Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

A tool to learn actors in project teams about the integration of circularity in construction projects

Management in the Built Environment – Design and Construction Management

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Content

1 Introduction

1.1 Context and problem

Climate change causes increasingly more challenges for our living environment. The weather is becoming more extreme, a loss of biodiversity is noticeable and the incremental risks on our health are in direct relation to the exhaust of greenhouse gasses (Rood & Hanemaaijer, 2017). In the following decades a balance is ought to be found between ecological growth, the environment and overall health of people. This would require new strategies on efficient use of raw materials and products (Winans et al., 2017). One of these strategies is the transition towards a circular economy (CE), which helps to lower production and consumption rates (Mulhall & Braungart, 2010). This strategy uses, instead of linear life cycle, a circular life cycle and replaces the end-of-life concept (Kirchherr et al., 2017). However, research on CE tends to focus mainly on the short-lived manufactured products and leaves research on circular buildings, due to the complexities in the built environment, often neglected (Moncaster & Pomponi, 2017).

Kirchherr et al. (2018) also concluded several barriers for the transition to circular economy. In his research he concluded that the barriers on the technological dimension were the least pressing for CE. But barriers on the cultural dimensions appeared to be most pressing and slowing down or even cease the transition towards a CE (Kirchherr et al., 2018). That is why this research will focus on the cultural dimension.

1.2 Research motivation

For the transitions towards a CE, approaches can take the form of either bottom-up or top-down, as shown in figure 1. Moncaster and Pomponi (2017) conceptualized the relation of six dimensions. The cultural dimension of Kirchherr et al. (2018) shows similar traits with the societal and behavioral dimension in figure 1 and can be positioned on the bottom of the circle. And while this research focuses on the cultural dimension, its starting position is therefore also the bottom.

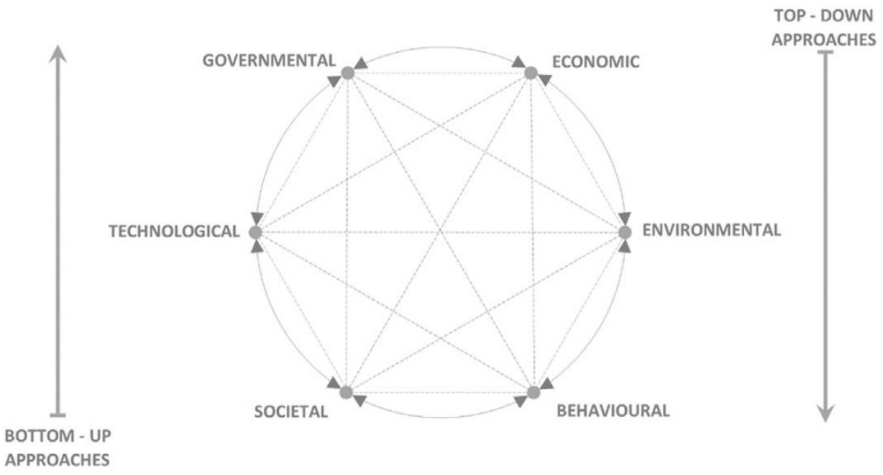

Figure 1: The six dimensions for building research with top-down and bottom-up approach (Moncaster & Pomponi, 2017, p. 715)

To solve the barriers in the cultural dimensions, they must first be identified. Kirchherr et al. (2018) sees two main barriers in this dimension. At first a 'hesitant company culture' and secondly 'lacking consumer awareness and interest.' Hart et al. (2019) mentions the lack of managerial skill as blockage for the transition towards a CE. Gerding et al. (2021) conclude that the required knowledge is lacking in conventional actors in project teams of construction projects and that they rely too much on experts. The latter is the focus of this research. To sum this all up, this research provides a bottom-up approach to provide a solution for the lack of knowledge on circularity among actors within project teams.

1.3 Aim and research questions

The aim of this research is to develop a tool to learn actors in project teams about the integration of circularity in construction projects. The main research question is therefore: *How does the tool look that learns actors in project teams the integration of circularity in construction projects?*

To validate the tool, a proposed tool is developed based on literature. This tool is shown in the appendix and also added as additional document. The development of the tool is explained in *3.1 The development of the proposed tool*. The tool consists of four main elements. The grey, framed, boxes, the grey boxes, the normal text boxes and the checklist. Respectively they show the hierarchy within this tool. Starting with the grey, framed boxes and ending with the checklist. The tool also shows, using arrows, a story line, which needs to be followed. In order to develop this tool, all elements mentioned above need careful attention. For this the following sub research questions are raised.

1) How could the storyline be improved?
2) How could the information be improved?
3) What should be added or deleted to the main elements in the tool to provide for better reflection opportunities?

1.4 Research potential and relevance

Gronheid (2021) argues that to transition towards a CE, learning must happen on organizational level. On this level, the lessons learned can be translated into policies or procedures (Crossan et al., 1999). This process is also called scaling up (van den Bosch & Rotmans, 2008). However, this research focuses on learning group level, because of the focus on project teams. This means that the lessons learned are integrated in the work processes of a particular project team (Crossan et al., 1999). The mechanism of scaling up is therefore only considered as an opportunity for this research to contribute to the transition towards a CE. In figure 2 a framework is shown, that illustrates the focus of this research and the potential it has when lessons are used for upscaling. Therefore, during the selection of the learning type, process and strategy and during the development of the tool, this potential is considered. This means that in the end the lessons learned from the tool should be able have the opportunity to be scaled up to organizational level.

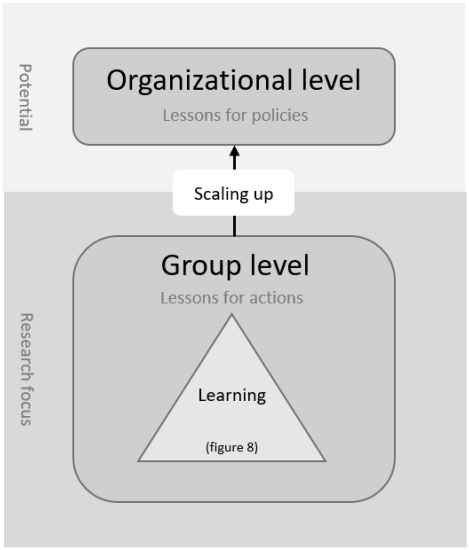

Figure 2: Research focus and the potential to scale up lessons into policies and procedures (Own figure)

1.5 Thesis Outline

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2 Literature review

2.1 Circular Economy

The built environment can be split up into three levels, micro, meso and macro. The smallest level, micro, focusses on the material dimensions and the supply chains, but this also includes businesses

and consumers. The meso level is where these materials come together as buildings or industrial parks. The largest scale is the macro, being the urban agglomerates (Moncaster & Pomponi, 2017).

Strategies on circularity are often described in R-models. Kirchherr et al. (2017) came up with a 4R-model, consisting of reduce, reuse, recycle and recover. But other models exist that go up to nine strategies, the 9R-model, which introduces the strategies of refuse, rethink, repair, refurbish, remanufacture and repurpose, in addition to the 4R-model (Potting et al., 2017). Bocken et al. (2016) addresses that these strategies go hand-in-hand with innovative business models that facilitate circularity. Key elements of these business models are slowing, narrowing and closing resource loops. Slowing resource loops, means extending a life cycle of a product, with for example remanufacturing. Narrowing refers to using less resources per product. Closing down resource loops, means to recycle or reuse and to connect the post-use and production phase (Bocken et al., 2016).

2.2 Dynamics for circular construction

In order to have an explicit and usable tool, an in-depth understanding is required of what a circular construction project needs to succeed. Kooter et al. (2021) illustrate in figure 3, the interplays between three clusters of dynamics in circular construction projects, which are prerequisites, temporal dynamics in interorganizational projects and contextual influences.

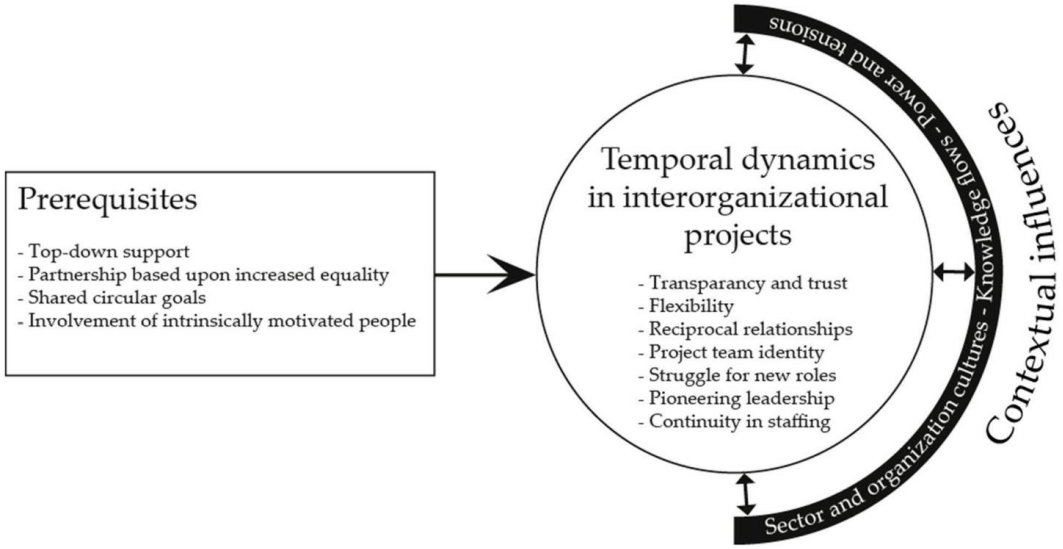

Figure 3: The interplay between the dynamics of interorganizational projects that are relevant in the realization of circular ambitions in construction projects (Kooter et al., 2021, p. 7)

The first cluster mentioned are the prerequisites for a circular construction project. The prerequisites are needed for formulation and realizing the circular ambitions, starting with the support from higher levels of the organization. The higher levels can show support by using policies, which is more formal, and by encouraging certain behavior on the work floor, which is more informal. Also it is required that

partnerships are considered as equal, sharing the circular ambitions and risks it upholds. Therefore it is also important that the visions are explicit with clear goals, to prevent the vision to lose value during the process. The last prerequisites Kooter et al. (2021) mention is that for realizing circular ambitions, the project should involve intrinsically motivated people.

The second cluster provides insights into the temporal dynamics in interorganizational projects. The first dynamic in the list is transparency and trust, which is required for flexibility, to achieve higher quality and to stop greenwashing in a project. Transparency and trust among actors is reached when they dare to be open an vulnerable and create their relation based on trust. Due to uncertainty created by circular ambitions and the general lack of practical knowledge projects have to be viable. therefore flexibility is a crucial dynamic in interorganizational projects. The necessity of equal partnerships also translates into actors in project teams sharing responsibility, not blame each other and act interdependently. In addition to this, Kooter et al. (2021) address the importance of project identity, which consists of the goals, values and norms of the project. The fifth dynamic in the list emphasizes on the demand of the certain expertise required in circular construction projects and the new roles in project teams this creates. As circular construction is relatively new, existing actors take upon these roles, which should first be renegotiated in the project. An important role that can be assigned is that of the pioneer leader. Kooter et al. (2021) suggest that in every project a project member should have the responsibility to put and keep circularity on the agenda. At last, actors in project teams can learn from each other by continuity in staffing between projects and organizations.

The third cluster are the contextual influences, that need to be taken into account when realizing the circular ambitions. The first contextual influence that is recognized is the culture that lives on national, organizational and project level. The culture can influence the values, norms, rituals and practices of the actors. As mentioned for circular construction projects, certain knowledge is still lacking. As different actors can have different knowledge or the lack of it, the knowledge flows in project is considered as the second contextual influence. The last contextual influence is power distribution and the tension between organizations. Power can be seen in the dominance of clients, which usually have a temporal perspective on projects, i.e. budget (Kooter et al., 2021). Tension can arise, when organization see each other as rivals or if there is distrust between them.

2.3 Learning theory and concepts

For the transition of knowledge theories and concepts about learning are examined. Brown et al. (2003) describes two types of learning, first order learning and higher order learning. First order learning provides insights on problems and higher order learning can, in addition to this, change

problem definitions, norms, values, convictions and goals of actors. To transition traditional processes into circular processes, the latter can be used for radical solutions and change (Leising et al., 2018).

Learning processes can be conceptualized in three learning loops. All three illustrate how actors can learn in circular building projects and how this translates to their context. The first two learning loops are single loop and double loop. The triple loop stands out from these two and is elaborated after explaining the single and double loop process. Single loop learning equals to the first order learning from Brown et al. (2003); (Leising et al., 2018). It identifies the problem in its context, correct actions, but does not reflect on it on a higher level. Argyris (1977) used an example of a manager that detected a problem and solved this with product X. Double loop learning is a type of higher order learning, as it is able to alter organizational policies, norms and objectives. It reflects on the problem and correction to lead to insights about the problem and how to solve it on organizational level (Argyris & Schon, 1974; Gronheid, 2021). Using the example of the manager, in double loop learning, the manager could question him- or herself if product X should be manufactured to prevent any additional problems (Argyris, 1977).

Then the triple loop learning, which can be seen as a 'meta' to the single loop and/or double loop learning processes. It is also not an incremental of the previous loops (Tosey et al., 2012). But it relates to the ability to learn. Argyris and Schon (1974) call this deuteron-learning, which is translated as 'learn-how-to-learn'. Triple loop learning results in learning strategies or structures, which was mentioned in 1.3 sub question 4 (Romme & Van Witteloostuijn, 1999).

During the learning process, there are three mechanisms present. The first is deepening, which is gathering the knowledge. This can happen with the single-, double or triple loop concept. The second mechanism is broadening, in which this knowledge is tested in different contexts. At last is scaling up, which refers to using the knowledge for integration in processes or policies (van den Bosch & Rotmans, 2008).

In addition to the learning process, Crossan et al. (1999) found that learning can happen on individual level, group level and organizational level. When individuals learn, they do this by intuition and interpretation of certain events or conversations. Learning on group level occurs when what is learned is also integrated in the work processes of the group, which means that actions to solve the problem are acquired. Learning on organizational level influences the institutional level, which means that these actions are also translated in policies or procedures (Crossan et al., 1999). For the transition of knowledge on circular building projects the learning process should go beyond individual level and must occur on organizational level (Gronheid, 2021). Organizational learning, explained by Crossan et al. (1999), is achieved by the learning strategy of project based learning (Yan, 2021). On the subject of

project base learning little literature is available. But, Yan (2021) emphasizes that it is a promising method to use when transitioning knowledge between construction projects. This is because finished projects provide opportunities to learn lessons from and obtain knowledge to solve problems on current or future projects. However, the uniqueness of the project makes it difficult to diffuse between projects and stages of the project. For successful project based learning five principles should be integrated, namely, owner commitment, social environment approach, collaboration vision, value orientation, and open mindset (Yan, 2021).

2.4 Design research

Hevner et al. (2004) provides guidelines for design-science research, , see figure 4. A good design research takes all into consideration, which is the strive for this research as well. In 2007, Hevner (2007) published another article on design-science research. This time he showed the relation between the environment and design science research (relevance cycle) and the relation between design science research and knowledge base (Rigor cycle). These cycles illustrate that the design process, is interrelated with the field, the research and literature, see figure 5. The principle of evaluating the design during the design process, is what Sein et al. (2011) calls action design research, which is a derivative of traditional design research.

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Figure 4: Design-Science research guidelines (Hevner et al., 2004, p. 83)

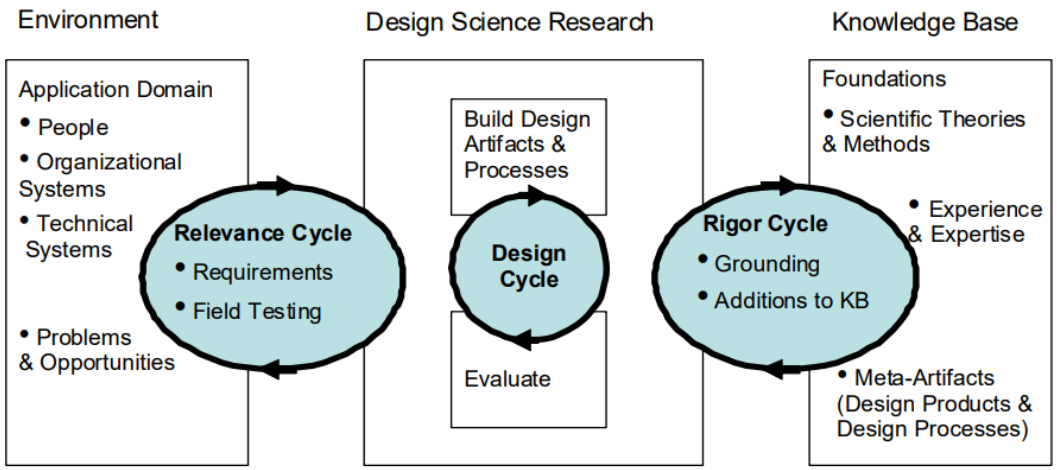

Figure 5: Design Science Research Cycles (Hevner, 2007, p. 2)

Another view on design-science research is the mental model of Peffers et al. (2007), see figure 6. This model is called the Design Science Research Methodology (DSRM) and illustrates the design science in a more chronological manner compared to the three cycle model from Hevner et al. (2004). It shows the steps to be taken in a design process more clearly, as well as when to evaluate. The advantage of the DSRM model is that it is developed for design processes that are substantiated with prior knowledge (Peffers et al., 2007).

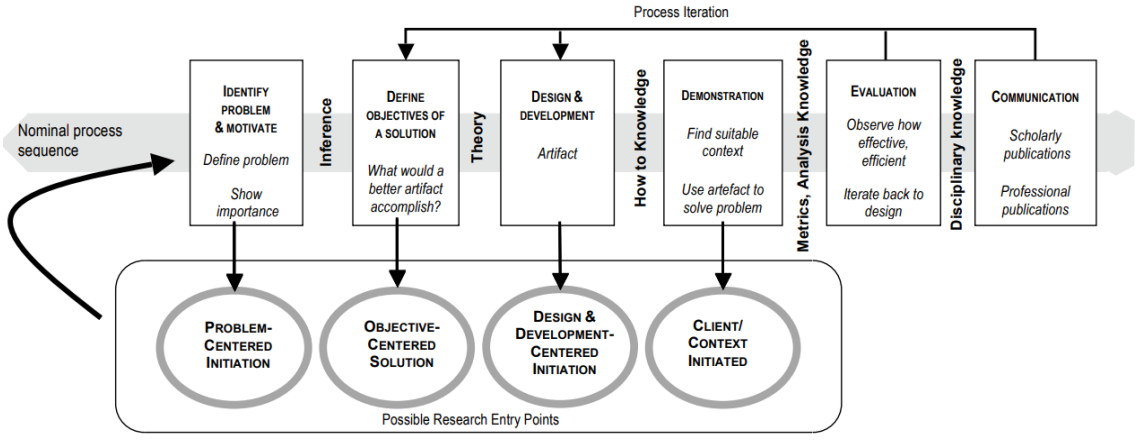

Figure 6: Design Science Research Methodology (DSRM) (Peffers et al., 2007, p. 2)

3 Research Methodology

3.1 The development of the proposed tool

To develop this tool, the content of what it learns about circularity must be explicit. This requires information on what a CE entails within the built environment. This results in the question: *what is key*

information that should be integrated in the tool? The tool should provide valuable lessons necessary for circular construction project. These lessons are provided by the temporal dynamics described by Kooter et al. (2021). From the seven in total the ones that are most challenging or fitting for circular construction projects compared to traditional projects are selected to be integrated in the tool, namely trust and transparency, flexibility and struggle for new roles.

Then, in order to develop a tool that transitions the knowledge effectively, concepts and theories about learning must be researched. The concepts and theories are split into learning type, process and strategy. Learning type are used as a definition to determine the level effect it has on the problem context. In this research the aim is not only to learn about circularity but also provide lessons on how to integrate circular ambitions into construction projects. Therefore the learning type should provide both, and thus the question that can be asked is: w*hat learning type enables to learn about circularity but also provide lessons on how to integrate circular ambitions into construction projects?* In the previous chapter, two types were examined, first order and higher order learning. For this research the learning type of higher order learning is selected, as this enables the opportunity to change problem definitions, norms, values, convictions and goals of actors (Brown et al., 2003).

To provide this type of learning a learning process must be selected that integrates both, which results in the question: w*hat learning process provides the opportunity to learn about circularity but also provide lessons on how to integrate circular ambitions into construction projects?* For the learning process, the single and double loop are potential candidates. This is because the triple loop can be seen as a meta to either of them (Tosey et al., 2012). The single-loop process is assumed to be too primitive and not able to fulfill the potential of scaling up the lessons learned, as explained in section 1.4 research potential and relevance. The double-loop learning process, which fulfills this potential as it can alter organizational policies, norms and objectives and is also a form of higher order learning (Argyris & Schon, 1974; Gronheid, 2021). Then in order to find the right learning strategy, the concept of triple learning is important

Then to develop the tool, the learning process must be shaped into something usable, this is called the learning strategy. Literature can provide concepts on strategies for learning and explain how the tool will facilitate the learning process. The production of such strategies is an elements of triple loop learning, explained earlier (Argyris & Schon, 1974; Romme & Van Witteloostuijn, 1999). And thus the question that raises is: w*hat learning strategy can facilitate the learning process?* Gronheid (2021) mentions the importance of learning on organizational level for the transition towards a CE. The strategy of Project Based Learning provides learning on this level, as it transitions knowledge between construction projects and provides opportunities to learn lessons from and obtain knowledge to solve

problems on current or future projects (Yan, 2021). However, this research only focuses on the learning on group level, but it is assumed that if organizational learning is possible, group level is as well.

Based on the choices above, a conceptual framework is made, see figure 7. This framework shows a conceptualization of how the tool will be used within project teams. It shows the triple loop learning process as a meta for the single and double loop and provides the learning strategy for the other two loops. Also the distinction between first order and higher order learning is illustrated. This figure shows the learning process on group level that the tool facilitates, see the box of group level in figure 2.

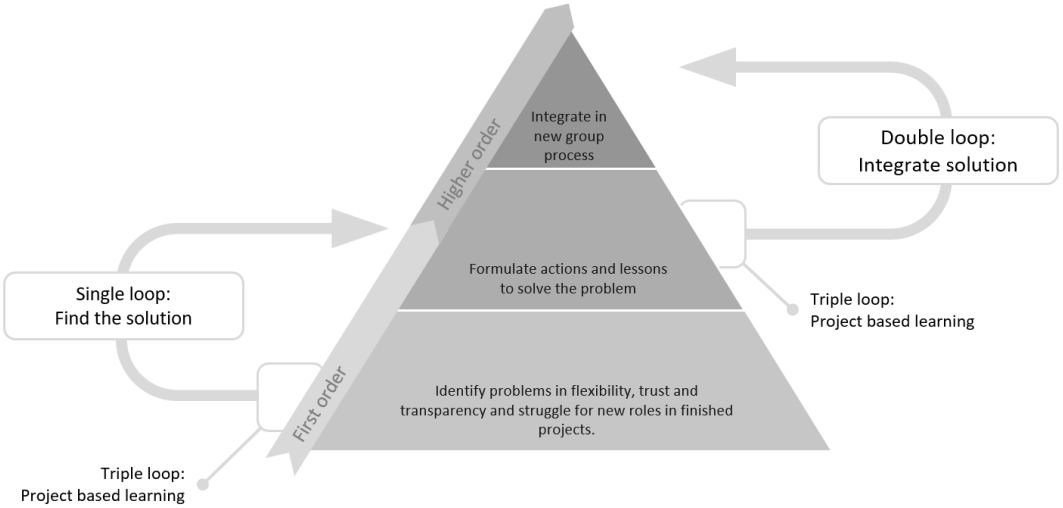

Figure 7: Conceptual framework (own figure)

3.2 Research Design

Literature on design science is assumed to provide sufficient insight to select a method to develop the tool further. In the section 2.4 Science research, two concepts were given, one from Hevner (2007) and the other from Peffers et al. (2007). The model of Hevner (2007) showed the interrelation with the field, the research and literature. Peffers et al. (2007) showed the steps to be taken in a design process and when to evaluate the artifact. Both methods provide other benefits, the relation (three cycle model) and the process (DSRM). Therefore the method that is used for this research is a combination of the two.

In figure 8, the research design is illustrated and can be read from top to bottom, starting at identifying the problem and finishing with communication. From left to right the research design is split into three columns, environment, design science research and knowledge base, which are derived from Hevner (2007). The oval shaped text boxes between the columns, show the relation between the columns and explain the switch between columns. They represent the relevance- and rigor cycle (Hevner, 2007). The process of this research is mostly based on the steps provided by Peffers et al. (2007), such as identify problem and objectives of the solution, find suitable context for demonstration, the moment

of evaluation and iteration of process and communication (Peffers et al., 2007). Only the iteration back to identifying objective of solution is left out, as this is not feasible to do in the time frame of this research, see also figure 6. Elements such as research question, literature review, case selection and conclusion are added independently as these are considered crucial for the process of this research. In addition the recruitment of participant for the focus group and interviews are added as this in an important part for this particular method (Powell & Single, 1996)

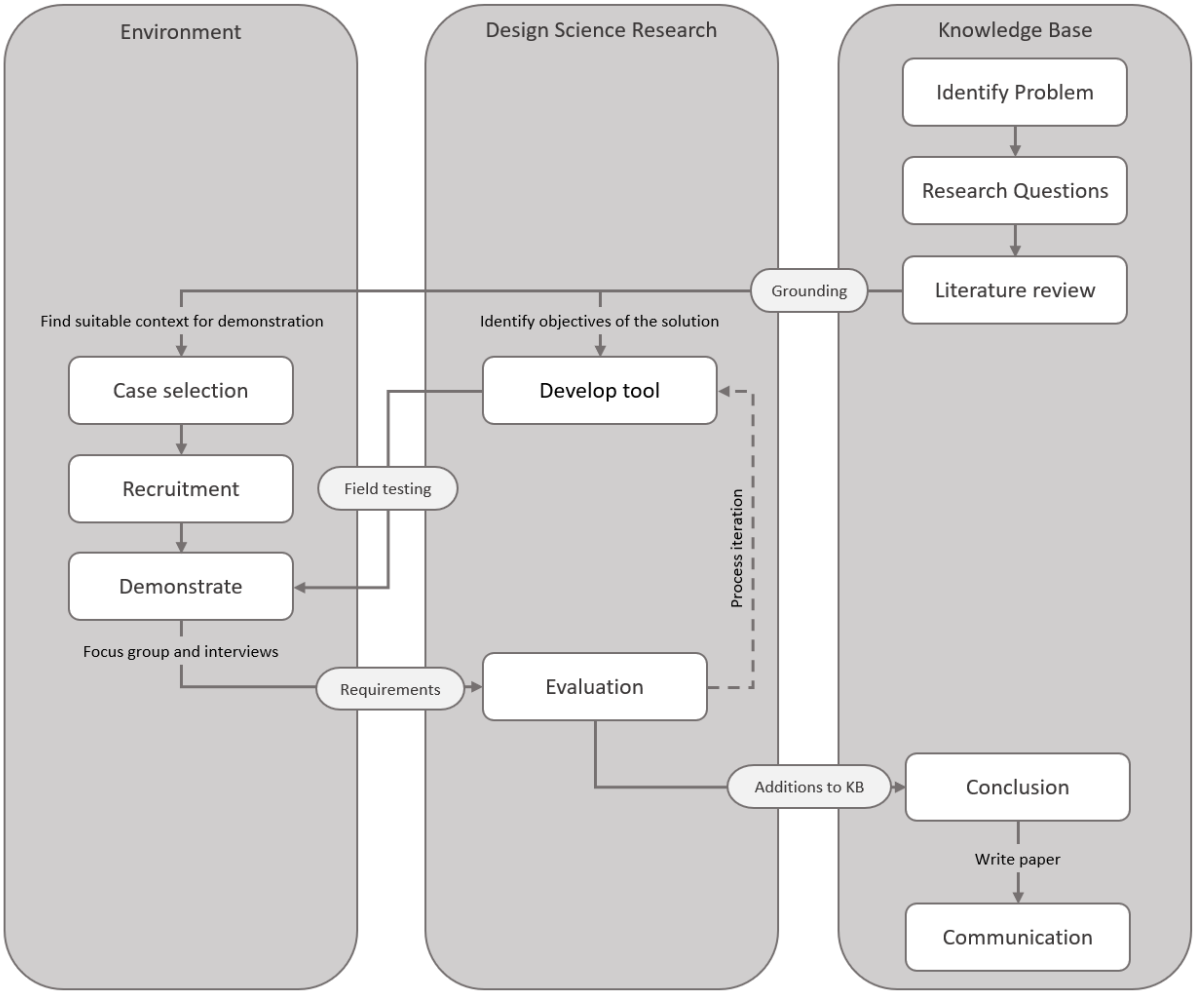

Figure 8: Research Design (own figure)

3.3 Data collection

As shown in figure 8, the demonstration of the tool is conducted via focus group and interviews. A focus group is an group of selected participants that discuss a topic of focus, which is prepared by the researcher (Powell & Single, 1996). The method is commonly used in social science, such as in researches used by marketers, policy analysis and political consultants. This is because it can be used to generate general knowledge on certain topics, diagnosing potential problems in services or products and stimulate the growth of new innovations and ideas (Stewart & Shamdasani, 1990). Benefits for

this research, design science research, are traits that enable additional data for validation or a specific focus on certain variables within the tool (Powell & Single, 1996).

Critical for a focus group is a well prepared interview guide and the group recruitment (Stewart & Shamdasani, 1990). The recruitment is important as this has a direct influence on the group dynamics, which then influences the behavior of people and can alter data. Powell and Single (1996) even mentioned that is beneficial if the participant do not know each other beforehand to prevent any restrained behavior. But as this research focuses on project teams within circular construction projects of the same company this is not feasible. Also it is believed that heterogeneity within group composition is more effective than homogeneity (Stewart & Shamdasani, 1990). Therefore, aside from being member of the project team, variables on demographic, physical appearance and personality can be well selected to generate as much heterogeneity. The group size mentioned by scholars vary from 6-12 and the sessions usually take between 90-120 minutes to conduct. All participant should be informed on the date of the focus group session at least 10-14 day before. The focus group is led by the moderator, which should relaxed and facilitate an open conversation. The moderator is usually accompanied by a note-taker. The structure of the focus group is prepared in a semi-structured manner. This means that questions and sub questions are prepared but that the conversation can evolve and develop independently. However, a guide or script should provide boundaries to make sure the data required is received. During the session the moderator should provide the opportunity to have the participant to 'break the ice' before the sessions, which can stimulate the conversation later. The moderator and note-taker minimize their interference in the discussion. Also all video or audio recording equipment present during the sessions should not interfere with the interaction (Powell & Single, 1996; Stewart & Shamdasani, 1990). For this research only an audio recording should suffice as it does not research the behavior of participants.

As this research is less explorative and more aiming on gathering specific requirements for the tool a more quantitative approach for the focus group is preferable. The approach can be accomplished by integrating elements of the nominal group method. These elements can be used when developing the script. This method is as follows. First, everyone writes their personal views on the subject down. Then the views are discussed within the group and the group has to rate them in order of important, influential and/or relevance. Discussing the elements and rating them, can change participants' personal views, therefore after the discussion the participants are asked to write their personal views down again. In addition the participant can be asked to make their own order of important, influential and/or relevance of the initial views. The results of these methods are the individual views, the group views, and at last possible changes in views (Powell & Single, 1996). This structure can be made clear in the script.

For a more in-depth gathering of the requirements for the tool, interviews are of use. Integrating in-depth interviewing in the research design provides a deeper understanding of certain requirements or topics discussed. This method can be used for when the focus groups do not provide specific enough answers to the questions. The in-depth interviewing method gives more freedom to the participant during the conversation as the interview is semi-structured as well. The inductive approach has the advantage of being flexible and it leaves room for interpretation (Burnard et al., 2008; Powell & Single, 1996).

3.4 Data analysis

First the whole session should be transcribed to enable readability and validity that can be shared with other researchers (Stewart & Shamdasani, 1990). For data analyzing multiple methods can be used. For this research the two stage method of Powell and Single (1996) is used with the integration of another technique explained by Stewart and Shamdasani (1990). In stage 1 the raw data is coded and classified for potential conceptual categories. The question prepared in the guide provide initial categories. In the second stage the constant comparison of differentiating views among participant is carried out. This more analytical approach is an inductive process and involves a conceptualization of categories and themes based upon empirical data (Powell & Single, 1996). In the first stage the cut-and-paste technique is integrated. With this the transcript is marked by color for each category, then all the categories are sorted. This provides alle data combined for each category. However, this technique is sensible for subjectivity, as the researcher is the one who decides what is marked and to which category it belongs. Therefore Stewart and Shamdasani (1990) suggest to have multiple researchers do this technique and then to compare the findings. This suggestion is not implementable in this research, as there is only one researcher available. That is why the second stage is so important. In this stage computer analysis can be made of the transcript using multiple codes. Then the computer can help to validate relations between data and the codes and categories individually. A program that enable such support is Atlas TI.

4. Research case

4.1 Research schedule draft

The internship will take three days of the week, which leaves two days of the week to focus on the research. Below the research schedule draft is shown for the two days per week reserved for the research. This will start in the second week of February, week 6.

week 6: First week to get acquainted with the company, my role and tasks.

week 7: Formulate a research description and objectives to share with project team for preparation of first focus group, inform project team

week 8: Prepare focus group

week 9: First focus group, general thoughts on the tool and circular construction projects

week 10: Analyze data

week 11: Develop tool further and inform project team for next focus group

week 12: Prepare focus group

week 13: Second focus group, using the tool to reflect on project case

week 14: Analyze data

week 15: Develop tool further

week 16: Possible week for additional interviews and analyzing it

week 17: Possible week for additional interviews and analyzing it

week 18: Finish the development of the tool and formulate conclusion

week 19: Formulate conclusion and finish report

week 20: **Possible P4**

week 21: **Possible P4**

week 22: Finish report

week 23: Finish report

week 24: Finish report

week 25: **Possible P5**

week 26: **Possible P5**

week 27: **Possible P5**

4.2 Internship

This research is conducted in collaboration with Bureau Bos, an architectural firm that also specializes in construction management, building physics, structures and installations. It was founded in 1965 by Arnold Bos, who started as a carpenter in the years of war and eventually mastered the profession of architect. During the Wederopbouw after the war, projects were in abundance, varying from shops, houses, offices to health care facilities. Soon the company chose an integral approach to keep control of the quality of the buildings (Bureau Bos, 2021a).

Characteristic to the firm is to always aim for continuation and designing with the future in mind (Bureau Bos, n.d.).

4.3 Case

The case for this research is a residential care facility in Vlaardingen, South Holland. It is a living community with 40 clients that require additional attention for their daily activities. The organization

Ipse de Bruggen desired a new care facility that fulfilled the need for more individual care opportunities, which enables them to offer their clients their own place in the society, see figures below.

Figure 9: Bird-eyed view of the residential care facility for Ipse de Bruggen in Vlaardingen (Bureau Bos, 2021b)

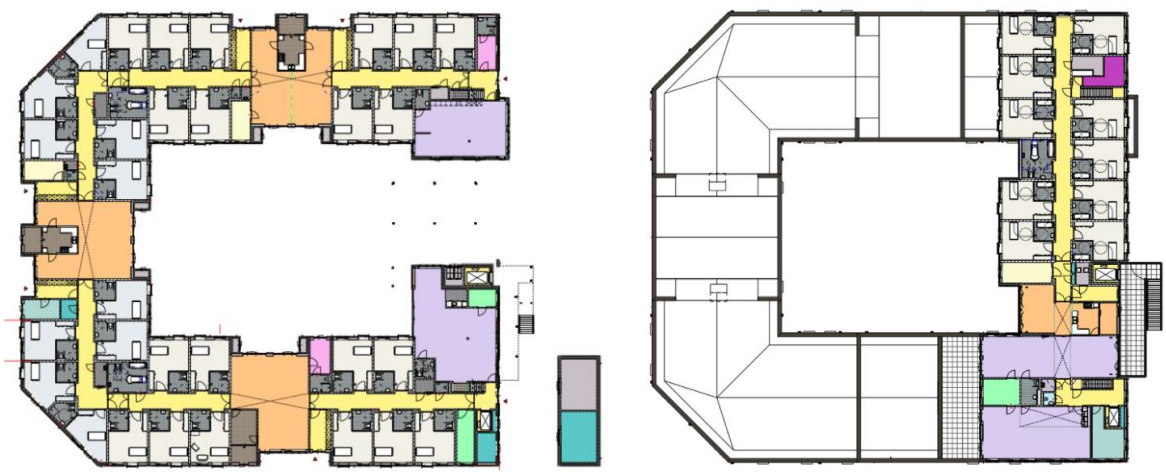

Figure 10: First (left) and second floor (right) (Bureau Bos, 2021b)

The project had high sustainable ambitions. This is translated in the floors which are easy transferable to other functions and the whole building being almost energy neutral. Interesting is the facade, which is due to a dry stacking method (fixbrick) completely demountable (Bureau Bos, 2021b).

The ambitions of this building were to develop it as a circular building. However, some ambitions were reached and others didn't. That is why this project is a perfect case to use in this research. As the critical reflection on this project using the tool can provide the right validation of the tool and potentially valuable lessons for new projects.

5. Literature

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Appendix

Proposed tool