Pós-Graduação em Ciência da Computação

Wylliams Barbosa Santos

Simplicity in Agile Software Development

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Este trabalho foi apresentado à Pós-graduação em Ciência da Computação do Centro de Informática da Universidade Federal de Pernambuco como requisito parcial para obtenção do grau de Doutor em Ciência da Computação.

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Orientador: Prof. Dr. Hermano Perrelli de Moura

BANCA EXAMINADORA

_____

Prof. Dr. Alexandre Marcos Lins de Vasconcelos
Centro de Informática / UFPE

_____

Profa. Dra. Tiziana Margaria
Lero the Irish Software Research Centre/ University of Limerick

_____

Profa. Dra. Teresa Maria de Medeiros Maciel
Departamento de Estatística e Informática / UFRPE

_____

Profa. Dra. Sheila dos Santos Reinehr
Programa de Pós-Graduação em Informática / PUC-PR

_____

Prof. Dr. José Gilson de Almeida Teixeira Filho
Departamento de Ciências Administrativas / UFPE

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ABSTRACT

The study of simplicity is an interdisciplinary endeavour with many concepts and attributes, challenger in defining, development and use. Several studies emphasise that the concept of simplicity is, in itself, by far not a simple concept because there are many perspectives on the perception of simplicity. Agile Software Development (ASD) has proven to be an important set of methods in promoting simplicity issues. However, there are difficulties in defining simplicity and its impact on IT development and use. This study presents a theory to foster the simplicity phenomena to improve agile software development. Additionally, this thesis focuses on understanding how project managers and software engineers interpret their experiences, considering the simplicity issues in agile software development. The research method used in this work is based on the principles of Evidence-Based Software Engineering. It is stated as basic (research outcome), inductive (research logic), exploratory and descriptive (research purpose), interpretivist (research approach), qualitative (research process), basic qualitative study (research methodology), literature review and interviews (data collection methods), grounded theory techniques and thematic analysis (data analysis methods). A set of categories (lightweight process, knowledge acquisition, effective communication, time consuming, and transparency) that affect the simplicity in agile software development were grounded. Finally, the categories and hypotheses with higher explanatory power were used to create the substantive theory about simplicity in agile software development. The results show that a better understanding of the implications of simplicity on agile software development may contribute to the projects' success.

Keywords: Simplicity. Agile Software Development. Theory. Qualitative Study.

RESUMO

O estudo da simplicidade é um empreendimento interdisciplinar com muitos conceitos e atributos, desafiador na definição, desenvolvimento e uso. Várias pesquisas enfatizam que o conceito de simplicidade não é, em si, um conceito simples, porque há muitas perspectivas sobre a percepção da simplicidade. O Desenvolvimento de Software Ágil (Agile Software Development) provou ser um importante conjunto de métodos para a promoção da simplicidade. No entanto, há dificuldades em definir a simplicidade e seu impacto no desenvolvimento e uso de Tecnologia da Informação. Essa tese apresenta uma teoria para explicar o fenômeno de simplicidade para melhorar o desenvolvimento de software ágil. Além disso, essa tese enfoca a compreensão de como os gerentes de projetos e engenheiros de software interpretam suas experiências em projeto, considerando os problemas de simplicidade no desenvolvimento ágil de software. O método de pesquisa utilizado neste trabalho é baseado nos princípios da Engenharia de Software Baseada em Evidências. A tese é declarada como básica (resultado da pesquisa), indutiva (lógica de pesquisa), exploratória e descritiva (propósito da pesquisa), interpretativista (abordagem de pesquisa), qualitativa (processo de pesquisa), pesquisa qualitativa básica (metodologia de pesquisa), revisão da literatura e entrevistas (dados métodos de coleta), técnicas de teoria fundamentada e análise temática (métodos de análise de dados). Foi extraído um conjunto de categorias (processo leve, aquisição de conhecimento, comunicação pessoal, tempo e produto com valor) que afetam a simplicidade no desenvolvimento de software ágil. Finalmente, as categorias e proposições com maior poder de densidade e fundamentação foram usadas para criar uma teoria sobre simplicidade em projetos de software ágil. Os resultados mostram que uma melhor compreensão das implicações da simplicidade no desenvolvimento de software ágil pode contribuir para o êxito dos projetos.

Palavras-chave: Simplicidade. Desenvolvimento de Software Ágil. Teoria. Estudo Qualitativo.

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LIST OF ACRONYMS

AM	Agile Methods
AMDD	Agile Model Driven Development
ASD	Agile Software Development
CIn	Centre of Informatics
CESAR	Recife Centre for Advanced Studies and Systems
CERTICS	Certificate on Technology and Innovation in Brazil
CNPq	Brazilian National Research Council
COBIT	Control Objectives for Information and Related Technologies
CSF	Critical Success Factor
CSIS	Computer Science & Information Systems
CSD	Certified Scrum Developer
CSM	Certified Scrum Master
CSPO	Certified Scrum Product Owner
DP	Decision Point
ESE	Empirical Software Engineering
EBSE	Evidence-Based Software Engineering
FG	Focus Group
FDD	Feature-Driven Development
GP2	Project Management Research Group
GT	Grounded Theory
ICT	Information and Communications Technology
IS	Information System
IT	Information Technology
ITIL	Information Technology Infrastructure Library
LSD	Lean Software Development

MS	Mapping Study
MPS.Br	Brazilian Process Improvement Model
NTP	National Technological Park
NUI	National University of Ireland
PM	Project Management
PMI	Project Management Institute
PMP	Project Management Professional
RPM	Rethinking Project Management
REC	Research Ethics Committee
SAFe	Scaled Agile Framework
SFI	Science Foundation Ireland
SE	Software Engineering
SMS	Systematic Mapping Study
SPF	Software Project Framework
SLR	Systematic Literature Review
SPI	Software Process Improvement
SR	Systematic Review
SwB	Science without Borders
TDD	Test-Driven Development
XP	eXtreme Programming
UL	University of Limerick
UPE	University of Pernambuco
UFPE	Federal University of Pernambuco

CONTENTS

1 INTRODUCTION

This chapter contextualises the focus of this thesis and starts by presenting its motivation in Section 1.1. A clear definition of the problem is given in Section 1.2. The research question is stated in Section 1.3 and the research goal in Section 1.4. Section 1.5 explores the environments and research groups in which this research was executed. Section 1.6 describe some related aspects that are not directly addressed by this work and, finally, Section 1.7 outlines the remainder structure of this thesis..

1.1 Motivation

Since the software crisis of the 1960's, announced by the Software Engineering (SE) conference sponsored by the NATO Science Committee (NAUR; RANDELL, 1969), concepts and methods associated with project management have gained increasing importance to the software development community.

For decades, organisations have been changing from a hierarchical approach in project management to a more collaborative and flexible, allowing constantly adjustment to emerging challenges and opportunities. An academic research in UK (WINTER et al., 2006) called Rethinking Project Management (RPM) highlights the need for new possible future research about the developing practice, as the need for new thinking in the areas of project complexity, social process, value creation, project conceptualisation and practitioner developer. In this direction, the need to distribute responsibility and initiative in support of adaptation to change is familiar territory to agile approaches to projects (FERNANDEZ; FERNANDEZ, 2008).

Agile Software Development (ASD) has had a huge impact on how software is developed worldwide (DINGSOYR; BJORNSON; SHULL, 2009). It represents an alternative to the heavyweight methodologies. It puts less emphasis on up-front and strict control and relies more on informal collaboration, coordination, and learning (DYBÅ; DINGSØYR; MOE, 2014). Besides, ASD achieves the organisation business goals through practices, principles, and values focused on people and interactions, working software, customer collaboration, responding to change, and continuous improvement (BECK et al., 2001). These practices embody the adaptability, flexibility and self-organisation.

A variety of methodologies and frameworks in software engineering have gained significant ground since the introduction of the agile manifesto in 2001 (BECK et al., 2001). Among such methodologies there are Adaptive Software Development (HIGHSMITH; ORR, 2000), eXtreme Programming (xp) (BECK, 2004), Scrum (COHN, 2009) (SCHWABER; BEEDLE, 2004) (SCHWABER, 2007), Lean Software Development (LSD) (POPPENDIECK; POPPENDIECK, 2003) (POPPENDIECK; POPPENDIECK, 2006) (POPPENDIECK; POPPENDIECK,

2009), Feature-Driven Development (FDD) (PALMER; FELSING, 2001), and Crystal (COCKBURN, 2001) methodologies.

Although ASD have become essential over the years for organisations, software development is a complex endeavour (SCHWABER; BEEDLE, 2004). Moreover, complexity has been widely acknowledged as one of the biggest barriers to agile project's success (The Standish Group International, 2013) (The Standish Group International, 2015). In line with agile manifesto, ASD has proven to be an important set of methods in promoting simplicity issues, but yet still, surprisingly, there are few academic studies that directly address the simplicity's topic (MARGARIA et al., 2011) (MEYER, 2014) (FLOYD; BOSSELMANN, 2013).

Some researches highlight that a deeper understanding of simplicity can be the key to a new generation of modelling paradigms, languages for design and development, and tools for the management of the artefacts and for the better communication of knowledge (FLOYD; BOSSELMANN, 2013). This thesis provides a theory of simplicity in ASD. In this sense, it is an invitation to practitioners to do what they already do, but to do so more consciously. This consciousness can make a substantial difference in real situations. From this perspective, rethinking means committing oneself to a course of action where plausible analysis exists, to reexamine the adopted practices focused on simplicity.

1.2 Problem Statement

Simplicity is highlighted as a foundation issue that enables many desired characteristics such as reliability, usability and trust (MARGARIA et al., 2011) (FLOYD; BOSSELMANN, 2013). According to Ebert, Hoefner e Mani (2015), what determines a product's success is not the number of features; it is the few features that differentiate it from others. Complexity scales but it must be mastered with product strategy, sound engineering processes, and technology management to achieve the necessary simplicity that secures your growth and sustains your markets.

Some studies (MARGARIA; STEFFEN, 2010) (MARGARIA; FLOYD; STEFFEN, 2011) give evidence that the community of researchers and practitioners believe that simplicity is strategically important, but it is still insufficiently understood. It is by far not a simple concept because, there are many perspectives on the perception of simplicity. Consequently, there are many different approaches to characterising and defining simplicity.

The field of ASD suffers from a lack of sustainable theories, which are based on empirical research of practice (ZUMPE; KARLHEINZ, 2008). In this sense, this thesis provides empirical evidence to further our understanding of the simplicity phenomenon in ASD.

1.3 Research Question

This research adopts the roadmap for building theories proposed by Eisenhardt (1989). According to Eisenhardt, without a research focus, it is easy to become overwhelmed by the volume of data. In this sense, motivated by the problem statement presented before, this research aimed to shed light on simplicity in ASD through the following research question: **(RQ) how is simplicity understood by agile team members?**

1.4 Research Goal

This research is interested in understanding how simplicity is perceived by the agile team members from their perspective, by interpreting their experiences regarding simplicity in their workplace. In this context, the research goal described in this thesis can be stated as: **(RG) to generate a substantive theory of simplicity in the context of ASD.**

According to Saunders, Thornhill e Lewis (2009), a substantive theory provides insights for a particular time, research setting and problem. A theory is useful because it is a way of understanding events, behaviours and/or situations. It helps to organise and narrow down the amplitude of phenomena, composed by a set of interrelated concepts, definitions, and hypotheses that explains or predicts events or situations by specifying relations among variables. Besides, it indicates points that have been convincingly explained (LAKATOS; MARCONI, 2017).

This general goal decomposes in the following specific research goals:

- **Simplicity in ASD: Exploratory Knowledge:** To determine the simplicity's state-of-art in ASD context (Chapter 3);
- **Simplicity in ASD: Definition** To synthesise the initial definition of simplicity in ASD and a conceptual model that support its definition (Chapter 5);
- **Simplicity in ASD: Systematic Mapping Study:** To conduct a Systematic Mapping Study (SMS) of simplicity in the context of ASD (Chapter 4);
- **Simplicity in ASD: A Substantive Theory** To advance and contribute to a better understanding of simplicity in the context of ASD, by emergence of the theory in this context (Chapter 6).

The theory proposed in this thesis contributes to the state-of-the-art of software engineering in three complementary ways:

- It advances the knowledge of the topic by providing a theoretical model through which the available knowledge on this field is analysed and encompassed;

- It is an invitation to practitioners to do what they already do, but to do so more consciously. This consciousness can make a substantial difference in real situations. From this perspective, rethinking means committing oneself to a course of action where plausible analysis exists, to reexamine the adopted practices focused on simplicity;
- It suggests crucial issues, worthy of further investigation, serving, thus, as a basis to substantiate and organise future research on the topic of simplicity in ASD.

1.5 Research Environment

This study is part of a wider research conducted by the Project Management Research Group(GP2)[1] in the Centre of Informatics (CIn)[2] at Federal University of Pernambuco (UFPE)[3], Recife, Brazil. The Project Management Research Group (GP2) is a research group that investigates and develops tools, methods, techniques and processes for improving Project Management (PM). The GP2's main research interests include (Figure 1): (i) Organisational Project Management Maturity Model (FILHO, 2010); (ii) Project Portfolio Management (CORREIA, 2005); (iii) Project Management for Distributed Software Development (JÚNIOR, 2014); (iv) Project Risk Management (GUSMÃO, 2007); (v) Agile Governance (LUNA, 2009) (LUNA, 2015); (vi) Uncertainty in Project Management (MARINHO, 2015); (vii) Human Aspects in Software Project Management (CUNHA; MOURA, 2015); (viii) Innovation in Projects Management (MARANHÃO; MARINHO; MOURA, 2015); (ix) Agile Software Development; and (x) Simplicity in Software Project Management (SANTOS; PERRELLI, 2016) (SANTOS, 2016) (SANTOS et al., 2017b) (SANTOS et al., 2017) (SANTOS et al., 2018), the focus of this thesis.

The theory of simplicity in ASD, presented in this thesis, is one of the key research areas of the GP2. Besides this, the present thesis was developed in partnership with the Lero, the Irish Software Research Centre[4] at University of Limerick (UL)[5], Limerick, Ireland. Lero brings together leading software research teams from Universities and Institutes of Technology in a coordinated centre of research excellence with a strong industry focus (LERO, 2016). Lero has a set of defined objectives that must be achieved to make its strategy. The building blocks of Lero's strategics objectives are (i) research: advance the state-of-art in SE; (ii) industry: work with industry partners to identify and solve industry problems and to generate new software-based products and services; and (iii) education: attract and educate software developers of the future.

[1] https://sites.google.com/a/cin.ufpe.br/gp2/
[2] http://www.cin.ufpe.br
[3] http://www.ufpe.br
[4] http://www.lero.ie
[5] http://www.ul.ie

Figura 1 – GP2's Research Areas

Lero's research programme is expressed by four research hub areas (Figure 2), they are Hub A: Methods and Standards for High Integrity Systems (largely concerned with design-time), Hub B: Autonomous and Adaptive Systems (has a large focus on run-time adaptation), Hub C: Software Performance, and Hub D: Security and Privacy (LERO, 2016). The theme of this thesis is related to Hub A.

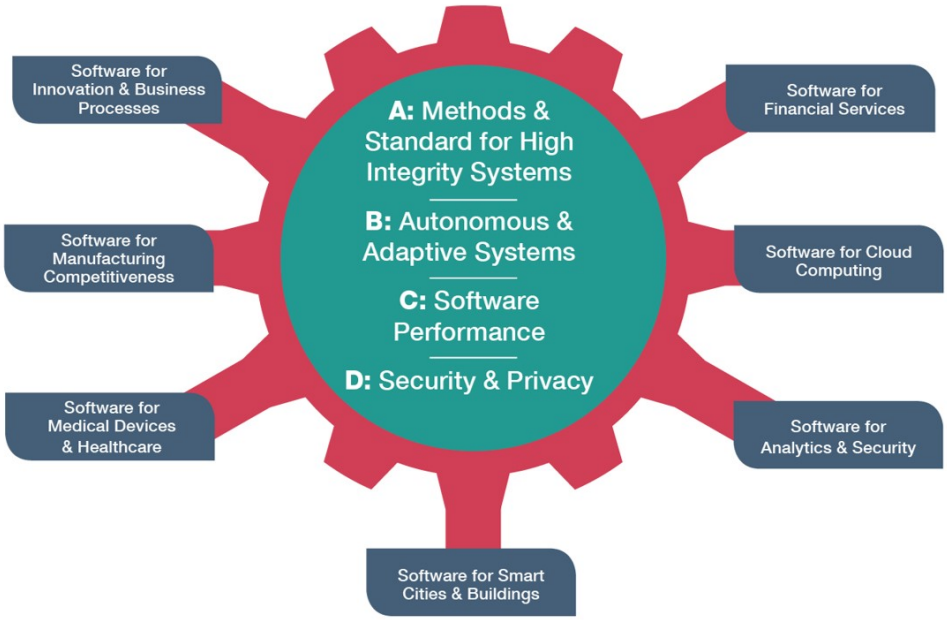

Figura 2 – Lero's four research Hub Areas (LERO, 2016)

1.6 Out of Scope

The substantive theory of simplicity in ASD is part of a broader context, a set of related aspects will be left out its scope. Thus, the following issues are not directly addressed by this work:

1. **Simplicity assessment method:** Software Process Improvement (SPI) provides software development organisations with mechanisms for evaluating their existing processes, identifying possibilities for improving as well as implementing and evaluating the impact of improvements (FLORAC; CARLETON, 1999). In this sense, several works (PIKKARAINEN; PASSOJA, 2005) (SALO, 2007) (MARÇAL et al., 2008) (MACIEL, 2014) specifically address agile assessment methods in the context of software process improvement. Even so, a method to evaluate simplicity in the context of ASD is out of scope of this thesis.

2. **Simplicity environment tool:** Simplicity tools are described as an important artefact. However, this aspects can be a challenge, involving the definition of architectures, infrastructure, patterns and a lot of technologies decisions. In this sense, an environment tool development is out of scope of this thesis.

3. **Overall Implications for Practice:** Initial implications for practices of the emerged theory are preliminary addressed in Chapter 6, Section 6.2.5. Even so, we are not focused in detecting and synthesising the overall implications for practices, due to time constraints. It is suggested as future work in Chapter 7 (Section 7.3).

1.7 Structure of the Thesis

In this introductory chapter the main aspects of this thesis were presented, describing the motivation, research environment, problem statement, research question, and research goal. Finally, this chapter addresses some issues that are not directly addressed by this thesis. Besides the introduction, this research is composed by other six chapters and two appendices (see Figure 3). The remainder of this work is organised as follows:

- **Chapter 2:** Presents the methodological framework and research design. The decision-making structure and strategy are discussed in details.
- **Chapter 3:** Discusses the state-of-the-art of ASD motivations, the main frameworks and foundations. Besides, this chapter also discusses about simplicity in different disciplines.
- **Chapter 4:** Presents the SMS conducted in order to investigate the current state-of-the-art of Simplicity in the context of agile software development.
- **Chapter 5:** Addresses the model underlying simplicity definition from the agile team's perspective, and the focus group with experts (practitioners and researchers).
- **Chapter 6:** Addresses the substantive theory of simplicity in ASD. Besides, this chapter also provides initial insights to the agile team to identify implications for practices, which leads to simplicity in their projects.
- **Chapter 7:** Concludes this thesis, summarising the initial findings, contributions and limitations. This chapter also discusses and proposes next steps, future enhancements and research areas.
- **Appendix A:** Presents the instruments used during the focus group session, as the consent form and information sheet.
- **Appendix ??:** Presents the instruments used during the theory emergence and interview process, as the application form, consent form, information sheet and questionnaire applied to the Faculty of Science and Engineering Ethics Committee at the University of Limerick.

Figure 3 shows the roadmap of this document. Additionally, although Chapter 3 presents the theoretical background related to agile software development and Simplicity, if the reader already knows the concepts of agile and simplicity, he/she might focus on the following Chapters 5, 4, 6, and 7.

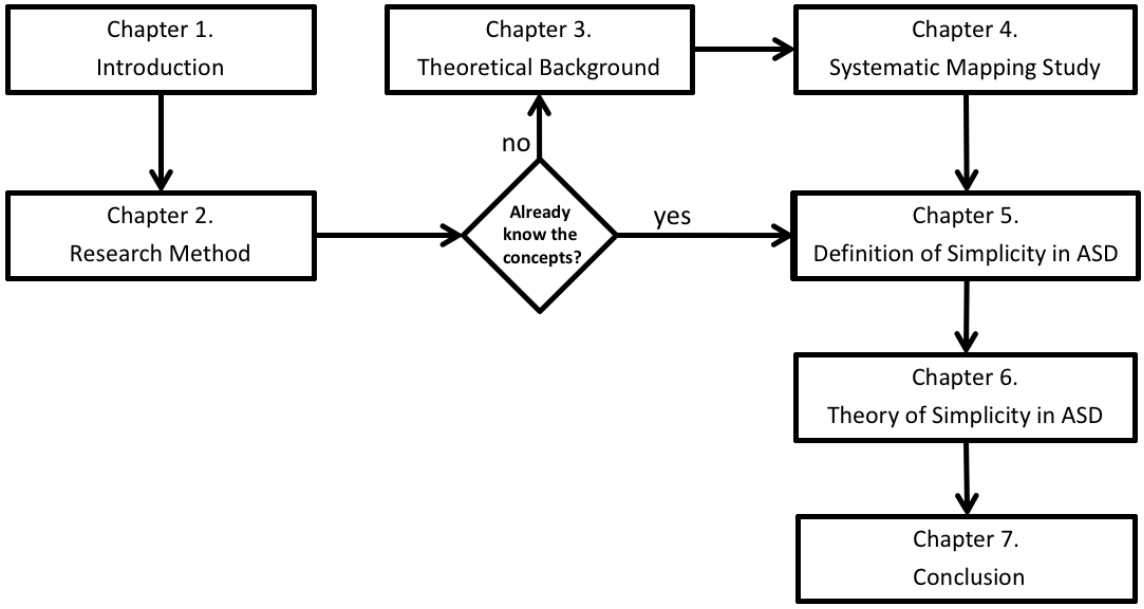

Figura 3 – Thesis roadmap (Inspired on (SILVA, 2013))

2 RESEARCH METHOD

This chapter describes the adopted research methodology in this thesis to achieve the stated goals. Several factors make empirical research in Software Engineering (SE) particularly challenging as it requires studying not only technology but its stakeholders' activities while drawing concepts and theories from social science (WOHLIN; AURUM, 2014). Several researchers (SEAMAN, 1999) (SHAW, 2003) (SJOBERG; DYBÅ; JORGENSEN, 2007) (EASTERBROOK et al., 2008) (RUNESON; HÖST, 2009) (CRESWELL, 2013) have addressed the challenges in selecting an appropriate research method in Empirical Software Engineering (ESE) research in the last two decades.

In this sense, this research adopts a decision-making structure containing a number of decision points. Each one of them represents a specific aspect on Empirical Software Engineering (ESE) research (WOHLIN; AURUM, 2014). The decision-making structure aims to support researchers by providing a foundation of knowledge about ESE research decisions, in order to ensure that researchers make well-founded and informed decisions about their research designs and the underlying research process to (i) understand the interrelationship of the main components of research; (ii) avoid confusion when discussing the logic behind the research design or assumptions that have been made; (iii) be able to present the research results with confidence and being able to persuade the reader of its conclusions; (iv) be able to comply research standards; and (v) be able to understand and put other researchers' work in context.

2.1 Research Decision-Making Structure

The research decision-making structure, in Figure 4, shows research from both a software engineers and an information system perspectives and its components are built from literature. Figure 4 illustrates three phases of research with eight decision points (1 to 8), covering the most common used approaches in software engineering. This structure is a useful guideline for researchers as it provides a common ground to them to guide the discussion for crating research design and selecting appropriate research methods (WOHLIN; AURUM, 2014).

In Figure 4, the decision points are organised into three phases: strategic, tactical, and operational (WOHLIN; AURUM, 2014).

- The Strategic Phase involves a plan that gives direction to the researcher for the tactical and operational phase of the research; The research strategy implicates decisions on research outcome, research logic, research purpose, and research approach;

- The Tactical Phase involves decisions on how to operationalise the research activities in terms of how to approach the research question more specifically. This phase focuses on selecting the actual process and methodology to use to achieve the research goal; and
- The Operational Phase is focused on actually carrying out the empirical research by collecting and analysing data, including data collection methods and data analysis techniques.

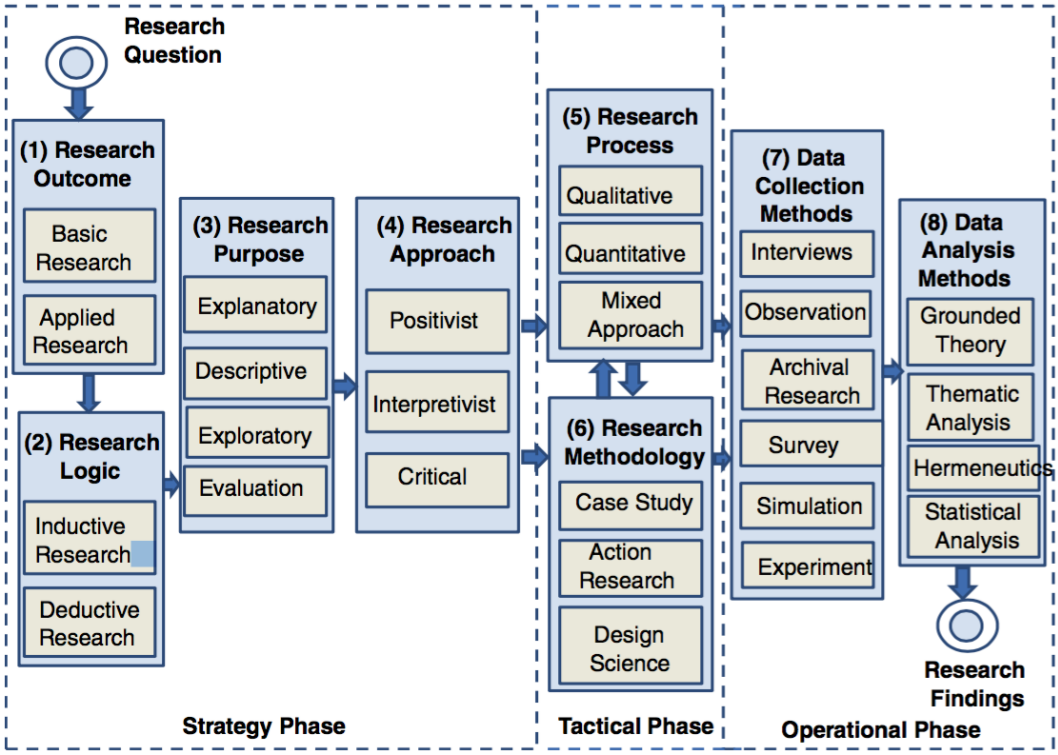

Figura 4 – Research decision-making structure (WOHLIN; AURUM, 2014)

Figure 5 shows the decision points outlining the structure of the decision process during the study design of this thesis. These eight Decision Points (DPs) are further explored as following, where options in relation to each decision point is discussed in more detail.

The decision points are logically ordered from left to right. Initially, the decision making-structure shows the starting point (bull's eye), the identification of the research question. The outcome of research (DP1) is classified as basic (pure research) because it applies to a problem where the emphasis is on the understanding of the problem rather than providing a solution to a problem, hence the main contribution is the knowledge generated from the research (COLLIS; HUSSEYROGER, 2009).

The "Inductive Research" is adopted as Research Logic (DP2). Research logic refers to in which direction the research proceeds in terms of whether it moves from general to specific or vice versa. According to Basili (1993), inductive research begins with specific observations, detects theoretical patterns, and develop some general conclusions or

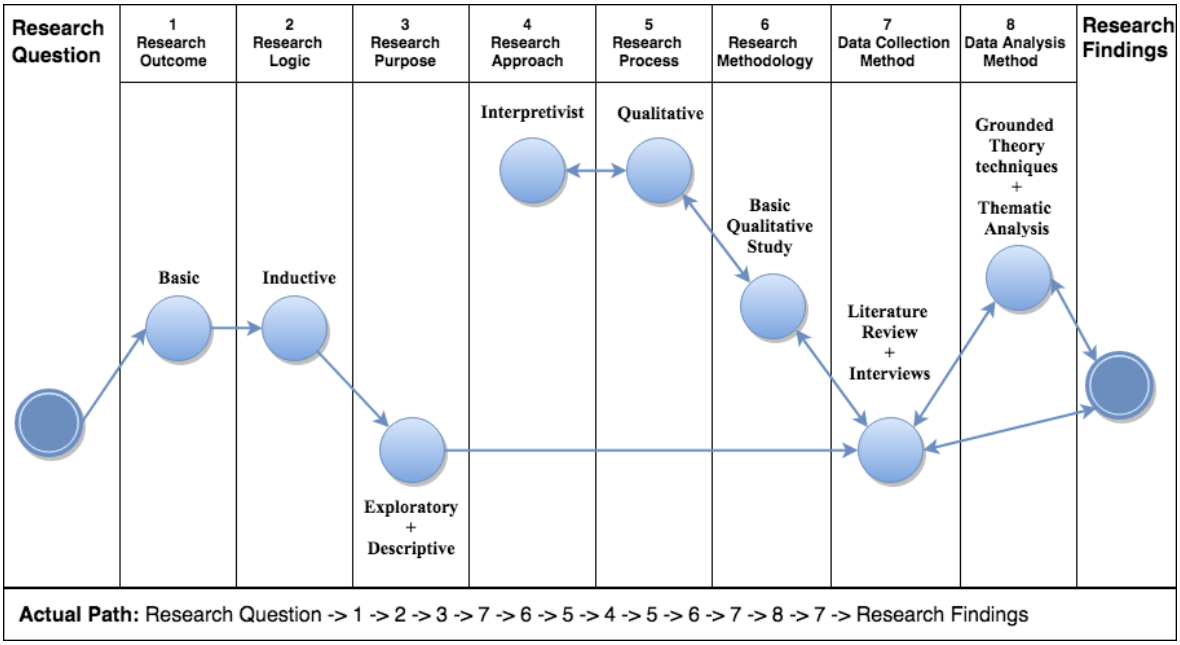

Figura 5 – Research paths through the research decision-making structure

theories. It can be used, for example, when a researcher is trying to understand software processes, product, people, and environment.

The purpose of this research (DP3) is classified as "exploratory" and "descriptive". According to Wohlin e Aurum (2014), exploratory research is applied when there is not much information available on the topic area that the researcher aims to gather some insights about the problem. Typical data collection methods are observation, interviews, and focus group interviews. Exploratory questions attempt to understand the phenomena, and identify useful distinctions that clarify our understanding (EASTERBROOK et al., 2008). Our research question is also classified as description and classification (EASTERBROOK et al., 2008). Collis e HusseyRoger (2009) points that descriptive research is applied to describe a phenomenon of characteristics of a problem.

The exploration is done from the perspective of the team in Agile Software Development (ASD) project, and hence the research is conducted (DP4) from an interpretivist (constructivism) research approach. Some authors point out that interpretivist is one of the most commonly used approach in literature (CHARMAZ, 2006) (BIRKS; MILLS, 2011). Interpretivist research aims to understand the human activities in a specific situation from the participants' perspective, hence it emphasises the context (KLEIN; MYERS, 1999) (EASTERBROOK et al., 2008). It assumes that validity of research can be gained by gathering qualitative (DP5) data that is powerful and in-depth, hence it tends to use qualitative methods (DP7).

The qualitative approach is defined as a research process (DP5). Qualitative research involves the use of qualitative data collection such as interviews, written documents and participant observation to understand and explain social phenomena (WOHLIN; AURUM,

2014). In the opinion of Creswell (2013), the distinction between the two widely recognized research process, qualitative and quantitative research is ambiguous but the use of the distinction provides a helpful umbrella for a range of issues concerned with the social aspects of ESE research. The distinction between qualitative and quantitative research comes not only from the type of data collected but also the research approach (DP4), its objectives and types of research question (DP3) (WOHLIN; AURUM, 2014) (CRESWELL, 2013). According to Myers (1995), qualitative methods are well suited for building theory, writing rich descriptions, explaining relationships, and describing groups of norms e.g. standards, models and frameworks.

It is decided that the research should be conducted as a basic qualitative study (DP6). According to Merriam (2009), basic qualitative research includes the phenomena understanding, and interpretation of recurrent patterns in the form of categories. Wohlin e Aurum (2014) emphasise the philosophical stance behind each method, based on the argument that this will help researcher selecting an appropriate research method. However, the research methodology's (DP6) options do not fit properly to the thesis. In this sense, basic qualitative study is selected to better describe the research methodology.

The Systematic Mapping Study and interviews are decided as data collection methods (DP7). In this sense, the literature review (DP7) applies a qualitative approach as a research process (DP5), which involves an interpretivist research approach (DP4), thematic analyses and Grounded Theory (GT) techniques as data analyses methods (DP8). Systematic mapping studies aim to identify, evaluate and interpret all available research relevant to a particular research question, topic area, or phenomenon of interest. Individual studies contributing to a systematic review are called primary studies; a systematic review is a secondary study (KITCHENHAM; DYBÅ; JORGENSEN, 2004) (KITCHENHAM; CHARTERS, 2007) (BEECHAM et al., 2008) (KITCHENHAM et al., 2009).

The Systematic Mapping Study (SMS) is analysed using thematic analysis (DP8) to identify what extent simplicity in ASD is covered in academic literature. The interviews are transcribed, and grounded theory techniques (DP8) are applied. Thus, the findings are iterated between data collection methods (DP7) and data analysis methods (DP8). This research adopts the roadmap for building theories proposed by Eisenhardt (1989) (further details are in Chapter 6).

2.2 Research Design Strategy

The research design strategy presented in Figure 6 is based on (LUNA, 2015) (REINEHR, 2008). It is structured in two phases: "Foundation" and "Theory Emergence". Each phase comprises some steps, and as a result of each step, several products are derived (expected results), hence some chapters of the thesis are represented (thesis structure).

The first phase (foundation) is composed by the (i) theoretical methodological posi-

tioning, which establishes the methodological strategy; (ii) exploratory literature review, gathering knowledge; (iii) definition of simplicity and conceptual model based on literature review; and (iv) systematic mapping review. Finally, the second phase (theory emergence) of our research design strategy incorporates the theory emergence (shaping the substantive theory of simplicity in ASD[1]).

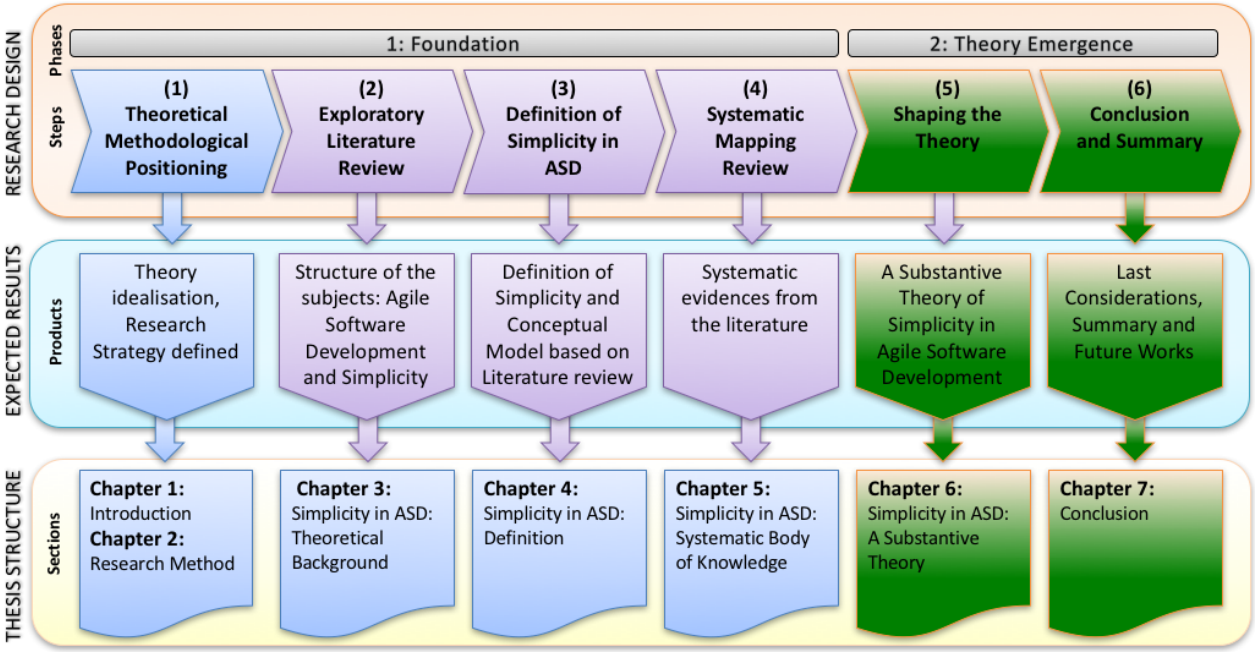

Figura 6 – Research Design Strategy (based on (REINEHR, 2008) (LUNA, 2015))

2.3 Chapter Summary

This chapter contextualised and discussed the adopted research methodology. Initially, Section 2.1 presented the research decision-making structure of this thesis, stating eight decision points: research outcome, research logic, research purpose, research approach, research process, research methodology, data collection methods and data analysis methods. Finally, Section 2.2 presented the research design strategy and its details. Next chapter outlines the theoretical background regarding simplicity in different areas, as simplicity in Philosophy of Science, Information and Communications Technology (ICT) and ASD.

[1] Project approved by the Research Ethics Committee of University of Limerick

3 SIMPLICITY IN ASD: THEORETICAL BACKGROUND

Considering the emerging challenges and opportunities in software development, Agile Software Development(ASD) represents an alternative to the heavyweight methodologies. It puts less emphasis on up-front and strict control and relies more on informal collaboration, coordination, and learning (DYBÅ; DINGSØYR; MOE, 2014) (MELLO; SILVA; TRAVASSOS, 2014).

According to the Agile Manifesto (BECK et al., 2001), the ASD demands a focus on simplicity stating that it is essential. Although there is a variety of methodologies and frameworks of ASD (eXtreme Programming, Scrum, Feature-Driven Development, Crystal methodologies, and LSD, few academic studies directly address simplicity (MARGARIA; STEFFEN, 2010) (MARGARIA; FLOYD; STEFFEN, 2011) (MARGARIA et al., 2011) (MARGARIA; HINCHEY, 2013) (FLOYD; BOSSELMANN, 2013) (SANTOS, 2016) (SANTOS; PERRELLI, 2016).

This chapter discusses the basic concepts of simplicity and ASD topics. The background here shall to provide a clear apperception of the chapters ahead, including the aspects surround the substantive theory of simplicity (Chapter 6). The remainder of this chapter is organised as follows. Sections 3.1 and 3.2 introduce the background and related work of ASD and Lean Software Development, respectively. Lastly, Section 3.3 introduces the background and related work of simplicity in three domains: Philosophy of Science, Information and Communications Technology (ICT), and ASD.

3.1 Agile Software Development

Agile methods provide ways to develop software which place emphasis on people and their creativity (COCKBURN; HIGHSMITH, 2001). ASD methods have emerged as a practice-led approach that has now become the predominant and popular mode of development in software industry (FITZGERALD; MUSIAŁ; STOL, 2014). According Dingsøyr et al. (2012), the articulation of the Agile Manifesto in 2001 has brought unprecedented changes to the Software Engineering field. The Agile Manifesto is a statement of values and principles that describes the various agile processes (BECK et al., 2001) (SCHWABER; BEEDLE, 2004).

The manifesto for ASD is a statement of values and principles that describe the various agile processes (BECK et al., 2001) (SCHWABER; BEEDLE, 2004) (DYBÅ; DINGSØYR, 2008) (DYBÅ; DINGSOYR, 2009), as follows: (i) Individuals and interactions over processes and tools; (ii) Working software over comprehensive documentation; (iii) Customer collaboration over contract negotiation; and (iv) Responding to change over following a plan. In order to assure these values, twelve principles should be esteemed (BECK et al., 2001):

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity–the art of maximizing the amount of work not done–is essential.
11. The best architectures, requirements, and designs emerge from self-organising teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.

These methods focus on values and principles defined by the Agile Manifesto. They include Adaptive Software Development (HIGHSMITH; ORR, 2000), eXtreme Programming (XP) (BECK, 2004), Scrum (COHN, 2009) (SCHWABER, 2007) (SCHWABER; BEEDLE, 2004), Lean Software Development (POPPENDIECK; POPPENDIECK, 2003) (POPPENDIECK; POPPENDIECK, 2006) (POPPENDIECK; POPPENDIECK, 2009), Feature-Driven Development (FDD) (PALMER; FELSING, 2001), and Crystal (COCKBURN, 2001) methodologies.

An important work presented by Dingsøyr et al. (2012) discusses a decade of agile methodologies and highlights the research progress of the area following the articulation of the manifesto. According to the evidence from the number of scientific publications, there is a widespread interest in the topic in various scientific forums, as observed by the number of countries involved on the issue related to ASD ever since the agile manifesto was pronounced in 2001. Although, the majority of the articles originate from USA, Canada, and Western Europe, ASD has been a research theme on all continents, in a total of 63 countries, stressing the research community's attention on the issues related to ASD.

The 11th annual State of Agile report (VERSIONONE, 2017) makes it clear that ASD has grown increasingly popular over the last decade. The data for this research was based on 3,880 participants, resulting in several significant and promising results:

- The number of large enterprises that are embracing agile continues to increase each year. 24% of respondents work for organisations with 20,000+ employees;
- Agile is scaling and going global as the number of enterprises around the world adopt it. Scrum still dominates, but the Scaled Agile Framework (SAFE) has been really representative;
- Agile talent and experience is growing. 63% said they were "very" to "extremely" knowledgeable about agile, an increase from 58% in 2014 to 63% in 2015;
- Agile is going global. 26% of the respondents work in Europe, and more than 18% work in Asia, South America, Oceania, and Africa.

3.2 Lean Software Development

Lean (WOMACK; JONES, 2003) also puts a very strong emphasis on simplicity. Lean comes from Lean Manufacturing and it is a set of principles for achieving quality, speed and costumer alignment. Poppendieck e Poppendieck (2003) adapted the principles from Lean Manufacturing to fit software development. The Lean principle of eliminate waste is supported and discussed by some empirical studies (ZANONI et al., 2014) (SEDANO; RALPH; PÉRAIRE, 2017). Zanoni et al. (2014) extend the definition of waste to fit in the software intensive product development context. More recently, Sedano, Ralph e Péraire (2017) identified and described different types of waste in software development: building the wrong feature or product, mismanaging the backlog, rework, unnecessarily complex solutions, extraneous cognitive load, psychological distress, waiting/multitasking, knowledge loss, and ineffective communication.

3.3 Simplicity

The study of simplicity is an interdisciplinary endeavour with many concepts and attributes, challenging in defining, developing and use. Margaria et al. (2011) emphasise that the concept of simplicity is, in itself, by far not a simple concept because there are many perspectives on the perception of simplicity. Consequently, there remain many different approaches to characterising and defining simplicity.

3.3.1 Simplicity in the Philosophy of Science

Simplicity principles have been proposed in various forms by theologians, philosophers, and scientists, from ancient to modern times. There is a widespread philosophical presumption that simplicity is a theoretical *virtue*. This presumption that simpler theories are preferable appears in many guises (GAMBREL; CAFARO, 2009) (BAKER, 2013). Often it remains implicit; sometimes it is invoked as a primitive, self-evident proposition; other times it is elevated to the status of a "Principle" and labelled as such (for example, the 'Principle of Parsimony').

According to Gambrel e Cafaro (2009), *virtue* refers to the generic term commonly used for any character trait people wish to commend. In both common speech and philosophical discourse, the "virtues" refer to those qualities whose possession makes a person, a good person and able to succeed in characteristic or important human endeavours, and which also help others to do so.

Additionally, following Nussbaum's schema (NUSSBAUM, 1988), Gambrel e Cafaro (2009) define simplicity as the *virtue* disposing us to act appropriately within the sphere of our consumer decisions. From this point of view, simplicity is a conscientious and restrained attitude toward material goods that typically includes (i) decreased consumption; (ii) a more conscious consumption; (iii) greater deliberation regarding our consumer decision; (iv) a more focused life in general; and (v) a greater and more nuance appreciation for other things besides material goods.

3.3.2 Simplicity in Information and Communications Technology

The study of simplicity in the context of Information and Communications Technology dates back to (MARGARIA; STEFFEN, 2010) (FLOYD; BOSSELMANN, 2013) (MARGARIA; HINCHEY, 2013). Some tendencies related to simplicity in the context of products are described in the specific article entitled "Simplicity is Highly Overrated" by Norman (2007). Norman believes that less is better, but in the meantime, he argues that marketing experts know that purchase decisions are influenced by feature lists. Products with an extensive list of features are fundamentally more complex, however they are preferred.

Besides, Norman (2007) emphasises that even if the buyers realise they will probably never use most of the features and, perhaps, these features will confuse the buyers more than helping them, they still prefer them.

Thus, according to Norman (2007) and Maeda (2012), the idea of getting less and paying more seems to contradict sound economic principles. People are not willing to pay for a system that looks simpler, because it looks less capable, hence the fully automatic systems that still contain lots of buttons and knobs. In this sense, simplicity is often far removed from actual product sales and distribution (NORMAN, 2008).

Maeda (2006) proposes ten Laws of Simplicity: (i) Reduce - the simplest way to achieve

simplicity is thoughtful reduction. (ii) Organise - organisation makes a system of many appear fewer; (iii) Time - saving in time feel like simplicity; (iv) Learn - knowledge makes everything simpler; (v) Differences - simplicity and complexity need each other; (vi) Context - what lies in the periphery of simplicity is definitely not peripheral; (vii) Emotion - more emotions are better than less; (viii) Trust - in simplicity we trust; (ix) Failure - Some things can never be made simple; and (x) The One - simplicity is about subtracting the obvious, and adding the meaningful. These laws could be applied to design, technology, business, and life.

According to Margaria e Hinchey (2013), simplicity is a mindset, a way at solutions, an extremely wide-ranging philosophical stance on the world, and thus a deeply rooted cultural paradigm. The authors state that the culture of "less" can be profoundly disruptive, cutting out existing "standard" elements from products and business models, thereby revolutionising entire markets.

In software-driven industries, Margaria, Floyd e Steffen (2011) present five major design principles resulting from their study in Information Technology (IT) issues, as follows: (i) Clearly defined system boundaries; (ii) Ease of explanation; (iii) Abstraction Layering Refinement; (iv) Focus on Simplicity first; and (v) Don't build for failure containment. In the same area, a recent analysis (EBERT; HOEFNER; MANI, 2015) outlines major software trends and offers recommendations for practitioners. This work indicates that "Complexity scale, but simplicity secures". Ebert affirms that what determines a product's success is not the number of features; it is the few features that differentiate it from other products. Complexity scales must be mastered with product strategy, sound engineering process, and technology management to achieve the necessary simplicity that secures your growth and sustains your markets (EBERT; BRINKKEMPER, 2014) (EBERT; HOEFNER; MANI, 2015).

The findings resulted from a Systematic Literature Review (SLR) and direct interaction with experts (individual interviews and focus group) in the area of ICT, Floyd e Bosselmann (2013) and Margaria et al. (2011) give evidence that the community of researchers and practitioners believe that the philosophy of simplicity is strategically important, but it is still insufficiently understood.

The interviews and panel discussions conducted during the ITSy project (FLOYD; BOSSELMANN, 2013) revealed a chain of perceived dependencies in ICT development and innovation. This value chain consists of the following activities, with each subsequent activity building on the previous: basic research, methodologies, tools, platforms, applications, and exploitation (Figure 7).

Besides the SLR, the exploratory study revealed various models of simplicity, such as: *Simplicity Wins* (Rommel, Gunter; Kluge, 1995), *The Laws of Simplicity* (MAEDA, 2006), *Simply Complexity* (JOHNSON, 2009), and *Living with Complexity* (NORMAN, 2010). All of these models present a variety of structured ways of looking at simplicity. In this sense, the authors compiled a set of recommendations for possible lines of action, characterisation

and dimensions of simplicity. These dimensions can be shared within and across these activities in a value network (Figure 7), as follows:

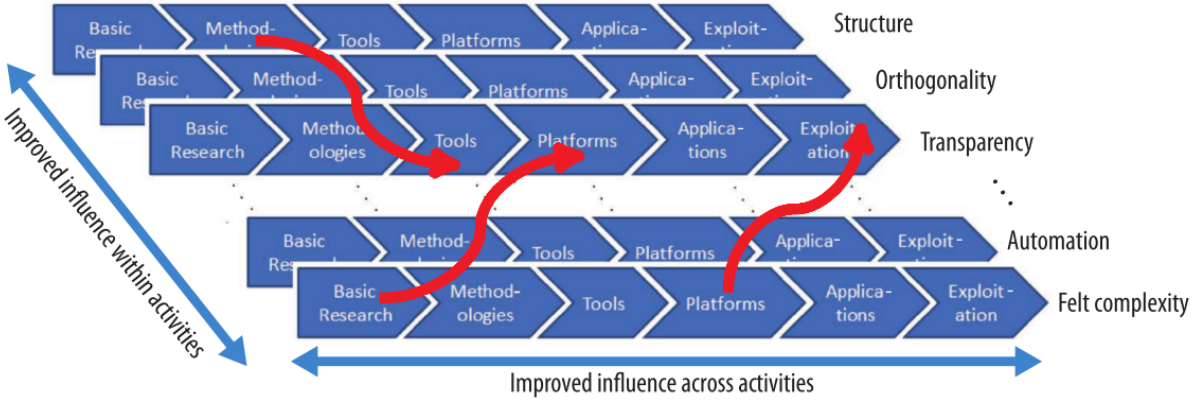

Figura 7 – Simplicity's Perspectives (MARGARIA et al., 2011)

- *The art of knowing:* The essence of simplicity from the perspective of participants in the interviews and focus group is knowledge (MARGARIA et al., 2011). According to them, knowing more about an IT system, more "simple" it appears to that user. But, simplicity is not just a question of knowledge, it's about having solution methods that are powerful.

- *Structure:* "(...) structured things tend to be simpler than unstructured things", both in terms of design and in terms of use. In this sense, the notions of layering and decomposition boundaries are mentioned as means of organising problems so that focus could be directed to a smaller subset of the problem thus leading towards a simpler problem domain.

- *Orthogonality:* We have techniques for decomposition and modularisation, but when we move to synthesis, we experience difficulties. Putting components together can result in unexpected (and unwanted) system behaviours. In essence, systems where the components are orthogonal and the results are predictable, they are viewed as simpler IT systems.

- *Size:* Simplicity is also related to size. The goal of simplicity in IT is to reduce aspects of systems, such as the number of functions offered, number of modules, to the core ones desired by users. By having fewer customers, the company was able to focus limited resources on fewer customers and on fewer products thus assuring a closer fit between delivering the right product to match their customers' needs.

- *Transparency:* Some participants of the focus group (MARGARIA et al., 2011) clearly stated that transparency is a desirable system property that acts on the perception

of systems, transparent systems are perceived as being simpler. One thing that is important is being explicit about assumptions, basically having all facts on the table.

- *Predictability:* "Simplicity means: no surprise" (MARGARIA et al., 2011). Concomitant to transparency was the concept that systems whose behaviour and structure are predictable, so they are perceived to be simpler. Early feedback to the user, early feedback to the designers, early discovery of mismatches in the descriptions of different facets of a system were repeatedly named to be fundamental assets for the engineering of complex systems. Each of them contributes to eliminate, or at least to mitigate through early discovery, the surprises that comes only at testing, deployment, or usage time.

- *Communication:* Transparency and predictability taken together led often to the fundamental question of how much, how, and when to communicate. In direction of this observation, the theory of organisational knowledge creation is mentioned (MARGARIA et al., 2011). The theory which the ever growing knowledge of an organisation is accrued, shared, and persisted according to the SECI model (Socialisation, Externalisation, Combination, and Internalisation) (IKUJIRO; TAKEUCHI, 1995) as the model that explains and steers the sharing and transfering of knowledge between humans, either directly (via socialisation) or mediated by some information support.

- *Automation:* Simplicity is also characterised as a measure of how little the end user has to do. If one can have a working system where the user consistently has to do less, then the system is easier to use.

- *Abstraction:* "simplicity is also a question of abstraction - that on the level of abstraction it is simple" (MARGARIA et al., 2011). By focusing on a right set of concepts and relationships, one can highlight the essence of the problem that needs to be addressed. In this sense, abstraction is another common theme expressed as a driver of simplicity.

- *Context and Subjectivity (felt complexity):* Simplicity does not so much relate to a problem as such, but rather to the way how this is perceived by the various stakeholders. IT researchers and developers must address simplicity by effectively dealing with IT's inherent complexities, its actual complexities, and, importantly, the user's felt complexities. Dealing with explicit and implicit knowledge and with the "right" amount of context information was mentioned as one of the crucial points in handling perceived simplicity.

The examples show that such dimensions rarely occur or are acted upon in isolation, so that in reality several dimensions play a role as initiator, mediator, or target of a

simplicity-driven change. This understanding seems to suggest that ASD should be an ideal turf for embracing simplicity.

Margaria et al. (2011) and Floyd e Bosselmann (2013) also conclude that the literature on complexity and complex system is equally difficult. They discuss that there are many relevant dimensions that interplay with these two concepts, but importantly if seen as cultures, and in particular as research and innovation cultures, these two worlds and dimensions have different objectives and different characteristics, and cannot be just simply seen as being one the opposite or the inverse of the other.

3.3.3 Simplicity in Agile Software Development

Based on the evolution of Project Management (PM) thinking, Moura (2011) and Moura e Skibniewski (2011) presented the Software Project Framework (SPF), composed by disciplines, principles and dimensions to verify how project management and related research have evolved over the years and to identify related trends. Simplicity is one of the 14 dimensions (directions) for advancing research proposed by the SPF. Moura e Skibniewski (2011) identified the agile methods as a promising approach to this dimension.

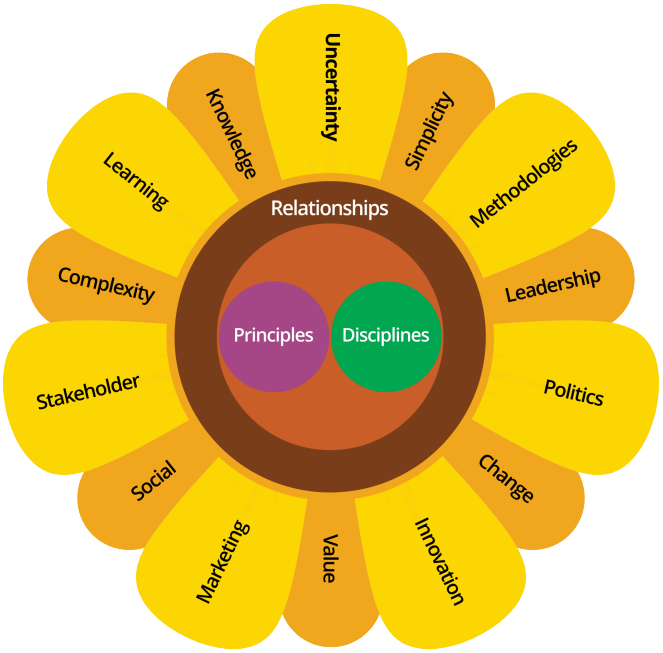

Figura 8 – Software Project Framework (MOURA; SKIBNIEWSKI, 2011)

In order to satisfy the values in ASD (see Section 3.1), some principles[1] should be respected, among them, the principle that "Simplicity - the art of maximising the amount of work not done – is essential". In the available literature, various methods propose agility in their definitions, aiming to find efficient ways for developing software of quality across

[1] http://agilemanifesto.org/principles.html

an agile development process. In essence, agile methods emphasise simplicity. The goal is to get user feedback quickly by delivering software at short increments, even if it covers only a subset of the expected functionality (MEYER, 2014).

Additionally, Meyer (2014) affirms that who has ever obtained the first solution to a problem of any kind, found it complex, and tried to simplify it. Therefore, achieving simplicity often means adding work, sometimes lots of it. Lippert e Roock (2001) affirm that simple things are easy to create, maintain, and understand. Although it seems obvious to create simple solutions most developers tend to choose overcomplicated ones. It is, in fact, a psychological issue to "do the simplest thing that could possibly work".

From this point of view, achieving simplicity is not the same as minimising work. Meyer (2014) discusses that both are worthy goals in SE, but they arise in different contexts and lead to different principles: (i) proponents of rigorous, elegant programming techniques; (ii) avoiding unneeded work which leads to such principles as "Eliminate waste" and "Decide as late as possible" in Lean (POPPENDIECK; POPPENDIECK, 2003) (POPPENDIECK; POPPENDIECK, 2006) (POPPENDIECK; POPPENDIECK, 2009). These two views meet, but not necessarily in the way agile authors (BECK et al., 2001) would like.

In this space, this thesis provides empirical evidence about simplicity at work and it leads towards proposing a substantive theory of simplicity in ASD that explains the phenomena. It can help researchers and practitioners to better understand the benefits of simplicity in this context.

3.4 Chapter Summary

In this chapter, it was provided the necessary background to comprehend the remaining of this thesis. The state-of-the-art on the Agile Software Development, its main concepts, motivations, and the related benefits to use were presented in Section 3.1. Lean Software Development backgroud was further detailed in Section 3.2. Additionally, this chapter discussed the main aspects of simplicity (Section 3.3) in several disciplines, as simplicity in Philosophy of Science (Section 3.3.1), Information and Communications Technology (Section 3.3.2) and in the context of Agile Software Development (Section 3.3.3) was also discussed. After presenting this subject, some challenges and how researchers have approached them were also discussed.

Next chapter outlines the development of a deeper knowledge and comprehensive understanding based on a Systematic Mapping Study (SMS). It was conducted in order to investigate the current state-of-the-art of Simplicity in the context of Agile Software Development, serving as basis to the proposal of this this study (Chapter 6). Besides, it was conducted in order to figure out how researcher community and practitioners have dealt with such aspects.

4 SIMPLICITY IN ASD: SYSTEMATIC MAPPING STUDY

The simplicity advocated by the agile manifesto[1] states that maximising the amount of work not done is essential (BECK et al., 2001). However, this principle does not aim to sacrifice the quality of software. On the contrary, maximising the amount of work in a project means concentrating on activities that will make the customer more satisfied and give more valuable product (HIGHSMITH, 2002).

According to Highsmith (2002), this principle needs to be analysed from a much broader spectrum for greater aggregation of value. In this sense, this chapter provides a Systematic Mapping Study that presents a comprehensive picture of the available material on simplicity in Agile Software Development (ASD). It covers published studies between 2001 (Announcement of the Agile Manifesto (BECK et al., 2001)) and 2016 about simplicity in ASD, detecting perspectives of simplicity and benefits of having simplicity in this context. Besides, the Systematic Mapping Study (SMS) reinforce the empirical evidence (categories) emerged from the preliminary theory of simplicity in ASD (SANTOS et al., 2017b).

The remainder of this chapter is organised as follows. Sections 4.1 presents the planning of the Systematic Mapping Study (research question, inclusion and exclusion criteria, data source and search strategy). Section 4.2 outlines the SMS execution (screening papers, manual sources, automatic sources, data extraction and synthesis strategy). Sections 4.3 and 4.4 address the results and limitations, respectively. Finally, selected primary studies are presented in Section 4.5.

4.1 Systematic Mapping Study Process

To operate this Systematic Mapping Study, the process illustrated in Figure 9 was used, based on the guidelines proposed by Petersen et al. (2007) and Kitchenham e Charters (2007). In this way, Phase 1 consisted of the planning stage, whose main goal was to define the protocol and identify the research questions. Phase 2 was responsible to guide and select articles from the developed protocol, whose purpose was to generate the complete list of studies. In Phase 3, the studies were selected and categorised through the relevant topics. Phase 4 focused on extracting and tabulating the data through the answers to the research questions. Finally, Phase 5 sought to perform the SLM analysis and synthesis. Besides the guides proposed by Petersen et al. (2007) and Kitchenham e Charters (2007), the process used was also inspired by the work of Veiga e Neto (2016).

[1] http://agilemanifesto.org/principles.html

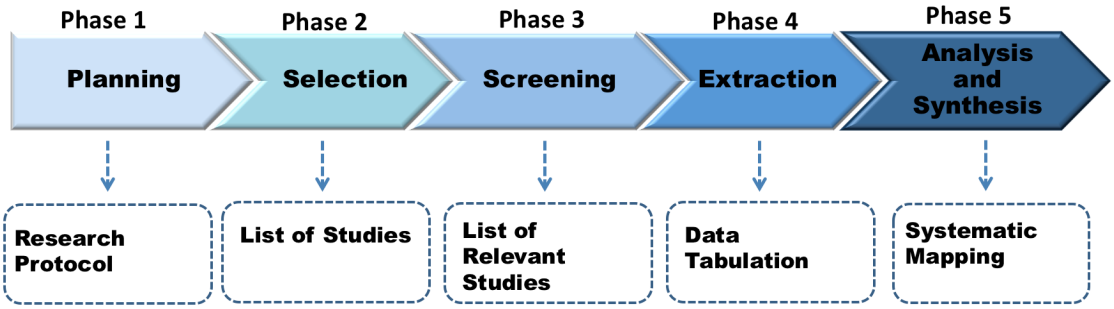

Figura 9 – Systematic Mapping Study Process (Adapted from (PETERSEN et al., 2007) (KITCHENHAM; CHARTERS, 2007))

4.1.1 Research Question

This SMS was guided by the following research question: *"What is the current state-of-the-art of Simplicity in studies presented in Agile Software Development?"*

In order to understand the role of simplicity in ASD, three specific research questions were developed.

(RQ1) What are the factors in Agile Software Development that lead to simplicity?

(RQ2) What are the benefits of having Simplicity in Agile Software Development?

(RQ3) What are the metrics used to evaluate Simplicity in Agile Software Development?

4.1.2 Inclusion and Exclusion Criteria

According to Kitchenham e Charters (2007), the selection strategy should be based on criteria of inclusion and exclusion.

Inclusion Criteria: (IC1) Research identifying factors that lead to simplicity/complexity in ASD; (IC2) Research that identifies techniques that lead to simplicity/complexity in ASD; (IC3) Researches that argue about simplicity/complexity in ASD; (IC4) The abstract of the researchs, explicitly mentions simplicity/complexity as a driver/factor for the ASD.

Exclusion Criteria: (EC1) Non-ASD related research; (EC2) Research referring to Simplicity only as future research projects; (EC3) Incomplete documents, drafts, documents from compilation of proceedings, documents accessible only through purchase and presentation on slides; (EC4) Documents not accessible via Internet; (EC5) Secondary and tertiary studies; (EC6) Researches written in languages other than English; (EC7) Duplicate searches; (EC8) Simplicity is not part of the study's contributions and is not mentioned in the abstract; (EC9) Documents not published between 2001 and 2016.

4.1.3 Data Source and Search Strategy

In order to reach a high level of coverage, a broad search process was carried out, combining manual and automatic searches according to the best practices used in systematic mapping and reviews (PETERSEN et al., 2007) (VERNER et al., 2014). Manual searches were carried out in the proceedings of the main conferences with interest in ASD topics (Table 1). Two researchers conducted title and summary searches on all articles from each source in manual search.

Tabela 1 – SMS: Manual Sources

Agile Brazil
Agile Conference
Brazilian Congress of the Computer Society (CBSC)
International Conference on Software Engineering (ICSE)
Brazilian Symposium on Software Engineering (SBES)
Brazilian Symposium on Information System (SBSI)
XP Conference

The automatic searches were performed in five search engines and indexers (Table 2), a number considered sufficient to guarantee acceptable coverage (KITCHENHAM; CHARTERS, 2007).

Tabela 2 – SMS: Automatic Sources

Automatic Sources	**Link**
ScienceDirect	http://www.sciencedirect.com/
IEEEXplore	https://ieeexplore.ieee.org/
ACM Digital Library	http://dl.acm.org/
Wiley Online Library	http://onlinelibrary.wiley.com/
Scopus	http://scopus.com/

The search strategy step seeks to create the search string by the following steps: (1) search query division in individual terms; (2) definition of a list of synonyms and associated terms; (3) translation of all terms into the English language; and the last part, (4) grouping the terms using double quotes and the logical operators AND and OR. The research mentioned in the theoretical background (Section 3) served as a basis for selecting individual terms that supported the search string (Figure 10).

("Agile" OR "Agile Methodologies" OR "Agile Methods" OR "Agile Principles" OR "Agile Process" OR "Agile Software Development" OR "Agile Project Management" OR "Extreme Programming" OR "XP" OR "Lean Software Development" OR "SCRUM" OR "Kanban") AND ("Simple" OR "Simplicity" OR "Simplification" OR "Complexity" OR "Complex")

Figura 10 – SMS: Research String

4.2 Screening Papers

The results obtained in this step were grouped in three steps: automatic search, manual search and list union.

4.2.1 Study Selection

Step 1 - Automatic Search: The automatic search consisted of obtaining primary studies of the automated bases through the generic search string. The search string returned a total of 4627 primary studies (Table 3). At this stage, the title and abstract of the 4627 studies were read and excluded according to criteria EC1, EC3, EC6, EC7 and EC8 (Figure 11). The studies selected in this stage went to the second list entitled "Potentially Relevant Studies". In this list 150 studies were selected (Scopus: 111, IEEE: 28, ACM: 7, Science Direct: 3 and Wiley Library: 1).

Tabela 3 – SMS: Automatic Search

Eletronic Source	**Studies**
Scopus	3381
IEEE	773
ACM	190
Science Direct	24
Wiley Library	259
Total	**4627**

Step 2 - Manual Search: The manual search was done by reading the title and summary of the papers presented at the following events: Brazilian Symposium on Software Engineering (SBES), XP Conference, Agile Brazil (WBMA), International Conference on Software Engineering (ICSE), Agile Conference, Brazilian Congress of the Computer Society (CSBC), and Brazilian Symposium on Information Systems (SBSI) (Table 4).

Step 3 - List Union: At this stage, it was found that when joining the lists, the total number of relevant studies was 150. All the studies were re-evaluated by the researchers and, in cases of doubt or divergence decisions on the inclusion or exclusion of the study were taken, reaching a consensus. At the end of this stage, only seventy-eight (78) studies

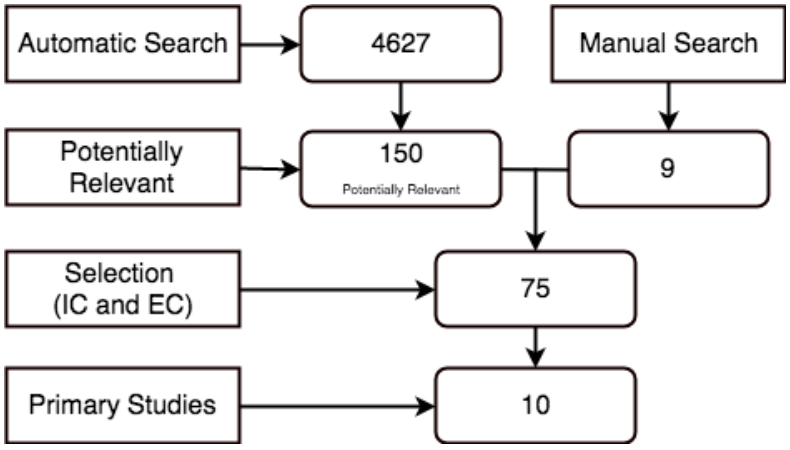

Figura 11 – SMS: Stages of the Search and Selection Processes

Tabela 4 – SMS: Number of Studies: Manual Source

Manual Source	**Studies**
Brazilian Symposium on Software Engineering (SBES)	0
XP Conference	6
International Conference on Software Engineering (ICSE)	1
Agile Brazil (WBMA)	0
Agile Conference	2
Brazilian Congress of the Computer Society (CSBC)	0
Brazilian Symposium on Information System (SBSI)	0
Total:	**9**

of the electronic base were selected and nine (9) of the manual bases, twenty-seven (27) of them being repeated. In the end, eighty-eight (88) unique and relevant studies were identified. Figure 12 illustrates the percentual of items excluded by criterion.

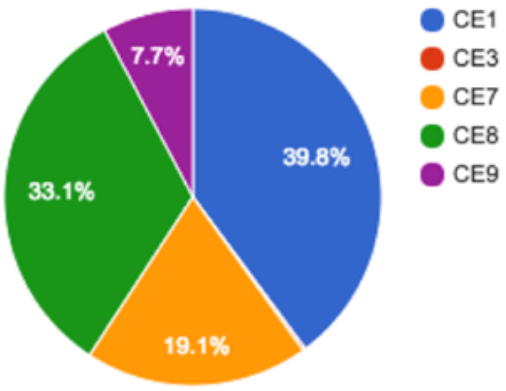

Figura 12 – SMS: Percentual of Items Excluded by Criterion

During this extraction, the 88 selected studies were read in their entirety. In this

process, 16% of the studies were still excluded because they fall under the exclusion criteria EC3, which exclude from the list of selected studies those documents accessible only through purchase. Thus, just 75 studies were extracted by complete reading. Of these, 73% did not respond to any search questions and, for this reason, were also removed from the list. In the end, only 10 primary studies were evaluated and answered at least one research question. These articles were published from 2001 to 2016 (Figure 11).

4.2.2 Data Extraction

The extraction strategy aims to analyse, classify and select the primary studies to answer the main research question and the specific research questions (KITCHENHAM; CHARTERS, 2007). To do so, the classification scheme elaborated for this stage of the mapping took into consideration the following aspects: (i) identification of the study and researcher; (ii) purpose of the study; (iii) factors that lead to simplicity in ASD; (iv) factors indicating benefits of simplicity in ASD; (v) simplification of the ASD methodology; (v) techniques that lead to simplicity in ASD and (vi) Concept of simplicity.

4.2.3 Synthesis Strategy

The synthesis strategy aimed at qualitatively understanding the data. According to Merriam (2009), the data analysis is the process used to answer the research questions. This process takes place from the classification into categories. Thus, it is possible to compare items and make analyses. Knowing this, primary studies were classified into categories.

4.3 Results

In the end, only ten primary studies were evaluated and answered at least one research question. These articles were published from 2001 to 2016. The most recent years of studies on simplicity in ASD were the years 2003 and 2008 (Figure 13). The full list of selected studies is presented in section 4.5.

The studies selected in this mapping are associated with six countries (Figure 14). The United States has a more significant representativeness of primary studies, with five published works. From the analysis of the primary studies, it was possible to identify the category of the ten studies selected after the extraction phase. Table 5 presents the classification of the studies.

RQ1. What are the factors in ASD that lead to simplicity?

The result of this research question provided a series of factors that, in the primary studies evaluated, are related to simplicity in the ASD (see Table 6). These factors are pointed out as the main agents of the existence of simplicity in ASD. Some factors,

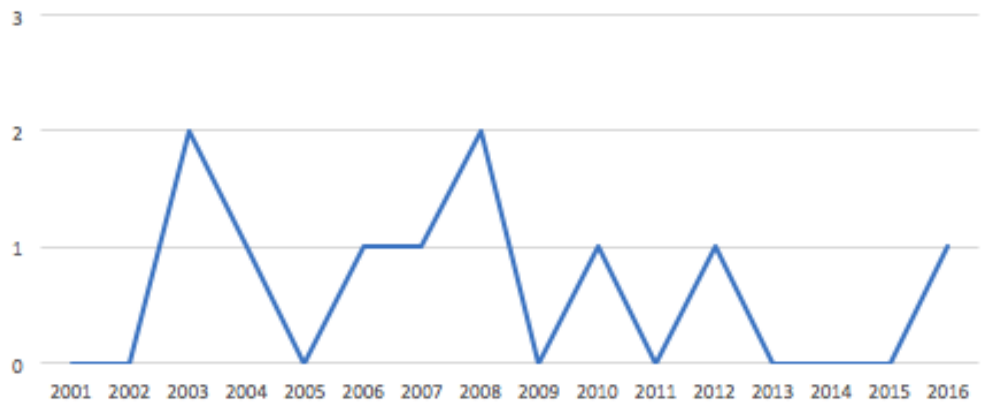

Figura 13 – SMS: Number of Studies per Year

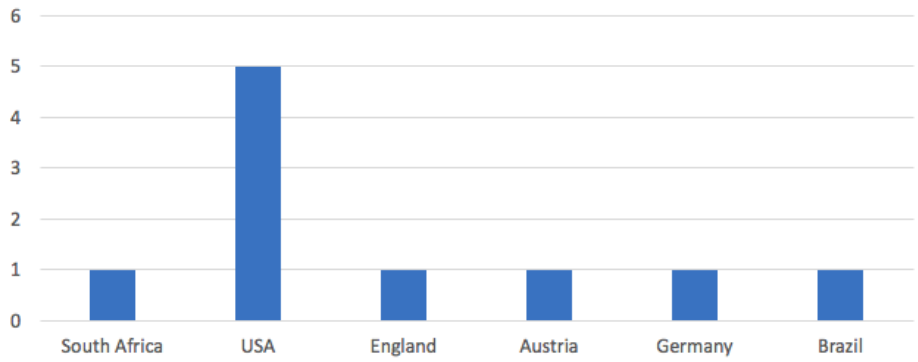

Figura 14 – SMS: Number of Studies by Country

Tabela 5 – SMS: Classification of Primary Studies

ID	**Classification**	**Selected Studies**
C01	Case Study	S01, S804, S1421
C02	Experiment	S1354
C03	Experience Report	S10, S114, S1271, S2006, S2743, S2880

however, have become critical targets when used with the aim of simplifying. Other factors demonstrated the techniques used to achieve simplicity in projects.

Table 6, presents eleven factors found in selected primary studies. Each study may have presented more than one factor. For the most part, studies point to the reduction of some process or artefact, as being the factors that lead to simplicity.

Only the S10 study presented the *development of the team* as one of the factors of simplicity in development. The S10 study took into account the social and managerial aspects as being influenced of simplicity in ASD. Study S114 defines the use of simple tools as a factor that leads to simplicity. From these answers, we can analyse that the simplicity is multifactorial, due to the different factors identified (Table 7).

RQ2. What are the benefits of simplicity in ASD?

Tabela 6 – SMS: Factors that leads to Simplicity in ASD

ID	**Factors**	**Primary Studies**
F01	Reduction of Time	S114, S1354
F02	Planning of Simple Design	S114, S1421, S1271, S804, S2880
F03	Development of the Team	S10
F04	Lightweight Management Tools	S114, S804, S2743
F05	Creativity and Innovation	S1354, S2006, S2743
F06	Necessary Documentation	S114, S804, S2743
F07	Adaptation of Methodology	S1, S10, S114, S804, S1421, S2743, S2880
F08	Agile Model Driven Development (AMDD)	S114
F09	Refactoring	S10, S1421, S2880
F10	Reuse of Code	S2880
F11	Test-Driven Development (TDD)	S114

Several beneficial factors are shown, such as reduction of time, maintenance, quality of the code, delivery of value to the client, among others identified in Table 7.

Tabela 7 – SMS: Benefits of Simplicity in ASD

ID	**Benefits**	**Primary Studies**
B01	Avoid Overbuilding	S10
B02	Minimising Time	S1354, S2743
B03	Maintainability	S10, S2880
B04	Quality of Code	S10, S114, S2880
B05	Lightweight Process	S114, S804, S2006, S2880
B06	Product with Value	S01, S10, S1271, S2006, S2743
B07	Simplify the Selection of Methodology	S01, S804, S2743
B08	Reuse Simplify the Design	S1421, S804, S2006

We have identified that all studies respond to questions *RQ1* and *RQ2*. The *International Conference on Software Engineering Advances (ICSEA)* and *International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE)* stand out among the conferences with articles related to the subject. The *IEEE Computer Society* journal is the most relevant journal since it presents three of the selected studies. A full list of studies can be found in Section 4.5.

RQ3. What are the metrics used to evaluate simplicity in ASD? This research question aimed to find metrics to evaluate simplicity in the context of ASD. However, this question was not answered by the selected studies.

4.3.1 Perspectives of Simplicity in Agile Software Development

According to Margaria et al. (2011), simplicity depends on the perspective of analysis. Our study presents (Table 8) five perspectives of simplicity in the context of ASD.

Tabela 8 – SMS: Simplicity Perspectives in ASD

ID	**Perspectives**	**Selected Studies**
P01	Agile Team	S01, S10, S114, S1421, S2743, S2880
P02	Product	S01, S10, S114, S1271, S1421, S2006
P03	Process of Project	S01, S10, S114, S1421, S2006, S2743, S2880
P04	Costumer	S10, S114, S2006
P05	End-user	S01, S10, S114, S1421, S2880

4.3.2 Categories: Preliminary Theory of Simplicity in ASD

The work of Santos et al. (2017b) presents a preliminary theory of simplicity aimed at understanding the phenomenon of simplicity in the context of ASD, based on a qualitative study. Our primary studies were also classified according to the categories that emerged in the theory of simplicity: *knowledge acquisition*, *lightweight process*, *communication (Personal communication)*, *product with value* and *time consumption* (Table 9). In addition to the above-mentioned categories, we also identified the *automation* category, which does not exist in the preliminary theory of simplicity.

Tabela 9 – SMS: Categories of Simplicity in ASD (Inspired on (SANTOS et al., 2017b))

ID	**Categories (Theory of Simplicity in ASD)**	**Selected Studies**
C01	Knowledge Acquisition	S114
C02	Lightweight Process	S01, S10, S1421, S114, S804, S1354, S2006, S2743, S2880
C04	Time consuming	S01, S10, S114, S2880
C05	Product with Value	S10, S1271, S114, S2006, S2743
C06	Automation	S01, S114

4.4 Limitations, Validity and Reliability

Research has shown that few primary studies have focused on simplicity within ASD. It was possible to identify some perspectives of simplicity, such as: simplicity in the perspective of the agile team, product, process of project, client and end-user. Also, the study

reveals eleven factors that lead to simplicity in the context of ASD, with emphasis on the tailoring process and coding aspects such as refactoring and reuse of code.

One of the limitations of this research was the low number of conferences reached during the manual analysis. The possibility of losing relevant publications that may have been left out by not mentioning any of the search string's key words in the automated databases may be considered another limitation, On the threat to validity, according to Perry, Poter e Votta (2000), threats to validity are influential factors that may impact the interpretation of the conclusions regarding the extracted data. Therefore, these threats should be minimised in a carefully way. In this research, the threats were analysed for the elaboration of the search string that sought to be as comprehensive as possible, allowing the capture of the most relevant works. In this context, we seek to minimise any threat to internal validity, especially in the selection of primary studies and data extraction. The researchers who performed this SMS conducted these activities in parallel, and any conflict or discord was discussed until reach the consensus.

4.5 Selected Primary Studies

[S01] Mnkandla E. and Dwolatzky, B. "Agile Methodologies Selection Toolbox", in International Conference on Software Engineering Advances (ICSEA 2007), 2007, no. ICSEA, pp. 72–78.

[S10] Hunt A. and Thomas D. "The trip-packing dilemma [agile software development]", IEEE Software, vol. 20, pp. 106–107, 2003.

[S114] Ambler S. "Agile Model Driven Development Is Good Enough", IEEE Software, vol. 20, pp. 71–73, 2003.

[S804] Delgadillo L., Gotel O., and Leip D. "Story-Wall: Supporting Agile Software Development in a Distributed Context", in International Society for Research in Science and Technology (ISRST), 2008, pp. 9–16.

[S1227] Irit H., Sherman S., Hadar E. and Harrison J., "Less is More: Architecture Documentation for Agile Development", in 6th International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE), 2013, pp. 121–124.

[S1354] Hollis B., Maiden N. "Extending Agile Processes with Creativity Techniques", IEEE Softw., pp. 78–84, 2012.

[S1421] Hussain Z., Lechner M., Milchrahm H., Shahzad S, Slany S., Umgeher M., and Vlk T. "Optimizing Extreme Programming", in International Conference on Computer and Communication Engineering, 2008, pp. 1052–1056.

[S2006] Margaria T. and Steffen B. “Simplicity as a Driver for Agile Innovation”, IEEE Computer Society, vol. 43, no. 6, pp. 90–92, Jun. 2010.

[S2743] Santos W. “Towards a better understanding of simplicity in Agile software development projects”, in Proceedings of the 20th International Conference on Evaluation and Assessment in Software Engineering - EASE ’16, 2016, pp. 1–4.

[S2880] Fowler M, and Shore J. “Continuous Design”, in IEEE Software, 2004, vol. 21, no. 1, pp. 20–22.

4.6 Chapter Summary

This chapter presented the Systematic Mapping Study for studies that introduce simplicity in the context of Agile Software Development. After the initial evaluation of 4627 papers, this mapping study selected ten relevant primary studies. Using the three questions, this SMS demonstrates a lack of studies that explore the benefits and characteristics of Simplicity in agile projects. Besides, it was possible to identify some perspectives of simplicity.

Next chapter introduces the definition of simplicity from the agile team’s perspective, and a conceptual model based on a literature review which were then triangulated with experts (practitioners and researchers) through a focus group session.

5 SIMPLICITY IN ASD: DEFINITION

Although Agile Software Development (ASD) has proven to be an important set of methods that promotes simplicity issues, there are difficulties in defining simplicity. In order to provide a better understanding of simplicity, this chapter presents a definition of simplicity from the agile team's perspective and a conceptual model based on a literature review (Chapter 3) which were then triangulated with experts through a focus group. In this space, it is an invitation to practitioners to rethink and do what they already do, but to do so more consciously. This consciousness can make a substantial difference in real situations. From this perspective, rethinking means committing oneself to a course of action where plausible analysis exists, to reexamine the adopted practices focused on simplicity (SANTOS et al., 2018).

The remainder of this chapter is organised as follows. Section 5.1 presents the research method and the focus group conducted with practitioners and researchers. Section 5.2 presents the conceptual model underlying simplicity definition from the agile team's perspective. Section 5.4 discusses the limitations, validity and reliability of this study. The implications for practices are discussed in Section 5.3.

5.1 Defining Simplicity in ASD: Research Method

Our conceptual model of simplicity in ASD was based on the general process (Figure 15). The first step, Literature Review, embodies the initial literature review (Section 3), gathering knowledge of ASD and the key concepts in the field of simplicity, with emphasis on the ASD aspects. Based on the early findings from the literature review, an initial conceptual model and simplicity definition from agile team's perspective is proposed (Section 5.2.1). The second step, Focus Group, addresses the focus group session performed to evaluate the main elements and relationships proposed in the Initial model step. The Conceptual Model (Section 5.2.2) is dedicated to incorporate and improve the model based on the focus group and literature review.

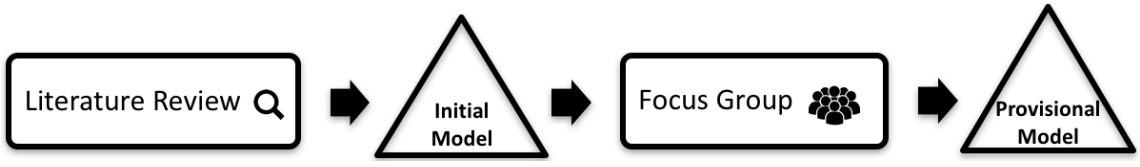

Figura 15 – Research Design (Focus Group): Definition of Simplicity in ASD

As a method of qualitative research data collection, a focus group is an interview

on a topic with a group of people who have knowledge of the topic (RUNESON; HÖST, 2009) (SEAMAN, 1999). Since the data we obtained from a focus group is socially constructed within obtaining feedback from the specific group, a interpretivist (constructivism) perspective underlies this data collection procedure.

In this sense, this research adopts the main steps of the guideline for conducting and discussing focus group sessions in software engineering research proposed by Kontio et al. (2004). Following, we provide more information about the design and arrangements of the study.

5.1.1 Defining the Research Problem: Focus Group

This study aimed to obtain an in-depth feedback on the proposed definition of simplicity, generating ideas, prioritising potential problems, discovering underlying ground and motivations. Furthermore, our focus group session also centralises attention on obtaining feedback on specific elements of our conceptual model underlying simplicity from the agile team's perspective.

5.1.2 Selecting the Participants

According to Kontio et al. (2004), the value of the method is very sensitive to the experience and insight of the participants. Thus recruiting representative, insightful and motivated participants is critical to the success of a focus group study. In this sense, we purposely sampled six high qualified researchers and practitioners in ASD with different roles, such as project manager, consultant, professor, researcher, scrum master and Project Manager Officer (PMO) with different genders, ages and levels of education, to achieve maximum variation in data collection. Table 10 compiles the participants' demographic profile. The email used in the initial contact to access potential participants is provided in Appendix C.

Due to anonymity and ethical issues, the participants are labelled by *P1* to *P6* codes. All the participants are Certified Scrum Master (CSM), with exception to *P4*, who are a Project Management Professional (PMP). Besides CSM and PMP, all participants are specialists in project management, governance and software quality. According to Table 10, they hold extensive industry certifications, including Certified Scrum Product Owner (CSPO), Certified Scrum Developer (CSD), Information Technology Infrastructure Library (ITIL), Control Objectives for Information and Related Technologies (COBIT), MPS-SW Appraiser and MPS-SW Implementer.

Tabela 10 – Focus Group: Profile of Participants

	Role	**Education**	**Gender**	**PM (years)**	**Agile (years)**	**Agile Methods**	**Certification**
P1	Researcher Consultant Professor Scrum Master	Ph.D.	Male	6 to 10	6 to 10	Scrum Kanban LSD	CSM
P2	Project Manager Researcher Professor Scrum Master	Ph.D.	Male	16 to 20	11 to 15	Scrum Kanban LSD ASD MAnGve (LUNA et al., 2014)	CSM ITIL COBIT
P3	Consultant Researcher Professor Scrum Master	Ph.D.	Male	11 to 15	6 to 10	Scrum XP	CSM CSPO MPS-SW Implementer
P4	PMO Manager Researcher Professor Scrum Master	Ph.D.	Male	11 to 15	6 to 10	Scrum Kanban	PMP
P5	Consultant Researcher Professor Scrum Master	Ph.D.	Female	6 to 10	6 to 10	Scrum Kanban	CSD MPS-SW Appraiser MPS-SW Implementer
P6	Researcher Professor Scrum Master	Ph.D.	Male	6 to 10	6 to 10	Scrum XP	PMP CSM

5.1.3 Planning and Conducting the Focus Group Session

We held a pilot session with two researchers, who are not included in those described in Table 10, in order to practice the focus group process and evaluate the questions. As a result, a few minor changes in question phrasing were made.

All the subjects agreed to participate in this focus group session and gave their written informed consent (Appendix **??**). The focus group session lasted 120 minutes and was recorded with an MP3 player. The use of audio recording ensured an identical replication of the session, thus facilitating its analysis.

The session started with an overview of the objectives of the study and full explanation about the nature of participation. The audio data of the session was transcribed by the investigator using oTranscribe[1] and analysed through ATLAS.ti[2]. Based on Kontio's guideline (KONTIO et al., 2004), the discussion transcript was issue-based, i.e., each issue or point raised was documented verbatim, but the transcript did not include clarification discussions, jokes, or other non-related communications in the meeting. Aiming to keep

[1] http://otranscribe.com
[2] http://atlasti.com

the anonymity and confidentiality, just the named investigators had access to the verbatim data collected during the session. These issues are present in the Information Sheet document (Appendix B).

The first investigator of this thesis worked as a facilitator of the session by motivating the participants to discuss and by leading the discussion. The interview script was composed of open-end questions. This kind of question is designed to encourage a full, meaningful answer using the subject's own knowledge. In order to reach the research problem (Section 5.1.1), we set out to answer the following research questions (RQs):

- *RQ1:* Is the definition of simplicity from the agile team's perspective understandable?
- *RQ2:* Are the conceptual model and their elements which support the definition of simplicity from the agile team's perspective understandable?
- *RQ3:* Are the conceptual model and their elements which support the definition of simplicity from the agile team's perspective reasonable?

5.2 Conceptual Model

According to our literature review (Chapter 3), we identified five simplicity perspectives in the context of Agile Software Development (ASD) (see Figure 16): agile team, product, process of project, customer, and end-user. Each of these perspectives is summarised, as follows.

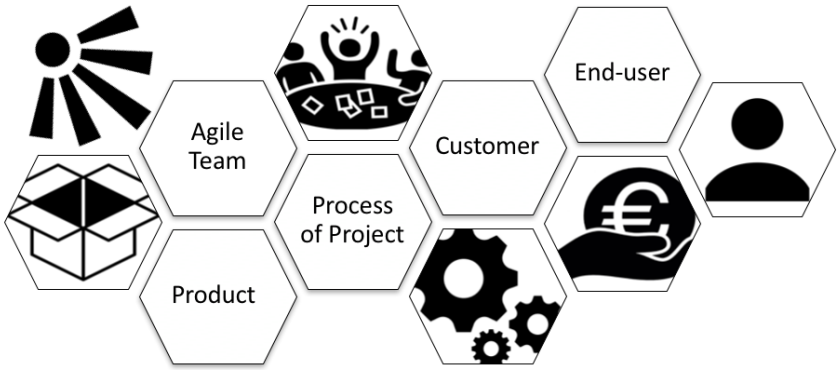

Figura 16 – Simplicity Perspectives in ASD

- Agile Team perspective addresses various aspects of team dynamics. e.g., organisation and communication;

- Product perspective focuses on aspects regarding the software (value) that are developed. e.g., usability and easy integration;
- Process of project perspective is related to agile practises and techniques for managing and developing the project. e.g., delivery strategy and pair programming;
- Customer's viewpoint addresses aspects regarding the business requirements. e.g., coordination of financial side, product backlog and sprint planning meeting.
- End-user's viewpoint addresses aspects regarding the user-experience (UX). e.g, you must first know the user and continually test your assumptions.

Additionally, our representation (see Figure 16) is composed by a pictogram, which represents different viewpoints or perspectives of each dimension of simplicity. The proposed model is particularly interested in addressing agile team's point of view. Conforming to Margaria et al. (2011) there are many perspectives on the concept of simplicity. For example, simplicity can be related to the number of components a system possesses. It can also reflect the amount of effort a user of the system has to expend to use the system or the level of effort and amount of knowledge to understand the system.

5.2.1 Initial Definition and Conceptual Model Based on a Literature Review

Outlining the diverse definitions from different areas, we defined simplicity from the agile team's perspective by adopting the ultimate function, rather than defining a set of practises. In this sense, we define simplicity in ASD as:

> *"The theoretical virtue disposing the team towards a conscientious, minimalistic and analytic attitude that leads agile projects to be successful".*

This definition was inspired by the functional definition of *agile* proposed by Kruchten (2013). He also illustrates a great analogy by defining a road: *"Would you define a road as something made of crushed rocks and tar, or define it as a surface that is black rather than white, flat rather than undulated, and with painted lines rather than monochrome? Or would you rather define a road as a component of a transportation system, allowing people and goods to be moved on the ground surface from point A to point B? And then let the properties or components of the road be derived from this functional definition, allowing some novel approaches in road design, rather than defining it narrowly using a common recipe."* The same analogy is applied to our definition of simplicity from the perspective of the agile team.

Our conceptual model (see Figure 17) is a coherent system of interrelated fundamentals that lead to consistent explanation regarding the definition of simplicity from the agile team's perspective. It is set up and inspired by Egyptian pyramids, certainly one of the most perfect and extraordinary shapes created by humans (Schadla-Hall RT, 2003). Additionally, the regular tetrahedron, comprising only four equilateral triangles, has a claim to simplicity and symmetry (HUMBERT; PRICE, 2003). Analogously, these are the main characteristics of our pyramid.

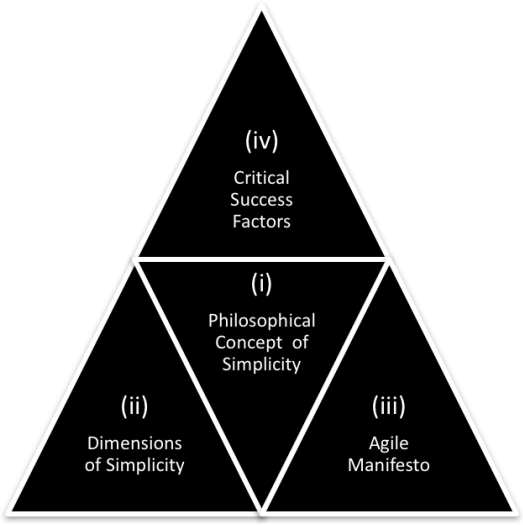

Figura 17 – Pyramid of Simplicity in ASD

Figure 17 provides an overview of the conceptual model illustrating the nature and relationships between the different components of the pyramid. The pyramid is revolving around the Agile Manifesto (iii), which unifies and establishes a common set of values and principles. (ii) dimensions of simplicity (Section 3.3.2), which identify the structures and aspects that lead to simplicity; On the top of the pyramid, (iv) Critical Success Factors (Silva, Karla; Santos, 2015) - are the factors that must be present for the agile project to be successful. The (i) philosophical concept of simplicity (GAMBREL; CAFARO, 2009) (BAKER, 2013) is considered as the centre or as a core part of the model.

5.2.2 Definition and Conceptual Model Based on a Focus Group

A focus group session was conducted to triangulate the conceptual model and definition with experts. Participants were asked about their understanding of the proposed definition of simplicity in ASD. The findings of this step are presented here. For each quote, the following format was adopted: *[P participant number]*. The main investigator acted as the moderator of the session with special care to not interfere in the discussion, just clarifying unclear issues.

The thematic analysis method was used for identifying, analysing, and reporting patterns (themes) within the transcribed data. Cruzes e Dybå (2011) describe the main steps and checklist items proposed for thematic synthesis in Software Engineering: extract data, code data, translate codes into themes, create a model of higher-order themes, and access the trustworthiness of the synthesis. The thematic map relating the categories extracted during the focus group analysis are illustrated in Figure 18 and described further.

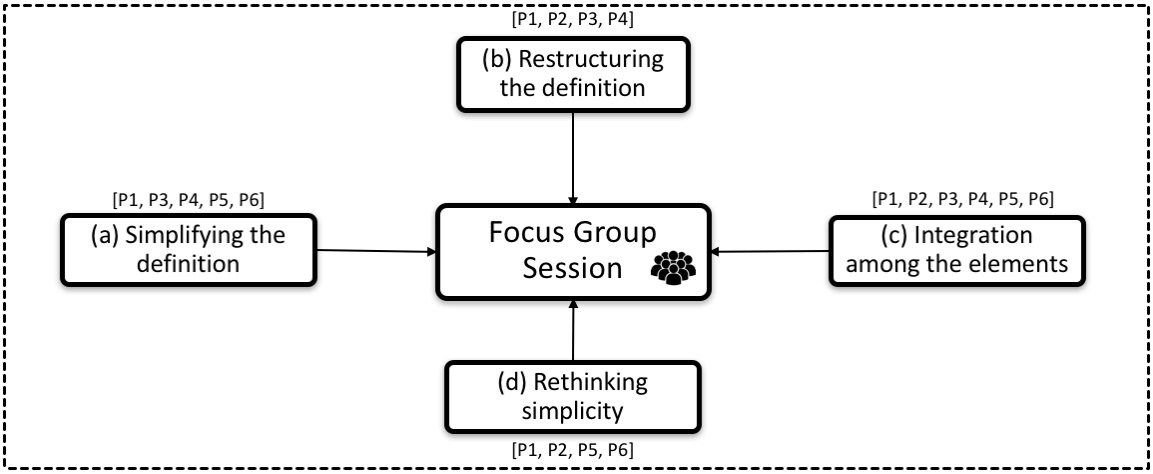

Figura 18 – Thematic Map: Focus Group Session

(a) Simplifying the definition: All participants were clear in standing that simplicity in the context of ASD needs a simple definition. According to them, the proposed definition (Section 5.2.1) is not clear and some enhancement are necessary in order to keep the desired statement as simple as possible. As some participants strongly indicated:

> *"(...) the definition of simplicity in agile software development must be simple." [P4]*
>
> *"There isn't a definition that the user can read and immediately understands, so we have to present additional explanations. The current setting is complex."[P3]*

Additionally, all experts state that according to the agile culture, simple definitions are preferred by the agile practitioners.

(b) Restructuring the definition: All experts were headed towards a systemic restructuring of the definition, as indicated in the following quote.

> *"(...) restructure the definition to make it cleaner (the way of writing). Make the definition less philosophical."[P5]*

(c) Integration among the elements: All experts claimed that all unit elements have to be in synergy towards simplicity, as indicated in the following excerpt:

> *"(...) the components (conceptual model) are coherent, but there must be a conceptual integration among them."[P2]*

As can be seen in Figure 19, the arrow involving the pyramid symbolises "the tailoring mechanism" of our conceptual model, which proposes an integration and accommodation of concepts among the different elements of our conceptual model: (i) philosophical concept of simplicity; (ii) dimensions of simplicity; (iii) agile manifesto; and (iv) critical success factors.

We argue that by incorporating the tailoring mechanism, an overarching concept-centric view of simplicity would allow practitioners and researchers to critically reflect on agile methods, and constantly find ways of extending or tailoring the method to foster and promote simplicity in order to continuous improvement.

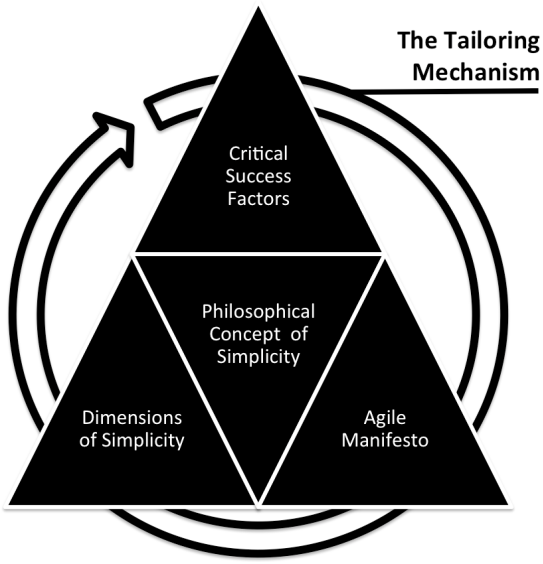

Figura 19 – Pyramid of Simplicity in ASD: The Tailoring Mechanism

(d) Rethinking simplicity: This new way of dealing with simplicity in the context of ASD requires the capacity to rethink the underlying competences under a different image of project, demanding a new team's mindset in order to further boost the success of the projects with focus on simplicity, as stated by one of our participants.

> *"(...) it's an interesting topic. Both, researchers and practitioners must discuss, enrich and extend the topic of simplicity beyond its current conceptual foundations".* [P1]

Furthermore, relationships between the components of the pyramid are not stated in a linear/sequential way. Essentially, they must be present in order to keep the "spirit of simplicity".

Definition and Conceptual Model: Based on participants understanding and analysis resulted from the focus group session, some enhancements were needed in our proposed definition. As following, we present the amended definition. The new text is underlined and important deletions are indicated using strikethrough.

> *"The theoretical virtue disposing the team towards a conscientious, minimalistic and an analytic attitude that leads agile projects to be successful".*

All participants were unanimous in emphasising that *conscientious* and *minimalistic* are embodied by the term *analytic attitude*. According to participants, a person who advocates or practises minimalism, automatically embodies an analytic attitude. Additionally, in order to proceed analytic attitude, a very seriously and conscientious posture is necessary. In this regard, these terms were removed from the definition, stated as:

> *"The theoretical virtue disposing the team towards an analytic attitude that leads agile projects to be successful".*

Each element of our definition is exploited in Figure 20 as: (i) "the theoretical virtue disposing the team towards an analytic attitude" is related with the philosophical concept of simplicity (core of the pyramid); (ii) the term "that leads" addresses the connection with "Dimensions of Simplicity", the first base of the pyramid; (iii) "agile projects" refers to the values and principles of "Agile Manifesto", the second base of the pyramid; and (iv) "to be successful" is based on the Critical Success Factors triangle (top of the pyramid).

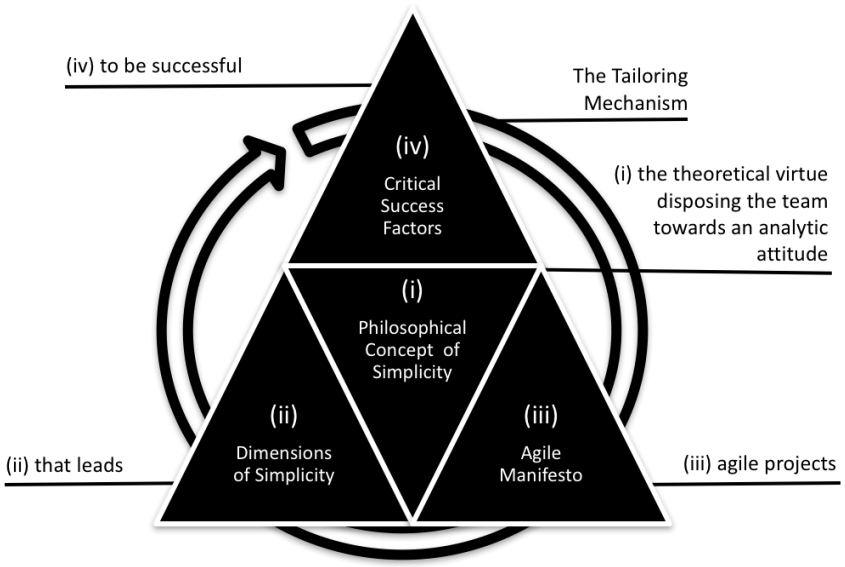

Figura 20 – Pyramid of Simplicity in ASD: Relationship between the Conceptual Model

5.3 Implications for Practice

The conceptual model and definition of simplicity is proposed to be a careful tool to understand the simplicity phenomena in ASD. It aims to be useful and reflective in its approach to both researchers and practitioners.

In this regard, the practitioners that desire to achieve simplicity through a thoughtful way can be benefited to do what they already do, but to do so more consciously. As an example, from this analysis, some agile practices could be refocused and re-prioritised as a vehicle to promote effective results, disposing the agile team toward the focus on critical factors to project success.

This consciousness can make a substantial difference in real situations, because simplicity does relate to the way how this is perceived by the agile team. It can influence the actions that follow, and the eventual results that might be achieved. As usual, when building mindsets, awareness sharpens the sight, especially in critical situations.

5.4 Limitations, Validity and Reliability

In this section, we discuss the limitations, validity, and reliability of our results from the perspective proposed by Merriam (2009).

Construct validity in qualitative research is related to the precise and clear-cut definition of constructs that is consistent with the meanings assigned by the research participants. Although we constantly compared and contrasted our construct definitions with the literature, another focus group session can be executed for obtaining additional qual-

itative insights and feedback from practitioners.

Internal validity, or *credibility*, is related to the extent that the results match reality. To increase credibility, we sampled experts in ASD with different roles in software projects, as described in Table 10. The preliminary results were discussed between the authors to refine the findings. In this sense, we reduced the potential bias in interpreting the results by having another person reviewing all interpretations made during the analysis. A limitation is that we conducted only one focus group session. Another limitation is that we just selected PhD's as participants of the focus group session.

Reliability refers to the extent that the results can be replicated. We tried to provide a rich description of the research method, the context in which the research was performed, and the results themselves.

Finally, this study reflects the results from a focus group with six experts with different points of view and perceptions about the studied phenomenon. Although they contributed to a rich description of the definition, we aim to replicate our protocol in other cases.

5.5 Chapter Summary

Simplicity has been increasingly recognised as a driving paradigm in Information and Communications Technology (ICT) development, maintenance, use and management, but according to the experts and the literature, there are difficulties in defining simplicity and its impact on projects.

This chapter presented the conceptual model (Section 5.2) underlying simplicity definition from the agile team's perspective. We believe that an exhaustive comprehension of this phenomena could support academics and practitioners in the direction of increasing the success rates of projects. Section 5.1 presented the research method and the focus group conducted with practitioners and researchers. Finally, sections 5.3 and 5.4 discussed the limitations and implications for practices of our study (SANTOS et al., 2018).

Next chapter outlines the aspects regarding the emerged substantive theory of simplicity in ASD. Its theory focuses in understanding how practitioners and researchers interpret simplicity in ASD projects, and how these interpretations shape their work towards simplicity.

6 SIMPLICITY IN ASD: A SUBSTANTIVE THEORY

This chapter provides a theory of simplicity, in which project managers, scrum masters and software engineers were interviewed about their perception in practice regarding the simplicity phenomena in Agile Software Development. The remainder of this chapter is organised as follows. Section 6.1 presents an overall of the methodological framework adopted during the theory emergence. The substantive theory of simplicity is detailed in Section 6.2. Finally, Section 6.3 discusses the limitations, validity, and reliability of this theory.

6.1 Theory Emergence: Research Method

This section describes the research methodology adopted during the substantive theory emergence. Several factors make empirical research in Software Engineering (SE) particularly challenging. It requires studying not only technologies but also its stakeholders' activities while drawing concepts and theories from social science (WOHLIN; AURUM, 2014).

This study aims to understand how practitioners and researchers interpret simplicity in ASD projects and how these interpretations shape their works towards simplicity. In this sense, this research adopts the roadmap for building theories, proposed by Eisenhardt (1989). Its roadmap synthesises techniques from grounded theory (BADREDDIN, 2013). The Eisenhardt's framework is composed by the following steps: (i) Getting started; (ii) Selecting the case; (iii) Crafting instruments and protocols; (iv) Entering the field; (v) Analysing data; (vi) Shaping hypotheses; (vii) Enfolding literature; and (viii) Reaching closure.

6.1.1 Getting Started

According to Eisenhardt (1989), without a research focus, it is easy to become overwhelmed by the volume of data. In this sense, the research focus is defined by the following initial research question: **How does the agile team understand simplicity?**

We performed a literature review of simplicity in several areas (Chapter 3), covering studies of simplicity in (i) Philosophy, (ii) Information and Communications Technology (ICT), and (iii) ASD. Besides, the Systematic Mapping Study (Chapter 4) presented a comprehensive picture of the available material of simplicity in ASD.

Research Ethics: We followed the norms of the Irish Institute of Health Science of

Ireland (REC, 2016) that regulates research with human subjects. We applied the study to the Faculty of Science and Engineering Research Ethics Committee Board (see appendix D for details), and the ethical approval was obtained on 30th November 2015 (Appendix E). The official approval allowed the conduction of interviews for the period from 23rd November 2015 to 31st October 2016.

The consent form (Appendix G) and the information sheet (Appendix H) were administrated before the interviews. The consent forms were signed assuring anonymity, confidentiality of data, and the right for the subjects to interrupt and withdraw without having to explain or give a reason at any time. All the subjects agreed to participate of this study and they gave their written informed consent.

Theory Emergence: Timeline:

As detailed in Chapters 3 and 5, the preliminary findings suggested a more grounded understanding of simplicity in ASD (SANTOS; PERRELLI, 2016) (SANTOS, 2016) (SANTOS et al., 2018) (SANTOS et al., 2017a). From this perspective, the initial cycle of interviews was conducted during the sandwich PhD of the principal investigator of this thesis in the research group at the Department of Computer Science & Information Systems (CSIS) of the University of Limerick (UL), during 2015 November and January 2016. The Lero's environment made possible to contact 21 agile experts in Ireland (Dublin, Limerick, and Galway), UK (London), and the USA (Tucson), as shown in Figure 21.

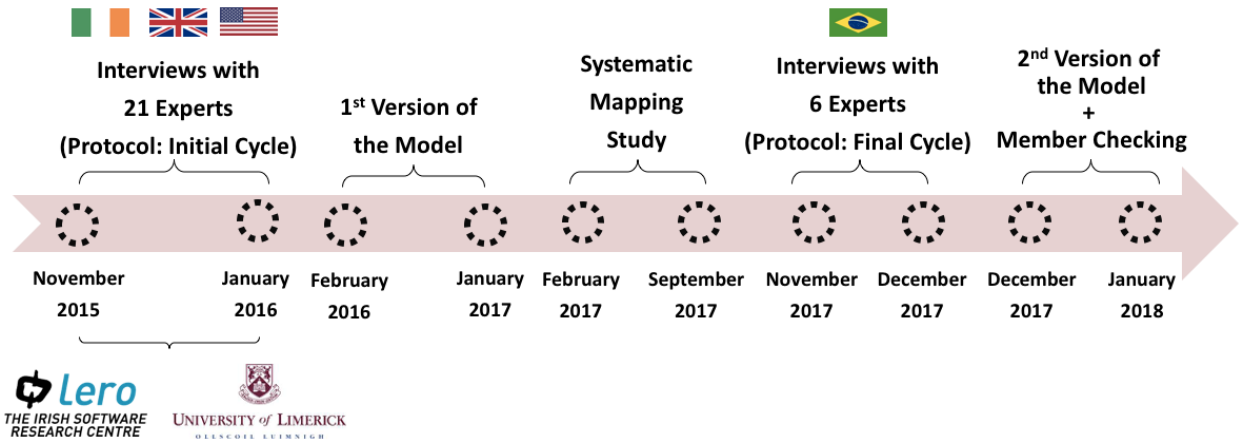

Figura 21 – Theory Emergence: Timeline

The preliminary theory of simplicity (SANTOS et al., 2017b) emerged in January 2017, as the first version of the model. A Systematic Mapping Study (MOREIRA et al., 2017a) (SANTOS et al., 2017) (Section 4) of simplicity in ASD was conducted just after the first version of the model emergence, as shown in Figure 21, to compare our findings with the literature and to support the refinement of the interview protocol (Appendix K - Final Cycle).

With the aim of reaching the saturation of the phenomena, and increase the diversity, it was collected more grounded data. The final cycle of interviews was conducted with Brazilian experts between November and December 2017. Lastly, the saturation was reached and the second version of the model emerged (Final Cycle), between December 2017 and January 2018. Additionally, the member checking (SANTOS; MAGALHÃES; SILVA, 2017) was conducted to ensure the consistency of our interpretation with the participants about the emerged theory.

6.1.2 Selecting the Case

This qualitative research is specified as a basic research study (see Section 2.2 for details). In this sense, we did not consider each organisation as a case study, and evidence of each company are no tabulated. In a general way, all participants were involved in organisations which:

- adopt agile methodologies in most projects, based on the concepts of adaptability, flexibility and self-organisation;
- achieve their organisation-level business goals through practices, principles, and values focused on people and interactions, working software, customer collaboration, responding to change, and continuous improvement;
- have simultaneous projects, of different size, technology, domain, scope; and
- provided us with full access to all the data and individuals necessary for our interviews.

Sample Selection: Once the general goal was identified (Section 6.1.1), the tasks become to select the population. The researcher thus needs to choose what, where, when, and whom to interview (MERRIAM, 2009). According to Merriam (2009), the two basic types of sampling are probability and nonprobability sampling, which are called purposive or purposeful (PATTON, 2003). In the following, the set of characteristics are specified from which the research sample was drawn.

Type of sampling: Purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore, it must select a sample from which the most can be learned (MERRIAM, 2009).

Inclusion and exclusion criteria: Inclusion Criteria are the attributes of subjects that are essential for their selection to participate. Industry and/or academic professionals, who satisfied the requirements listed in Section 2 of the Appendix D, and have expertise

in agile projects, are representative agents of the phenomena in the study. As excluding criteria, participants who do not satisfy any of the requirements listed in Section 2 of the Appendix D, who do not speak English and whose experience in agile development is restricted to short-term (less than two years) projects and thus are not likely to be representative agents of the phenomena in the study.

Gaining access to potential participants: Approach practitioners and researchers that work for companies or research centres that are partners of Lero (the Irish Software Research Centre)[1]. Experts that are in the National Technological Park (NTP) and through the networks Limerick Information Technology (IT) and start-up, as well as are individuals attending the workshops, seminars, and industrial days promoted by UL and Lero, apart from the other events during the term 2015/2016 (Appendix D, Section 5d).

6.1.3 Crafting Instruments and Protocols

Semi-structured interviews were performed with experienced practitioners and researchers. According to Merriam (2009), the semi-structured interview is in the middle, between structured and unstructured. In this type of interview either all of the questions are more flexibly worded or the interview is a mix of more and less structured questions. The interview script was composed of open-end questions (Figure 22), structured as (i) respondent demographic profile, (ii) simplicity in ASD, and (iii) key dimensions of simplicity. Initially (see Q5 and Q6), the interview guide encompasses quick questions, aimed at exploring experience and the background of the participants (see Appendix F for details). The next phases were presented in a funnel model (RUNESON et al., 2012), beginning with general questions focused on understanding the broad aspects of simplicity in ASD (see Q12 and Q13), which were refined toward more specific questions.

The general questions encouraged relevant and unbiased reflections bringing more details when answering the specific questions. The set of innovative research topics on the concept of simplicity pointed out by Floyd e Bosselmann (2013) and Margaria et al. (2011) identified dimensions that leads to simplicity. Thus, some questions (see Q21, Q22, and Q23) embodied in the interview guide aim at characterising these dimensions of simplicity in the context of ASD. The last question of our instrument (see Q24) explores additional possibilities of dimensions that lead to simplicity in ASD.

Pilot Test: According to Merriam (2009), pilot interviews are crucial for trying out the questions. Besides, using the pilot in the study not only provides each interviewer with valuable experience but also forms the basis of subsequent updated in the protocol (Barriball, K. While, 1994).

[1] http://www.lero.ie

...
Q5. How many years have you participated in or were involved in initiatives using agile methods?

Q6. Please indicate the agile methodologies in which you work (or worked).

...
Q12. What do you understand by simplicity in agile projects?

Q13. The agile manifesto defines the principle of simplicity, as "Simplicity – the art of maximizing the amount of work not done – is essential". How would you explain the principle of simplicity?

...
Q21. How would you describe the importance of "knowledge" as dimension that lead to simplicity in the context of agile software development? Please indicate some examples.

Q22. How would you describe the importance of "communication" as dimension that lead to simplicity in the context of agile software development? Please indicate some examples.

Q23. How would you describe the importance of "time" as dimension that lead to simplicity in the context of agile software development? Please indicate some examples.

Q24. Which other Dimension do you believe that lead to simplicity in the context of agile software development?

Figura 22 – Interview guide extract

The instrument (Appendix F) was pre-tested with two pilot interviews to get some practice in interviewing and also quickly learn which questions might need rewording or might yield useless data. As a result, a few changes in the sequence of questions improved the final interview guide, and some useless data was removed. These pilot test subjects are not part of the subject identified in Section 6.2.1.

6.1.4 Entering the Field

According to our exploratory research strategy (EISENHARDT, 1989), we purposely sampled 27 practitioners and researchers. We selected various types of roles, such as software engineers, team leaders and project managers with different genders, ages and levels of education (See Table 11 for details). We considered only professionals and researchers who are experts in agile projects with more than three years of experience.

Potential participants were initially contacted by email and invited to participate (see the email template in Appendix L). The participants were interviewed at their workplace (company or university), except for the five interviews with Americans experts, using Skype. As illustrated in Figure 21, data were collected over seven weeks, from November

2015 to January of 2016 (Initial Cycle). The interviews with Brazilians occurred from November 2017 to December 2017 (Second Cycle).

The interviews were recorded with an MP3 player and lasted 60 minutes on average. All the interviews with the experts totalled 17 hours and 50 minutes of audio time. The use of audio recording ensured an identical replication of the content of each interview, which facilitated analysis. The audio data, transcriptions and fields notes were securely stored on a password-protected computer.

Each session started with an overview of the objectives of the study and a full explanation about the nature of participation, considering the following topics: initial personal and academic presentation, the purpose of the study, the interview average duration, confidentiality, audio recording information. Besides, it was informed the Research Ethics Committee (REC)' telephone for further information. These issues are present in the Information Sheet document (Appendixes H - Initial Cycle and J - Final Cycle).

6.1.5 Analysing Data

According to Eisenhardt (1989), analysing data is the heart of building a theory, but it is also considered the most challenging phase. Initially, the audio data of the interviews were transcribed using oTranscribe[2]. Aiming to keep the anonymity and confidentiality, just the named investigators had access to the verbatim data collected during the interviews. According to the ethics issues (Section 6.1.1), participants information was stored separately from the survey instrument data, so that the participant data is private.

We used ATLAS.ti[3] tool to analyse and synthesise the data. It is a versatile workbench for the qualitative analysis of large bodies of textual, graphical, audio, and video data. The data were labelled thorough qualitative coding (open coding) to distil, identify similarities and sorts them to describe the phenomenon of simplicity in ASD (see Figure 23). Charmaz (2006) clarifies that coding means that we attach labels to segments of data that depict what each segment is about (see Figure 24).

In sequence, the constant comparative method of qualitative analysis (GLASER, 1965) was adopted to compare each code from the same interview and those from other interviews. As we continuously compared the codes, many fresh concepts emerged (Figure 25). As the process of data analysis progressed, relationships among categories (Figure 26) and memos were written to keep us involved with the analysis, thus helping to increase the level of abstraction of our ideas about the codes, concepts, categories and possibly even relationships. These memos forced us to look beyond impressions and see evidence

[2] http://otranscribe.com
[3] http://atlasti.com

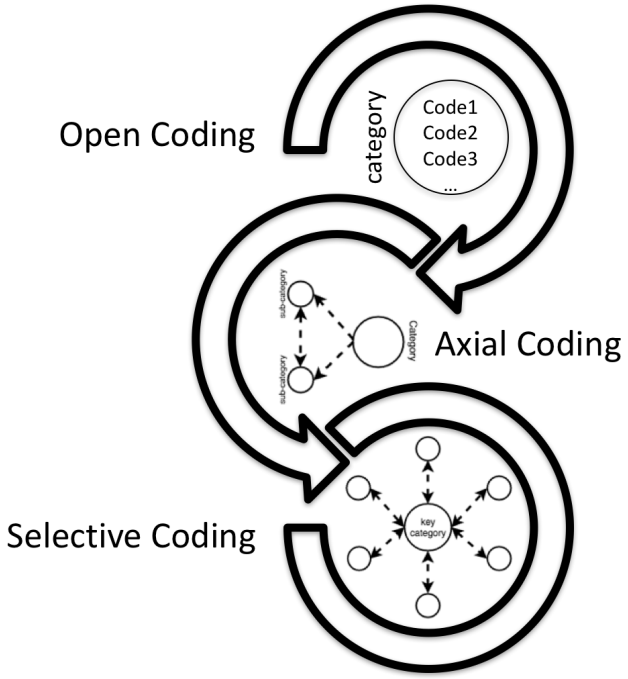

Figura 23 – Grounded Theory Techniques

Interview quotation:
"[simplicity] is about focusing on the few things that have the most impact. Things like communicating well with your team, with your customer."

Code: customer communication

Figura 24 – Open Coding: Building Codes

through multiples lenses.

Codes:

customer communication

communication between the participants

in-depth communication

formal communication

Category:
Effective Communication

Figura 25 – Open Coding: Building Categories

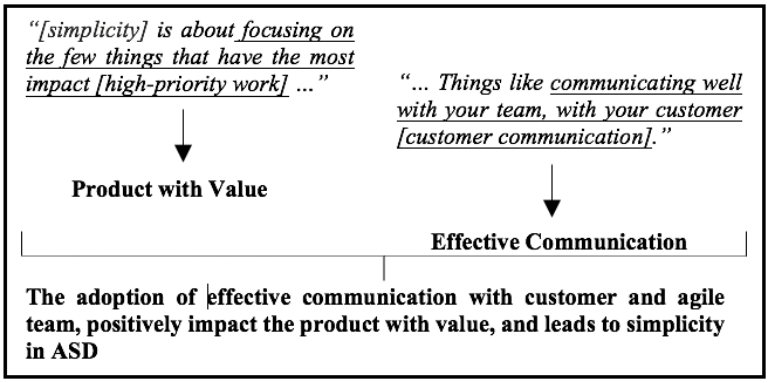

Figura 26 – Axial Coding: Building Relationships

6.1.6 Shaping Hypotheses

The process of building theory proposed by Eisenhardt (1989) also considers the analysis of relationships among the grounded categories, thus shapes the hypotheses that iterate toward a theory which tightly fits the data and explains the phenomena.

6.1.7 Enfolding Literature

Shortly after the qualitative analysis, Eisenhardt (1989) also considers that comparison of the emergent concepts or theory with extant literature is an essential feature of theory building. In order to identify different phenomena, we deeply analysed and discussed our evidence and results, considering the broad range of studies, outlined in Chapters 3 and 4. This way, we increased the confidence of the emerging theory.

6.1.8 Reaching Closure

Lastly, as illustrated in Figure 21, just after the emergence of the second version of the model (Final Cycle), we conducted the member checking with the six experts. Its technique was applied to validate the findings, improving accuracy, credibility, and internal validity of our interpretations. According to Santos, Magalhães e Silva (2017), member checking can be defined as a research phase performed during qualitative research in which the researcher compares the answers of participants to increase accuracy and consistency of results. We then used member checking to avoid misinterpretations of what participants said.

After presenting the hypothesis obtained from the data analysis process, we constructed a questionnaire to evaluate the level of agreement of participants. The questionnaire was composed of five items, one for each hypothesis, with answers based on a 5-point Likert scale (VAGIAS, 2006). It were submitted to the participants through Google Forms (see appendix N).

The member checking questionnaire (Appendix N) and information sheet (Appendix M) were pre-tested with a pilot session to get some quick learning on which hypotheses might need rewording or might yield useless data. As a result, a few changes in the sequence of hypotheses improved the final member checking guide. The pilot's participant holds a PhD in Empirical Software Engineering (ESE).

6.2 Shaping the Theory of Simplicity in ASD

In the following sections, we present our findings of theory emergence of simplicity in ASD, based on interviews with experts (see Section 6.2.1). In the sequel, are addressed the results relating the characterisation of simplicity, the analysis of relationships among the grounded categories and hypotheses. Moreover, it is described the central story that explains simplicity in ASD.

6.2.1 Context Description: The Participants

As mentioned in Section 6.1.4, 27 skilled practitioners with different roles (software engineer, scrum master, project manager, lead developer, test leader, consultant, designer, and researcher) were purposely sampled to achieve maximum variation in data collection. Table 11 compiles the participants' demographic profile. Due to anonymity and ethical issues (Section 6.1.1), the participants are labelled by *P1* to *P27* codes. Table 11 presents a total of 27 individuals with high level of professional experience in ASD - the time of involvement with agile methodologies of the interviewers vary from six to ten and 11 to 15 years. Among them, 21 participants are male and six female. Regarding the level of education, 23 participants stated they either already hold a postgraduate degree (i.e., MSc or PhD) or that they currently study towards such a degree.

All of the participants worked or have been working on projects which use an agile process based on Scrum and Kanban. Some of them were involved with Scrum, Kanban, eXtreme Programming (XP), Lean Software Development (LSD), or Feature-Driven Development methodologies. Additionally, most of them also hold extensive industry certifications, including Certified Scrum Master (CSM), Certified Scrum Product Owner (CSPO), Certified Scrum Developer (CSD), Project Management Professional (PMP), Information Technology Infrastructure Library (ITIL), Control Objectives for Information and Related Technologies (COBIT).

Figure 27 indicates that interviews were undertaken in different countries (Ireland, United Kingdom, Brazil and the United States of America). Darker colour indicates more interviews. Note that we covered three continents (Western Europe, South America and North America) - it contributes to constructing a more grand theory.

Tabela 11 – Theory: Profile of Participants

ID	Role	Education	Gender	Agile (years)	Agile Methods	Country
P1	Software Engineer; Scrum Master	BSc	Male	6 to 10	Scrum; Kanban	UK
P2	Software Engineer; Project Manager; Scrum Master	MSc MBA	Female	6 to 10	Scrum; Kanban; XP; LSD; FDD	UK
P3	Software Engineer; Scrum Master	BSc	Male	6 to 10	Scrum; Kanban; Lean	UK
P4	Software Engineer; Scrum Master; Tester	MSc	Female	6 to 10	Scrum; Kanban; XP; Lean	UK
P5	Software Engineer; Scrum Master; Designer	BSc	Male	6 to 10	Scrum; Kanban; LSD	UK
P6	Software Engineer; Project Manager; Scrum Master	BSc	Male	6 to 10	Scrum; Kanban	UK
P7	Software Engineer; Scrum Master; Researcher	PhD	Male	6 to 10	Scrum; Kanban; Lean	Ireland
P8	Software Engineer; Project Manager; Scrum Master; Consultant; Researcher	PhD	Male	11 to 15	Scrum; Kanban; XP; LSD; FDD	Ireland
P9	Consultant; Researcher	MSc	Male	6 to 10	Scrum; Kanban; Lean	Ireland
P10	Software Engineer; Scrum Master; Researcher	MSc	Male	6 to 10	Scrum; Kanban; XP; LSD; FDD	Ireland
P11	Consultant; Researcher	PhD	Male	6 to 10	Scrum; Kanban; Lean	Ireland
P12	Software Engineer; Scrum Master; Consultant; Researcher	PhD	Female	11 to 15	Scrum; Kanban; XP; Lean	Ireland
P13	Software Engineer; Scrum Master	MSc	Male	6 to 10	Scrum; Kanban; XP; Lean	USA
P14	Software Engineer; Scrum Master; Researcher	MSc	Male	6 to 10	Scrum; Kanban; XP; Lean	USA
P15	Software Engineer; Project Manager; Scrum Master; Consultant; Researcher	PhD	Male	11 to 15	Scrum; Kanban; XP; Lean	USA
P16	Software Engineer; Scrum Master	MSc	Male	6 to 10	Scrum; Kanban; XP; Lean	USA
P17	Software Engineer; Project Manager; Scrum Master	MSc	Male	11 to 15	Scrum; Kanban; XP; Lean	USA
P18	Software Engineer; Scrum Master; Consultant; Researcher	MSc	Female	6 to 10	Scrum; Kanban; XP; Lean	Ireland
P19	Software Engineer; Scrum Master	MSc	Male	6 to 10	Scrum; Kanban; XP; Lean	Ireland
P20	Project Manager; Scrum Master	MSc	Female	11 to 15	Scrum; Kanban; XP; Lean	Ireland
P21	Software Engineer; Scrum Master	MSc	Male	6 to 10	Scrum; Kanban; XP; Lean	Ireland
P22	Project Manager; Scrum Master; Consultant; Researcher	MSc	Male	11 to 15	Scrum; Kanban; XP; Lean	Brazil
	Project Manager;					

Figura 27 – Interviews by country (Darker colour indicates more interviews)

6.2.2 Characterising Simplicity in ASD

Participants were asked about their understanding of simplicity in ASD. The findings of this step are presented here. For each quote, the following format was adopted: *[P participant number]*. From the agile team's perspective, simplicity in ASD is broadly related to different kind of categories, such as (i) **lightweight process**, (ii) **knowledge acquisition**, (iii) **time consuming**, (iv) **product with value**, and (v) **effective communication**. These categories are better discussed in the following excerpts.

According to participants, simplicity is broadly related to **lightweight process**. It means that the overhead of the process is kept as small as possible, to maximise the amount of productive time available for getting useful work done.

> *"I would say that simplicity in agile is about not having too much complicated process."*[P4]
>
> *"(simplicity in ASD) it has to be straight full to do - If it's a process. You know, it has to be not taking a lot of different steps."* [P5]
>
> *"(...) suppose like if an agile method is simple, there won't be too much processes involved."* [P3]

One of the benefits of ASD is that organisations are capable of significantly reducing the overall risk associated with software development. Agile also focus on **reduction** of the amount of overhead in communication and documentation:

> *"Or we can even break it up. Well, they're kind of, let's say, a first goal and how we get to that and break into little tiny simple steps."* [P6]
>
> *"(...) it comes to mind lean in particular because at lean you got a concept model and anyone wants to reduce as much as possible."* [P2]

Additionally, participants reinforce the connection of simplicity with the essence of lean principles (POPPENDIECK; POPPENDIECK, 2006), such as eliminate waste, amplify learning, and deliver as fast as possible. Strengthened by the spirit of Lean, [P2] claims that:

> *"(simplicity in ASD) absence of that which does not add value (...) anyone wanna reduce that as much as possible. I think that the principles of lean really embodies what I think simplicity should be."* [P2]

When the team prioritise things that add knowledge at the beginning of the project, they could speed up the pace of understanding the requirements and therefore lower risks of misunderstanding (MALMQUIST, 2013). Participants emphasised that **knowledge acquisition** is widely related to simplicity.

> *"Oh, I think there's probably two aspects to that (simplicity in ASD). One is that something has to be easy to understand (...)"* [P5]

Essentially, the agile team needs kick-start by understanding their readiness for project's context and focusing resources most effectively to minimise **time consuming** (time spent on process overhead). According to participants, time management also influences simplicity to avoid unnecessary time consuming and downtime (time during which a machine is out of action or unavailable for use), as seen in the following quotes:

> *"(simplicity in ASD) it has to be quick to do."* [P5]
>
> *"(...) suppose like if an agile method is simple than it won't take me long. So it will be quick for me to use and either won't do the wrong thing."* [P3]

Fundamentally, agile teams must ensure consistent delivery of a product with value to customers. It makes sure that product or service always is of the highest quality possible (COCKBURN, 2001). According to participants, focusing on **product with value** leads to simplicity, as seen in the following quotes:

> *"(simplicity in ASD) about focusing on the few things that have the most impact. Kind of focusing on what the project is meant to achieve."* [P4]
>
> *"Yeah, it is getting down to what is the client optimal tools and follow one of those, and one of the simplest steps we can imagine with the least amount of work we can do to get that attempt done."* [P6]

In particular, the agile methodologies focus more on effective communication, collaboration, and coordination within a dynamic team environment than up-front planning and documentation (BECK et al., 2001). According to evidence, **effective communication** with team and customer also promotes simplicity, as seen in the following quotes:

> *"(simplicity in ASD) is also about focusing on things like communicating well with your team, with your customer."* [P4]

6.2.3 Understanding of the Agile Manifesto

The participants answered questions regarding their understanding and explanation of the principle in the agile manifesto. The statement of simplicity "Simplicity – the art of maximising the amount of work not done – is essential" (BECK et al., 2001). Generally speaking, participants agreed that this principle is aligned with the grounded categories of (i) **lightweight process**, (ii) **knowledge acquisition**, (iii) **time consuming**, (iv) **product with value**, and (v) **effective communication**, (vi) as follows: The majority of participants understand the principle of simplicity from the perspective of **product with value**, as exemplified in summary in the following excerpts:

> *"So I think you want to maximise the amount of work that doesn't add value - not done."* [P2]
>
> *"(...) if you're not wasting time doing, spending effort, doing things that aren't important. So I think you are aligned with that far."* [P3]

Furthermore, participants reinforce the connection of simplicity's principle with the **essence of Lean** (POPPENDIECK; POPPENDIECK, 2006).

> *"(...) I think it comes back to lean right? You need to maximise the work not done without compromising the results."* [P2]
>
> *"That's quite like Lean sort of. The art of maximising the amount of work not done. I feel like it's a good thing to aim for. Like, before you even do anything you should think of whether it is worth doing."* [P4]

On the other hand, participants also express their concern about the statement. P5 declares that the principle of simplicity is itself **not simple - it is a convoluted definition**.

> *" (...) it's kind of a convoluted way of putting it. It's not a simple way of defining simplicity. It's not a simple definition."* [P5]

6.2.4 Theoretical Model

The relationships between the categories were analysed and focused using selective coding (STRAUSS, 1987) to provide the overall theoretical picture. In this instance, the analysis showed that **effective communication** emerged as the fulcrum category of the study. This central story is presented below and is illustrated in Figure 28. The numbers between relationships represent the hypotheses (Section 6.2.4).

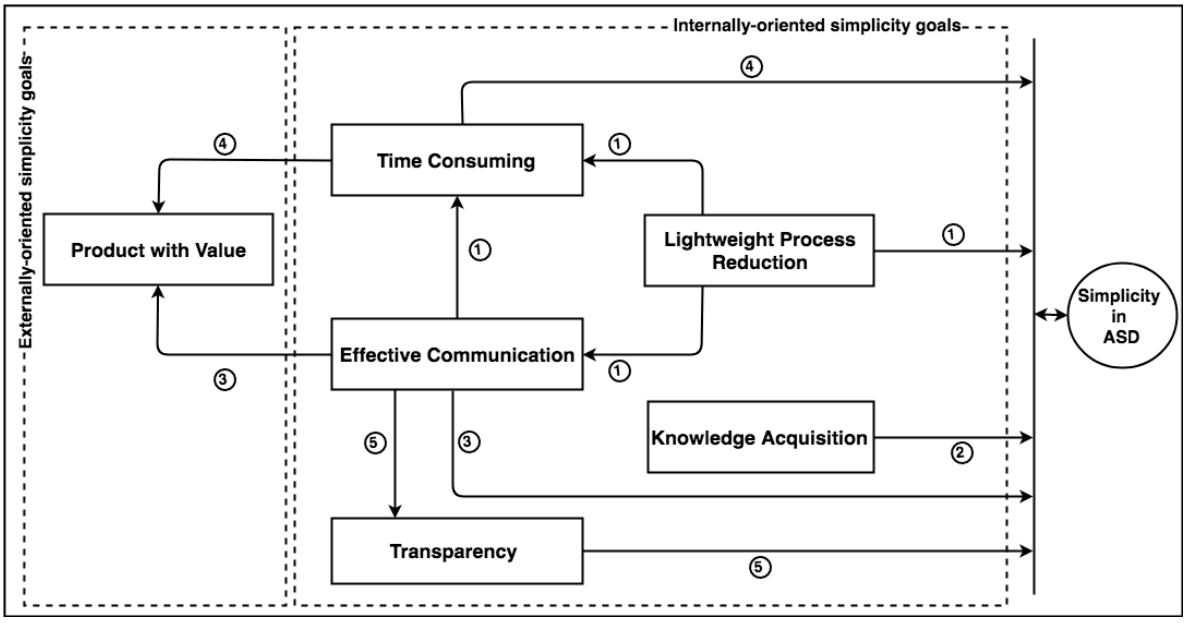

Figura 28 – Theoretical Model of Simplicity in ASD

Furthermore, when analysing the interrelationship between these categories, we find that there are two clusters of goals, organised in externally-oriented simplicity goals and internally-oriented simplicity goals. Firstly, composed by **lightweight process**, **knowledge acquisition**, **time consuming**, **effective communication**, and **transparency**. Secondly, aiming for **product with value**. This structure is inspired by the study proposed by Agerfalk (2006), which grouped internal and external goals of the agile manifesto.

Table 12 outlines the highest ranking categories emerged from the axial coding. The level of empirical groundedness indicates the number of quotes (frequency of occurrence) that substantiates the existence of that category. In what concerns theoretical density, it

states the number of codes linked with each code. As is evident from Table 12, **effective communication** (first row), get the highest groundedness (62), and highest density (26).

Tabela 12 – Theory: Groundedness and density of codes

Category	**Groundedness**	**Density**
CAT: Effective Communication	62	26
CAT: Knowledge Acquisition	52	17
CAT: Time Consuming	42	13
CAT: Lightweight Process	39	11
CAT: Product with Value	26	13
CAT: Transparency	21	6

Nomological Networking: Atlas.ti tool offers the possibility of building graphical networks connecting codes to codes, and quotations to quotations, through meanings. In these network views, the connecting lines have names, and those names represent a meaning that the researcher has defined through interpretation. The emerged theoretical model (Figure 28) is an abstraction from the nomological networks emerged during the data analysis.

Figure 29 represents one of the many nomological networking emerged during the qualitative analysis (open coding, axial coding and selective coding). For instance, its network highlights that several codes (e.g. *informal communication*, *customer communication*, and *face-to-face communication*) are *<part of>* the central category *Effective Communication*. In sequence, the *Effective Communication <is associated with>* several categories, such as *time consuming*, *product with value* and, *knowledge acquisition*.

Shaping Hypotheses: The relationships among categories that emerged from the data analysis were organised in hypotheses, each one describing a particular view of the phenomena, resulting in five key relationships (see Figure 28 for details).

Hypothesis 1: The inclination towards *lightweight process* enhances *effective communication*, reduces *time consuming* tasks, and leads to *simplicity in ASD*.

In general, agile methods are very lightweight processes that embody less process, employ short iteration cycles; actively involve users to establish, prioritise, and verify requirements; and rely on tacit knowledge within a team as opposed to documentation (COCKBURN, 2001). Participants identified that enhancement of effective communication and reduction of time consuming are caused by the promotion of lightweight process (Figure 30).

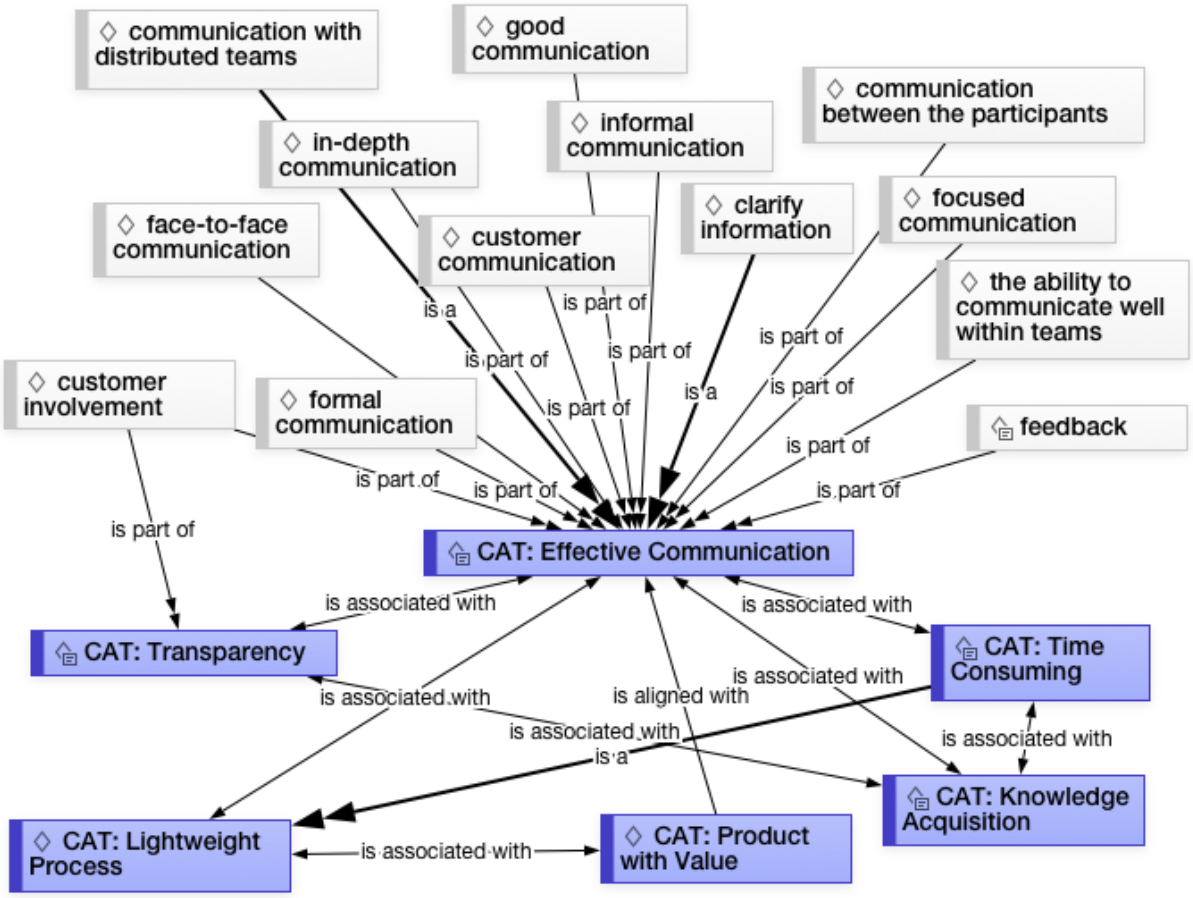

Figura 29 – Theory: Nomological Networking (Effective Communication)

> *"(...) not having too much complicated process. Again about focusing on the few things that have the most impact. Things like communicating well with your team, with your customer."* [P4]

Hypothesis 2: The encouragement to *knowledge acquisition* promotes *simplicity in ASD.*

The agile development environment is considered as a platform for the extraction of knowledge without extra effort, overcoming cultural and psychological barriers (LEVY; HAZZAN, 2009) (Figure 31). Participants identified knowledge acquisition as an important tool that leads to simplicity in ASD and helps the longer term productivity and flexibility of the team, as seeing in the following quotes:

> *"(...) if your knowledge that comes out it is really useful, that certainly makes things simpler."* [P6]

> *"The more you understand about what you are trying to achieve and about what your system can do; that leads you to get to a solution faster."* [P5]

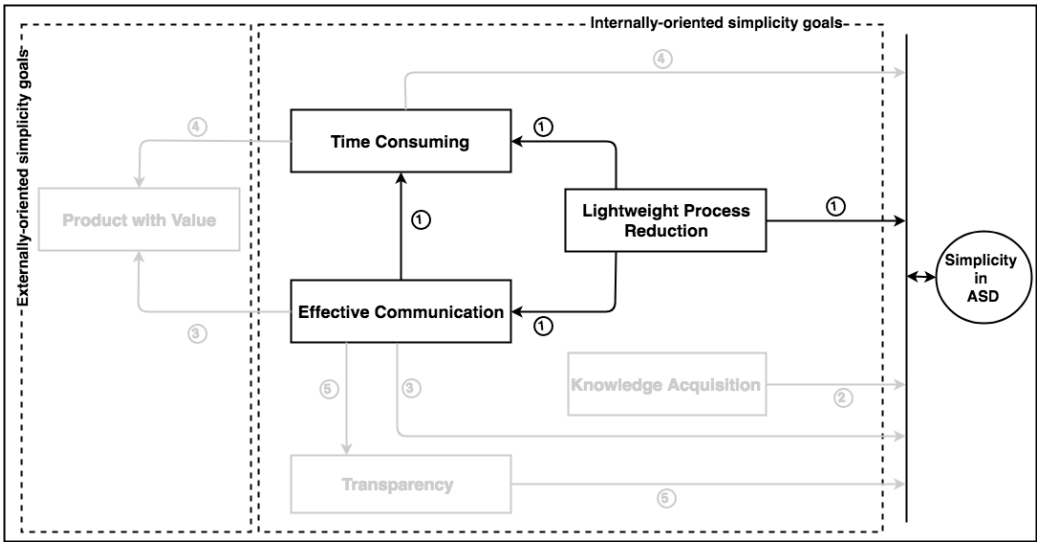

Figura 30 – Theoretical Model: Hypothesis 1

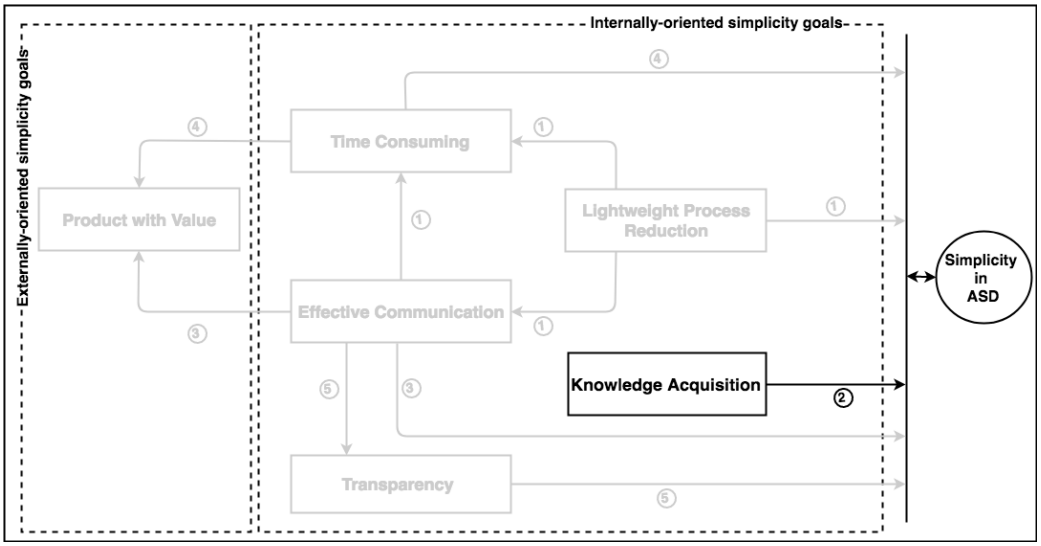

Figura 31 – Theoretical Model: Hypothesis 2

Hypothesis 3: The adoption of *effective communication* between customer and agile team positively impacts the *product with value*, and leads to *simplicity in ASD*.

The effective communication among the team members and customers were highlighted as crucial to achieve simplicity in ASD and ensure effective feedback (Figure 32), as seen in the following quotes:

> *"(...) communication is definitely on the top of the pyramid of customer involvement"* [P2]

> *"(...) the less communication you have the more difficult it is to do anything"*

[P5]

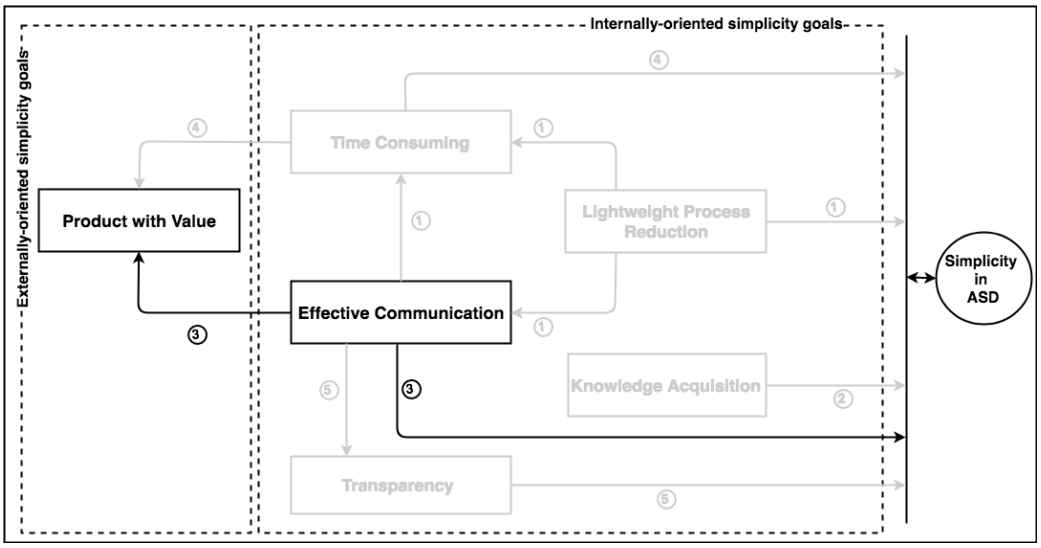

Figura 32 – Theoretical Model: Hypothesis 3

Hypothesis 4: The optimisation of *time consuming* positively promotes on development of *product with value*, and leads to *simplicity in ASD*.

According to participants, the high-quality of product (value to the customer) is a consequence of a focused time prioritisation, towards a thoughtful reduction of unnecessary work done upfront (Figure 33).

> *"(...) if something is simpler in the context of ASD it should take less time. But in that, it should, say to break the things down in stories and stories smaller, simpler then each story will take less time to develop. They'll take less time to test, they'll take less time to understand the requirements"* [P2]

Hypothesis 5: The inclination to *effective communication* promotes *transparency*, and leads to *simplicity in ASD*.

According to participants, the focuses on effective communication promotes transparency. According to our analysis, transparency leads to simplicity in ASD (Figure 34), as seen in the following quotes:

> *"(...) transparency as well, so if people don't feel you are being open with them (...) doesn't matter on what level it is, for them as a team or with management on the team."* [P19]

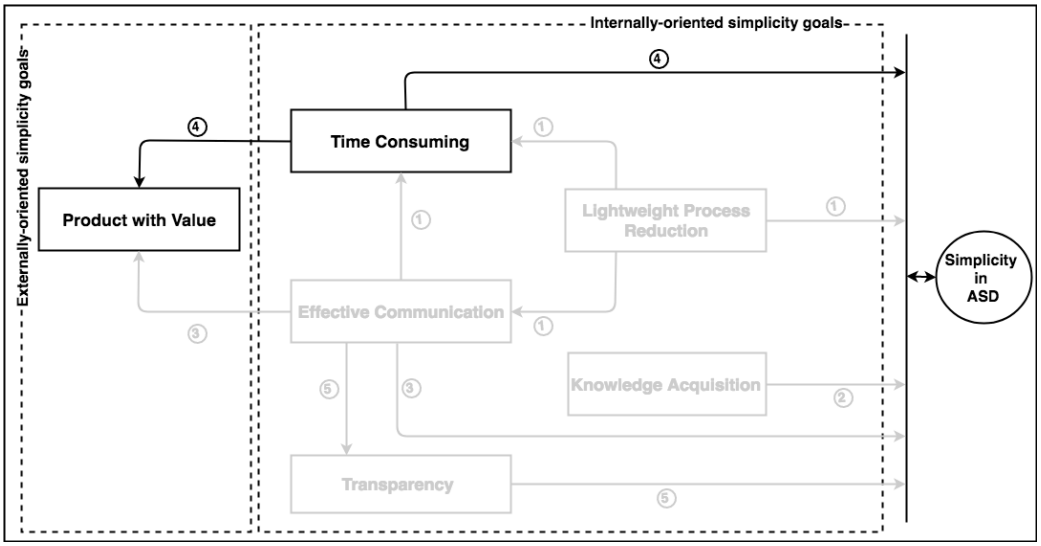

Figura 33 – Theoretical Model: Hypothesis 4

"(...) it's about being clear, where we are, where we need to be, why, where, you know, why we're doing what we're doing like, you know if we finish this by the end of the next sprint then the customer will be happy with that (...)" [P20]

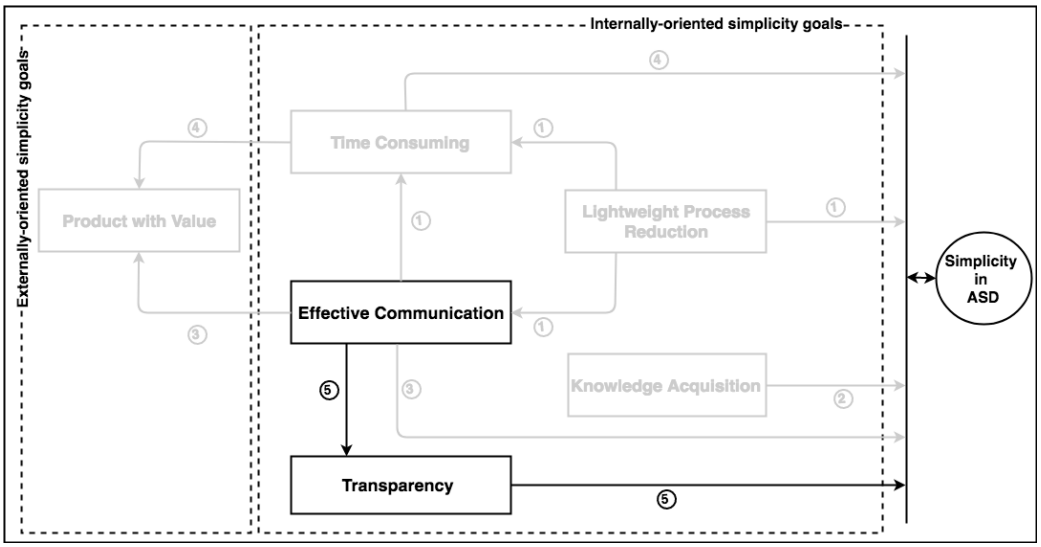

Figura 34 – Theoretical Model: Hypothesis 5

6.2.5 Implications for Practice

The emerged theory is proposed to be an analytical tool to understand the simplicity phenomena in ASD that aims to be useful and reflective in its approach to both, researchers and practitioners. In this sense, practitioners could benefit the agile team and organisation that desire to achieve simplicity through directions promoted by categories (elements of

theory), which underpin the agile team towards a better focus on agile practices related to those categories. However, the theoretical model (central story of simplicity in ASD) (Figure 28) has a high-level abstraction and do not describe the practices related to those categories and hypotheses.

In this sense, Figure 35 illustrates the symbiotic relationship between the theory and practices. The theoretical level (bottom) focuses on understanding simplicity in ASD from grounded data. The second level sheds light on the relative importance of various agile practices; hence, it provides useful insights to the agile team to identify best practices which leads to simplicity in their projects.

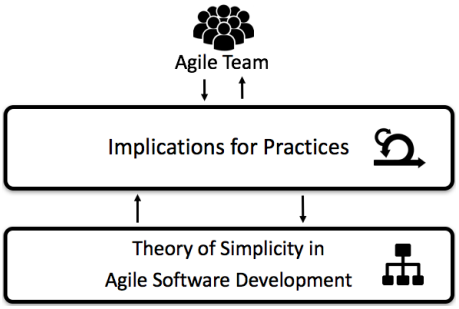

Figura 35 – Theory: Implications for Practices Usage

Furthermore, both levels have a symbiotic relationship, in which practices (level two) are specifically connected with categories of theory (level one). In other words, the second level (implications for practices) is instrumental in helping the agile team to sort and select a set of best practices. Additionally, it is reflexive in recommending attitudes and behaviours, in two manners:

1. **Embody practices:** We recommend that practitioners carefully study their projects' characteristics and try to incorporate those practices with the aim of enhancing simplicity in their projects. Theses agile practices can be combined with overall agile projects and methods.

2. **Rethinking (Mindset):** If those practices are already applied, we suggest rethinking agile practices. In a preliminary study, Santos et al. (2018) defined simplicity as "the theoretical virtue disposing the team towards an analytic attitude that leads agile projects to be successful". This definition is supported by a conceptual framework, which was then triangulated through a focus group with six ASD experts. The conceptual framework of simplicity in ASD is an invitation to practitioners to do what they already do, but to do so more consciously. This consciousness can make a substantial difference in real situations. From this perspective, rethinking means committing oneself to a course of action where plausible analysis exist, in order to reexamine the adopted practices.

Enfolding Literature: In this section, are analysed initial implications for practices (based on the literature review) in light of our substantive theory of simplicity in ASD. The idea of instantiating the theory of simplicity make it easier for the agile team to tune the selected practices into their projects, following some recommendations (implications for practices):

- **Lightweight Process:** An important direction towards a *lightweight process*, is through the *simple design* and *refactoring* (HUSSAIN et al., 2008). In order to reach an optimised process for projects, Hussain et al. (2008) reflected it has to be tailored to the nature of each team and project in order to provide the benefits it promises. In this sense, from the very beginning the team has to keep the design as simple as possible. Refactoring of code also contributes in keeping the design simple.

  These practices that lead to simplicity is also supported by Hunt e Thomas (2003). Hunt e Thomas (2003) argue that unfortunately many developers have a knack for making one of two errors: (i) Oversimplifying something that really is complex; and (ii) Overcomplicating something that should be easy. As a solution, they boost simplicity by implementing essential features or framework functionality and by taking steps (such as constant refactoring) to avoid future problems that might require extra work.

  In line with Hunt e Thomas (2003), Shore (2004) also endorses the focus on *continuous design* through simplicity and continuous improvement.

- **Effective Communication:** ASD changes the nature of collaboration, coordination, and communication in software projects. It involves a radically new approach to decision-making in software projects, since project teams deliver working software in short iterations, which results in more frequent, short-term decisions, compared with a traditional software development approach (CUNHA; MOURA; VASCONCELLOS, 2016).

  According to the theory (Figure 28), *effective communication* is being empirically identified as an important way to achieve simplicity. From this analysis, some agile practices could be refocused as a vehicle to promote an effective communication with the team and customer, such as daily stand-up meetings, video conversation, and instant messaging rather than just mediated communication (e.g. bug tracking or Kanban board).

  Besides the benefits related to *simple design* and *refactoring*, Hussain et al. (2008) also highlight practices related to *effective communication*, as instruments which contribute to improve not only our process but also to increase the overall morale of the team, such as: sitting together, face-to-face communication, feedback, stand-up meetings, the planning meetings, pair programming and reflection meetings.

According to Ambler (2003), modelling is a way to think issues through before you code because it lets you think at a higher abstraction level. The Agile Model Driven Development suggests you to work with the simplest (not just simple) tools. Ambler advocates the use of tools that strengthen the team's *effective communication*, such as whiteboards and paper, when work with users to explore and analyse their requirements. Amble emphasises that "simple tools are easy to work with, inclusive (my stakeholders can be actively involved with modelling), and flexible, and they are not constraining". In this sense, with Agile Model Driven Development (AMDD), programmers write the code progressively in step with the models and promotes an evolutionary approach, in which implementation occurs iteratively and incrementally.

- **Knowledge Acquisition:** The action learning cycle is described as a style of *knowledge acquisition*. It is by definition an iterative process and is never accurately conveyed as a single cycle of action. Instead, the action learning cycle should be represented as a continuous, and possibly never-ending process (continuous iterative loop of activities: plan, act, observe and reflect) (HEINZE et al., 2016).

- **Time Consuming:** With respect to time, our theory supports that *time consuming* is one category that leads to simplicity in ASD. In this direction, Ambler (2003), also suggest Test-Driven Development (TDD) as a way to think issues through before you code - Agile Model Driven Development (AMDD). It lets the practitioner think at a higher abstraction level, saving time incrementally.

- **Product with Value:** Several studies suggest that agile projects can incorporate changes more easily and demonstrate business value more efficiently than traditional projects (DYBÅ; DINGSØYR, 2008)(DYBÅ; DINGSOYR, 2009). In addition, our theory addresses *product with value* as a consequence of overall categories that came up into our theory of simplicity, which is classified as an externally-oriented simplicity goal (see Figure 28).

6.3 Limitations, Validity and Reliability

This chapter presents the results of a qualitative study to build a theory that explains the phenomena of simplicity in ASD. In this section, the validity and reliability of our results are discussed from the perspective proposed by Merriam (2009).

Construct validity in qualitative research is related to the precise and clear-cut definition of constructs that are consistent with the meanings assigned by the research participants. Although we constantly compared and contrasted our construct definitions with the literature and applied the member checking with Brazilians participants, another round

with the preliminary subjects from Ireland, United Kingdom, and the United States of America can be conducted in the future to ensure our interpretations were consistent with those of the participants.

Internal validity, or *credibility*, is related to the extent that the results match reality. To increase credibility, we sampled skilled participants with different roles in ASD, and from various countries (Ireland, United Kingdom, Brazil and the United States of America), as described in Table 11, and illustrated in Figure 27. The preliminary results were discussed between the authors to refine the categories and the hypotheses. A limitation is that we used only interviews as data collection method.

Reliability refers to the extent that the results can be replicated. Although we do not expect all our findings to be directly applicable to other contexts, it is possible to learn from the characterisation of this study, and decide to what extent the results can be applied or transferred to different situations. We tried to provide a rich description of the research method (Section 6.1), and the results themselves (Section 6.2).

Finally, a common challenge in qualitative studies is to reach *theoretical saturation*. In this study, we interviewed 27 participants with different points of view and perceptions about the studied phenomenon. The initial cycle of this research encompassed 21 interviews with skilled participants from Ireland, United Kingdom and the United States of America to reach the theoretical saturation. Although they contributed to a rich description of the phenomenon, we conducted six additional interviews with skilled Brazilians practitioners and researchers (Final Cycle) to reach the theoretical saturation (see Figure 21 for details).

6.4 Chapter Summary

In this chapter, we presented the main results of a qualitative study focused on understanding how practitioners and researchers interpret simplicity in ASD projects and how these interpretations shape their work towards simplicity. Qualitative coding techniques (open coding, axial coding and selective coding) were employed to identify the categories that lead to simplicity in ASD. From the interpretation of data, we constructed hypotheses that describe the relationships, and also build a theory that explains the phenomena.

The substantive theory that explains the phenomena of simplicity in ASD emerged from the understanding of practitioners and researcher from Ireland, United Kingdom, Brazil and the United States of America. The theoretical model, hypotheses, limitations, validity and reliability of this theory were also discussed. Additionally, this chapter also addressed the initial practical implications surrounding the theory of simplicity in ASD.

Next chapter, summarises the conclusions of this thesis, highlights the research contributions and shared publications with the scientific community. Finally, it also synthesises the limitation of this research, and proposes the directions and challenges for future works.

7 CONCLUSION

Agile Software Development (ASD) emerged as a popular paradigm, and agile methods became the most software development in the software industry (DINGSØYR et al., 2012) (KRUCHTEN, 2013) (HAMED; ABUSHAMA, 2013). Complementary, the principle and values of the agile manifesto[1] identify the central elements of agility that should be embedded in any method claiming to be agile. Although the agile manifesto declares that simplicity is essential, several studies expose that simplicity is still insufficiently understood by practitioners and researchers (MARGARIA et al., 2011) (MEYER, 2014).

In this sense, this research aimed to understand how simplicity is perceived by the agile team members from their perspective, by interpreting their experiences regarding simplicity in their workplace. After presenting the research results throughout this thesis, we argue that an exhaustive comprehension of simplicity's phenomena could support academics and practitioners in the direction to improve the ASD. The remainder of this chapter is organised as follows. Section 7.1 summarises the main contributions and current publications. The limitations, validity, and reliability of this thesis are addressed in section 7.2. Finally, we provide some ideas on potential future work in section 7.3.

7.1 Research Contributions

As mentioned in Chapter 1, the theory proposed in this thesis contributes to the state-of-the-art of Software Engineering (SE) in three complementary ways. (i) it advances the knowledge of the topic by providing a theoretical model (Chapter 6) through which the available knowledge on this field is analysed and encompassed. (ii) it is an invitation to practitioners to do what they already do, but to do so more consciously. This consciousness can make a substantial difference in real situations. From this perspective, rethinking means committing oneself to a course of action where plausible analysis exists, to reexamine the adopted practices focused on simplicity. (iii) it suggests crucial issues, worthy of further investigation, serving, thus, as a basis to substantiate and organise future research on the topic of simplicity in Agile Software Development.

The results of this research, as well as the main contributions, are described as follows. These contributions are in line with the specifics research goal (Section 1.4). It is also in accordance with the research design, presented in Figure 6. Besides, at the end of each following contribution, their related chapter and publication are also addressed.

[1] http://agilemanifesto.org/principles.html

1. **Exploratory Knowledge:** A literature review (state-of-the-art) in different areas, as simplicity in Philosophy of Science, Information and Communications Technology (ICT), and in the context of Agile Software Development. [Chapter 3; Publication: (SANTOS et al., 2017a)].

2. **Definition of Simplicity in Agile Software Development:** An initial definition of simplicity in Agile Software Development and a conceptual model that support its definition from the agile team's perspective. [Chapter 5; Publication: (SANTOS et al., 2018)].

3. **Systematic Body of Knowledge:** A Systematic Mapping Study (SMS) of simplicity in the context of Agile Software Development. It provided a deeper knowledge and comprehensive understanding of simplicity. Besides, it was conducted in order to figure out how researcher community and practitioners have dealt with such aspects. [Chapter 4; Publications: (SANTOS et al., 2017) (MOREIRA et al., 2017b)].

4. **A Substantive Theory of Simplicity in ASD:** Emergence of the substantive theory of simplicity in the context of ASD. Its theory advances and contributed to a better understanding of simplicity in the context of ASD. [Chapter 6; Publication: (SANTOS et al., 2017b)].

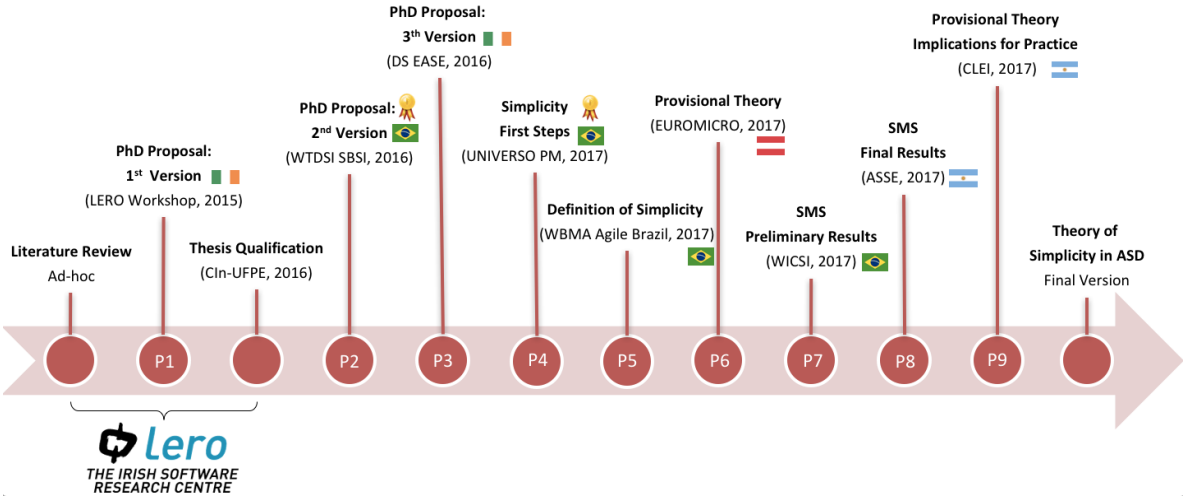

Figura 36 – Timeline: Ph.D. Milestones

Some of the results have been partially shared with the scientific community, based on the following contributions. These publications (P1 - P9) are detailed as follows, and chronologically highlighted in the Ph.D. timeline (Figure 36)

- **(P9)** Santos W. B., Cunha, A., Moura H. Margaria T. 2017 *Practical Implications from a Provisional Theory of Simplicity in Agile Software Development based on a*

Qualitative Study. Simposio Latinoamericano de Ingeniería de Software (SLISW). Conferencia Latinoamericana de Informática (CLEI 2017), Córdoba, Argentina (SANTOS et al., 2017c).

- **(P8)** Santos W. B., Moreira B. Junior I., Moura H., Margaria T. *Simplicidade no Desenvolvimento Ágil de Software: Um Mapeamento Sistemático da Literatura.* Jornadas Argentinas de Informática (JAIIO 2017). Simposio Argentino de Ingeniería de Software (ASSE 2017), Cordoba, Argentina. [In portuguese] (SANTOS et al., 2017).

- **(P7)** Moreira, B., Santos, W. B., Junior I., Moura H. Margaria T. *Simplicidade no Desenvolvimento Ágil de Software: Resultados Preliminares de um Mapeamento Sistemático da Literatura.* In XIII Brazilian Symposium on Information Systems (SBSI), 4th Workshop on Information Systems Undergraduate Research (WICSI). Lavras, MG, Brazil: Brazilian Computer Society (SBC), pp. 89–92. 2017. [In portuguese] (MOREIRA et al., 2017b).

- **(P6)** Santos W. B., Cunha, A., Moura H. Margaria T. 2017 *Towards a Theory of Simplicity in Agile Software Development: A Qualitative Study* 43rd Euromicro Conference on Software Engineering and Advanced Applications (EUROMICRO 2017). Vienna, Austria (SANTOS et al., 2017b).

- **(P5)** Santos W. B., Cunha, A., Moura H. Margaria T. 2017 *Towards a Definition of Simplicity in Agile Software Development: A Focus Group Study.* In: Santos, V.; Pinto, G; Neto, A (Editors). *Agile Methods.* (ISBN: 978-3-319-73672-3). Heidelberg, Germany: Springer International Publishing, 2018, v. 802, p. 3-17. (SANTOS et al., 2018).

- **(P4)** [Best paper award] Santos, W., Simões, R and Araújo, A., Moura, H. *Primeiros Passos Rumo ao Sucesso em Projetos Ágeis Utilizando Princípios de Simplicidade.* Universo PM: Revista de Gerenciamento de Projetos. September, 2017. p. 21 - 28. [In portuguese] (SANTOS et al., 2017a).

- **(P3)** Santos W. *Towards a Better Understanding of Simplicity in Agile Software Development Projects.* Doctoral Symposium - 20th International Conference on Evaluation and Assessment in Software Engineering (EASE 2016) (SANTOS, 2016).

- **(P2)** [Best paper award] Santos, W.; Moura, H.. *Towards an Approach to Foster Simplicity in Agile Software Development Projects.* The Workshop on Information Systems Ph.D. and Master's Thesis (WTDSI 2016) - Brazilian Symposium on Information Systems (SBSI 2016) (SANTOS; PERRELLI, 2016).

- **(P1)** Santos, W.; Moura, H.; Margaria, T. *CLIMATE: an approaCh to evaLuate sIMplicity in Agile sofTware dEvelopment.* Lero (the Irish Software Research Centre) Workshop - Poster Session (2015). Athlon, Ireland.

Other co-related work to this thesis were published:

- Santos, W. B.; Arteiro, I. C. J. B. ; Silva, L. *O Projeto como um processo de mudança.* In: Valença, A., Moura. H. (Org.). *Teoria de Ação Comunicativa Sistêmica em Gestão de Projetos: Sete leituras complementares de um mesmo projeto* (ISBN: 978-84-415-0504-8). 1ed.Recife: Editora Universitária da UFPE - EDUFPE, 2014, v. 1, p. 506-523. [In portuguese] (SANTOS; ARTEIRO; SILVA, 2014).
- Timoteo, A.; Arteiro, I.; Santos, W. B. ; PEDROSA, P. T. B. . *Pesquisas Futuras em Gerenciamento de Projetos - Predições, Desafios e Potencialidades Futuras.* In: Valença, A., Moura. H. (Org.). *Teoria de Ação Comunicativa em Projetos - Experimentos de Aprendizagem-Na-Ação Numa Comunidade Reflexiva De Prática* (ISBN: 978-85-415-0138-5). 1ed.Recife: Editora Universitária da UFPE - EDUFPE, 2013, v. 1, p. 251-267. [In portuguese] (TIMOTEO; ARTEIRO; SANTOS, 2013).

Lastly, as a researcher, this research contributed to my academic maturity. It permitted extensive academic opportunities, regarding subject knowledge deepening, networking, and collaborations. In particular, the experience as an intern, during the sandwich Ph.D. in the research group at the Department of Computer Science & Information Systems (CSIS) of the University of Limerick (UL) and in collaboration with Lero - the Irish Software Research Centre. The internship promoted the opportunity to develop contacts with the rich Lero research environment, with researchers from other Irish universities like National University of Ireland (NUI) in Galway, and with global and national industrial partners. Besides, the participation in international academic workshops, seminars, and conferences allowed the possibility of interaction and feedback from both, scientific and professional community.

7.2 Limitations

In this section, we summarise the limitations and potential weakness of this thesis. Each contribution of this research has their specific limitations, validity and reliability of our results from the perspective proposed by Merriam (2009), as follows:

- Chapter 5, Section 5.4 discusses the limitations regarding the proposed definition of simplicity and focus group session.
- Chapter 4, Section 4.4 addresses the limitations regarding the Systematic Mapping Study (SMS).

- Chapter 6, Section 6.3 argues the limitations, validity and reliability, about the substantive theory that explains the phenomena of simplicity in ASD, and its methodological framework.

Next section addresses potentially future works for some of those limitations.

7.3 Future Work

Finally, considering other themes borderline discussed in this work, many opportunities for the continuity of the developed studies can be identified. Some investigation points and recommendation for future research are described in the following items:

- **Further Implications for Agile Practices:** Our preliminary results (SANTOS et al., 2017c) shedded light on the relative importance of various agile practices (chapter 6, Section 6.2.5). However, we strongly recommend future research to develop more systematic investigations addressing further implications for practices. It may be useful and helpful to determine the situations (scenarios) in which agile practices on ASD lead to simplicity, and can be suitably applied in their projects.
- **Extension of the Systematic Mapping Study:** Conduction of a Systematic Mapping Study extension, to get a better understanding of the landscape of the current scientific work reporting simplicity in ASD, extending evidence concerning the topic of study throughout the year 2017. We suggest the extension of our preliminary results (SANTOS et al., 2017) (MOREIRA et al., 2017b), which covered the years between 2001 - 2016 (Chapter 4).
- **Refining the Definition of Simplicity (Focus Group):** Our results (SANTOS et al., 2018) addressed an initial definition of simplicity in ASD, and a conceptual model that support its definition from the agile team's perspective (Chapter 5), which were then triangulated with Brazilian experts (practitioners and researchers) through a focus group. As future work, we recommend the refinement of the definition, and conceptual model through another focus group session with non-Brazilian's experts to capture their perspectives.
- **Action Research Study (Academia and Industry Collaboration):** We urge companies to participate in research projects that target goals relevant regarding simplicity in their agile software projects. Action research is a reflective process of progressive problem solving led by individuals working with professionals to improve the way they address issues and solve problems, while simultaneously contributing

to new theoretical knowledge (BADREDDIN, 2013). It would be one way to organise further collaboration between industry and researchers that would be highly pertinent to the topic of simplicity in ASD.

- **Replication in Other Context:** Replication of empirical studies is regarded as an essential activity in the construction of knowledge in any empirical science (SILVA et al., 2012). According to Lindsay e Ehrenberg (1993), replication is needed not merely to validate one's findings, but more importantly, to establish the increasing range of radically different conditions under which the findings hold, and the predictable exceptions. Consequently, replicating this research with other practitioners and researchers from different countries, besides those countries (Ireland, United Kingdom, United States and Brazil) previously mentioned in Chapter 6. It may advance and contribute to constructing a more grand theory.

7.4 Final Words

The empirical analysis resulted from this PhD research reveals the importance of thinking about simplicity in ASD as a mindset. In this regard, the practitioners that desire to achieve simplicity in a thoughtful way can be benefited to do what they already do, but doing it more consciously. From this perspective, this consciousness can influence the actions and the eventual results that might be achieved in their agile projects.

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APPENDIX A – FOCUS GROUP: CONSENT FORM

This appendix provides evidence that the interviewee gives consent to take part in the current focus group session.

UNIVERSIDADE FEDERAL DE PERNAMBUCO

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

CONSENT FORM

I, the undersigned, declare that I am willing to take part in research for the project entitled "Simplicity in Agile Software Development"

- I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.
- I declare that I am between 18 and 65 years old.
- The nature of my participation has been explained to me and I have full knowledge of how the information collected will be used.
- I am also aware that my participation in this study will be recorded (audio).
- However, should I feel uncomfortable at any time I can withdraw my participation without having to explain or give a reason. I am entitled to copies of all recordings made and am fully informed as to what will happen to these recordings once the study is completed.
- I fully understand that there is no obligation on me to participate in this study.
- I fully understand that I am free to withdraw my participation at any time without having to explain or give a reason.
- I am also entitled to full confidentiality in terms of my participation and personal details.

_____ _____

Participant's signature Date

APPENDIX B – FOCUS GROUP: INFORMATION SHEET

This appendix gives potential participants the necessary understanding of the motivation and procedures of this focus group session. It also enables any further questions, to interviewee provides the informed consent.

UNIVERSIDADE FEDERAL DE PERNAMBUCO

UNIVERSITY of LIMERICK
OLLSCOIL LUIMNIGH

INFORMATION SHEET

My name is Wylliams Santos and I am a PhD Student at the Federal University of Pernambuco (UFPE) under the supervision of Professor Hermano Moura. The title of our research project is "Simplicity in Agile Software Development (ASD)".

The purpose of the study is to obtain an in-depth feedback on the proposed definition of simplicity, generating ideas, collecting, prioritising potential problems, discovering underlying ground and motivations by means of an focus group. This focus group takes, approximately, 120 minutes to be completed and will be audio-recorded to facilitate analysis.

In fact, this study is part of a wider research conducted by the Informatics Centre (CIn) at Federal University of Pernambuco (UFPE) in partnership with Lero – The Irish Software Research Centre at University of Limerick (UL).

Only the named investigators will have access to the verbatim data collected by this instrument. The study outcome shall be presented as a summary of gathered anonymized data, but no personally identifying information shall be reported. If you feel uncomfortable at any time, you can withdraw your participation without having to explain or give a reason.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study, being a representative agent of the phenomena, and possessing the expertise that is relevant to this study.

If you have further questions regarding this research please feel free to get in touch with either myself or my supervisors using the email addresses listed below.

If you have concerns about this study and wish to contact someone independent, you may contact the Secretary of the Board of Research (SEC-DPQ) in the UFPE Office for Research Affairs and Graduate Studies (PROPESQ) at +55 (81) 2126 7041 or dpq.propesq@ufpe.br.

Yours sincerely,

Wylliams Santos
wbs@cin.ufpe.br

Professor Hermano Moura
hermano@cin.ufpe.br

Professor Tiziana Margaria
tiziana.margaria@lero.ie

APPENDIX C – FOCUS GROUP: INITIAL CONTACT

Subject: Invitation to Focus Group: Simplicity in Agile (CIn-UFPE and Lero-UL)

Dear [name],

We hope this email finds you well.

The Project Research Group (GP2) in the Informatics Centre (CIn) Federal University of Pernambuco (UFPE) in partnership with the Lero (the Irish Software Research Centre) at University of Limerick are conducting a research in order to discuss and get a better understanding of some relevant aspects related to simplicity management in the context of Agile Software Development, by means of a focus group session.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study, being a representative agent of the phenomena, and possessing the expertise that is relevant to this study.

Please, if possible, let me know which time and location works best for you to take part in the interview. This interview takes approximately 45 minutes to be completed.

If you have further questions regarding this research please feel free to get in touch.

I am looking forward to meeting you.

Best regards,

Wylliams Barbosa Santos

Doctoral Researcher, Project Research Group (GP2)
Federal University of Pernambuco (UFPE), Brazil

Visiting Doctoral Researcher, Lero, the Irish Software Research Centre
University of Limerick, Ireland

APPENDIX D – THEORY: UL RESEARCH ETHICS COMMITEE

This appendix provides the form applied to the Faculty of Science and Engineering Research Ethics Committee Board. It provides the ethical issues and further details about the research project and investigators.

Faculty of Science and Engineering Ethics Committee
Expedited Form for
research involving human participants

1: Applicants Details **Form Must Be Typed**

Principal Investigator name (ie supervisor): Professor Tiziana Margaria Principal Investigator email: tiziana.margaria@lero.ie
Student name: Wylliams Barbosa Santos
ID number: 15817326
Email address: wylliamsbarbosa.santos@lero.ie
Programme of study: Science without Borders - Visitor PhD Student (Sandwich)
FYP, MSc or PhD Dissertation: PhD
Working title of study: An Approach to Evaluate Simplicity in Agile Software Development (ASD)
Date of Approval: 20st November 2015 **End date**: 30th October 2016

2. Human Participants

Does the research proposal involve:

- Working with participants over 65 years of age? No
- Any person under the age of 18? No
- Adult patients? No
- Adults with psychological impairments? No
- Adults with learning difficulties? No
- Relatives of ill people (e.g. parents of sick children) No
- Adults under the protection/control/influence of others (e.g. in care/prison)? No
- People who may only have a basic knowledge of English? No
- Hospital or GP patients (or HSE members of staff) recruited in medical facility No

3. Subject Matter

Does the research proposal involve:

- Sensitive personal issues? (e.g. suicide, bereavement, gender identity, sexuality, fertility, abortion, gambling)? No
- Illegal activities, illicit drug taking, substance abuse or the self reporting of criminal behaviour? No
- Any act that might diminish self-respect or cause shame, embarrassment or regret? No
- Research into politically and/or racially/ethnically and/or commercially sensitive areas? No

4. Procedures

Does the research proposal involve:

- Use of personal records without consent? No
- Deception of participants? No
- The offer of large inducements to participate? No
- Audio or visual recording without consent? No
- Invasive physical interventions or treatments? No
- Research that might put researchers or participants at risk? No
- Storage of results data for less than 7 years? No

If you have answered **Yes** to any of these questions in sections 2 to 4 above, you will need to fill in the S&E full application form and submit to the Faculty Ethics Committee for review. However, if the research is to be conducted **during or after/associated with School Placement**, and within the Department of Education subject syllabus outline, and provided the student has the permission of the class teacher and the school principal and that parent/guardians consent to participation, this expedited form can also be used. Please note that if the Faculty Ethics Committee deems it necessary you may be asked to fill in the full application form.

Please note that only **1** hard copy of the FREC form is required for the Faculty Ethics Committee. You can get more information and download the forms needed at this address: www.ul.ie/researchethics/ **NB:** If you answered **Yes** to the last bullet point in section 2 then you will need to apply to the local HSE ethics committee not the FREC.

If you have answered **No** to all of these questions, please answer the following questions in sections 5.

---

5 Research Project Information

5a Give a brief description of the research.

The purpose of the study in the development of software systems is to discuss some relevant aspects related to simplicity management phenomena, by means of a survey (semi-structured interview and questionnaire). This interview will be audio-recorded to facilitate analysis. We are specifically interested in understanding the factors that influence the simplicity dimension in agile methods. Our intention is to use the knowledge gained during this study to develop a systematic evaluation approach that can be used by the industry in order to measure the level of simplicity of their way to implement agile software development and use these insights to guide how to improve the performance of the organizations and its projects.

In fact, this study is part of a wider research conducted by the Lero – The Irish Software Research Centre at University of Limerick (UL) in partnership with the The Project Research Group (GP2) in the Informatics Centre (CIn) at Federal University of Pernambuco (UFPE).

5b How many participants will be involved?

Semi-structured interview (40 individuals); Questionnaire (400 individuals);

5c How do you plan to gain access to /contact/approach potential participants?

Approach companies that are partners of Lero, such as Nexus and others that are in the National Technological Park (NTP) and through the networks Limerick IT and startup Ireland as well as are individuals attending the workshops, seminars and industrial days promoted by University of Limerick and Lero, apart from the other events during the term 2015/2016.

5d What are the criteria for including/excluding individuals from the study?

Including criteria: Industry and/or Academic professional who satisfy the requirements listed in Section 2 and are involved in agile projects and are representative agents of the phenomena in the study.

Excluding criteria: Participants who do satisfy any of the requirements listed in Section 2, who do not speak English and who experience in agile development is restricted to short-term (less than 6 months) projects and thus are not likely to be representative agents of the phenomena in the study.

5e Have arrangements been made to accommodate individuals who do not wish to participate in the research? (NB This mainly relates to research taking place in a classroom setting)

N/A

5f Can you identify any particular vulnerability of your participants other than those mentioned in section 2?

N/A

5g Where will the study take place?

At the offices of the Department of Computer Science & Information Systems (CSIS) located on campus at Lero (Tierney Building) and / or at private office located at company premises, or at other suitable locations providing privacy and convenience.

5h What arrangements have you made for anonymity and confidentiality?

Only the named investigators will have access to the verbatim data collected by this instrument. Identifying participant information will be stored separatedly from the survey instrument data so that the participant data is private. The study outcome shall be presented as a summary of anonymized gathered data; no personally identifying information shall be reported. Audio data shall be transcribed using a professional transcription service or by the investigators. Only the named investigators shall have access to the interview transcripts.

5i What are the safety issues (if any) arising from this study, and how will you deal with them?

N/A

5j How do you propose to store the information once the project is completed? Will the file/computer be password protected?

The audio data, transcriptions and fields notes will be securely stored on a password-protected computer with the data stored in encrypted files. In particular, the audio data will be destroyed immediately after they have been transcribed.

Where will the information be stored (room number):

The transcriptions, fields notes and information will be used for the emergence of the proposed approach to evaluate simplicity in agile projects. For the duration of the project the preliminary data set will be stored in Tierney Building at the Lero offices (Room T3-028).

5k Insurance Cover

Insurance cover is required for all research carried out by UL employees. Principal Investigators/Supervisors should carefully view the University's 'Guidelines on Insurance Cover for Research' document and the University's Insurance cover to ascertain if their proposed research is covered. These documents are available at www.ul.ie/insurance.

Where any query arises about whether or not proposed research is covered by insurance, the Principal Investigator/Supervisor must contact the University's Insurance Administrator at cliona.donnellan@ul.ie to confirm that the required level of insurance cover is in place.

Please indicate by way of signature that the research project is covered by UL's insurance policies:

PI/Supervisor signature: T. Noonan

5l Please attach the relevant information documents and complete the following checklist to indicate which documents are included with application

Participant Information Sheet	Yes
Participant Informed Consent Form	Yes
Parent/Guardian Information Sheet	No
Parent/Guardian Informed Consent Form	No
School Principal Information Sheet	No
School Principal Informed Consent Form	No
Teacher Information Sheet	No
Teacher Consent Form	No
Child Protection Form	No
Questionnaire & Explanatory Cover Letter	No
Interview/Survey Questions	Yes
Recruitment letters/Advertisements/Emails, etc.	No

6. Declaration

The information in this form is accurate to the best of my knowledge and belief and I take full responsibility for it.

I undertake to abide by the guidelines outlined in the UL Research Ethics Committee guidelines http://www.ul.ie/researchethics/

I undertake to inform S&EEC of any changes to the study from those detailed in this application.

Student:	**Name:** Wylliams Barbosa Santos **Signature:** Wylliams B. Santos	**Date:** 3/11/2015
Principal Investigator*:	**Name:** Professor Tiziana Margaria **Signature:** T. Margaria	**Date:** 3/11/2015

* In the case where the principal investigator is not a permanent employee of the University, the relevant head of department must sign this declaration in their place.

You should return this form with signatures to the S&E Ethics Committee c/o Faculty Office, Faculty of Science & Engineering, University of Limerick. In addition, a single pdf file containing the completed form and additional information (e.g. participant information sheet) should be emailed to SciEngEthics@ul.ie **This form must be submitted and approval granted before the study begins.**

APPENDIX E – THEORY: APPROVAL NOTIFICATION

This appendix provides the ethical approval from the the Faculty of Science and Engineering Research Ethics Committee Board.

UNIVERSITY of LIMERICK
OLLSCOIL LUIMNIGH

OLLSCOIL LUIMNIGH
UNIVERSITY OF LIMERICK

30th November 2015

Prof Tiziana Margaria
Head
Department of Computer Science & Information Systems
University of Limerick

Re: 2015_11_01_S&E An Approach to Evaluate Simplicity in Agile Software Development (ASD)

Dear Tiziana,

The Faculty of Science & Engineering Research Ethics Committee has reviewed and approved the above application for the period from 23rd November 2015 to 31 October 2016.

Yours sincerely

Thomas Waldmann

Dr. Thomas Waldmann FIES AFPsSI
Chair, Science and Engineering Ethics Committee

c.c. Wylliams Barbosa Santos

APPENDIX F – THEORY: PROTOCOL INTERVIEW - INITIAL CYCLE

This appendix provides the initial protocol interview (Initial Cycle). It outlines the demographic information about the respondents and their organisation, besides information about simplicity.

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

PROTOCOL INTERVIEW

Respondent's Demographic Profile

D1. How many years of professional **work experience** related to using agile development methods in IT projects do you have?

- ❍ Up to 1 year
- ❍ 1 to 5 years
- ❍ 6 to 10 years
- ❍ 11 to 15 years
- ❍ 16 to 20 years
- ❍ More than 20 years

D2. What is your level of **education** (completed)?

- ❍ Undergraduate
- ❍ Masters
- ❍ PhD

D3. What are your current **areas of action**?

- ☐ Business owner
- ☐ CEO/CIO
- ☐ Executive/Manager
- ☐ Consultant
- ☐ Researcher
- ☐ IT Professional
- ☐ Agent of the Public Administration
- ☐ Other: _____

D4. What is your current **job position**?

- ☐ Project Management
- ☐ Software Engineer
- ☐ System Analyst
- ☐ Designer
- ☐ Researcher
- ☐ Other: _____

D5. Who are the **customers** for your current (or most recent) project where you used agile methods?

- ☐ IT
- ☐ No IT
- ☐ End customers
- ☐ Other _____

D6. How many years of **project management** experience do you have?

- ❍ None
- ❍ Up to 1 year
- ❍ 1 to 5 years
- ❍ 6 to 10 years
- ❍ 11 to 15 years
- ❍ 16 to 20 years
- ❍ More than 20 years

D7. How many years have you participated in or were involved in initiatives using **agile methods**?

- ❍ Up to 1 year
- ❍ 1 to 5 years
- ❍ 6 to 10 years
- ❍ 11 to 15 years
- ❍ 16 to 20 years
- ❍ More than 20 years

Organizational Demography Profile

D8. In which of the following groups would the **organization** in which you work (or worked recently) be best classified?

- ❍ For-profit organization
- ❍ Non-profit organization
- ❍ Government
- ❍ Academia

D9. How would you rank the **size of the company** where you work? Use the table from the EU recommendation 2003/361[1] as reference:

- ❍ Micro
- ❍ Small
- ❍ Medium
- ❍ Large

Size of Organization	Employees		Annual Turnover (Million €)		Annual Balance Sheet (Million €)
Micro	<10	and	≤ 2	or	≤ 2
Small	<50		≤ 10		≤ 10
Medium	<250		≤ 50		≤ 43
Large	>250		> 50		> 43

D10. Please indicate the **type of organization** in which you most recently worked.

- ❍ Software Engineering
- ❍ Manufacturing
- ❍ Business administration
- ❍ Public administration
- ❍ Services
- ❍ Other: _____

D11. Please indicate the **industry sector** (economy sector) of your current organization?

- ☐ Information and communication
- ☐ Professional, scientific and technical activities
- ☐ Education
- ☐ Agriculture, forestry and fishing
- ☐ Manufacturing
- ☐ Electricity, gas, steam and air conditioning supply
- ☐ Water supply; sewerage, waste management and remediation activities
- ☐ Construction
- ☐ Wholesale and retail trade; repair of motor vehicles and motorcycles
- ☐ Transportation and storage
- ☐ Accommodation and food service activities
- ☐ Financial and insurance activities
- ☐ Real estate activities
- ☐ Administrative and support service activities
- ☐ Public administration and defense; compulsory social security
- ☐ Human health and social work activities
- ☐ Arts, entertainment and recreation
- ☐ Other service activities

D12. Please indicate the **geographic scope** for the operation of the organization where you currently worked (or most recently).

- ❍ Local
- ❍ Regional
- ❍ National
- ❍ Multinational (present in up to 5 countries)
- ❍ Global (present in more than 5 countries)

[1] Official Journal of the European Union, L 124, 20 May 2003 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003H0361&from=EN

Simplicity and Agile Projects

Q1. What do you understand by **simplicity**?

Q2. What do you understand by **simplicity** in **agile projects**?

Q3. According to your professional experience, could you give some **examples** of **simplicity** in **agile projects**?

Q4. The agile manifesto[2] defines the **principle of simplicity**, as "*Simplicity – the art of maximizing the amount of work not done – is essential*". Do you agree with the principle of simplicity? Please explain.

- ❍ Yes, because _____
- ❍ No, because _____

Simplicity Evaluation

Q5. What do you understand by **simplicity evaluation** in **agile projects**?

Q6. In the context of your **agile projects**, do you use some **metric** or **measures** related to simplicity?

❍ Yes ❍ No

Q7. Please name and describe 3 **metrics** or **measures** you would suggest to evaluate simplify in **agile software development**.

Q8. Does your organization practice systematic **simplicity management** in **agile software projects**? Please explain. _____

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

Q9. Does your organization adopt practices for handling **simplicity evaluation** in **agile software projects**? Please explain. _____

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

Q10. Does your organization have an interest in **adopting** an approach to handle **simplicity evaluation**? Please explain. _____

Not all Interested	Slightly Interested	Moderately Interested	Very Interested	Extremely Interested
❍	❍	❍	❍	❍

Q11. Do you agree with the development of an **approach**, in order to **evaluate the level of simplicity** in **agile projects**? Please explain. _____

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
❍	❍	❍	❍	❍

[2] http://agilemanifesto.org/principles.html

Key Dimensions of Simplicity

Q12. The existing literature presents high-level **dimensions of simplicity**[3][4][5]. In your experience, how important are these dimensions for **agile software development**? Please indicate an example of a **practical application** in your everyday context of **agile projects** for each dimension.

	Very Unimportant	Unimportant	Neutral	Important	Very Important
Knowledge (Learn) *"Knowledge makes everything simpler"*	❍	❍	❍	❍	❍
Structure (Organization) *"Organization makes a system of many appear fewer"*	❍	❍	❍	❍	❍
Structure (Decomposition and Modularization) *"certain components of the system must be decomposed", "separation of concerns in layering"*	❍	❍	❍	❍	❍
Structure (*Reduction and Size)* *"The simplest way to achieve simplicity is through thoughtful reduction", "Simplicity is related to size"*	❍	❍	❍	❍	❍
Structure (Time) *"Savings in time feel like simplicity"*	❍	❍	❍	❍	❍
Orthogonality *"Putting components together can result in unexpected (and unwanted) system behaviours", "Systems where the components are orthogonal are viewed as simpler (and more desirable) IT systems ", "Integration of systems from different areas."*	❍	❍	❍	❍	❍
Emotion *"More emotion are better than less", "When emotions are considered, don't be afraid to add more layers of meaning."*	❍	❍	❍	❍	❍
Transparency *"One thing that is important is transparency and being explicit about assumptions, basically having all facts on the table."*	❍	❍	❍	❍	❍
Predictability *"Systems where the components are predictable are viewed as simpler (and more desirable) IT systems ", "Simplicity means: No surprises."*	❍	❍	❍	❍	❍
Communication *"proactive communication"*	❍	❍	❍	❍	❍
Automation *"If one can have a working system where the user consistently has to do less, then the system is easier to use. "*	❍	❍	❍	❍	❍
Abstraction *"Abstraction focusing on a right set of concepts and relationships, one can highlight the essence of the problem that needs to be addressed."*	❍	❍	❍	❍	❍
Context *"simplicity as a matter of subjective and context-dependent perception"*	❍	❍	❍	❍	❍
Felt complexity *"What lies in the periphery of simplicity is definitely not peripheral"*	❍	❍	❍	❍	❍

[3] Floyd, B. D., & Bosselmann, S. (2013). ITSy - Simplicity Research in Information and Communication Technology. Computer, 46(11), 26–32.

[4] Maeda, J. (2006). The Laws of Simplicity.

[5] Margaria, T. (2011). *ITSy - Recommendation Document*. Postdam. Retrieved from https://www.cs.uni-potsdam.de/gsse/ITSy/files/ITSy_final_report.pdf

Critical Success Factors

Q13. Please indicate which **Key dimension of Simplicity**[6][7][8] you think that each **Critical Success Factor**[9]. is related to. (Possible to give more than one key dimension for each Critical Success Factor)

	Delivery Strategy *"continuous delivery of valuable, working software in short time scales"*	**Agile Software Engineering Techniques** *"continuous attention to technical excellence and simple design"*	**Team Capability** *"namely building projects around motivated individuals"*	**Project Management Process** *"face-to-face conversation within a team, and sustaining a constant pace"*	**Team Environment** *"self-organizing team"*	**Customer Involvement** *"satisfying the customer, and business people working closely with developers"*
Knowledge (Learn)	☐	☐	☐	☐	☐	☐
Structure (Organization)	☐	☐	☐	☐	☐	☐
Structure (Decomposition and Modularization)	☐	☐	☐	☐	☐	☐
Structure (Reduction and Size)	☐	☐	☐	☐	☐	☐
Structure (Time)	☐	☐	☐	☐	☐	☐
Orthogonality	☐	☐	☐	☐	☐	☐
Emotion	☐	☐	☐	☐	☐	☐
Transparency	☐	☐	☐	☐	☐	☐
Predictability	☐	☐	☐	☐	☐	☐
Communication	☐	☐	☐	☐	☐	☐
Automation	☐	☐	☐	☐	☐	☐
Abstraction	☐	☐	☐	☐	☐	☐
Context	☐	☐	☐	☐	☐	☐
Felt Complexity	☐	☐	☐	☐	☐	☐

[6] Floyd, B. D., & Bosselmann, S. (2013). ITSy - Simplicity Research in Information and Communication Technology. Computer, 46(11), 26–32.

[7] Maeda, J. (2006). The Laws of Simplicity.

[8] Margaria, T. (2011). *ITSy - Recommendation Document*. Postdam. Retrieved from https://www.cs.uni-potsdam.de/gsse/ITSy/files/ITSy_final_report.pdf

[9] Chow, T., Cao, D. (2008). A survey study of critical success factors in agile software projects. *Journal of Systems and Software*, *81*(6), 961–971.

Q14. Literature[10] identifies the following **Critical Success Factors (CSF)** of agile software projects. Please, indicate to which extent you think they are indeed **critical**.

	Not at all Critical	Somewhat Critical	Critical	Very Critical	Extremely Critical
Delivery Strategy *"continuous delivery of valuable, working software in short time scales"*	❍	❍	❍	❍	❍
Agile Software Engineering Techniques *"continuous attention to technical excellence and simple design"*	❍	❍	❍	❍	❍
Team Capability *"namely building projects around motivated individuals"*	❍	❍	❍	❍	❍
Project Management Process *"face-to-face conversation within a team, and sustaining a constant pace"*	❍	❍	❍	❍	❍
Team Environment *"self-organizing team"*	❍	❍	❍	❍	❍
Customer Involvement *"satisfying the customer, and business people working closely with developers"*	❍	❍	❍	❍	❍

Q15. Which other **Success Factors** do you believe are **critical** for **agile projects**?

[10] Chow, T., Cao, D. (2008). A survey study of critical success factors in agile software projects. *Journal of Systems and Software*, *81*(6), 961–971.

APPENDIX G – THEORY: CONCENT FORM - INITIAL CYCLE

This appendix provides evidence that the interviewee gives consent to take part in the current research (Initial Cycle).

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

CONSENT FORM

I, the undersigned, declare that I am willing to take part in research for the project entitled "An Approach to Evaluate Simplicity in Agile Software Development (ASD)"

- I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.
- I declare that I am between 18 and 65 years old.
- The nature of my participation has been explained to me and I have full knowledge of how the information collected will be used.
- I am also aware that my participation in this study will be recorded (audio).
- However, should I feel uncomfortable at any time I can withdraw my participation without having to explain or give a reason. I am entitled to copies of all recordings made and am fully informed as to what will happen to these recordings once the study is completed.
- I fully understand that there is no obligation on me to participate in this study.
- I fully understand that I am free to withdraw my participation at any time without having to explain or give a reason.
- I am also entitled to full confidentiality in terms of my participation and personal details.

_____ _____

Participant's signature Date

APPENDIX H – THEORY: INFORMATION SHEET

This appendix gives potential participants the necessary understanding of the motivation and procedures of this study (Initial Cycle). It also enables the possibility of any further questions, before the informed consent being provided by the interviewee.

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

INFORMATION SHEET

My name is Wylliams Barbosa Santos and I am currently a visitor PhD Student at the University of Limerick under the supervision of Professor Tiziana Margaria and regular PhD student at the Federal University of Pernambuco (UFPE) under the supervision of Professor Hermano Perrelli de Moura. The title of our research project is "An Approach to Evaluate Simplicity in Agile Software Development (ASD)".

The purpose of the study in the software development projects is to discuss some relevant aspects related to simplicity management phenomena, by means of a semi-structured interview. This interview takes, approximately, 60 minutes to be completed and will be audio-recorded to facilitate analysis. We are specifically interested in understanding the factors that influence the simplicity dimension in agile methods. Our intent is to use the knowledge gained during this study to develop a systematic approach that can be used by the industry in order to measure the level of simplicity of their way to implement agile software development and use these insights to guide how to improve the performance of the organizations and its projects.

In fact, this study is part of a wider research conducted by the Lero – The Irish Software Research Centre at University of Limerick (UL) in partnership with the Project Research Group (GP2) in the Informatics Centre (CIn) at Federal University of Pernambuco (UFPE).

Only the named investigators will have access to the verbatim data collected by this instrument. The study outcome shall be presented as a summary of gathered anonymized data, but no personally identifying information shall be reported. If you feel uncomfortable at any time, you can withdraw your participation without having to explain or give a reason.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study, being a representative agent of the phenomena, and possessing the expertise that is relevant to this study.

If you have further questions regarding this research please feel free to get in touch with either myself or my supervisor using the email addresses listed below.

If you have concerns about this study and wish to contact someone independent, you may contact: The Chair, Faculty of Science & Engineering Research Ethics Committee, University of Limerick, Limerick. Tel: 061 202802

Yours sincerely,

Wylliams Barbosa Santos
wylliamsbarbosa.santos@lero.ie

Professor Tiziana Margaria
tiziana.margaria@lero.ie
Tel: +353 83 61213072

APPENDIX I – THEORY: CONSENT FORM - FINAL CYCLE

This appendix provides evidence that the interviewee gives consent to take part in the current research (Final Cycle).

CONSENT FORM

I, the undersigned, declare that I am willing to take part in research for the project entitled "A Substantive Theory of Simplicity in Agile Software Development"

- I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.
- I declare that I am between 18 and 65 years old.
- The nature of my participation has been explained to me and I have full knowledge of how the information collected will be used.
- I am also aware that my participation in this study will be recorded (audio).
- However, should I feel uncomfortable at any time I can withdraw my participation without having to explain or give a reason. I am entitled to copies of all recordings made and am fully informed as to what will happen to these recordings once the study is completed.
- I fully understand that there is no obligation on me to participate in this study.
- I fully understand that I am free to withdraw my participation at any time without having to explain or give a reason.
- I am also entitled to full confidentiality in terms of my participation and personal details.

_____ _____

Participant's signature Date

APPENDIX J – THEORY: INFORMATION SHEET - FINAL CYCLE

This appendix gives potential participants the necessary understanding of the motivation and procedures of this study (Final Cycle). It also enables the possibility of any further questions, before the informed consent being provided by the interviewee.

INFORMATION SHEET

My name is Wylliams Santos and I am currently a PhD Student at the Federal University of Pernambuco (UFPE) under the supervision of Professor Hermano Moura. The title of our research project is "A Substantive Theory of Simplicity in Agile Software Development".

The purpose of the study is to discuss some relevant aspects related to simplicity management phenomena, by means of a semi-structured interview. This interview takes, approximately, 60 minutes to be completed and will be audio-recorded to facilitate analysis. We are specifically interested in understanding the factors that influence the simplicity in agile software development. Our intent is to use the knowledge gained during this study to develop a theory that can explain the phenomena of simplicity in agile software development. This theory can be used by the researchers or industry in order to improve the performance of the organisations and its projects.

In fact, this study is part of a wider research conducted by the Project Research Group (GP2) in the Informatics Centre (CIn) at Federal University of Pernambuco (UFPE) in partnership with the Lero – The Irish Software Research Centre at University of Limerick (UL).

Only the named investigators will have access to the verbatim data collected by this instrument. The study outcome shall be presented as a summary of gathered anonymised data, but no personally identifying information shall be reported. If you feel uncomfortable at any time, you can withdraw your participation without having to explain or give a reason.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study, being a representative agent of the phenomena, and possessing the expertise that is relevant to this study.

If you have further questions regarding this research please feel free to get in touch with either myself or my supervisor using the email addresses listed below.

If you have any concerns about your treatment or rights as a research subject, you may contact the Secretary of the Board of Research (SEC-DPQ) in the UFPE Office for Research Affairs and Graduate Studies (PROPESQ) at +55 (81) 2126 7041 or dpq.propesq@ufpe.br.

Yours sincerely,

Wylliams Santos
wbs@cin.ufpe.br

Professor Hermano Moura
hermano@cin.ufpe.br
Tel: +55 (81) 2126 8430

APPENDIX K – THEORY: PROTOCOL INTERVIERW

This appendix provides the initial protocol interview (Final Cycle). It outlines the demographic information about the respondents and their organisation, besides information about simplicity.

PROTOCOL INTERVIEW

Simplicity in Agile Software Development

Q1. What do you understand by simplicity in Agile Software Development?

Q2. The agile manifesto defines the principle of simplicity, as "Simplicity – the art of maximising the amount of work not done – is essential". Do you agree with the principle of simplicity? Please explain.

Categories of Simplicity

The existing literature presents high-level categories of simplicity in agile software development. In your experience, how important are these categories as aspect that lead to simplicity in the context of agile software development? Please indicate some examples.

Q3. How does **effective communication** influence on simplicity in Agile Software Development?

Q4. How does **knowledge acquisition** influence on simplicity in Agile Software Development?

Q5. How does the focus on **product with value** influence on simplicity in Agile Software Development?

Q6. How does **reduction** influence on simplicity in Agile Software Development?

Q7. How does **time-consuming** influence on simplicity in Agile Software Development?

Q8. How does **automation** influence on simplicity in Agile Software Development?

Q9. How does **decomposition** influence on simplicity in Agile Software Development?

Q10. How does **transparency** influence on simplicity in Agile Software Development?

Q11. How does **light-weight process** influence on simplicity in Agile Software Development?

Q12. Which other **categories** do you believe that lead to simplicity in the context of agile software development?

Respondent's Demographic Profile

D1. What is your level of **education** (completed)?

- ❍ Undergraduate
- ❍ Graduated
- ❍ MBA
- ❍ Masters
- ❍ PhD

D2. What are your current **areas of action**?

- ☐ Business owner
- ☐ CEO/CIO
- ☐ Executive/Manager
- ☐ Consultant
- ☐ Researcher
- ☐ IT Professional
- ☐ Agent of the Public Administration
- ☐ Other: _____

D3. What is your current **job position**?

- ☐ Project Management
- ☐ Software Engineer
- ☐ System Analyst
- ☐ Designer
- ☐ Graduate student
- ☐ Other: _____

D4. Who are the **customers** for your current (or most recent) project where you used agile methods?

- ☐ TI
- ☐ No TI
- ☐ End customers
- ☐ Other _____

D5. How many years of **project management** experience do you have?

- ❍ None
- ❍ Up to 1 year
- ❍ 1 to 5 years
- ❍ 6 to 10 years
- ❍ 11 to 15 years
- ❍ 16 to 20 years
- ❍ More than 20 years

D6. How many years have you participated in or were involved in initiatives using **agile methods**?

- ❍ Up to 1 year
- ❍ 1 to 5 years
- ❍ 6 to 10 years
- ❍ 11 to 15 years
- ❍ 16 to 20 years
- ❍ More than 20 years

D7. Please indicate the agile methodologies in which you work (or worked).

- ☐ Scrum
- ☐ Kanban
- ☐ Adaptative Software Development (ASD)
- ☐ eXtreme Programming (XP)
- ☐ Lean Software Development
- ☐ Dynamic Systems Development Methods (DSDM)
- ☐ Feature-Driven Development (FDD)

D8. How many people **report** directly or indirectly to you?

- ❍ <= 5
- ❍ <= 10
- ❍ <=50
- ❍ > 50

Organisational Demography Profile

D9. In which of the following groups would the **organisation** in which you work (or worked recently) be best classified?

- ❍ For-profit organisation
- ❍ Non-profit organisation
- ❍ Government
- ❍ Academia

D10. How would you rank the **size of the company** where you work? Use the table from the EU recommendation 2003/361[1] as reference:

- ❍ Micro
- ❍ Small
- ❍ Medium
- ❍ Large

Size of Organisation	Employees		Billing (Million €)		Total Assets (Million €)
Micro	<10		≤ 2		≤ 2
Small	<50	and	≤ 10	or	≤ 10
Medium	<250		≤ 50		≤ 43
Large	>250		> 50		> 43

D11. Please indicate the **type of organisation** in which you most recently worked.

- ❍ Software Engineering
- ❍ Manufacturing
- ❍ Business administration
- ❍ Public administration
- ❍ Services
- ❍ Other: _____

D12. Please indicate the **industry sector** (economy sector) of your current organisation?

- ☐ Information and communication
- ☐ Professional, scientific and technical activities
- ☐ Education
- ☐ Agriculture, forestry and fishing
- ☐ Manufacturing
- ☐ Electricity, gas, steam and air conditioning supply
- ☐ Water supply; sewerage, waste management and remediation activities
- ☐ Construction
- ☐ Wholesale and retail trade; repair of motor vehicles and motorcycles
- ☐ Transportation and storage
- ☐ Accommodation and food service activities
- ☐ Financial and insurance activities
- ☐ Real estate activities
- ☐ Administrative and support service activities
- ☐ Public administration and defense; compulsory social security
- ☐ Human health and social work activities
- ☐ Arts, entertainment and recreation
- ☐ Other service activities

D13. Please indicate the **geographic scope** for the operation of the organisation where you currently worked (or most recently).

- ❍ Local
- ❍ Regional
- ❍ National
- ❍ Multinational (present in up to 5 countries)
- ❍ Global (present in more than 5 countries)

[1] Official Journal of the European Union, L 124, 20 May 2003 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003H0361&from=EN

APPENDIX L – THEORY: INITIAL CONTACT

Subject: Invitation to Interview: Simplicity in Agile (Lero-UL and CIn-UFPE)

Dear [name],

We hope this email finds you well.

The Lero (the Irish Software Research Centre) at University of Limerick in partnership with the Project Research Group (GP2) in the Informatics Centre (CIn) at Federal University of Pernambuco (UFPE) are conducting a research in order to discuss and get a better understanding of some relevant aspects related to simplicity management in the context of Agile Software Development, by means of semi-structured interviews.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study, being a representative agent of the phenomena, and possessing the expertise that is relevant to this study.

Please, if possible, let me know which time and location works best for you to take part in the interview. This interview takes approximately 45 minutes to be completed.

If you have further questions regarding this research please feel free to get in touch.

I am looking forward to meeting you.

Best regards,

Wylliams Barbosa Santos

Visiting Doctoral Researcher, Lero, the Irish Software Research Centre
University of Limerick, Ireland

Doctoral Researcher, Project Research Group (GP2)
Federal University of Pernambuco (UFPE), Brazil

APPENDIX M – THEORY: INFORMATION SHEET - MEMBER CHECKING

This appendix gives potential participants the necessary understanding of the motivation and procedures of this member checking. It also enables the possibility of any further questions, being performed by the interviewee.

INFORMATION SHEET
(MEMBER CHECKING)

My name is Wylliams Santos, and I am currently a PhD Student at the Federal University of Pernambuco (UFPE) under the supervision of Professor Hermano Moura. The title of our research project is "Theory of Simplicity in Agile Software Development".

The purpose of the study is to conduct a member checking to discuss and validate the findings, improving accuracy, credibility, and internal validity of our interpretations. We intend to use the knowledge gained during this study to increase the accuracy and consistency of the emerged theory. This theory explains the phenomena of simplicity in agile software development. It can be used by the researchers or industry to improve their projects.

This study is part of broader research conducted by the Project Research Group (GP2) in the Centre of Informatics (CIn) at Federal University of Pernambuco (UFPE). It is also a collaboration with the Lero (the Irish Software Research Centre) at University of Limerick (UL).

The study outcomes is a summary of gathered anonymised data. If you feel uncomfortable at any time, you can withdraw your participation without having to explain or give a reason.

We are inviting you because you have professional or academic experience compatible with the sample profile designed for this study. You are a representative agent of the phenomena, and possess the expertise that is relevant to this study.

If you have further questions regarding this research, please feel free to get in touch with either myself or my supervisor using the email addresses listed.

If you have any concerns about your treatment or rights as a research subject, you may contact the Secretary of the Board of Research (SEC-DPQ) in the UFPE Office for Research Affairs and Graduate Studies (PROPESQ) at +55 (81) 2126 7041 or dpq.propesq@ufpe.br.

Yours sincerely,

Wylliams Santos
wbs@cin.ufpe.br

Professor Hermano Moura
hermano@cin.ufpe.br
Tel: +55 (81) 2126 8430

APPENDIX N – THEORY: MEMBER CHECKING QUESTIONNAIRE

This appendix presents the member checking questionnaire to evaluate the level of agreement of participants about the emerged theory and hypotheses.

MEMBER CHECKING QUESTIONNAIRE

Hypothesis 1: The inclination towards *lightweight process* enhances *personal communication*, reduce *time-consuming* tasks, and leads to *simplicity in Agile Software Development*. ( ) I strongly disagree ( ) I disagree ( ) I neither agree nor disagree ( ) I agree ( ) I strongly agree
Hypothesis 2: The encouragement to *knowledge acquisition* promotes *simplicity in Agile Software Development*. ( ) I strongly disagree ( ) I disagree ( ) I neither agree nor disagree ( ) I agree ( ) I strongly agree
Hypothesis 3: The adoption of *effective communication* between customer and agile team positively impacts the *product with value*, and leads to *simplicity in Agile Software Development*. ( ) I strongly disagree ( ) I disagree ( ) I neither agree nor disagree ( ) I agree ( ) I strongly agree
Hypothesis 4: The optimisation of *time-consuming* positively promotes on development of *product with value*, and leads to *simplicity in Agile Software Development*. ( ) I strongly disagree ( ) I disagree ( ) I neither agree nor disagree ( ) I agree ( ) I strongly agree
Hypothesis 5: The inclination to *effective communication* promotes *transparency* in ASD, and leads to *simplicity in Agile Software Development*. ( ) I strongly disagree ( ) I disagree ( ) I neither agree nor disagree ( ) I agree ( ) I strongly agree
Do you have any suggestion or comment about the emerged hypotheses?