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Crossing Boundaries: Stage-Gate Model as a Boundary Object

A qualitative study on the function of the stage-gate model as a boundary object in cross-functional work

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A case study on the function of the stage-gate model as a boundary object in cross-functional work

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Abstract
Industry 4.0 has set new market demands for traditional industrial companies to foster innovation. There has therefore been a heightened interest within industrial organizations to produce new products by working in cross-functional teams. Most traditional organizations currently use a traditional management tool, the stage-gate model, during new product development. This paper investigates the stage-gate model’s function as a boundary object in cross-functional work through a qualitative single case-study in a traditional industrial organization. It sets to explore the dispersed opinions of researchers on a management tools function as a boundary object. The purpose of this study is therefore to provide a better understanding of how a management tool, the stage-gate model, functions as a boundary object in cross-functional work. The findings show that boundary objects function in cross-functional work, when complemented with boundary spanning activities such as training, pulse meetings, informal and formal encounters. The paper provides further insight to the research field of management on boundary objects’ function when complemented with boundary spanning activities. The research further contributes to practitioners by highlighting the importance of additional activities and their support to the management tool used in cross-functional work.

Keywords: Stage-Gate model, Industry 4.0, Product Development, Boundary Object, Boundary Spanning Activities, Cross-functional work, Cross-functional teams
Introduction

Industry 4.0 is setting new market demands for traditional industrial companies (Lasi and Kemper, 2014; Deloitte, 2019). The industrial transformation has led to highly complex and smart products, which have created market requirements to continuously deliver new products (Rauch, Dallasega and Matt, 2016; Nunes Lopez, Pereira and Alves, 2017). In addition to the above, new market players have entered the otherwise traditional field of a few strong actors (Tesch, Brillinger and Bilgeri, 2017). Traditional organizations are therefore experiencing high market pressures to deliver innovative products at a faster pace, while simultaneously facing strong competition. As a result of industry 4.0, there is a heightened interest to produce new products (Schneider, 2018). Traditional organizations have, however, shown to experience a harder time than start-ups to reach innovation within the timespan requested by the market (Beaumont, 2017).

There has been criticism towards traditional management tools, such as the stage-gate model used by traditional organizations for slow production, stating that it is too linear to address the shifting and ambiguous market demands (Cooper, 2014). Interestingly enough, traditional management tools, such as the stage-gate model, are still applied in most organizations to support development of new products, despite the criticism of the model (Cooper, 2014). The criticism is that the stage-gate model is too linear and too rigid to handle more innovative environments (Cooper, 2014). The stage-gate model is defined as a management tool that helps guide development of new products (Cooper, 1990) by dividing the product development process in different stages (Cooper, 1994). The model has been shown useful in cross-functional work, where multiple actors have engaged in collaborative work via the model (Cooper and Sommer, 2016). Organizations that produce new products with the support of the stage-gate model have found it useful (Bers, Dismukes and Mehserle, 2012; Cooper, 2014), but whether the new market demands of industry 4.0 have been overwhelming for the stage-gate model are still in question.

Some scholars have argued that industry 4.0 has had a negative impact on the management tool’s function in the market (Schneider, 2018). The usefulness of the stage-gate model in new product development is thereby important to explore since industrial companies are pressured by industry 4.0 to deliver innovation. To produce new products and innovation, traditional organizations choose to work in cross-functional teams; combining individuals from different fields in one team to work together (Kotlarsky et al., 2015). Collaborative work is argued crucial for successful development of products since it creates a common understanding among team members (Herter and Ovtcharova, 2016). However, when people of different expertise work together, they have to overcome obstacles related to knowledge embeddedness (Lenvina and Vaast, 2005). One of the challenges that organizations therefore face when working cross-functional is concerning the knowledge boundaries (Carlile, 2002; Majchrzak et al., 2012; Kotlarsky et al., 2015), which are caused by different knowledge backgrounds, different expertise and different understandings of the challenges (Kotlarsky et al., 2015). Overcoming these obstacles better than competitors, enable companies to maintain a competitive advantage in the market (Lenvina and Vaast, 2005). To be innovative organizations have to work across boundaries to sustain their competitive advantage (Leonard, 1995). In this
paper, the concept of boundary objects has therefore been used to understand how to overcome knowledge boundaries in cross-functional work.

Boundaries are important factors to take into account since “they speak both to why organizations are unique and advantaged, and why they fail.” (Santos and Eisenhardt, 2005 p. 505). Important research has been done on the function of boundary objects and their ability to cross boundaries (Star and Griesemer, 1989; Bechky, 2003; Papadimitriou and Pellegrin, 2007; Yakura, 2012), however, scholars do not agree on whether a management tool functions as a boundary object when working in cross-functional teams (Sapsed and Salter, 2004; Nicolini, Mengis and Swan, 2012). Some argue that management tools cannot function as boundary objects during cross-functional work since it does not allow for face-to-face interactions (Sapsed and Salter, 2004). Others, argue that boundary objects can function in cross-functional work and that boundary spanning activities are crucial in supporting its function (Nicolini, Mengis and Swan, 2012). Even though boundary objects and their function have been highly discussed in literature (Star and Griesemer, 1989; Bechky, 2003; Sapsed and Salter, 2004; Papadimitriou and Pellegrin, 2007; Van de Ven and Zahra, 2016), there has been little attention paid to boundary objects’ use in combination with boundary spanning activities.

The purpose of this study is therefore to provide a better understanding of how a management tool functions as a boundary object in cross-functional work. This study thereby contributes to previous research by answering the question, how does the stage-gate model function as a boundary object in cross-functional work? To fulfill the purpose of this study and answer the research question, a single case study has been conducted at a global industrial organization that works in cross-functional teams and use the stage-gate model when developing new products. Although cross-functional teams consist of several departments, only two of these were studied due to the time frame of this study. The chosen departments are, however, closely linked to the development of new products and could provide important insight to how a cross-functional team works during product development.

Moreover, the report is structured as follows; in the next section the chosen theoretical framework is described, in which mainly the concepts of boundary objects and boundary spanning activities are discussed. In the theoretical framework, knowledge translation through boundaries is also presented. This is followed by the methodology where the chosen method, gathered data and overall process of the study is described and argued for. Thereafter, the empirical data is presented by summarizing three ways through which new products are simultaneously created in the case organization; through the cross-functional team, by using the stage-gate model and through other activities. In the following discussion, the current knowledge boundaries in the case organization are identified. Thereafter, the stage-gate models function as a boundary object is discussed and the stage-gate model’s ability to cross knowledge boundaries is discussed. The analysis of the empirical data is followed by conclusions and a description of the implications and limitations of the study.
Theoretical framework

The theory presented below has been chosen to understand the function of a boundary object. The chosen concept of boundary objects is considered useful for this study to gain a perception of how boundary objects have been shown to function in previous research. The concept of boundary spanning activities is also illustrated to gain a broader understanding of its impact during cross-functional work. By gaining this insight, the authors will be able to discuss and draw conclusions on the boundary objects’ function in the study. The section begins with a description of how boundary objects have been conceptualized and criticized, whereafter boundary spanning activities are described. Lastly, a boundary object’s ability to translate knowledge is illustrated.

Boundary objects

The concept of boundary objects originates from the sociology of science and have in recent years gained attention in the management literature (Sapsed and Salter, 2004). The boundary object is shared between people from different social worlds, to facilitate a common understanding (Star and Griesemer, 1989). In the original article on boundary objects, Star and Griesemer (1989) define four types of these, which cover a wide range of objects. The concept was thereafter viewed as ambiguous and criticized. Star (2010) has written an article reflecting on the concept of boundary objects after receiving much criticism as to “what is not a boundary object?” (Star, 2010 p. 604). The author argues that the concept is most useful at an organizational level and that it is more interesting to study people and their work arrangements in relation to boundary objects (Star, 2010). The concept has been extended to include business tools, such as documents and business processes commonly used in project environments (Brown and Duguid, 2001). Boundary objects have thereby had a high uptake in organizational and management studies (Zeiss and Groenewegen, 2009). In the management studies, the concept of boundary objects is often studied in cross-functional work and during knowledge sharing (Zeiss and Groenewegen, 2009). Moreover, boundary objects are also often researched in relation to product development (Zeiss and Groenewegen, 2009). Therefore, the concept of boundary objects is relevant for this study.

“Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites.” (Star and Griesemer, 1989 p. 393)

The boundary object functions as a means of negotiation and exchange of knowledge between actors from different organizational fields (Sapsed and Salter, 2004). Boundary objects are viewed as a means to create a common ground between organizational teams and individuals (Zeiss and Groenewegen, 2009). Nevertheless, boundary objects still allow actors to interpret information in different ways, while simultaneously sustaining their identity within their workplace. This, since boundary objects are adjustable to the local needs and are strong enough to maintain a common understanding among different local sites (Star and Griesemer, 1989).
They are flexible in use because each actor can interpret the object in different ways, while the structure of the object is still kept familiar to all actors (Nicolini, Mengis and Swan, 2012). Boundary objects can facilitate collaborative work since they can be shared between different actors while simultaneously allowing for different interpretations of the object (Nicolini, Mengis and Swan, 2012). An engineer can in that sense communicate and share their knowledge with a manufacturer via a drawing when developing a product, without having the same work experience or expertise of a manufacturer (Carlile, 2002). Collaboration between actors is thereby maintained through a shared boundary object (Nicolini, Mengis and Swan, 2012). Hence, the basis of a boundary object’s function has been conceptualized as creating a common understanding by enabling actors from different social worlds to communicate and share their knowledge through the object to pass boundaries (Star and Griesemer, 1989; Carlile, 2002; Bechky, 2003; Nicolini, Mengis and Swan, 2012).

Furthermore, the concept has been conceptualized in various settings, such as during cross-functional work (Nicolini, Mengis and Swan, 2012). A boundary object has been shown to support cross-functional work in three ways – by motivating and driving collaboration, by helping actors work through their boundaries, and by creating a clear structure of the actors’ different activities (Nicolini, Mengis and Swan, 2012). Boundary objects have therefore been argued to facilitate collaborative work and encourage cooperation between different actors (Brown and Duguid, 2001). This being said, “boundary objects are no magic bullets” since people may change, and new complex problems may arise over time (Carlile, 2002 p. 452). Consequently, different boundary objects have been criticized to not function when there is no face-to-face interaction (Sapsed and Salter, 2004), to only function temporarily (Yakura, 2002), and to even lose its function in instances of change (Lindberg and Walter 2013).

Boundary objects have been questioned as to whether they can cross boundaries, in global project-based companies undergoing tough competition (Sapsed and Salter, 2004). The authors argue that in project-based organizations there is a need, not only to create a common understanding, but to facilitate trust and commitment among workers. These needs have been shown to be maintained through face-to-face interaction and not via boundary objects (Sapsed and Salter, 2004). Management tools have therefore been argued to not function as efficient boundary objects in projects when there is no face-to-face interaction (Sapsed and Salter, 2004). Objects are however, still argued to be important in cross-functional work if there are boundary spanning activities, as for instance human interaction, that support the object to achieve collaborative work (Nicolini, Mengis and Swan, 2012).

Furthermore, timelines as boundary objects have shown to only function temporarily during projects (Yakura, 2002). A timeline has shown to be useful in enabling interpretation and negotiation of information illustrated by objects but did so only during a certain period of time (Yakura, 2002). A boundary object has thus been argued to not always have a central role nor function in all instances of collaborative work. At times, the object’s function can take center stage, while at other times stay in the background (Nicolini, Mengis and Swan, 2012). In Bechky (2003) research, drawings have been shown to be useful tools for engineers to communicate how to build a product to other workers. The drawings were however not shown to be effective in solving coordination problems (Bechky, 2003). The boundary object did thereby function as a tool for communicating knowledge but did not fulfill the
function of overcoming issues with coordination (Bechky, 2003), which corroborates the argument by Nicolini et. al (2012), stating that a boundary object can be more useful in some instances of collaborative work than in others.

Additionally, Lindberg and Walter (2013) argue that a boundary object can lose its function completely in moments of change. In their research, they present a story of a boundary object that was silent and black boxed since it had reached its purpose of connecting different social worlds. Once the boundary object was flawed, it was separated into different parts for examination, and different groups of actors were reallocated since the object no longer worked as a boundary object (Lindberg and Walter, 2013). The boundary objects’ function therefore became visible and questioned during instances of change (Lindberg and Walter, 2013). Hence, the concept has been criticized to lose its function in instances of change (Lindberg and Walter, 2013), function temporarily (Yakura, 2004), and not function without human interaction (Sapsed and Salter, 2004). On contrary, it has been found that boundary spanning activities can complement the object in cross-functional work and that boundary objects may be more useful in some instances than in others (Nicolini, Mengis and Swan, 2012).

**Boundary spanning activities**

Another stream of literature, that complements the work of boundary objects is boundary spanning activities. Boundary spanning is the process where individuals gather information and make sense of developments outside their expertise. All activities that are related to the transcending of knowledge across boundaries are therefore boundary spanning activities (Van de Ven and Zahra, 2016). The activities can be both formal, structured and organized, as well as informal arrangements (Van de Ven and Zahra, 2016). The concept is particularly studied in global organizations (Birkinshaw et al., 2017; Schotter et al., 2017) as well as large organizations with cross-functional work teams (Harvey et al., 2014).

Schotter et al. (2017) have found that as boundaries become more complex in a global organization, boundary spanning activities become more crucial and someone needs to be responsible for them, a so-called boundary spanner. The authors proposed a rubber band model to understand the role of a boundary spanner; like a rubber band, a boundary spanner connects two or several organizational units, although providing enough flexibility to allow them to work independently. The rubber band allows for flexibility simultaneously as it connects the organizational units in alignment with the agreed upon structure (Schotter et al., 2017). In this sense, boundary spanners are important individuals who facilitate sharing of knowledge by linking two or more groups (Levina and Vaast, 2005). A boundary spanners role is to deal with challenges around boundaries and how to manage these challenges (Levina and Vaast, 2005). Furthermore, Levina and Vaast (2005) make a distinction between two types of boundary spanners; nominated boundary spanners and boundary spanners-in-practice. The former is someone who has a dominant role in the organization e.g. a manager. The nominated boundary spanners therefore use their position to help others cross boundaries in the organization (Levina and Vaast, 2005). The latter, boundary spanners-in-practice, are individuals that do not have a dominant role in the organization however, they act as boundary spanners in the organization (Levina and Vaast, 2005).
Moreover, Birkinshaw et al. (2017) focus on boundary spanning activities carried out by executives in a global organization and found four generic boundary spanning activities, among which two focus on overcoming boundaries and differences. The two activities are facilitating activities, which occur on a regular basis and lubricated activities, which are more related to improvement. Facilitating activities included linking individuals from different subunits together, through e.g. weekly meetings, and creating opportunities for individuals to interact through events and trainings. Meanwhile, lubricating activities include creating equilibration procedures across all units, as well as questioning and challenging assumptions with the current way of working (Birkinshaw et al., 2017).

The purpose of the boundary objects’, the boundary spanning activities’ and the boundary spanners’ roles is to work across boundaries between organizational units when collaborating (Harvey et al., 2014; Nicolini et al., 2012). Kislov et al. (2017) look at boundary spanning activities through a Bourdieusian lens and have found that gaining legitimacy is linked to the processes of accumulation and mobilization of different capital. The capital is highly context-dependent and field-specific (e.g. an engineer’s knowledge within a specific field) and the legitimation of boundary spanning depends on the approval from the different professional groups (Kislov et al., 2017). However, when attempting to integrate knowledge - differences, dependencies and understandings - occur between the actors (Carlile, 2004).

Carlile (2004) describes differences as the degree of unique and specialized knowledge an employee has as opposed to another worker. If there are significant differences in the actor’s expertise, there is a need to share knowledge among the actors. Furthermore, dependencies are, by Carlile (2004), defined as the degree of which an actor is dependent on another to proceed with the work task. If an actor is not dependent on another worker, their differences in knowledge are not considered significant to their work. However, if the actors are highly dependent on each other to finish their work tasks, communication becomes important in order to be able to work together. Lastly, understanding is referred to how well the actors are able to understand each other via the object, and if there is a lack of understanding, the actors may experience difficulties in sharing knowledge among each other. (Carlile, 2004).

It has been shown that overcoming these knowledge boundaries has a positive relation to innovation (Van de Ven and Zahra, 2016). Hence, boundary objects and boundary spanning activities have shown to function as useful tools for innovation in overcoming differences, dependencies and understandings among team members. This, by helping actors integrate their knowledge and create new ideas to generate innovation (Van de Ven and Zahra, 2016). One criticism against boundary objects has thus been whether they can translate knowledge that is not “…simplified, reduced or filtered…” which can lead to misunderstandings regarding the relevance or meaning of knowledge (Van de Ven and Zahra, 2016 p. 11) when creating new ideas. Boundary objects’ usefulness therefore always relies on their ability to act as a means of translation (Star and Griesemer, 1989).

**Boundary objects as a means of translating knowledge**

“Objects become boundary objects when they function as translation and transformation devices at the disciplinary or professional boundaries between different work communities. “(Nicolini, Mengis and Swan, 2012 p. 616)
Knowledge translation is about learning and creating a common understanding among actors that work with the boundary object (Corsaro, 2018). Project-based organizations that work globally have an even greater need to translate knowledge in order to achieve successful project outcomes (Ioro and Taylor, 2013). Boundary objects can be used as a means of translation since the object, as mentioned, can have different meanings for different social worlds, while the structure of the object is commonly understood by all actors (Nicolini, Mengis and Swan, 2012). The coherence of translation, however, depends on the extent to which the different social worlds coexist. By using boundary objects, there is an unlimited number of ways for actors to cooperate between boundaries and there is also an indefinite number of ways for translation (Star and Griesemer, 1989). In order for knowledge to be translated, Carlile (2004) has identified three knowledge boundaries that need to be passed – syntactic, semantic and pragmatic knowledge boundaries.

Syntactic knowledge boundaries emerge when actors have different vocabularies. More specifically when people use their own dictionary that individuals from other professions cannot understand. In order for translation of knowledge to occur, there needs to be a commonly understood vocabulary among the actors (Carlile, 2004). Furthermore, semantic knowledge boundaries occur when actors have different understandings. There needs to be a common understanding among the actors for translation of knowledge to occur. The author explains that research within translating knowledge emphasizes the cross-functional teams, and some researchers focus on particular individuals and their ability to translate knowledge (Carlile, 2004). Techniques to translating knowledge include cross-functional teams and the use of boundary spanners, in order to pass the semantic knowledge boundary (Carlile, 2004). This since, “Knowledge translation is concerned with making the perspective of one community intelligible to other communities.” (Corsaro, 2018 p. 219). Lastly, pragmatic knowledge boundaries need to be passed for translation of knowledge to occur. This boundary regards the conflicting interests of the professionals that make it difficult for the actors to create a common understanding (Carlile, 2004). The three distinctions between the types of knowledge boundaries reminds us that, “depending on the type of boundary faced, boundary objects with different capacities are required” (Carlile, 2004, p. 565).

In sum, boundary objects have been conceptualized in the management literature as business tools (Brown and Duguid, 2001) and have been studied in cross-functional work (Sapsed and Salter, 2004; Nicolini, Mengis and Swan, 2012). Boundary objects have shown to help create a common understanding among actors from different social worlds (Star and Griesemer, 1989). The boundary object is flexible in use (Star and Griesemer, 1989) and can be interpreted in different ways (Nicolini, Mengis and Swan, 2012). Previous research of boundary objects has thus shown that the studied object does not function in cross-functional work (Sapsed and Salter, 2004), only works temporarily (Yakura, 2002) and loses its function in instances of change (Lindberg and Walter, 2013). In addition to the literature on boundary objects, a complementing stream of literature on boundary spanning activities and boundary spanners has been discussed. The purpose of boundary objects, boundary spanning activities and the boundary spanner is to work across boundaries between organizational units (Harvey et al, 2014; Nicolini et al, 2012). Lastly, the boundary object has been shown to function as a means of translating knowledge (Star and Griesemer, 1989).
Methodology

Case study

With the ambition of answering the research question, a single case study was conducted at a Swedish global industrial company that produces business to business products. During new product development, the organization currently uses a traditional stage-gate model that has been criticized for its usefulness in creating innovative products (Cooper, 2014). However, the organization recognizes the fourth industrial revolution and the increased market demands and competition that follow. One way in which the organization responds to Industry 4.0 is through working in cross-functional teams during new product development. The corporation has established a project management office to lead the cross-functional team which consist of individuals from various departments, such as manufacturing, product development, quality and software development.

Each team member of the cross-functional team contributes with their knowledge during new product development, however, one of the challenges that organizations face in cross-functional work is knowledge boundaries (Kotlarsky et al., 2015; Majchrzak et al., 2012; Carlile, 2002). Therefore, given the objective to explore how a management tool functions as a boundary object in cross-functional work, a qualitative single case study was conducted in the organization; more specifically in two departments of the cross-functional team. The chosen departments were the product development department and the project management office, due to the former’s leading role in product development and the latter’s role in leading the cross-functional team. The product development department works closely with the stage-gate model and with other team members in the cross-functional team. The project management office was specifically created in 2016 to manage the cross-functional team in projects related to new product development. Therefore, the two departments were chosen to be most suitable to study in order to answer the research question.

Collection of data

This study was conducted based on a qualitative design with focus on interviews conducted in the case organization. A qualitative approach is chosen to gain a better understanding of the case organization. Qualitative research method is useful for this study since it highlights the individual and its perception of the questions asked (Bryman and Bell, 2013). Qualitative studies are characterized by single case studies, semi structured interviews and as previously mentioned, by emphasizing the individual's understanding (Bryman and Bell, 2013). In this single case study, primary and secondary sources were collected. The data from the interviews were gathered in parts following the grounded theory (Corbin and Strauss, 1990). In total, 27 interviews were conducted in English to fulfill the scope of the research. A confidentiality agreement between the company and the researchers was signed prior to the interviews. The interviewees were chosen with the help of the enterprise that provided a list of potential interviewees to contact. To gain an understanding of the organizational set-up, five initial interviews were done with one representative from each of the five different previously mentioned departments; more precisely the product development, project management office,
software, manufacturing and quality department. As already described, two of these were chosen, whereafter a snowball sampling was used in order to gain access for further people to interview (Silverman, 2013).

Among the 27 interviews, 24 interviews were found to be helpful in answering the posed research question; 11 interviews with each chosen department and two interviews with two representatives from the top management. As such, the interviews consisted of top managers, middle managers and white-collar employees. The interviews were semi-structured to gain a better perception of the interviewees’ insights (Eisenhardt, 1989; Kvale and Brinkmann, 2009; Bryman and Bell, 2013). Semi structured interviews are more flexible, since the respondents receive open-ended questions to which they can answer freely (Bryman and Bell, 2013). However, the questions are chosen by the researchers on the concerned topic (Bryman and Bell, 2013). Power asymmetries could exist during the interviews since the researchers are in power of the interviews and the questions asked (Kvale, 2006), however, the researchers were aware of this. Therefore, open-ended questions were asked that did not constrain the answers of the interviewees (Kvale, 1996). The researchers agreed upon the questions and created an interview guide, on which all the questions were written down in a theme regarding their current way of working. This was done in order to gain an understanding on how they work, thereafter the interview guide was adjusted during the study, depending on the interviewees professions and role in the organization.

Furthermore, the interviews were conducted in an ethical manner by keeping the interviewees anonymous. The participants were informed about the study prior to the interviews and they were all recorded with the consent of the interviewees. The interviews were mainly conducted in person at the head office of the company, with the exception of a couple of Skype-interviews, which worked as good as face-to-face interviews. Each interview was held for approximately 30 minutes to one hour, and a number of quotations from the interviews are presented in the empirical section of this report. The quotations are revised in content to not reveal any internal information, as agreed upon in the confidentiality agreement. In order to maintain anonymity, details from the quotations are removed.

Furthermore, to gain a shared understanding of what the interviewees do in relation to new product development, the researchers had an office at the organization where they spent a couple of days a week during the study. Observations enable researchers to further strengthen their claims about the organization (Watson, 2010). In addition to the interviews and observations, secondary sources such as organizational documents were used to gain a better understanding of the organization. The organizational documents provided insight to their stage-gate model and its guidelines. Thus, the documents complemented the interviews by visualizing the interviewees description of the stage-gate model and therefore providing a better understanding for the researchers. Other secondary sources used were found in management journals, as well as consultancy and research articles discussing industry 4.0 and its effects.
Analysis of data

The interviews were first transcribed, whereafter transcriptions were analyzed in the following described process. Units, meaning the collection of words and arguments that have a common feature (Graneheim and Lundman, 2008), were extracted from the transcripts. The collection of these phrases helped shorten the transcriptions and exclude information that was not feasible for the research. This part in the analysis process is referred to as condensation, which is a technique in decreasing the amount of text without reducing the quality of the data (Graneheim and Lundman, 2008). The meaning of units then acted as a basis for coding, among which codes consist of words, sentences and stories including features that can be related to one and other (Graneheim and Lundman, 2008). Codes are useful in order to be able to form categories and by that, compare the data (Strauss and Corbin, 1998). Examples of codes used in this study are; stage-gate model, cross-functional, knowledge boundaries etcetera.

When the data was coded, various categories were formed (Strauss and Corbin, 1998). The categories consisted of a set of information that had something in common, for instance information related to the stage-gate model. The categories were complete and mutually exclusive, meaning that one set of data was only included in one category and that there was no data included that fell between different categories (Graneheim and Lundman, 2008). Examples of categories are; cross-functional work, pulse meetings, etcetera. Further on, themes were created based on the codes and categories, which connected the fundamental meaning that reoccurred in the categories (Graneheim and Lundman, 2008). For example, the cross-functional work category was added to the main theme, the cross-functional team. Another example is the category pulse meetings, was added to another main theme, other activities.

Lastly, it is important to mention that during the analysis process, all decisions on what to include and exclude were made by both researchers. The analysis process was not linear, at times the researchers moved from one stage of the process to another. The categories and codes were continuously compared to extract differences and similarities between them (Whiteside, 2012). The comparison of data enabled theoretical sampling, which helped to identify gaps in theory (Charmaz, 2006). When finalizing the analysis of the data, the researchers chose a theoretical framework in order to not misconceive the data (Czarniawska, 2014). Since the theoretical framework was chosen after the data was analyzed, the material was not misconceived by the researchers to fit the framework. Therefore, the data was analyzed without any alterations or changes made.

Trustworthiness and limitations

When analyzing the data, it is important that the findings are shown to be trustworthy (Graneheim and Lundman, 2008). Trustworthiness is, among other things, determined through credibility (Graneheim and Lundman, 2008). Credibility is determined through the decisions regarding how the data is collected and analyzed, based on the choices of the participants of the study (Graneheim and Lundman, 2008). The data is considered to be credible if there is a variety of participants chosen, contributing with different aspects of the phenomenon by having different experiences (Graneheim and Lundman, 2008). As mentioned, in this study top
managers, middle managers and white-collar employees were interviewed to gain as broad of a perspective on the phenomenon as possible. Another aspect to consider in order to make the research more credible is the amount of data used during the research (Graneheim and Lundman, 2008). For a master thesis of this scope, 24 out of 27 interviews generated relevant data for the aim and enough data to answer the research question.

There are, however, some limitations with the above described choice of methodology. One limitation is that this study is based on one case study and it is often argued that it is not possible to generalize based on one case study (Flyberg, 2006). Nevertheless, the information provided by a single case study can be applied to multiple companies and thereby, one case study can provide researchers with the ability to collect relevant data (Flyberg, 2006) which was shown to be the case in this study. Another limitation is that the company is a large organization and, due to the scope of this study, it was not possible to get an understanding of the entire enterprise. The decision was therefore taken to narrow the scope of the organization and focus the research on mainly two key departments within the organization. Lastly, the stage-gate model was not studied during an ongoing product development process since it takes years to finalize a product. The model has however been used in the organization for many years, in various projects and could be closely studied through interviews and documentation.

Empirical section

The empirical section covers the case organization’s current way of working with product development by summarizing three ways through which new products are created— the cross-functional team, the stage-gate model and other activities. These three aspects are illustrated since the cross-functional team consists of actors from different departments who all use the stage-gate model as a tool when developing new products. The actors also engage in other activities that are important when creating new products. The cross-functional team, the stage-gate model and the other activities are thereby crucial to highlight in order to understand how new products are developed in the case organization.

The cross-functional team

The corporation is an industrial organization that works globally in cross-functional teams. The cross-functional teams consist of several departments - the product development, purchasing, supply chain, business development, quality and manufacturing department - and each of these departments are responsible for different project deliverables. A project deliverable is the outcome that each department contributes with to guide a project forward. In each division, there is one department manager that coordinates the department. When developing new products, a project team is assigned that often includes a person from each department mentioned above. The cross-functional team is facilitated by project managers from the project management office (PMO).

The organization works in cross-functional project teams to create new products. The various departments in the team have different pieces of knowledge that are valuable when developing new products. One part of the cross-functional team is the product development (PD) department. The engineers in the PD department mainly work with creating drawings and
specifications of new products. The engineers have a relationship with suppliers and customers. During new product development, the engineers also maintain a continuous relationship with other departments to understand what features of a product that need to be improved and how these features can be enhanced. The respondents argued that it is by obtaining all pieces of knowledge, from the various departments in the cross-functional team, that success can be achieved in the market. As such, the departments work together as a cross-functional team to create innovation. During collaborative work within the cross-functional team, the respondents, however, described some difficulties that arise.

Dependencies, understandings and differences

The respondents emphasized that using their network, experience and knowledge is important during new product development. It is crucial to have a good network when working in a cross-functional team since the project team members often are dependent on each other to fulfill their work tasks. One respondent exemplified this by stating that manufacturing and product development are two departments that are highly dependent on each other, explicitly arguing that one cannot live without the other. The two departments are dependent on each other’s expertise and their cooperation affects the outcome of their mutual projects. For instance, the product developers are reliant on the assistance of the manufacturing team’s expertise to be able to produce their product in the factory. The respondents therefore argued that it is necessary to have a good network when working in cross-functional teams. One respondent explained that good networks are built through informal encounters with other team members. One such encounter is to discuss a work task by having a cup of coffee or Swedish fika (coffee break). The actors exchange their knowledge during these informal encounters and help each other move forward in their work. One product developer highlighted that progress in work happens when people are able to meet and connect in informal settings, such as by the coffee machine or during lunch. By having quick conversations with people from other areas of work, team members are able to connect with each other.

It is during these informal meetings and in these settings that networks are built. If the project manager has a good network… sometimes you don’t need the formal meeting to see the next step, during fika time or a cup of coffee, you fix it. (Respondent, Product Development)

Furthermore, another aspect of having a good network is to obtain a common understanding among team members. The team members in the cross-functional team are located in different geographical locations, which limits the opportunities for informal encounters between them. The cross-functional team therefore uses a management tool (Stage-gate model) to help guide them in their work across different locations. The management tool provides the team with information to help them move forward in their work. The respondents, however, argued that some team members in different geographical locations do not always have the same understanding of what information in the model is most important to utilize. In some geographical locations, team members have the perception that all information provided by the stage-gate model should be used during the development of new products. In the head office,
team members only use some of the information that they perceive necessary to reach the intended goal. Therefore, the cross-functional team members have different interpretations of how to apply the stage-gate model in order to proceed with their work tasks.

You have your process of working, no problem. He has his own process, no problem. A little bit different (in this country) than in Sweden (Respondent, Product Development)

Moreover, there are also differences in knowledge and experience among the cross-functional team members. Most interviewees argued that people rely on their experience and knowledge when creating new products. One project manager shared his experience on where he decided that following the model’s guidelines was not necessary and even inefficient since it suggested two separate meetings with two management groups. The project manager argued that based on his previous experience, two meetings with different departments in this specific situation was inefficient. He therefore decided to combine the meetings, because he knew that most of the people within the two groups required the same information. By combining the meetings, the manager saved time both for the project team, but also for the management groups involved. The project manager concluded that people with enough experience and knowledge of the stage-gate model are able to make the right judgment on which guidelines that are necessary to follow to reach a project goal.

We have to be smart enough to understand what is needed and smart enough to understand what is not needed and do just what is needed. Of course, that can be achieved by having good knowledge and experience. (Respondent, Product Development)

Priorities and resources

The interviewees described two further difficulties that exist when working in cross-functional teams within their organization, namely dispersed resources and scattered priorities. There is currently no efficient way to allocate resources, the project managers have to turn to either a department manager or to the individual to gain resources for their project. The cross-functional team members often work with multiple projects, which creates dispersed resources. The cross-functional team members spend somewhere between 20 to 30 percent of their time on each project and therefore have to divide their time between several projects. Being involved in several projects implies that the team members report to more than one manager, since each project has its own project manager. In addition to having multiple project managers, the members also have their own department managers. The different managers arguably have different priorities which often collide, leaving the cross-functional team members in the middle to navigate between these priorities. The respondents argued that an understanding of priorities are important when working in cross-functional teams since a lack of priorities creates non-alignment.
The problem is that.... usually all organizations are pushed from many
directions and all of a sudden there is somebody coming in from the left
and they have now this very important project that takes priority
(Respondent, Project Management Office)

Furthermore, it is difficult to identify what the top priorities are for each team member in the
cross-functional team. There is no list of priorities that the members can follow and there is no
information in the stage-gate model that can help guide the team members on which project to
prioritize. The project members are often left on their own to determine which project to focus
on. One project manager shared an example of a department within the organization where
there are no difficulties related to priorities or common understandings. In this department, each
worker has a clear understanding of which projects and work tasks to focus on. The clear
prioritizations within the department have generated a more dynamic and customer focused
department, and in turn lead to greater business value for the project. The respondent drew the
conclusion that when team members have a common understanding of the prioritizations, the
team can generate a greater business value for the projects.

In sum, the cross-functional team drive new product development forward by
combining their different pieces of knowledge to reach project success. There are certain
aspects of the cross-functional team that the interviewees argued influence their work. The
project members described that they often are dependent on each other to fulfill their work tasks
and, therefore, need to sustain a good network. They further argued that a good network is
created and maintained through informal encounters. These informal encounters cannot always
be sustained across different geographical locations and the stage-gate model is instead used to
exchange information between team members. There is thus an expressed difference in how
team members interpret and use the information and guidelines provided by the stage-gate
model. Lastly, there are expressed difficulties in dispersed resources and lack of priorities
within the cross-functional team. These difficulties create a non-alignment and lack of common
understanding among team members. In order to explore these concerns of the interviewees
even deeper, the management tool is described in more detail in the next section.

**The management tool: Stage-Gate model**

The management tool that the cross-functional team uses during development of new products
is similar to a traditional stage-gate model. The stage-gate model is divided in certain steps and
gates. In each step, deliverables of the cross-functional team are specified. The cross-functional
team gathers information from the stage-gate model to proceed with their work tasks, but also
report their progress via the model. The stage-gate model is then shared between team members,
hence sharing the progress of the project amongst each other. The quality of the products’
progress is thereafter determined in each gate.

The (stage-gate model) give guidelines, a list of things to do, to
restructure your projects. I mean, basically the structuration is good.
The fact that you know, exactly the big phases, in which you have to go
through following the same meta structure. So, you have to make a pre-
study, then you have (for instance) development etc. (Respondent, Project Management Office)

This management tool has been used in the organization for many years to facilitate new product development. The stage-gate model has been argued to work well during its years, however, as of recently the usefulness of the model has been questioned in the organization. Before diving into the troubles of the model, this report will first illustrate the interviewees descriptions of the ways in which the model is helpful when creating new products.

The model as a helpful tool

The interviewees argued that the structure of the stage-gate model, described above, is very well known within the organization. The respondents further claimed that having a common understanding of the structure eases the cross-functional team work by creating rationalizations and harmonization’s in the way of working. The structure of the stage-gate model provides the team members with a clear guideline on how to proceed with their work. For instance, by having a model that is used in all projects, team members know what to do when they start working on a new project. Team members do not need to start from scratch during new projects since there is a common understanding of the guidelines among the cross-functional team. Clear guidelines are described as useful since team members often work on several projects at the same time and having a common understanding of the model’s structure used during product development eases their collaboration. The respondents further described that all information in the stage-gate model’s guidelines are comprehended by all professions within the team. There are therefore no language barriers between the team members when referring to the stage-gate model.

The current stage-gate model, we have been using it for years. Everybody knows it, there's a common understanding (Respondent, Product Development)

The model was further described to be an object that is placed between team members to share and exchange information among them, which has been useful during the product development. For instance, team members update the model to ensure that it is still relevant to invest in a product. These updates are thereafter deliberated in the recommended gates of the stage-gate model, to determine whether the project should obtain further investments. The interviewees thereby argued that the model’s guidelines are useful since the cross-functional team members can share updates and information via the model to help guide them in their work.

We update the (stage-gate model) because that is a time when you check if the (investment) is still relevant. So, that's why the gates are absolutely relevant, because you cannot just continue working. (Respondent, Project Management Office)
In addition to the above, the gates were further described as useful checkpoints that can inform the cross-functional team if a project needs to be stopped. The gates check whether the project is still valid and if the project goal is obtainable. Large investments are made in heavy industrial products and the checkpoints are extremely important for that reason. The respondents recognized that the aim of the project may change during the project’s time-frame and without the gates as checkpoints, the information gathered in the beginning could be misunderstood or even outdated.

I've personally performed projects, in which I followed the model thoroughly because it was a very complex project. I really thought that following the model helped me in doing less work afterwards.

(Respondent, Product Development)

The stage-gate model is, however, described to be very flexible and can be applied to various types of projects. The model is used for complex projects that require a lot of investment, as described above. It is also used for smaller projects that are not as complex. The model is further described as flexible in use since the user is free to interpret the guidelines. The interviewees described that during complex projects, the guidelines are often strictly followed. However, during less complex projects the guidelines can be interpreted differently and not as strictly. For instance, one product developer argued that during less complex projects usually all stages in the stage-gate model are not necessary to follow. The product developer shared a previous experience of working with a less complex project, where the team members did not use all the steps in the stage-gate model. The product developer concluded with this example that the model can be adjusted depending on the project and that team members can interpret the guidelines freely. The respondents thereby described the model as flexible since it can be used for different projects and the interviewees agreed that the model is a helpful tool in giving them guidance during different projects.

It's very flexible. You can do any kind of project with that. You can do complex projects, you can do simple projects. It's very versatile.

(Respondent, Project Management Office)

The model as a constrain

Even though the stage-gate model has been described as useful, some guidelines are not always beneficial when developing new products. The model was argued by the interviewees to be weak in the early stages. The early stages of the stage-gate model include for instance, defining the purpose of the project and identifying the intended target for the project. The interviewees described that the target often is unknown during the early stages of the product development. The initial phases of the stage-gate model are therefore argued to be weak and, in the end, often prolong the timeline of the project. The interviewees argued that a more rigorous preparation than the one suggested in the stage-gate model is more helpful to keep the intended timeline of the project. This was clarified with an example of a project manager who spent more time on preparation than suggested in the stage-gate model. The project manager, for instance, focused
heavily on finding the right people and stakeholders for the project. The respondent witnessed that putting more focus on the initial phase enabled the project manager to execute the project faster than usual. Hence, the respondent underlined the correlation between a more rigorous scoping phase and a fast execution of a project.

The person spent like half a year to just set up the project. Normally, that is not accepted, but then at the end of the day the product went on and was ready within a couple of months. I think this probably would have taken like... years if it were traditionally done...with all the preparation the execution became very fast. (Respondent, Project Management Office)

Furthermore, another restriction with the stage-gate model is that it does not encourage much customer contact. The customer contact is argued to be important in order to understand what the customer need is. The project team first has to understand the customer’s needs in their own words in order to give the customer more value. Once this is understood, the project team is able to provide not only a solution but something more, in terms of added value. As mentioned above, the interviewees described that the customer often is unknown in the beginning phase of the project and that the customer also may change during the process. A project therefore often starts with pilot customers who are the basis of the project. Once the pilot customer is a part of the project, the contact is not as frequent as the respondents would like it to be. The contact is important since new products are heavy investments and having continuous customer contact means that it is more likely for the customer to receive exactly what they requested, or sometimes even exceeding their expectations.

We try to understand before being understood…. I understand what (the product) means for him and I´m providing not only the best solution for that but even something more. (Respondent, Product Development)

The stage-gate model was thereby argued to not be sufficient enough to gain quick feedback from customers. One project manager explained that the team receives the feedback during a later phase in the project when a lot of time has already been invested by the team and the organization. The organization then needs to make adaptations to fulfill the requirements of the market and the customers. Often, these adjustments are not possible to make since there has already been too much time invested in the product. The stage-gate model therefore does not encourage customer feedback which has consequences on the execution of the project.

It means you have invested already quite a long time and you realize after maybe several months, that it is too late to make adjustments. (Respondent, Project Management Office)

Hence, the stage-gate model is described as useful since all team members are acquainted with the structure and guidelines of the model. All team members understand the model and its guidelines. The cross-functional team perceived the model as useful since information can be
both gathered from the model but also shared via the model. The model is further perceived as helpful in determining the quality of the product and whether it should obtain further investments, which otherwise is a great concern when developing new products. It has, however, also been argued that the model does not function well in some instances of developing new products. Two examples of such instances are that the model is weak in the early phases of the project and that it does not encourage much customer contact.

Other activities

In addition to the management tool, the respondents shared two other activities conducted in relation to new product development. These activities are not included in the stage-gate model’s guidelines, rather the organization has deployed them outside the model. However, the other activities described here complement the stage-gate model for the cross-functional team. The first activity is pulse meetings, a way to create face-to-face interaction within the cross-functional team. The second activity is increasing knowledge through training in management tools.

Pulse meetings

The respondents described that face-to-face interaction is important to create a common understanding within the cross-functional team. To achieve face-to-face interaction, the organization has pulse meetings which are shorter meetings during which the team exchanges information. During the pulse meetings, the team members discuss, and check the status of the project. The meetings are also when the team members divide the tasks related to the project, amongst each other. Another key part of the pulse meetings is that the team members are able to ask each other for help as well as deliver information needed for other team members to move forward with their work.

To have this short update, short pulse meeting where you go…. Okay, I did this and now I need this from you and so on. There are current topics and decisions that are needed that keep the pace in a project which if you never meet.... You have no clue what's going on. So that's quite good. (Respondent, Project Management Office)

The pulse meetings are usually conducted once a week. If there is a specific topic that requires a longer discussion, a separate meeting is set up with only the concerning individuals. As previously explained, team members are involved in several projects simultaneously and, therefore, shorter pulse meetings are preferred, and longer discussion are rescheduled. A project manager explained that the meetings are conducted to create visibility for the whole team, in line with the above quotation. The pulse meetings frequency, once a week, and the short timespan leads to transparency on the tasks and activities assigned to each individual.

It's important for the project team to get visibility and clear tasks. That's why we have for each project a weekly pulse meeting that we use to
check the status of the activities. If there is a need for a specific issue to be discussed, we plan a separate meeting with limited number of people involved. I always try to think about not wasting the time of my team because I am fully aware that each of them are fully loaded with a lot of tasks, not only the ones related to my project. (Respondent, Project Management Office)

The respondents made it clear that the frequency of the pulse meeting is important, however which day and time the meeting is held is negotiated in each team. When one project team moved their pulse meetings from Monday morning to Friday afternoon, they felt more satisfied. None of the respondents have highlighted a specific day or time of the week to be better suited for the pulse meetings, meaning that this varies from one project team to another depending on their schedule and preferences.

We had the pulse meeting every Monday morning. That meeting was intended to be maximum an hour. And we highlighted that it was not okay. Because in pulse meetings, you are supposed to inform, the other people and your manager, of what you have done during the week and we did not feel satisfied about the outcome of that. Therefore, we moved it to Friday afternoon and we have the meeting a little bit longer, where we do not explain everything in detail but at least the main task that we have performed for the week and what is the main focus for the next week. Moving it to Friday also improved our feeling, that when you exit from work on Friday evening, very tired but at least I've planned what I have to do next week. And then I'll go to work on Monday and start fresh. (Respondent, Product Development)

Training

As shown in previous sections, the team is dependent on each team member when creating new products and most employees rely on their knowledge and experience when working on new product development. For this reason, the respondents have highlighted training of the existing management tools and how training is a way to increase knowledge. For everyone to be able to take part of the training, it is also available online for all employees.

We have training on (the model). We have training that can be done by everyone. So, there is training on the web, that each person in the product development team can do. This is one of the first steps that each new engineer has to do in training knowledge. And then of course there is the training on the job, so just applying what you learn (Respondent, Product Development)
Moreover, some employees are trained in productivity to create new products at a faster and more efficient pace. The training on productivity had other results as well, such as creating a common vision and energy to reach the vision. In the below quotation, a product development manager explained how the training in productivity made a difference within his team, consisting of both product developers and engineers.

Last year I had to make this training on productivity. It was great, and then I summarized everything. I deployed it to the team and then we decided to start the journey to get there, to get to that vision. And when you see the results of what you have been talking about together, then it creates an energy which you cannot stop. You don't even have to put fuel every day, you know what I mean. Something which is auto-generating. It really makes the difference. (Respondent, Product Development)

The product development manager was trained on productivity and deployed the lessons to the rest of his team. In some instances, however, only training the manager did not work since the training involved certain rules and vocabulary. In these cases, the whole team needs to be trained. When the entire cross-functional team is not trained, it could lead to possible non-alignment.

I tried to start in the same team, some people who were trained and some people who did not have the opportunity to be trained and it was a mess. I gave up because there are specific vocabulary. There are specific words, rules in fact to be known from the beginning. You cannot have just for example the project manager say, okay, you will be the project manager and you will be trained and then you will deploy it inside your team. That's not... all the people have to be trained. (Respondent, Project Management Office)

Hence, the respondents viewed pulse meetings and training as activities that the cross-functional team conducts, which complement the activities guided by the stage-gate model. Pulse meetings create face-to-face interaction on a continuous basis, once a week, however the day and time is completely up to each cross-functional team. During the pulse meetings, the team members update each other on what they have done and what they plan to do moving forward with the new products. Furthermore, the cross-functional team has training sessions related to the model, which are accessible online to everyone. In some instances, however, the training is only conducted by a manager; either department manager or project manager, who then deploys the training on to their teams. Two examples of such instances are portrayed and the outcomes are different, nevertheless, the activities serve the purpose to align the cross-functional team members towards the same goal.

Summarizing the empirical findings, the case organization works with development of new products through; the cross-functional team, stage-gate model and other activities. Firstly, the cross-functional team consists of individuals with different expertise and
knowledge. The team members are dependent on each other to proceed with their work tasks, when creating new products. Thus, the cross-functional team has differences and dependencies which have led to different understandings. Two further issues related to the cross-functional work is prioritization and resources that create a non-alignment and lack of understanding within the cross-functional team. Secondly, the stage-gate model is a management tool used by the cross-functional team to help guide them in their work and their collaboration. The structure and guidelines of the model are common to all team members. The model was further argued to allow team members to gather and share information via the object. These aspects of the model have been argued useful when developing new products. The model is, however, weak in the early phases and does not encourage much customer contact. Thirdly, the cross-functional team performs other activities during collaborative work. The cross-functional team has pulse meetings and training to help them during development of new products. The activities are described to complement the stage-gate model, while informal encounters are shown as activities performed in relation to the model.

Discussion

The purpose of the study was to gain a better understanding of how the stage-gate model functions as a boundary object in cross-functional work, as there is criticism towards the traditional stage-gate model’s function (Cooper, 2014) when dealing with the market pressures of industry 4.0 (Lasi and Kemper, 2014; Deloitte, 2019). One way in which the studied organization deals with industry 4.0 is through cross-functional work, where knowledge boundaries are common (Kotlarsky et al., 2015; Majchrzak et al., 2012; Carlile, 2002). In the previous section, the findings show the cross-functional team’s difficulties as well as the stage-gate model’s function and other activities that are performed in relation to new product development. In this section of the paper, the findings are discussed with the help of the theoretical framework that mainly concerns the concept of boundary objects and boundary spanning activities. The discussion begins with identifying boundaries in cross-functional work. Thereafter, the function of the stage-gate model as a boundary object is discussed and boundary spanning activities are illustrated. Lastly, the boundary objects ability to cross the boundaries in cross-functional work is discussed.

Boundaries in cross-functional work

As shown in the findings, the cross-functional team consists of individuals from several departments, amongst which each individual has specific expertise and knowledge. Therefore, within the cross-functional team there are differences in knowledge and expertise. Carlile (2004) describes differences as the degree to which the employees have specialized knowledge, which is apparent in this study where the cross-functional team members have specialized knowledge. When creating new products, the cross-functional team is dependent on each team member. The findings illustrated for example that the manufacturing department and the product development department are dependent on each other when working on new product development. Carlile (2004) describe dependencies as the degree of which an actor is dependent on another to proceed with their work task, which is also apparent in this study. This thereby
creates a need for information sharing on a continuous basis. As such, the respondents describe that they have both formal and informal encounters to inform each other on what they have done related to the new product development.

During the informal encounters, the respondents describe that networks are formed and a good network is described to be crucial to obtain a common understanding among team members. The reason for this, as illustrated in the findings, is that team members are located in different geographical locations which inhibits the possibility for informal encounters and network formation. A good complement for networking is to use the stage-gate model to share updates and information regarding the project. The findings, however, illustrate that the understanding of how to use the stage-gate model differs depending on the geographical location, e.g. respondents in one geographical location interpret how to use the stage-gate model differently than the respondents located in Sweden. The study shows that the stage-gate model is well known and the model’s guidelines are clear for the respondents. The respondents therefore claim that there is a difference in understanding how to apply the model, rather than a difference in understanding of the stage-gate model and its content. A respondent exemplifies this by referring to the geographical differences, where one individual in another country has their own process of working with the stage-gate model, which differs from the way individuals usually work with the model in Sweden. Carlile (2004) argues that differences in understanding are semantic knowledge boundaries, and to overcome these boundaries, knowledge needs to be translated among actors (Carlile, 2004). As such, semantic knowledge boundaries exist within the cross-functional team regarding how to utilize the model.

However, Carlile (2004) further argues that there can exist syntactic and pragmatic knowledge boundaries in an organization, in addition to the semantic knowledge boundaries. This study has not found syntactic knowledge boundaries in relation to the stage-gate model, which occur when actors have different vocabularies (Carlile, 2004). This since the stage-model and its guidelines are understood by the respondents. The study did further not find any pragmatic knowledge boundaries, which occur when there are conflicting interests (Carlile, 2004), since the cross-functional team works together towards a common goal during product development. As the boundaries are identified, the stage-gate models function as a boundary object, as well as boundary spanning activities are discussed in the following section.

The objects function and boundary spanning activities

Drawing from the interviews, it was found that the respondents use the stage-gate model when developing new products to support the cross-functional work. The stage-gate model has been used in the organization for many years and is viewed as the main management tool when creating new products. As such, the stage-gate model is used by the organization as a management tool to help support the creation of new products, since there are new market demands posed by industry 4.0 (Lasi and Kemper, 2014; Deloitte, 2019). The study further shows that the stage-gate model is used during cross-functional work to share updates between the team members, which can be interpreted in different ways by different actors. As demonstrated in the empirical section, the respondents argue that the guidelines of the stage-gate model can be interpreted differently, even though all respondents are well acquainted with the model. These findings reveal that the stage-gate model can be identified as a boundary
object since it follows the statement that boundary objects are shared between different social worlds while simultaneously allowing for different interpretations of the object (Star and Griesemer, 1989; Nicolini, Mengis and Swan, 2012).

Furthermore, a boundary object is flexible in use (Star and Griesemer, 1989). The findings show that the stage-gate model is applicable to both complex and simple products, which indicates that the model is very versatile. The model’s flexibility was further exemplified when a project manager was able to use the guidelines in a flexible way by combining two meetings in one. The respondents thereby argue that the model is flexible in use, since it is applicable to all projects and can be used in different ways. Furthermore, the findings reveal that the stage-gate model was found useful in facilitating collaborative work since actors are able to exchange knowledge via the object. For instance, the differences in profession, such as experience and knowledge, are overcome by the stage-gate model due to the fact that all team members can share updates and information through the model. Actors with different work experience and expertise are therefore shown to overcome their differences by communicating and sharing knowledge via the object (Star and Griesemer, 1989; Nicolini, Mengis and Swan, 2012).

Nevertheless, according to the respondents there are instances where the stage-gate model is not useful, as for instance in the early phases of a project or regarding customer interactions. The findings illustrate the former through an example where a project manager spent more time on the initial phase than suggested in the stage-gate model. In this example, the stage-gate model’s guidelines were insufficient since the project manager was advised by the model to spend less time in the early phases than the project manager needed. Carlile (2002, p. 452) argues that boundary objects cannot be viewed as “magic bullets”, as such the stage-gate model’s early phases can be an example of where its function as a boundary object is limited.

Furthermore, according to the respondents the boundary object did not encourage much customer contact, which was argued essential in order to understand the customers’ need. The customer is often unknown when developing new products and pilot customers are therefore used to gain an understanding of the market. The customer may also change during the process of new product development. An additional weakness of the stage-gate model that the respondents describe is the lack of feedback from the customers that is captured by the model. The feedback is often captured too late in the process, when the team has invested a lot of time in the project. This is argued important since changes in product development are realized too late in the process, sometimes after several months. Lindberg and Walter (2013) argue that boundary objects lose their function in instances of change. Hence, as the customer in new product development changes and feedback is not captured, the stage-gate model does not function as a boundary object.

The findings further show that the team members in the cross-functional team are involved in several projects simultaneously and as a result, individuals have many managers to respond to. This ultimately results in scattered priorities and dispersed resources, leaving each individual to navigate between priorities set by the different managers while individuals work on several projects. Team members cannot use the stage-gate model to gain guidelines on what project to priorities. Therefore, the cross-functional team have to navigate between different priorities on their own. Moreover, project managers cannot rely on the stage-gate model to gain
resources for their project and therefore, they have to turn to either a department manager or to the individual to allocate resources for their project. The findings show that issues related to scattered priorities and disperse resources cannot be solved by the stage-gate model as a boundary object. Problems with resource and priorities cannot be resolved within the cross-functional team with the help of a boundary object, scattered priorities and disperse resource need to be managed beyond the cross-functional work. A boundary object can thus function as a tool without fulfilling the function to overcome all apparent issues (Nicolini, Mengis and Swan, 2012). In Becky's (2003) study for instance, drawings did communicate knowledge without overcoming coordination problems in the organization. As such, the stage-gate model as a boundary object may not cross all existing boundaries in an organization.

In line with the above, Nicolini, Mengis and Swan (2012) argue that boundary objects can be more useful in some instances than others. In that sense, the stage-gate model can still be perceived useful in cross-functional work even though it does not help to overcome all difficulties during cross-functional work, e.g. early phase of the project, customer changes, scattered priorities and dispersed resources. The stage-gate model was shown to be useful since it is a commonly known tool in the whole organization, a flexible tool and a tool for exchanging knowledge to overcome different professional and geographical boundaries. The findings therefore show that the stage-gate model passes through different social worlds, and the function of a boundary object is conceptualized to the ability for actors from different social worlds to communicate via the object (Star and Griesemer, 1989; Carlile, 2002; Bechky, 2003; Nicolini, Mengis and Swan, 2012).

On the other hand, Sapsed and Salter (2004) argue that a boundary object cannot cross boundaries alone in an organization. The object needs to be complemented with face-to-face interaction to support the function of a boundary object (Sapsed and Salter, 2004; Nicolini, Mengis and Swan, 2012). The study shows that other activities are conducted in the organization, such as pulse meetings and trainings. The pulse meetings are a way to have face-to-face interaction within the cross-functional team, usually once a week. During these pulse meetings, each team member shares updates regarding their specific area of expertise related to the project, e.g. the product developers share updates regarding product development. The pulse meetings are kept short and longer discussions are rescheduled to involve only the individuals that are concerned. Birkinshaw et al. (2017) categorize weekly meetings as a boundary spanning activity, since they link individuals from different units together. Therefore, the pulse meetings are viewed as boundary spanning activities, since the cross-functional team have the opportunity to come together and share updates. Boundary spanning is a process where individuals make sense of knowledge outside of their own expertise, and all activities related to boundary spanning are boundary spanning activities (Van de Ven and Zahra, 2016). As such, the pulse meetings are boundary spanning activities. The rest of the project team have a possibility during the pulse meetings to make sense of the developments occurring outside of their own expertise (Van de Ven and Zahra, 2016).

In line with the above, the findings illustrate that training is a way to increase knowledge within the organization and it is important for everyone to take part of the training, which is why it is available online. Training is also a boundary spanning activity since it enables individuals to share knowledge and receive knowledge beyond their expertise (Birkinshaw et al, 2017). However, the findings also demonstrate that training is sometimes
only conducted by a department manager or a project manager, and it is then that individuals’ responsibility to deploy the training within the team. In their study, Birkinshaw, Ambos and Bouquet (2017) focus on boundary spanning activities carried out by corporate executives. In this study, it is also shown that a manager held a training within productivity for his team, that included both product developers and engineers. However, Birkinshaw, Ambos and Bouquet (2017) do not refer to executives as boundary spanners, a role in which Schotter et al. (2017) recognize as someone who is responsible for the boundary spanning activities. This study therefore highlights boundary spanning activities in another context than that of Birkinshaw et al (2017), by also including boundary spanners.

The findings show that a product development manager was trained in productivity and deployed the training to his team, which had a great effect on the group's energy. In this case, the manager functioned as a boundary spanner, connecting two organizational units through training, whilst the individuals still worked independently within their fields (Schotter et al., 2017). The manager, who has a formal role in the organization, was therefore a nominated boundary spanner (Levina and Vaast, 2005). The manager was able to create great energy and alignment through deploying the productivity training onto his team, despite the fact that the whole team did not take part of the training. The team, consisting of product developers and engineers, continued to work independently whilst working in alignment on the new agreed upon structure on productivity, which is the role of the boundary spanner (Levina and Vaast, 2005).

Boundary spanning activities are linked to the processes of accumulation and mobilization of different capital, e.g. knowledge within a specific field (Kislov et al., 2017). Training and pulse meetings are two examples of boundary spanning activities, since the activities gather and mobilize the cross-functional team. However, the legitimation of boundary spanning depends on the approval from several professional groups (Kislov et al., 2017), the whole cross-functional team (not just product developers and engineers) need to be on board. A different example of training shows that a project manager had difficulties in the cross-functional work in an instance where the whole project team was not trained together. Due to the fact that the training contained specific vocabulary and rules, it was not as easily deployed compared to the training within productivity. In this instance, training as a boundary spanning activity did not work to create alignment since the knowledge was not translated across the organizational units. The different vocabularies used in the project team created syntactic knowledge boundaries as described by Carlile (2004) and therefore, knowledge translation was not possible. Knowledge translation is about learning and creating a common understanding among actors that work with the boundary object (Carlile, 2004; Corsaro, 2018). As such, the training that contained specific vocabulary did not succeed in creating common understanding and knowledge translation was therefore not achieved.

In sum, the stage-gate model functions as a boundary object in some instances while it does not function in other moments of cross-functional work. The stage-gate model is used as a tool to share knowledge between different actors, it can be interpreted in different ways, and applied in various projects as it is flexible in use. However, the respondents explain that the model does not function in the early phases of a project, during instances of change e.g. customer change, and does not offer a way to handle prioritization. Moreover, activities such as pulse meetings and training are two boundary spanning activities that are performed within
cross-functional work. Lastly, for knowledge to be translated in the cross-functional team, the whole team needs to be aligned and a common understanding needs to be achieved.

**Crossing boundaries**

The existing boundaries in the cross-functional team are semantic knowledge boundaries due to the respondents different understandings of how to apply the model. To overcome these boundaries, knowledge needs to be translated among actors (Carlile, 2004). Knowledge is translated through the stage-gate model in some instances, where the model functions as a boundary object. However, in those instances where the stage-gate model does not function as a boundary object, boundary spanning activities could work as a complement or assistance in translating knowledge. For example, during the pulse meetings, the cross-functional team members have the opportunity to share updates face-to-face and divide work tasks, as a complement to the stage-gate model. Furthermore, training complements the stage-gate model as shown in the example of the manager who worked as a nominated boundary spanner, connecting two organizational units through productivity training. The training in this example worked as a boundary spanning activity through translating knowledge and creating alignment towards the same goal. The training also created great energy for the team which fueled them to reach the aligned goal. Thus, the training in productivity complements the stage-gate model’s function, through these achievements that are not obtained from the stage-gate model. As such, the stage-gate model as a boundary object is able to cross the semantic knowledge boundary, if complemented by boundary spanning activities.

In addition to other activities (pulse meetings and training), the findings illustrate that during informal encounters, the actors are also able to exchange and negotiate their knowledge. This, since what is not understood via the model could be clarified through face-to-face interaction. The boundary spanning activity of informal encounters, thereby act as a complement to the stage-gate model even though the respondents did not recognize e.g. coffee breaks as an additional activity that helps to support the stage-gate model’s function as a boundary object. Moreover, boundary spanning activities can be informal arrangements, but also formal, structured and organized ones (Van de Ven and Zahra, 2016). Therefore, formal meetings proposed by the stage-gate model are also a complement to the boundary object. The quality of the product is discussed during the meeting and complements the updates written in the stage-gate model. As such, the formal meetings are boundary spanning activities that are recommended by the boundary object to fulfill the purpose of translating knowledge within the cross-functional team.

As mentioned in the discussion above, in some situations boundary objects work on their own, while at other times they need to be complemented by boundary spanning activities to function, e.g. by discussions during a coffee break or during a formal meeting at each gate. Nicolini, Mengis and Swan (2012) argue that a boundary object can be more useful in some instances of collaborative work than in others, which this case study supports since the stage-gate model is shown to be more useful in e.g. translating knowledge than during early phases of a project. This finding was also made in Beckhy’s (2003) research, where the use of the boundary object worked better during some moments than in others. Sapsed and Salter (2004) further claim that boundary objects cannot function on their own, which is similar to the
findings of this study which show that the stage-gate model does not function as a boundary object during e.g. scattered priorities which create a non-alignment within the cross-functional team. However, training as a boundary spanning activity created alignment within the team and great energy that fueled the team to pursue the vision. Also, the pulse meetings functioned as a boundary spanning activity by creating face-to-face interactions on a regular basis, an opportunity to update other team members and deal with changes. This study therefore shows that boundary spanning activities can complement a boundary object. Hence, the findings of this study follow the findings and arguments of Nicolini et al. (2012), Sapsed and Salter (2004) and Beckhy (2003). The findings of this study also highlight the importance of using boundary spanning activities to support the boundary object, when it cannot translate knowledge on its own.

During cross-functional work, there are knowledge boundaries that exist within the cross-functional team consisting of individuals with different expertise and knowledge (Kotlarsky et al, 2015; Majchrzak et al, 2012; Carlile, 2002), more specifically semantic knowledge boundaries (Carlile, 2004). This study shows that there are differences in how to apply the model’s guidelines depending on the geographical location, as such there are semantic knowledge boundaries within the cross-functional team. To be innovative, organizations have to work across boundaries to sustain their competitive advantage (Leonard, 1995) and this study shows that the stage-gate model together with other activities can cross the knowledge boundaries that exist.

In this study, boundary spanning activities are shown to complement the boundary object, the stage-gate model, during cross-functional work. The stage-gate model is a traditional management tool that has been used for many years to support new product development (Cooper, 1990; Cooper, 1994) and in recent years, the model’s function has been criticized (Cooper, 2014). Traditional organizations are struggling to manage the market demands posed by industry 4.0 (Nunes et al, 2017; Tesch et al, 2017; Rauch et al, 2016). One way in which the studied organization tackles the market demands of industry 4.0 is through cross-functional work, with the support of the stage-gate model and other activities. The model is shown in this study to not function as a boundary object in all instances of cross-functional work and is, therefore, complemented by boundary spanning activities. The critique towards the stage-gate model is that it is too linear and rigid to handle a more innovative environment (Cooper, 2014), nevertheless, Cooper (2014) does not consider the impact of boundary spanning activities in his paper. Perhaps, the stage-gate model does not have the sole responsibility in dealing with industry 4.0 and researchers need to pay more attention to other activities conducted during new product development. The other activities have, at least in this study, shown to have a great impact in working as boundary spanning activities during cross-functional work.

Conclusion and Implications

In this paper, the purpose was to explore how a management tool functions as a boundary object in cross-functional work. In order to answer the research question, a qualitative single case study was conducted in a global industrial organization that works in cross-functional teams during new product development. The study found that the stage-gate model functions as a
boundary object in some occurrences during cross-functional work, whilst it does not function during other occurrences. Boundary spanning activities, such as pulse meetings, formal meetings, informal encounters and training, were shown to support the boundary object in instances where it does not function. This study therefore concludes that the stage-gate model functions as a boundary object in cross-functional work, if complemented by boundary spanning activities. Thus, the study contributes to previous research by addressing the dispersed opinions of whether management tools can function as boundary objects in cross-functional work. Some scholars have argued that management tools do not function as boundary objects in cross-functional work since they do not encourage face-to-face interactions (Sapsed and Salter, 2004). Other researchers, argue that boundary objects can function in cross-functional work when complemented with face-to-face interaction (Nicolini, Mengis and Swan, 2012). This study contributes to previous studies by showing that the stage-gate model as a boundary object does function in cross-functional work, if complemented with boundary spanning activities.

The importance of the stage-gate model’s function lies in the boundary object’s ability to translate knowledge. When a management tool is able to function as a boundary object, it can translate knowledge during cross-functional work. However, when the stage-gate model does not function, it can be complemented with boundary spanning activities. As the findings show, pulse meetings, training, informal encounters and formal meetings help support the stage-gate model to translate knowledge. This study therefore shows the importance of considering boundary spanning activities in cross-functional work. This finding might have practical implications for the management of cross-functional work, by recognizing the importance of boundary spanning activities during cross-functional work. Moreover, the study shows that boundary objects and boundary spanning activities cannot overcome issues related to scattered priorities and dispersed resources. These issues are shown to be too complex for the boundary object, which main purpose is to cross boundaries. This finding can have practical implications for managers where they might need to address these issues with other means than a boundary object.

Furthermore, the study suggests that practitioners and researchers should put more emphasis on boundary spanning activities during cross-functional work. Future research could thereby look further into, and observe, the entire product development process in order to better understand the relation between boundary objects and boundary spanning activities, to complement this research. Due to the time limitation of this study, the boundary spanning activities could not be studied in further detail. An additional limitation concerns the whole cross-functional team since the study was not able to cover all departments, leaving an argument that not all team members view the stage-gate model in a similar way as depicted in the study. Therefore, there might be conflicting ideas from other parts of the organization which the study does not cover. Future research could thereby be conducted in different departments of cross-functional teams than those studied in this research.
Reference list


