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Scrum, a revolutionary approach for design research

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DESIGN RESEARCH can be characterised as being dynamic, *wicked*, and multidisciplinary. To accommodate these characteristics, design research needs to be approached differently from other types of research. Existing design research approaches identifiable in the literature are deemed insufficient to address the characteristics of design research and furthermore, the current options are limited. In this paper, we offer a new approach, adapted from a new product development framework called Scrum. It is an iterative and incremental approach, based on knowledge as it is gained. This is beneficial to address the dynamic and wicked characteristics of design research. Scrum also allows the use of multiple research techniques, which can accommodate the multidisciplinary characteristic of design research. To exemplify the application of Scrum adaptation in design research as well as to identify its pros and cons, the Scrum Design Research (SDR) approach was employed in a Collaborative Engineering Design (CED) study that aimed at developing a socio-technical architectural model. The example application shows that SDR allows the model to be created in an incremental manner. SDR also facilitates continuous lessons learned and improvement throughout the research. It encourages gathering of multiple perspectives from multiple sources and techniques to increase objectivity. The application illustrates that the approach can potentially provide a more comprehensive (from iterations) and objective (from triangulation) research result.

Keywords: design research approach, methods, engineering design

1 Introduction

The nature of design is “multi-facetted, multi-layered, and complex” (Eckert, Clarkson, and Stacey 2003, p.1). Design deals with ill-defined design problems (Bierhals et al. 2007) and consists of interrelated elements (Ouertani 2008). “There are many factors that need to be simultaneously considered to effectively manage the complexity [of design]” (Whitfield et al. 2002, p.243). Design research commonly aims to gain a better understanding on the phenomenon of design and/or improving specific elements of design (Eckert, Clarkson, and Stacey 2003) through, for example, the development of new methods and tools (Duffy and O’Donnell 1999). Due to the nature of design, design research has characteristics that differentiate it with other research areas. These characteristics are:

- Design research is dynamic (Green, Kennedy, and McGown 2002). There are uncontrollable or difficult to control factors (Sim and Duffy 2004), which can potentially force the researcher to adapt when conducting design research (Collins, Joseph, and Bielaczyc 2004).

- Design research is *wicked*. Problems in design research are often not clearly understood before working on the solution. As new findings emerge, interpretations and knowledge towards the research problem evolve (Farrell and Hooker 2013). Validity of research findings needs to be assessed following the evolved knowledge (Eckert, Clarkson, and Stacey 2003).
- Design research is multidisciplinary. To understand design, with its complex nature, requires multidisciplinary research (Eckert, Clarkson, and Stacey 2003). The use of multiple methods is often required (Green, Kennedy, and McGown 2002) to cater to the need of different disciplines.

To address the aforementioned characteristics, design research needs to be approached differently (Blessing and Chakrabarti 2009). Authors have done this by developing methodologies for design research identifiable in literature. We identified three pertinent shortcomings of these approaches. Firstly, they are created for a specific type of research. For example, Eckert, Clarkson, and Stacey's (2003) spiral of applied research was developed for group research projects that involve multidisciplinary parties, and Bracewell et al.'s (2001) methodology was created for computational design tool research. Secondly, many design methodologies are inflexible, for example, the Design Research Approach created by Duffy and O'Donnel (1999), which breaks down design research into rigid, linear steps. Finally, they can be restrictive. An example is the Design Research Methodology developed by Blessing and Chakrabarti (2009). This methodology emphasises the importance of defining clear success criteria as a parameter throughout the four-stage methodology. Although we agree that this is important, fixed success criteria can create barriers for exploration - a concern echoed by Eckert, Clarkson and Stacey (2003). Additionally, the options of design research approach are limited. Consequently, researchers adapt approaches from other fields (Eckert, Clarkson, and Stacey 2003) such as social science.

In this paper, we present an alternative approach towards design research that addresses the characteristics of design research and the three shortcomings of existing approaches we identified from literature. Our approach was adapted from a framework that was originally created for software development, called Scrum. Due to its agility, Scrum has been used in many product development processes as well as in different areas, such as research project management (see Hicks and Foster 2010, Ota 2010). We have explored the potential adaptation of Scrum in design research and applied it in our research project. How the framework was adapted, and its pros and cons based on our application are discussed and presented in this paper.

The remainder of the paper is organised as follows: Section 2 explains the adaptation of the Scrum framework to the SDR approach, Section 3 provides an example of the SDR approach being applied and its pros and cons being discussed, and Section 4 concludes the paper with a summary of work.

2 Scrum approach

The Scrum framework (hereafter referred to as Scrum) applies an iterative, incremental approach based on the belief that "knowledge comes from experience and making decisions based on what is known" (Schwaber and Sutherland, 2017, p.4). The framework is built upon three principles: 1) transparency, i.e. ensuring visibility of all aspects of the process, 2)

inspection, i.e. frequently scrutinising the process and progress, and 3) adaptation, i.e. adjusting the process based on the inspection results (Schwaber and Sutherland 2017). Because of these three principles, Scrum is deemed agile and flexible (Permana 2015). We believe that the agility and flexibility characteristic of Scrum could accommodate the dynamic and wicked nature of design research.

Scrum accepts the use of processes with various techniques (Ota 2010; Schwaber and Sutherland 2017). This addresses the multidisciplinary nature of design research. The use of various processes and techniques in research is one of four types of triangulation, along with data sources, investigators, and theories (Stake 1995). Triangulation is essential in research as it addresses potential misinterpretation and bias (Blessing and Chakrabarti 2009).

Scrum in a product development process starts with defining a set of requirements that will be used as the foundation to develop the product. This set of requirements, called the "product backlog", are defined based upon the initial knowledge and understanding the development team has of the problem. In research, aim and objectives are equivalent to product backlog as they are commonly used as the basis to conduct research and defined based on the identified research problem. As such, we used aim and objectives as the starting point of our SDR approach.

The core product development process starts after the product backlog is created. The process is called "sprint" in Scrum. *Sprint* consists of different stages depending on the decisions of the design team, e.g. design – build – test. At the end of each *sprint*, inspection is conducted. The decision to start another sprint (adaptation) or to terminate and deliver the end-product is taken based on the result of inspection. Through inspection, Scrum maximises the opportunity for feedback and adapts the next process based upon said feedback. Figure 1 depicts the Scrum framework for a general product development process.

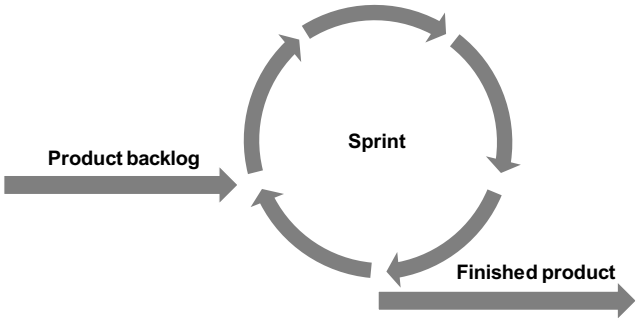

Figure 1 Scrum framework

Similar with *sprint*, the core research process can vary greatly. However, in principle, the basic research process consists of selecting methods and resources, collecting data, interpreting and analysing data, and developing a solution to the defined research problem. We used this basic research process as the *sprint* process in Scrum to create the SDR. We further added "reflection" to assess the research methods and the solution based on the incremental knowledge and lessons learned. Similar to Scrum, we used the result of reflection to decide if a new cycle of the design research process needs to be done or if the process should be terminated and the solution delivered. The steps of the SDR approach are explained in the following paragraphs.

The aim and objectives underpin any decision taken during research as research itself is conducted to achieve them. More specifically, the aim and objectives act as the basis when selecting methods and sources (Easterby-Smith, Thorpe, and Jackson 2012), and thus, need to be determined prior to conducting the research process. Since design research commonly serves two purposes: to gain a better understanding on design phenomenon and to improve design practice (Blessing and Chakrabarti 2009; Duffy and O'Donnell 1999; Eckert, Clarkson, and Stacey 2003), the formulation of the aim and objectives of design research needs to be based on the literature, through literature review, and on the design practice, through, for example, industrial investigation. From literature, knowledge gaps can be derived, while from design practice, areas for improvement can be identified. The identified knowledge gaps and areas for improvement can then be used to determine the research focus, which underpins the aims and objectives of the research.

In addition to research aim and objectives, the selection of methods and sources for data collection and interpretation needs to consider practicality factors such as time and resource availability (Saunders, Lewis, and Thornhill 2007). For a project that has a one-year time limitation, for instance, time-consuming methods such as in-depth interview and thematic analysis may not be selected. The selection of methods is also dependent on the researcher's philosophical assumptions (Creswell 2013). For example, if a researcher's philosophical assumption is *positivism,* which believes that there is a fixed, universal, single truth of reality (Rubin and Rubin 2012) that is divisible and fragment-able, and therefore measurable (Lincoln and Guba 1985; Anderson and Ozanne 1988), the researcher will typically select methods that facilitate empirical tests and follow a scientific procedure (Anderson and Ozanne 1988), e.g. experiments.

Once the methods and sources for data collection and interpretation are selected, the process to gather the information needed to achieve the aim and objectives of the study starts. As an example, a semi-structured interview is selected as a method for data collection. To collect information through a semi-structured interview, a researcher is required to prepare a set of questions for guiding the interview, allowing the questions to evolve based on the response of the participants (Kvale 2007). The data collected is then interpreted and analysed using a selected method. For example, the data collected through interview can be interpreted and analysed using thematic analysis.

The results of the data interpretation and analysis are used as the basis to generate a solution to achieve the research aim and objectives. The solution generated is then assessed against the aim and objectives of the study through reflection. During this process, lessons are learned that lead to a decision to either create an adapted plan for the next iteration of the research process, or to terminate the process. This decision also depends on research constraints, for example, time and resource availability. In other words, the number of iterations of each research process depends on the aim, objectives, and constraints of the research.

Figure 2 shows the SDR approach that was adapted from the Scrum framework.

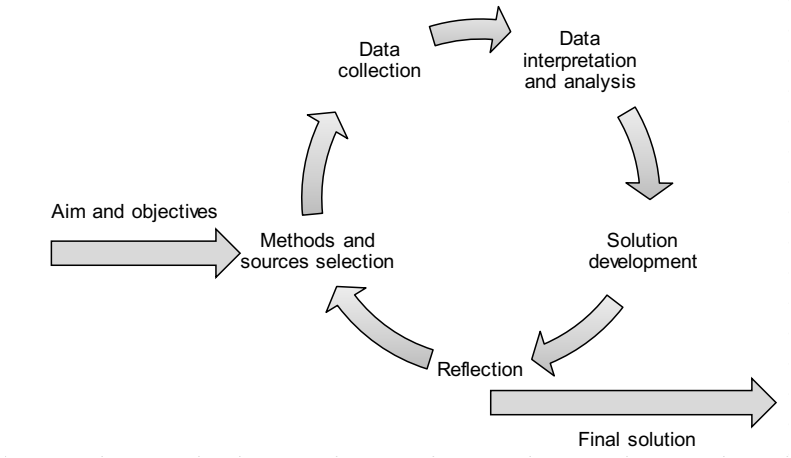

Figure 2 Scrum design research approach

3 A case example: understanding collaborative engineering design phenomena from socio-technical perspectives

To explore the application of the SDR approach, we used it in our study that aimed to better understand collaborative engineering design phenomena from a holistic socio-technical perspective. The objectives of the study were as follows:

O1. Identify issues of collaborative engineering design literature and design practice to form the basis for defining the focus of the study.
O2. Identify social and technical elements of CED and their inter-relationships to gain a better understanding of the socio-technical phenomena of CED.

The study to better understand the nature of a phenomenon that has been lacking or not properly understood may be categorised as an *exploratory study* (Saunders et al. 2007, p.133). Creswell (2013, p.47) states that a qualitative study is needed when “a problem or issue needs to be explored…”. Thus, exploratory studies are often approached qualitatively, as they both seek to explore and understand a phenomenon.

The philosophical assumption that underpins the study was *interpretivism*, which has the following basic beliefs: 1) reality can be accessed through the interpretation of individuals (Creswell 2014; Easterby-Smith, Thorpe, and Jackson 2012), and 2) there are multiple perceptions of reality (Easterby-Smith, Thorpe, and Jackson 2012). As reality is perceived to exist in human beings’ interpretation, human beings may be considered the main source of information to collect knowledge about reality. Furthermore, within the *interpretivism* philosophical assumption, the researcher (i.e. a human being) is seen as the main instrument to collect and interpret information. Lincoln and Guba (1985) argued that human beings tend to favour methods of data collection that extend their natural activity, e.g. speaking, listening, and observing, which are the main methods identified in qualitative study. Based on these points, we selected the following from within the qualitative study field: interviews and focus groups for data collection, and coding for interpretation.

To assess whether we had achieved the aim and objectives of the study, we used a *theoretical saturation point*, i.e. the point where the theory can be considered well established (Bowen 2008). The saturation point can be used as an end-point to explore a phenomenon of something (Kvale 2007). One of the parameters to measure whether the

saturation point has been reached is when new knowledge is considered seldom or no longer identifiable (Kvale 2007).

A traditional literature review was done as a starting point. The traditional literature review was selected as it could cover a wider research domain than a systematic review due to the flexibility it allows (Jesson, Matheson, and Lacey 2011). From the literature review, it was concluded that a model (hereafter referred as Socio Technical Architectural Model - STAM) needed to be developed to achieve the aim of the study. This model is what we referred to as a "solution" in our study. The first version of the model was generated from the literature review. During the SDR reflection process of the literature review, it was learned that the motivation of the study came from knowledge gaps in the literature and challenges in a CED practice. Because of this, it was deemed important to develop the model based on the literature and CED practice. Thus, the research process was continued to the second iteration, involving CED practitioners (hereafter referred as "IP-1").

In the second iteration, a semi-structured interview was selected as the method for collecting information from CED practitioners. It was considered appropriate since it allowed in-depth conversations towards a topic and could delve into individual interpretations of CED practice as required. The interviewees were chosen mainly based on practicality, i.e. CED practitioners who work in the company that funded the study. An inductive approach through coding was chosen to interpret and analyse information elicited from the interviewees as the aim of the study was to understand a phenomenon that was lacking. In an inductive approach, the data collected is interpreted with strictly-limited, or without pre-defined theories and/or assumptions (Lincoln and Guba 1985; Thomas 2006). It allows findings to emerge "…from the frequent, dominant, or significant themes inherent in raw data…" (Thomas 2006, p.238). Based on the findings identified during the interviews, the first version of the solution (i.e. the model) was significantly refined to give the second version. The main refinements included: merging the two segregated social and technical models into one socio-technical model, adding 116 elements of CED, and changing the much of the terminology used in the model. Additionally, nine socio-technical themes were identified from grouping the elements based on their commonalities.

The SDR reflection step from iteration 2 revealed three main lessons learned: 1) all interviewees were practitioners, and leaders in their team (e.g. supervisors, managers, directors). As such, the model was developed based on a single perspective (i.e. a leader of CED practitioning perspective), and 2) interview was a time-costly approach. Based on these lessons, we decided to continue the research process using a more time-effective data collection method, involving subordinate CED practitioners (hereafter referred as "IP-2") and CED academics (hereafter referred as "ED academics") to obtain multiple perspectives.

We employed the focus group method in iteration 3 to collect information from subordinate practitioners and CED academics. The focus group method involves multiple people at once and it is considered effective for obtaining insight from different points of view in a relatively short period of time (Saunders, Lewis, and Thornhill 2007). Hence, the method is considered time-effective. Furthermore "…[a] focus group allows for the proliferation of multiple meanings and perspectives, as well as interactions between and among them [the participants]" (Kamberelis and Dimitriadis 2011, p.560). Denscombe (2014) remarked that through interactions between participants, the reason underlying their response (e.g. opinion) may be understood. This cannot be obtained through individual interviews

(Denscombe 2014). We used the same interpretation and analysis approach in iteration 3 as iteration 2 as we did not find any shortcoming from its prior utilisation. The result from data interpretation and analysis was used as the basis to refine the model further. The refinements included: 38 elements deletions, 53 additions, and 46 terminology changes. In addition, the nine themes identified in iteration 2 were refined: two themes were merged into one, which reduced the total themes from nine to eight, and two theme names were changed.

One notable lesson that we learned from the reflection in iteration 3 was that the data came from people with a background in technical expertise. As the aim of the model was to understand the phenomena of CED from a socio-technical perspective, we needed to collect insights from not only those with technical expertise, but also from those with social expertise, to enhance the social perspective. For this reason, the research process was continued to the fourth iteration, involving people with social expertise and a background in CED.

To obtain a social perspective towards the model, we selected a social science academic with industrial practice expertise. This choice was based on two considerations: 1) that CED involves human beings and their interactions, which can also be found in the social science field, and 2) based on practicality reasons, i.e. such an academic exists in our university and it was challenging to find an academic with social expertise and a background in CED. A semi-structured interview method was used to elicit insight from the social science academic, due to its strengths discussed previously. The time-consuming nature of semi structured interviews experienced in iteration 2, was not deemed a problem as there was only one interviewee involved. We did not change the interpretation and analysis approach. Based on the findings, we added four new elements to the model, removed none, and did not alter any existing terminology. No new themes were identified, and no change was made to the existing themes. In other words, little new knowledge was obtained, and therefore, it was concluded that the model had reached what was recognised as the *saturation point*. However, according to Marshall et al. (2013), to confirm that no new knowledge is identifiable, research needs to be conducted past the saturation point. Furthermore, we learned in the reflection that the social perspective was still lacking, i.e. amongst the four iterations, only one iteration (iteration 4) obtained a social perspective. For these reasons, to confirm the saturation point had been reached and to further enhance the social perspective of the model, the research process was continued to a fifth iteration.

For a better insight into the social elements of collaborative work in an organisational context, we conducted a review of social literature recommended by the social science academic. Of interest from the literature were the sentences pertinent to the elements of collaborative work in an organisation that were not presented in the model and/or presented differently in the model. Based on the findings, we added 19 new elements, deleted 3 existing elements, and changed the term of one element. As with iteration 4, no new themes were identified, and no changes were made to the existing themes in iteration 5. According to Strauss and Corbin (1998), one of the parameters that can be used to determine the saturation point is when new themes can no longer be identified (or refined). Thus, although several elements changed, the lack of change to the themes was viewed as confirmation that the model had reached its saturation point. On this basis, we decided to terminate the research process and deliver the final solution.

The five-iteration research process as explained above is depicted by Figure 3.

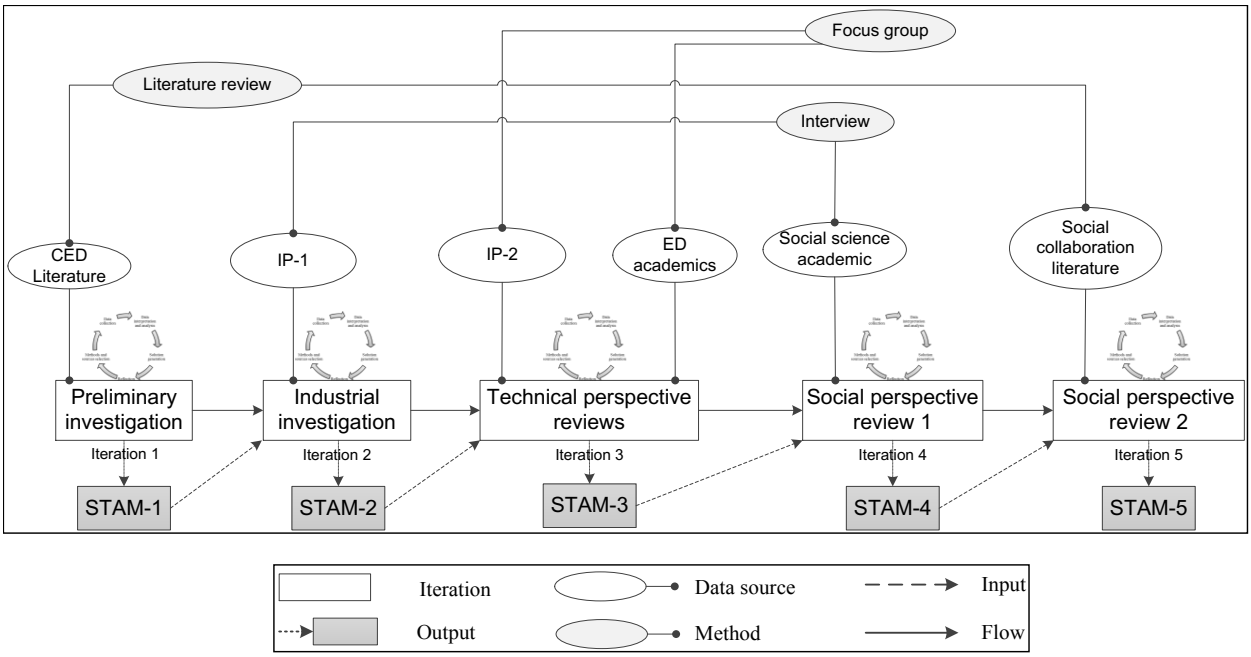

Figure 3 Five iterations of STAM development

3.1 Discussion

We applied the SDR approach in our CED study to gain a better understanding of CED phenomena from the socio-technical perspective. This was done through the development of a model that consists of socio-technical elements and their inter-relationships. Through the adaption of Scrum, the model was evolved in line with the level of understanding of the socio-technical CED phenomena. Instead of creating one final model at the end, the model was created incrementally. This was an advantage of the study, as it allowed multiple perspectives to be considered as they arose. Additionally, because of the iterative nature of the approach, issues identified from the previous iteration could be learned and mitigated. In other words, it facilitated a continuous learning process and improvement throughout the research. The lessons learned were used as the basis to plan the next iteration to increase the result's comprehensiveness and reliability. The final advantage that we identified from employing the SDR approach was that it encouraged the use of multiple data sources, methods/approaches, and/or theories (i.e. triangulation). This was useful, particularly to mitigate potential misinterpretation and bias in a qualitative study.

In addition to its advantages, we identified limitations with the SDR approach. The iterative nature of SDR brought a degree of uncertainty to the study. As the plan (e.g. methods adopted, data sources targeted) for the next iteration was determined by the lessons learned from the previous iteration, it was difficult to be fully prepared in advance. For this reason, having contingency plans was important and proved to be useful. Additionally, as Scrum could only be planned to a certain degree in the future (i.e. one to two iterations in advance) and research was typically limited by time, the plans selected for the next iteration were often driven by practicality reasons (i.e. time and data source constraints). Thus, methods that were considered to be time-consuming were often dismissed, although they might have helped to add insight towards the solution from different perspectives.

During the study, we learned that it was essential to define the termination point prior to commencing the research process. In our study, we used a theoretical saturation point, i.e.

the point where new knowledge is no longer obtained, as our termination point. We believe that this point would differ from one study to another, depending on the aim and objectives of each study. The most important thing is to define the termination point to conclude the study. Finally, SDR was tested on CED research only. However, its application was meant for all design research study. Other design research cases application would be appropriate for future work.

4 Conclusion

Design research may be characterised as being dynamic, *wicked*, and multidisciplinary. To address these characteristics, design research needs to be approached differently. Several approaches have been developed and are identifiable in the literature, such as Design Research Methodology (Blessings and Chakrabarti 2009) and Design Research Approach (O'Donnell and Duffy 1997). However, these approaches have their limitations, particularly in addressing the characteristics of design research. Furthermore, the options are limited, and thus, design researchers often use research approaches from different fields. To address these limitations, we proposed the Scrum Design Research (SDR) approach as an alternative from the existing design research approaches.

The SDR approach was adapted from the Scrum framework that was initially developed for software development. Nowadays, Scrum is broadly applied in many product development processes. Scrum facilitates continuous inspection and adaptation, allowing the product to be developed in an iterative and incremental manner, following the level of knowledge of the development team. This makes Scrum agile and flexible, which we believe addresses the characteristics of design research aforementioned.

In this paper, the SDR approach was explained and its application was exemplified in a CED study. Although the approach had its limitations (i.e. detailed plans cannot be prepared in advance), its advantages were beneficial to support our study – it allowed incremental knowledge development and facilitated triangulation. More importantly, the approach accommodated the dynamic and *wicked* nature of design research by facilitating the continuous learning process and improvement in a systematic way. The example of its application in our study illustrated that the approach also has potential in providing more comprehensive (from iterations) and objective (from triangulation) research results. SDR application in other design research study is suggested for future work.

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