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Co-creating Digital Services with and for Facilities Management

Abstract

Purpose – This study aims to increase understanding about the co-creation of digital facilities management (FM) services with and for FM during a construction project.

Design/methodology/approach – The paper reports a case study on the co-creation of a digital facilities management service during the Mission Bay medical center construction project for the University of California, San Francisco. The sub-contractors and the FM team co-created a quick-response (QR) code system for valves on the project. This digital service is now used by the FM team for training purposes and in emergency situations when information on valves and their service areas is quickly needed. Researchers made on-site observations, conducted 84 interviews, and reviewed archival data in 2012, 2014, and 2016.

Findings – The findings show that a successful co-creation process consists of three elements: 1) A dialogue between the project parties, 2) The creation of shared context between the project parties, and 3) The creation of shared understanding about the FM's needs and the service providers' ways of satisfying those needs. The study describes ways to promote these elements.

Originality/value – Previous studies emphasize the need for digital FM but few explain how FM teams can be involved in creating digital services for them. This paper describes how to co-create digital FM services with and for FM in the context of a construction project.

Keywords Co-creation, facilities management, digital service, construction project, dialogue, shared understanding

Paper type Research paper

Introduction

The operation and maintenance costs of a commercial building over its life can be many times more than its design and construction costs (Lewis et al., 2010; Becerik-Gerber et al., 2012). Thus, the building owners, users, and facility managers should demand and be offered services that lower and optimize the operation and maintenance costs of the building. These services should be digital to receive the benefits of quickly sharing and analyzing building data that serve different facility operation and maintenance tasks. During the current handover and commissioning phase of most projects, facilities management (FM) receives a stack of paper boxes filled with building data and two-dimensional 'as-built' drawings. The first task of the FM is to type in all the required paper-based data into their computerized maintenance management system (CMMS) which the FM staff uses daily in their work. (Lewis et al., 2010) The reason behind this manual data entry is that the digital data needs of FM are not considered during the design and construction phases of the building. According to a recent study conducted by Jylhä and Suvanto (2015), incomplete information is a real harm that causes extra work and lost financial potential in FM. In the perfect world, building data created during the construction project would be automatically transferred to the CMMS (Korpela et al., 2015).

Digital building data allows the creation of digital FM services that can reduce the building life-cycle costs, increase the performance of the building, and increase the productivity of the users. Understanding the digital building data needs of the customers, i.e., owners, end-users, and maintainers, is crucial in developing digital services that support the business needs of the customers. Project owners are increasingly demanding that projects incorporate these new digital FM services. However, construction project parties have little experience creating these digital services. Their definition of project success is one handed off to owners on time and on budget. They are not necessarily interested in understanding the digital building data needs of the customers over the lifespan of the structure.

One way for construction parties to understand and satisfy the needs of the customers is to create services with them (Blazevic and Lievens, 2008; Ford et al., 2012). However, more research is needed to understand how the building construction sector's parties can create digital FM services (Becerik-Gerber et al., 2012). Our research addresses this research gap by studying the co-creation of digital FM services.

This paper presents a framework for co-creating digital services with and for FM. The framework is based on a case study conducted in the medical center construction project of the University of California, San Francisco (UCSF) at Mission Bay. The Medical Center has been operating since February 2015. The project was selected because a successful co-creation process took place during the construction phase of the project, and the process resulted in a digital FM service that supports the current ongoing work of the FM team.

Value co-creation in Construction

A recent study on innovation barriers in the construction sector concluded that customers should be involved as early as possible in the design and construction phases to facilitate innovation implementation at the project level (Wei and Lam, 2014). Value can be created by a collaborative effort between the customer and other construction project parties. This collaboration requires that the construction project parties interact with each other more frequently during the construction project. However, co-creation has not yet been thoroughly studied in the construction context in order to understand how the construction project parties should interact. (Liu et al., 2014)

Co-creation is an approach to involve customers and understand their business needs. Value co-creation is one of the most important antecedents of innovation (Ramaswamy, 2010). Co-creation is a process where personal interaction takes place and where meaningful knowledge between the parties is shared. Thus, the co-creation process is reciprocal in nature: both the customer and the supplier receive value. The end-result of co-creation can be, for example, a service, product, or user experience. The role of the supplier is to produce the resources which the customer uses in his/her value creation process. The role of the customer is to manage the process of value creation. The supplier can influence the customer's process of value creation by coordinating its resources in various ways when interacting with the customer. Thus, the supplier can serve as a value facilitator and a co-creator of value, but not the sole creator of value for the customer. (Grönroos and Ravald, 2011)

Research on co-creation in construction projects argues that "the quality and quantity of value co-creation are determined by the relationships and interactions between a client and construction firm" (Liu et al., 2014:126). The probable inhibitors of co-creation in a construction project originate from goal incongruence and performance ambiguity. Goal incongruence refers to the different goals of the project parties, whereas the performance ambiguity refers to the inability of a project party to assess the performance of the other project parties. For example, low performance ambiguity from the contractor's perspective means that the performance specification is detailed enough to know what is expected of the contractor. In this case, the customers know what they want from the project, and communicate it in the contract. Low goal incongruence, on the other hand, means that the customers and the contractor can work collaboratively as they both share mutual goals. (Liu et al., 2014) Low performance ambiguity and low goal incongruence are not self-evident in construction projects because typically each project phase has different project parties, decision makers, and values. This structure supports the phenomenon of engaging in self-interested behavior and passing costs off to future project parties, which is called broken agency or displaced agency (Henisz et al., 2012). To minimize the inhibitors of co-creation, the project parties should create a collaboration platform that encourages interaction and relationship building between the project parties (Liu et al., 2014).

Research shows that a lack of adequate trust between the customers and the contractor reduces sufficient communication and hinders co-creation in construction projects (Liu et al., 2014). According to Hinds and Mortensen (2005), mistrust may also increase task conflicts but a shared context may increase trust between parties. Team members share a context when the members have access to same information and share tools, work processes, and even work cultures (Hinds and Mortensen, 2005).

Prahalad and Ramaswamy (2004) have found that the building blocks of co-creation between a provider and its customers are dialogue, access, risk assessment, and transparency. These four attributes constitute the DART model of co-creation. *Dialogue* refers to communication between the parties and shared learning. Dialogue implies that the co-creation process involves social interaction. It is important that the parties have *access* to the tools and data in the design and production process. The provider should perform *risk assessments* on the service while it is being co-created and inform the customers about all risks associated with it. *Transparency* means that the provider informs the customers about the costs and profit margins of the co-created solutions. (Prahalad and Ramaswamy, 2004)

The DART model has been developed in the business to consumer context. Multiple studies demonstrate that the DART model has the potential to facilitate value co-creation. Prahalad and Ramaswamy (2004) state that by combining the DART model's building blocks, companies are better able to collaborate with their customers. For example, when a company combines risk assessment and transparency, its ability to co-develop trust with the customers enhances. Another case by Ramaswamy (2008) shows that by applying the DART model's building blocks, the Nike company found a new source of value. The company set up a social networking site that enables their customers to interact and provide experiences about Nike's products. The customers can also provide product development ideas.

This paper applies the DART model as a starting point for analyzing case study data. However, the project-based, fragmented nature of building construction projects requires multiple transactions between independent businesses before the product reaches the end customer. This research recognizes that co-creation might arise in alternative or refined models due to the business-to-business-to-customer context of the industry.

Research methodology and approach

Case Study Context

The authors conducted a case study on the co-creation of a digital service with and for the FM in the construction project of the UCSF Medical Center at Mission Bay in San Francisco. Three sub-contractor companies and the FM team co-created a quick-response (QR) code system for valves on the project. This digital service is regularly used by the FM team for training new facilities engineers to operate the medical center and in emergency situations when information on valves and their service areas is quickly needed. In the near future, the service will be linked to building information modeling (BIM) to better benefit from digital building data in the operations and maintenance of the center. BIM is a digital representation of the physical and functional characteristics of the building.

The purpose of the research was to understand how the co-creation took place and what factors enabled it. The unit of analysis was the collaborative activities between the FM team members and other project parties during the co-creation process. The focus of the study was not on the technical elements of QR codes but instead the implementation of existing QR code technology as a co-created digital FM service. The researchers chose a case study strategy because it allowed the examination of the co-creation process in the project, which is a temporary phenomenon and difficult to separate from its context (Yin, 2003).

The construction project of the medical center was a great success. The 1.5 billion dollar project was delivered on schedule and under budget. The Engineering News-Record selected the project as the best health care project in California in 2015. The design of the medical center started in August 2007, construction ended in August 2014, and the center opened to the public in February 2015. The 878,000 square feet medical center is comprised of a 289-bed children's, women's and cancer hospital, outpatient building with a helipad, and an energy center. The delivery of the construction project implemented an IPD (Integrated Project Delivery) philosophy – often referred to as "IPD-ish" - where the project parties work as one team and make decisions collaboratively but do not share a relational multi-party contract.

The main project team consisted of a public owner organization, a construction management consultant, architect, and the general contractor. Altogether 29 organizations were involved in the project. The project included a joint financial incentive for better performance. Early in the project, the owner, and the general contractor decided to co-locate all project parties in a large job site trailer to ease the challenging coordination of collaborative work of the complex medical center construction project. The co-location of the project parties provided an ideal collaboration platform for co-creation. At the beginning of the project, the project parties decided that BIM would be mainly used for coordinating mechanical, engineering and plumbing (MEP) design. From the FM's perspective, the medical center consists of 3,500 rooms which include the assets of mechanical, electrical, plumbing, fire protection, telecommunications data, and pneumatics.

Altogether, there are 38,000 assets, and each asset has seven attributes, such as description, location, manufacturer, and model number.

Data Collection

Three researchers collected longitudinal data to understand how the FM team interacted with the three MEP teams during the project and what enabled the co-creation. Multiple data sources were used to increase the validity of data (Yin, 2003): observation, interviews, and background archives. Observation took place at different project meetings held on-site and during the parties' daily work routine. The researchers took a passive observer role rather than an active role to minimize their impact (Marshall and Rossman, 1995). The observation and interviews at the site allowed the identification of key interviewees and access to rich empirical data. The interviewees represented several organizations, and they were chosen using snowball sampling (Biernacki and Waldorf, 1981). Each interview started with general questions, such as professional experience, role on the project, work tasks in practice, interaction with other project parties, challenges and development suggestions. Next, each interviewee was posed questions related to his/her specific role in the project. The researchers also took photos to remember the context later during data analysis. Background data from the project documentation database were also examined.

Data originates from three points of time: 2012, 2014, and 2016. In the fall of 2012, the researchers studied the design and construction phases of the project. At that time, construction was ongoing for the exterior skin of the medical center. The researchers stayed at the site for three weeks and observed the interaction between the project parties. The researchers video-recorded eleven project meetings and conducted 41 interviews. The aim was to understand how the project parties collaborated. In spring 2014, the researchers studied the commissioning phase of the project for four weeks and conducted 35 interviews. This time the aim was to understand the effects of involving the FM team in the project. It was during this period that the digital service co-creation between the FM team and the MEP teams emerged from project interviews. In spring 2016, the researchers conducted seven in-depth follow-up interviews with the FM team during the operation and maintenance of the medical center. The interviews helped to confirm the details of the co-creation process, and the researchers observed the outcome of co-creation. Table 1 presents the data collection methods and data collected in different phases of the project.

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Data Analysis Process

The interview data analysis followed the recommendations of Miles and Huberman (1994). First, after each interview round, the researchers transcribed the interviews verbatim. Second, the researchers read the transcriptions to get a preliminary understanding of data. Then, the researchers encoded the transcriptions twice and analyzed them using qualitative data analysis software, Atlas.ti. The first analysis included higher-level codes, such as FM, problems in the project, integrated way of working, development ideas, and project peculiarities. These codes emerged from data. The second analysis focused on the quotes marked with the code FM. After the third interview round, the four attributes of the DART model were used in the third coding analysis. The researchers categorized the quotes into sub-codes, such as the needs of FM, problems faced by FM, collaboration with other disciplines, and benefits of involving FM in the project.

The rich data was analyzed using abductive scientific reasoning (Danermark et al., 2002) to understand the co-creation process of the digital service. In this interpretive research, the analysis progressed as a continuous dialogue between the theoretical pre-understanding and empirical data collected at different points of time (Mantere and Ketokivi, 2013).

Case: Co-creation of a Digital FM Service

Next, we describe the case data. First, we provide a short description of the co-creation process. After that, we present the case analysis on the enablers for co-creation. Finally, we provide two barriers for co-creating digital FM services.

The Co-creation Process

Three MEP sub-contractor companies were involved in the design and construction of three buildings of the medical center. The sub-contractors had a contractual obligation to deliver a set of valve drawings, label the installed valves and deliver a valve matrix to the owner. The valve matrix lists each valve by the system, their location, and normal position. Traditionally, when the valve drawings are delivered to the FM team after project completion, the FM team spends a lot of time looking at drawings to interpret which service area the valve serves. Quickly finding the information on the spot can be critical in emergency situations such as a water leakage. The information is also needed during preventive maintenance tasks to ensure patients' safety. For example, when closing a valve, the FM team must be careful they do not accidentally turn off a patient's oxygen tube by mistake.

On one day during the construction phase of the Medical Center, one FM team member (a chief facilities engineer) started doing research on the Internet and found out that the valve matrix information could be printed into a quick response (QR) code. He envisioned that the MEP sub-contractors could put this QR code on each valve. When the FM team members would need information on a particular valve, they could scan and read the QR code with their mobile device to quickly access the needed information, such as the service areas of the valve. The idea was born for a digital FM service to quickly and easily access valve information.

The FM team member told the MEP sub-contractors about FM's need to quickly access valve information. The FM team and the MEP sub-contracts started to further develop the idea. The implementation of the idea required co-creation between the project parties, especially the FM team members, general contractor, and the MEP sub-contractors. The project contracts did not specify the creation of the digital FM service, so the project parties had to voluntarily give their working time to this collaborative effort without being directly compensated for it. The FM team provided a spreadsheet with all the required information needed in the QR codes. The sub-contractors printed their unique QR codes which they put on each medical gas and energy valve in all three buildings of the medical center. During the implementation process, the parties had to solve many technical details, such as what kind of a QR code sticker material would best last on a valve. Overall, the FM team considers the co-creation and its end-result successful:

> *"It [co-creation] was a great effort... It [QR code system] is helpful because it is a quick link to everything. It gives us more information and it works very well."* (FM team member in 2016)

Three Elements of Successful Co-creation and Their Enablers

Next, based on the case analysis we describe three elements that form the basis for successful co-creation of a digital FM service. The three elements are dialogue, shared context, and shared understanding. Also, we provide the enablers of those elements.

Starting a Dialogue

A medical center has several end-user groups such as the FM representatives, medical staff (physicians, nurses, pharmacists, and clinical researchers), administrative staff, patients, and their relatives. The owner of the USCF Medical Center intentionally involved its different user groups during the design and construction of the center. FM was one of the most involved user groups. The owner allocated four representatives from the FM group to join the co-located project team during the preconstruction and construction phases. Two individuals represented the management level of FM and the other two individuals represented facility engineers. During preconstruction, the team consisted of one FM manager and one facility engineer. The following quotes show that the project parties considered discussions with the FM team critical in order to design and construct a medical center that is easy and cost-efficient to operate and maintain.

> *"The input of people that are actually going to be living with the solutions and the facilities folks and having them involved as early as is really helpful."* (MEP project manager in 2012)

> *"Lots of projects, health care side that you don't really have the facilities, people around that can give you an idea of what they actually need. As a designer, you carry lots of time, you get them your best solution, but that's not necessarily what they need."* (Mechanical designer in 2014)

> *"It is critical for facilities to be involved at preconstruction because so many decisions are being made in that phase. … if you don't see it built; you don't have the real understanding of what you need to do to keep it running."* (FM team member in 2016)

The role of the FM team was to bring the maintenance perspective into the project. For example, the team reviewed the BIM to ensure that FM had access to valves and variable air volume boxes. The contractor estimated that the reviews resolved more than 250 access problems and saved about $2.5 million in prospective rework ("Case study on UCSF Medical Center at Mission Bay", 2016). During the construction phase, the FM team also did a number of factory acceptance testing for generators and transfer switches.

The FM team attended "daily huddle" meetings in the field and meetings with the owner, architect, and contractors. The FM team tried to follow the design and construction choices the project parties made, and suggest changes if the choices were not adequate from the FM's point of view. One of the FM team members (an MEP project manager) functioned as an informal liaison between the other project parties and the FM team. His role was to make sure that the FM team could review the design solutions made by the design team. He also helped the FM team and the contractor to collaboratively select the pieces of equipment. He describes his role in the following quote:

> *"The contractors are selecting different equipment, they want to know they have three prices and three pieces of equipment, we sit down and look at the advantages and disadvantages of the equipment because we need to maintain them. We are looking at actual equipment datasheets, and I just point the right people. Different questions come, and my role is to know who to involve."* (FM team member in 2016)

Another FM interviewee told that the inventor (a chief facilities engineer) of the digital FM service idea had both construction and FM experience, which helped in the further development of the service. Also, the interviewee told that good personal skills help in getting people to work with you.

> *"He has been in [FM of] healthcare for over 20 years…and involved in construction. He has some excellent personal skills; he had an understanding of what it means to put something into the ceiling."* (FM team member in 2016)

Building a Shared Context

When the FM team entered the pre-construction phase, the general contractor and all the sub-contractors were resistant to having the FM team in the project. They feared the FM team would complicate their project work by asking for changes. As a result, they did not initially give the FM team access to project documentation, such as the designs, project's decision-making structure, meeting schedule, or meeting minutes.

Over time, the project parties realized the FM team's presence was saving a tremendous amount of rework and benefiting the project team. Co-location and collaboration helped in building interpersonal trust between the parties. As a result, the FM team was given access to project documents. The following quotes describe that the general contractor started thinking how the FM team works and how to effectively collaborate with them. The FM team also started to provide their view in a constructive manner. Together, interpersonal trust, understanding how the different parties work, access to project documentation and constructive feedback contributed to the building of a shared context.

> *"There has to be some degree of trust. That doesn't just come from, oh, I just met you; I trust you, we're great. That doesn't come through … some [contractual] agreement. There's got to be some work done. It requires a degree of understanding how people work, what those behaviors are and how to get people to effectively collaborate with one another. I do think the final product of the building is really good in part because of the user input and facilities input."*
> (General contractor in 2014)

> *"By providing constructive, correct input and over time, you start to be more listened to. Your comments carry out a little bit more weight. We started to be trusted by the design team, and*

that was an important part. … You start building relationships with architects, consultants, and subs." (FM team member in 2016)

Creating a Shared Understanding

The FM team members and the project parties started to ask questions and learn from each other once the shared context was built. For example, the sub-contractors learned about the needs of the FM team, whereas the FM team learned about the different ways the general contractor and the MEP sub-contractors could meet those needs. The contractors taught the FM team to navigate in the BIM, and the FM team used the BIM to inform the contractor where the location of equipment would result in difficult access for future maintenance. The following quotes show that a shared understanding between the FM team and other project parties about the needs of FM and contractors' ways of satisfying those needs started to be created as a result of learning from each other.

"I think a lot of times, the subs; they just don't understand how the building is run. [In this project,] the subs would come and talk to us, what you think about this, what do you think about that? At the end of the day, I think we agreed on a lot of things. Anyway, I think the long story is they started to understand the kinds of things we wanted." (FM team member in 2012)

"We had owner buy-in was a big one because they had their staff here, their facility staff to help us make mechanical decisions. I loved it because when we know what they [FM team] like, it helps us design, and when they know what we're trying to do for them, it helps them understand what the hard parts are, what the tight spots are and what they might want to look at." (Mechanical engineer sub-contractor in 2014)

Construction projects involve a lot of stress. One of the FM team members expressed that the participants need to possess certain personal traits and capabilities in order to be able to work collaboratively in a stressful environment. Participants need to have patience, be well-spoken, understand the collaboration process, and understand other project parties.

Barriers for Co-creating Digital FM Services

Two barriers to co-create digital FM services could be observed when analyzing the case. One of the barriers was the lack of financial compensation for co-creation opportunities that arise during the construction phase of the project. One of the three sub-contractors chose not to participate in the co-creation process because the project did not financially compensate for the additional effort required. The contracts did not have enough contingencies to compensate it.

The other barrier to co-create digital FM services was the lack of a BIM execution plan at the initial phases of design development. The BIM execution plan is a document that defines the BIM strategy and processes for successful implementation on the project. The information retrieved from the QR code could have been put into the BIM if a BIM execution plan had stated it. The FM team is now in the process of integrating the digital FM service with BIM and their CMMS. The project taught the owner and the FM team that it is critical to have a BIM execution plan early in the project to make sure that each project party knows what data to put into the BIM.

"Our biggest regret is not having a BIM execution plan in place at the beginning. They didn't build the model for the operations folks down the road. If we would have had a BIM execution plan, we would have said hey with this little extra work you could help us a lot down the road." (FM team member in 2016)

"We did not emphasize facility management… We had not done enough research, and it was not marketed well enough about how you could make the model useful for operations." (Owner in 2012)

Discussion and Conclusions

The above is an example of successful co-creation of a digital service with and for FM in the context of a construction project. Next, the case analysis is discussed using the four attributes of the DART (dialogue, access, risk assessment, and transparency) model as a framework. The paper concludes with implications from the study and a discussion of future endeavors.

A Framework for Successful Co-creation with and for FM

The project parties were involved early in the project and co-located for the duration of the project. This enabled a continuous dialogue between the FM team and other project parties. One of the FM team members functioned as a liaison between the other project parties and the FM team. The liaison was essential in ensuring that the FM team was given a chance to review and comment on design solutions from the FM's point of view. The case points out that the FM team members had both FM and construction experience which was considered necessary in communicating the FM's point of view to other project parties.

The continuous dialogue was essential in building good relationships. As the project proceeded, the project team gave the FM team access to project documentation, such as designs, meeting schedules and meeting minutes, to help the FM team find the right meetings to attend and provide feedback on design solutions. The FM team members eventually started providing their view and feedback in a constructive manner. Shared context was built as a result of having access to project documentation and providing feedback in a constructive way. Dialogue was also essential in building the shared context, which supports the similar findings made by Hinds and Mortensen (2005).

One of the FM team members was considered patient, well-spoken, collaborative, and able to understand the views of other project parties. Zhang and Fan (2013) call these attributes empathy skills. These skills helped in building shared understanding about the needs of the FM and contractors' ways of satisfying those needs. This finding adds to the earlier discussion on co-creation in the construction project context by suggesting that the FM team members benefit from using empathy skills in building shared understanding with the other project parties. Also, the fact that the project parties were co-located and made decisions collaboratively provided an ideal platform for different project parties to learn about the needs of each other. These findings support previous research that has found co-location to increase knowledge sharing and collaboration between parties (e.g. Appel-Meulenbroek, 2010; Sailer, 2011; Artto et al., 2017).

Together, the continuous dialogue and the shared context between the project parties contributed to the creation of a shared understanding of the needs of the FM team and the MEP sub-contractors' possible technical solutions to them. In the case, an experienced FM team member expressed his need to quickly access valve information, whereas the MEP sub-contractors helped in the technical implementation of the digital FM service. For example, the MEP sub-contractors provided their view on the risks of using certain types of QR code sticker materials on valves. Based on this informal risk assessment, the FM team members and the MEP sub-contractors collaboratively decided on which QR code sticker materials to use on valves.

The general contractor informed the FM team about the probable costs generated when implementing the digital FM service. Because the probable costs were understood, the FM team was able to wisely make decisions based on their budget and quality requirements. The shared understanding between the FM needs and MEP technical solutions boosted the co-creation process between the MEP sub-contractors and the FM team members. These findings strengthen the finding made by Liu et al. (2014) that early contractor involvement is important for enabling co-creation in a construction project context. The findings also reinforce the view of Wei and Lam (2014) that the customer, in this case, the FM team, needs to be early involved in the project to facilitate the implementation of the co-created service.

In summary, the study finds that the four attributes of the DART model are present in the co-creation process of a construction project. In the study, (1) *dialogue* took place between the FM team and other project parties. The other project parties gave FM (2) *access* to project documentation, such as designs, the project's decision-making structure, and meeting schedule and minutes. (3) *Risk assessment* occurred when the teams provided estimates on the costs of the digital service. The FM team received (4) *transparency* when other teams communicated the actual costs of the digital FM service. However, this study finds that in addition to the four attributes of the DART model, the co-creation of a digital FM service includes *shared context* and *shared understanding about the FM needs and MEP sub-contractors technical solutions to them*. Dialogue is essential throughout co-creation and provides the momentum for building shared context and shared understanding. Based on the case analysis, DART model's *access* is one of the enabling factors for creating shared context, whereas *risk assessment* and *transparency* enable the creation of shared understanding. As a result, Figure 1 illustrates the case findings as a framework for enabling successful co-creation of digital services with and for FM. The framework includes three elements of co-creation and their enabling factors.

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Implications and Future Research Endeavors

This study contributes to the theoretical discussion on co-creation by providing a framework for the successful co-creation of a digital service with and for FM in the construction project context. The framework is built on the DART model of co-creation. The study claims that co-creation includes three elements that can be promoted with different factors: 1) dialogue, 2) shared context, and 3) shared understanding. Dialogue and the building of the shared context precede the creation of shared understanding about the business needs of the customers and the providers' ways to satisfy them. However, further research is needed to confirm the findings of this single case study.

The study implies that the co-creation of digital FM services can be boosted by co-locating all construction project parties in a shared facility, which functions as a collaboration platform enabling a dialogue between the parties. The dialogue is the first step in the co-creation process. Creating a shared context and shared understanding were essential elements of co-creation as well. Future research should study the enabling factors of the co-creation process in more detail. For example, one of the key findings of this study was the importance of empathy skills for co-creation. Thus, managers aiming for innovation should look for employees with good empathy skills.

Regardless of the continuous dialogue and the shared context between the FM team and the service providers, one of the service providers could not take part in the co-creation process. The reason was that the contracts did not have enough contingencies to compensate for the additional working hours required by co-creation. Hence, one implication from this study is that it would be beneficial to have enough contingencies in the contract to allow co-creation also financially. Prior research has suggested that an integrated form of an agreement (IFOA) with agile cost shifting creates a mechanism to implement systemic innovations like the digital FM service that cross company boundaries (Hall and Lehtinen, 2015). Future research could study whether an IFOA contract would provide the incentive and the mechanisms necessary to reduce the cost risk burden for project parties to implement systemic innovations with the potential to dramatically decrease life cycle costs. In addition, appropriate contractual mechanisms might be needed in the future to facilitate co-creation when digital construction work, without the possibility for physical co-location, becomes the standard practice.

The limitation of this study is that it only presents a single case study of a successful co-creation. In future work, researchers could compare findings from this case study with findings from another case study of a successful or unsuccessful co-creation. It would be especially interesting to compare the findings of this study with a case study conducted in a project with an IFOA contract to understand the role of formal and informal collaboration in co-creation.

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Table 1. Data collection methods and data collected in different phases of the project

Data collection method	**During construction phase in 2012**	**During commissioning phase in 2014**	**During operations phase in 2016**
Observation on site	• 10.9.-28.9.2012 • 11 meetings (~15 hours) • 40 pages of field notes	A tour at the nearly completed medical center in May 2014	A tour at the operating medical center in February 2016
Audio-recorded, semi-structured interviews	12.9.-28.9.2012 41 interviews (~1530 min): • 7 owners • 5 architects • 4 construction management consultants • 20 general contractors • 5 sub-contractors	16.4.-14.5.2014 36 interviews (~1050 min) • 6 owners • 6 architects • 2 construction management consultants • 6 general contractors • 15 sub-contractors • 1 fire marshal	5.2.-23.3.2016 7 interviews (~280 min): • 4 facilities engineers • 2 facilities managers • 1 facilities director
Archival documents	Organization charts, meeting minutes, communication plans, cost and scheduling plans, quality control plan, and BIM execution plan	A survey on positives and negatives of an IPD-collaborative approach, KPI data (submittals, RFIs, change orders), and Internet articles	Internet articles and interviews with construction professionals in journals, such as Healthcare Design Magazine and The Engineering News-Record

Three Elements of Co-creation and Their Enabling Factors

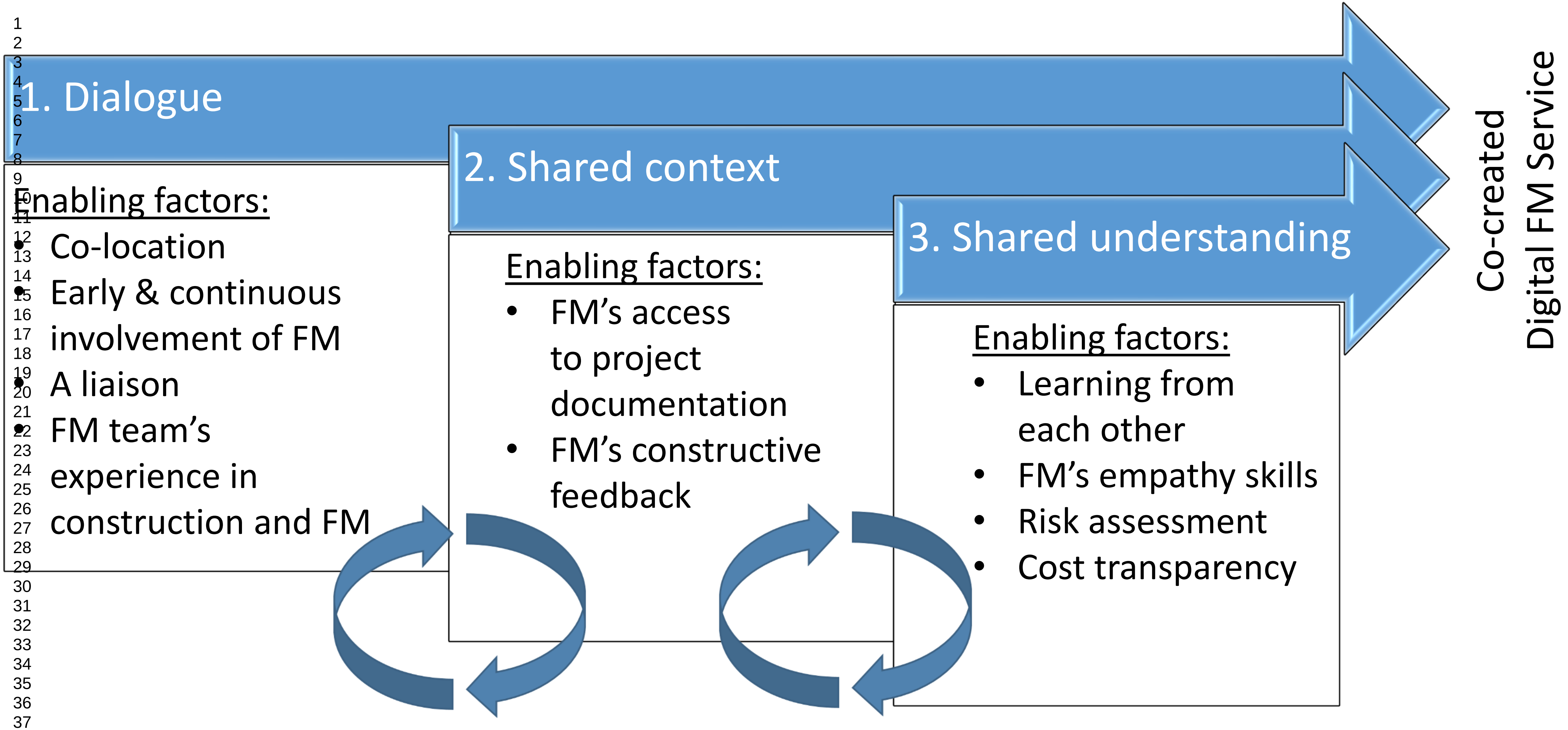

Figure 1. A framework for the successful co-creation of digital services with and for FM.