaboration across development and manufacturing functions. Manufacturer B was a medium sized manufacturer delivering engineered-to-order projects with high product variation and complexity in limited quantities. Manufacturer B changed strategic focus from single

stand-alone projects to a small, customized series of projects, where engineering increasingly reused designs from previous projects. In addition, Manufacturer B found it necessary not to tie designers into a bureaucracy that could hamper their creativity in design and capability to meet customer needs. These two manufacturers are typical cases illustrating the challenges in product realization.

Each action research cycle was planned in collaboration with the two manufacturers relating the activities to specific situations with expressed purpose. Table 1 and Table 2 presents the activities, situations, purposes, outcomes and learnings for the two manufacturers. These activities occurred from February 2015 to June 2017 (further details are available [17]).

4.2 Outcome from Applying Prototypes of a Problem-Solving Practice

From the practitioner's perspective, the immediate outcome of the collaborative development process was applying the problem-solving practice onto practical problems in product realization. The findings indicate that management in the two manufacturers gained insight from scoping and evaluating feedback. Participants taking part of the problem-solving practice also gained insight into creating and implementing new organizational practices addressing the practical problems in product realization. As such, the manufacturers experienced practical and short-term outcomes by taking part in the collaborative research.

Similarly, the researcher conducting this collaborative research gained insight into the challenges in product realization and the applicability of the problem-solving practice through the development process. Learning from applying the prototypes and evaluating the application through refinements led to a final version of the problem-solving practice. The researcher gained early insight into the context and problem-solving practices, and collected data for further research. In this way, the collaboration also met the long-term objective for research.

4.3 Challenges in Applying Prototypes of a Problem-Solving Practice

Three challenges emerged from analyzing data from the development process: scoping problems and action, learning from outcome, and committing to change. Despite the similarities in challenges, differences also exist between the two manufacturers, and between the manufacturers and the researcher.

The challenge of scoping problems and activities arise when practitioners and the researcher collaborate on framing the purpose of solving problems, negotiate access and organizational involvement, and evaluate the outcome. Changing contact persons twice at Manufacturer A caused a discontinuity in the research process. Aligning expectations under such circumstances was a challenge at Manufacturer A, where the responsibility for accepting access was less clear and mutual stakeholders had different expectations. For the researcher adapting wording to internal terminology eased the negotiating process. Consequently, negotiations with Manufacturer A postponed actions applying prototypes of the problem-solving practice until late in the research project. In contrast, Manufacturer B initiated actions to apply a prototype of the problem-solving practice instantly.

Table 1. Activities, situation, purpose, outcome, and learning from four action research cycles in Manufacturer A.

Action re-search cycle	Situation	Purpose	Outcome	Learning
1. Scoping	A1 Production system	To identify challenges in product realization	SIPOC for the production system	Identified challenges in developing a future production system
2. First prototype application	A2 Challenge	To test the equipment capacity and train designated employees	Insight into situations that reduce the equipment capacity.	Identified problems that reduced equipment capacity and, were not used in further problem-solving activities.
	A2 Breakdown	To get the production line up and running after a breakdown	Knowledge about calculating operational ratio	Identified problems and their causes not used in problem-solving activities to prevent similar situations.
3. Second prototype application	A3 Analysis function	To improve the exchange of failing prints and fixtures for testers	A board visualizing knowledge in the project was integrated into work practice	Participants focused on making a task list and completing tasks more than understanding what caused the problems.
4. Testing the practice	A4 Analysis function	To reduce lead-time and failures from repair (FPY) To ensure new types of failures are detected and analyzed	Insight into and shared understanding of the problem	Instant collective action in changing the layout supported collective thinking and experimentation with prototypes of suggested solutions
	A5 Composite	To reduce lead-time by reducing the number of problem-solving loops or shortening the loops. To ensure that all relevant stakeholder knowledge is considered in the process	Technicians gained insight into each other's work practices as a prerequisite for mutual adjustments and coding knowledge into procedures. New layouts supported integrating new work practices into the process	Lack of facts and limited experimentation restrained the challenges of cognitive maps, and few suggestions for solutions were developed.

Table 2. Activities, situation, purpose, outcome, and learning from four action research cycles in Manufacturer B.

Action re- search cycle	Situation	Purpose	Outcome	Learning
1. Scoping	B1 engineered-to-order project	To identify challenges in an engineered-to-order project	Management team chose to focus on knowledge sharing across customized projects.	Identified challenges related to resource planning, knowledge sharing and diverse business units
2. First prototype application	B2 Knowledge sharing I	To improve knowledge sharing between projects in a project group	Insight into and shared understanding of the problem causing stops on the production line.	Time constraints made designers cut corners and left limited time for improving their work practices.
3. Second prototype application	B3 Knowledge sharing II	To prevent deviations from recurring in successive projects	Insight into the problem on the board and structures for integrating coordination between two functions into work practices	The problem highlighted issues of ambiguous priorities that management representatives needed to be involved in.
4. Testing the practice	B4 Knowledge sharing III	To prevent deviations from recurring in successive projects	Shared understanding of the insufficiencies in the development process and suggestion to develop and integrate the functional-activity list as a new work practice.	Frequent fact-checking challenged participants' cognitive maps and thus provided new insight Experimentation with prototypes revealed how suggestions could be integrated into existing systems and procedures.

Differences between the two manufacturers also became apparent as Manufacturer A had extensive experience collaborating with researchers whereas this experience at Manufacturer B was limited. These differences influenced the building of trust, and contributed to ambiguous and conflicting objectives. Especially ambiguous and conflicting objectives challenged scoping problems and actions for both practitioners and the researcher.

The challenge of learning from outcome addresses primarily local learning for practitioners participating in problem-solving activities. Practitioners emphasized improved collaboration and mutual understanding as important outcomes along with solving the problems. Despite that solved problems in product realization provided short-term outcomes and learning, Manufacturer B continuously asked, “What do we get out of this?”. At Manufacturer B, disagreements occurred regarding the countermeasures selected to solve the problem. These disagreements had roots in the management team and, as such, were out of scope for the research process. Management at Manufacturer A lacked attention and commitment to the problem-solving activities and outcome, which resulted in limited learning for the rest of the organization. Furthermore, ownership of the problem-solving practice remained for the researcher to share externally. Learnings based on analyzing the development process was shared with the two manufacturers but gained limited attention.

The challenge of committing to change arise in activities where practitioners and the researcher evaluated application of the problem-solving practice. The problem-solving practices include confronting assumptions and visualizing insight, which required active participation as a critical resource. Despite a scoping process with management, resources for such activities were scarce. However, participants were committed to solving problems relevant to their daily work. The problems that were mitigated and further improvements had to be followed up on by team management. As the researcher withdraws, there is a risk that solving the specific problem and the problem-solving practice will be discontinued. In this case, the contact persons at the manufacturers were not given a role. Therefore, commitment for change relied on the practitioners individually and not on the organization.

5 Discussion

Researchers have proposed various approaches to mitigating challenges in collaborative research [2], [4]. However, the efforts to meet these proposals do not necessarily lead to success for all stakeholders taking part in collaborative research. When scoping problems and action, practitioners and researchers aimed at developing mutual understanding of the research objective and negotiated practical application of the problem-solving practice. Collaborative management research is based on true partnership among the individuals “encompassing the dynamics and equality of integrated collaboration, emergent and systematic inquiry” [4, p. 1682]. However, establishing a true partnership based on equality requires attention to the authority relations between managers on different levels, such as manufacturers of different sizes and stakeholders within a research program. Authority relations and other intra-organizational activities,

such as organizational changes that are out of the scope for the research project also influence the required development of mutual trust. Practitioners do have ambiguous or conflicting objectives for participating in research.

Practitioners and researchers focus on the task to learn from outcome, and commit to change. Ellström [2] suggest that a research model address a three-fold task aimed at practical concerns, creating scientifically acceptable knowledge and enhancing the competencies of the involved parties. The first two tasks were accomplished through the action research cycles. As for the learning task, researcher, especially Ph.D. students, accept the precondition of entering the learning process. Especially young researchers need skills to help practitioners design and co-create solutions to complex problems within operations management, and to improve the accessibility of research for practitioners by clarifying implications [4]. The researcher conducting this case study was a former consultant experienced in process consultation, scoping, negotiating and facilitating problem-solving processes but was inexperienced in enhancing practitioners' competencies in participating in collaborative research. Consequently, attention draws to the role of the supervisor.

Practitioners gained insight by applying prototypes of a problem-solving practice; however, implications emerge for practitioners when mutual stakeholders have ambiguous or conflicting objectives for participating in research. Implications for research draw attention to the tension between researchers and practitioners in the organization. Therefore, researchers, practitioners and consultants can benefit from considering these challenges when engaging in collaborative research.

6 Conclusion and Future Research Directions

This case study describes three challenges in collaborative research applying prototypes of a problem-solving practice. The first challenge relates to scoping problems and action collaboratively between the researcher and management representatives. The second challenge addresses practitioner's immediate learning from outcome of the problem-solving practice. Finally, the third challenge addresses practitioner's commitment to change. The findings exemplify challenges in applying prototypes of a problem-solving practice better than providing an exhaustive list of challenges in collaborative research. As such, collaborative research for this paper provided value for both practice and research. Practitioners gained insights from applying the prototypes and solving real problems in product realization. For the researcher, the application of prototypes generated data for research about the challenges in collaborative research.

Topics for further research could include authority relations between stakeholders such as a contact person as an insider, a researcher, and management representatives in collaborative research. In what way does the interplay of organizational systems with ambiguous or conflicting objectives influence the management of collaborative research? Furthermore, findings draw attention to describing the supervisors' role in a research program with more than one research project, researchers from more than one university. Collaborative research is based on the assumption that students have strong advocacy of the supervisors. However, what does that imply?

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