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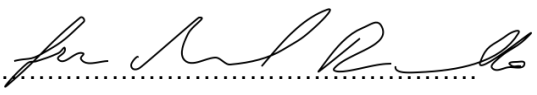
Signed:  Date: 18/08/2018

How Augmented Reality Can Help Develop the Sense of Belonging in Software Engineers Working Remotely

A dissertation by
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ABSTRACT

The rise of remote working is creating not only opportunities but also challenges to organisations. One important challenge is how to to develop belongingness when employees are working at distance from their colleagues and the organisation premises. This study presents a qualitative synthesis review of the literature on the effects of remote working on the sense of belonging of software engineers and explores how augmented reality could help develop it. It examined the topics of sense of belonging, software engineers working remotely and augmented reality with the intention of finding correlations between them as well as providing a comprehensive background and current knowledge in these areas. This review has found that augmented reality could potentially be used to develop the sense of belonging of software engineers working remotely by creating a feeling of presence, allowing for the development of an identity and generating opportunities for informal communication to take place. However, the research has also shown that the current state-of-the-art augmented reality technology has not yet reached a stage where it would be feasible to use it to develop the sense of belonging of remote employees. Therefore, further research could use the insights from this summary of the literature to direct the development of augmented reality technologies towards practical implementations that could be used in the real world in order to develop the sense of belonging of employees working remotely.

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AUTHOR'S DECLARATION

I have read and understood the rules on cheating, plagiarism and appropriate referencing as outlined in my handbook and I declare that the work contained in this assignment is my own, unless otherwise acknowledged.

No substantial part of the work submitted here has also been submitted by me in other assessments for this or previous degree courses, and I acknowledge that if this has been done an appropriate reduction in the mark I might otherwise have received will be made.

Signed candidate: 

The project should normally be related to the management of:

1. companies in the engineering sector;
2. the engineering function within a non-engineering company or;
3. the supply chain within the engineering sector.

The project could address many different aspects such as operational, financial, human resource, technical or strategic management issues.

Where the project is of a technical nature, there must be clear evidence of business benefit from this technology.

If the focus of the project is outside the above industrial spectrum it MUST contain considerable comparative analysis of practices in the engineering sector.

My project relates to this definition in the following way:

The author would like to pursue a career working as an engineering manager in the software engineering industry where remote working is growing substantially every year. Therefore, being able to understand not only how to manage remote workers but also how to develop their sense of belonging towards the organisation and their colleagues is a competence that is part of the strategic management of the people resource. Therefore, this dissertation meets the course requirements as well as providing the author with considerable personal growth and competence for his managerial career.

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LIST OF ACRONYMS

AR Augmented Reality

CAGR Compound Annual Growth Rate

CSCW Computer Supported Collaborative Work

FoV Field of View

GPS Global Positioning System

HHD Hand Held Display

HMD Head Mounted Display

ITC-SOPI ITC-Sense of Presence Inventory

MBTI Myers-Briggs Type Indicator

PTSD Post-Traumatic Stress Disorder

RAM Random-Access Memory

VR Virtual Reality

Chapter 1

INTRODUCTION

In this chapter the researcher will establish the context, background and importance of this study. The goal being to identify the gap that the researcher will address in this paper and give the necessary information for the subsequent chapters to be adequately grasped. Furthermore, the research focus, design and methods will be introduced followed by the establishment of the research question, objectives and the value added by this study. These will clarify how the research will be conducted and also what in detail will be researched.

1.1 Context

In today's competitive markets, organisations need talented people and the talent pool is evermore global (GlobalWorkplaceAnalytics.com 2018). This globalisation together with advances in communication technologies is propelling the rise in remote work which is particularly in demand by people that work in the 'digital world' such as software engineers (Thompson, Payne and Taylor 2015; Durward, Blohm and Leimeister 2016; Bentley et al. 2016; Perry, Rubino and E. M. Hunter 2018; Nash et al. 2018). This type of work arrangement, in connection to software development, is also referred in the literature as global software development (GSD), distributed software engineering (DSE), global software engineering (GSE) or distributed software development (DSD) (J. M. Verner, Brereton, B. A. Kitchenham et al. 2014; Mahmood et al. 2017).

In this dissertation, the term 'remote working' will refer to software engineers that work from a remote location for an organisation that can have a physical office or be entirely virtual. Moreover, it is also important to distinguish remote workers from telecommuters. Remote workers are people that work solely from a distance without physical contact, whereas telecommuters are individuals that work remotely part-time (Eddleston and Mulki 2017). These remote software engineers work in teams and form an intricate socio-technical system that has the aim of developing software (Binder 2016; Raduescu and Gill 2014). Thus, the focus of this paper is to investigate these remote workers and the impact that this type of work has on them. In particular, the research seeks to examine the impact that remote working has on the sense of belonging of software engineers. The sense of belonging is, in essence,

the psychological feeling of connectedness to a group or community (Hurtado and Carter 1997), and it is crucial for the physical and psychological well-being of human beings (Bonnie M Hagerty and A. Williams 1999). Nonetheless, the sense of belonging will be covered in detail in Section 1.2.1 and Section 3.2.

Subsequently, this paper will explore how new technology, specifically augmented reality, can help develop the sense of belonging in these software engineers that are working remotely. The topic of augmented reality will be discussed in Section 1.2.3 and Section 3.4, but it can very simply be defined as an enhanced version of reality which combines virtual elements with the physical world (R. Azuma, Baillot et al. 2001).

1.2 Background

In this section a brief overview of the main topics (i.e. sense of belonging, software engineers working remotely and augmented reality) is discussed, these will be explored in more detail in the literature review (Section 3).

1.2.1 Sense of Belonging

In order to understand the origin of the sense of belonging it is important to step back and understand what drives the human behaviour.

The sense of belonging, as known as belongingness, has been thoroughly studied in the literature. The earliest theory to emerge in was the one from Maslow (1943) who posited that the sense of belonging a need that will emerge if the physiological and safety needs are satisfied and that an individual will be dominated and their behaviour formed only by unfulfilled needs. This needs are organised hierarchically and are illustrated in figure 1.1. Moreover, the consequences of not meeting the need to belong will culminate in loneliness, psychological distress and a substantial urge to create new relationships.

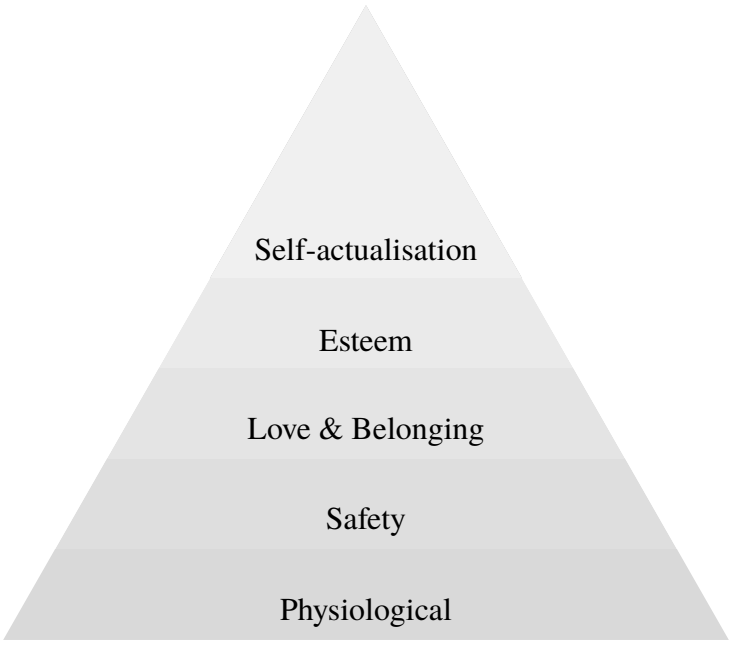

Figure 1.1: *Maslow's hierarchy of needs (Maslow 1943)*

In addition to these early studies by Maslow (1943), multiple other theories have been proposed, such as the notable McClelland (1965), Alderfer (1967) and Herzberg et al. (1968), among others that appear to suggest that the sense of belonging is a fundamental human need that needs fulfilment.

As this paper investigates factors connected to the career of a software engineer working remotely it is valuable to touch on the sense of belonging not only as a fundamental human need but also as it is present in the workplace.

Thus, a form of manifestation of the belongingness in the workplace is through work engagement (O'Neill, Hambley and Bercovich 2014). Schaufeli et al. (2002) writes that work engagement is "a positive, fulfilling, work-related state of mind that is characterised by vigour, dedication, and absorption". The level of engagement of employees that are physically present in the workspace has been proved to be higher than those that work remotely (O'Neill, Hambley and Bercovich 2014). Even so, the disengagement experienced by remote workers is not always necessarily a negative aspect, as Ellison (2004) pointed out that remote workers are able to dissociate themselves from office politics and gossip. In fact, studies (Loewen and Suedfeld 1992; Maher and Hippel 2005; Smith-Jackson and Klein 2009) have been consistent in finding that the distraction caused by overhearing unrelated conversations have been associated with lower employee performance, stress and unfavourable feelings towards the workplace. Moreover, if the individual has an adequate psychological

health they will be more energised and devoted to the job which can then lead to higher job satisfaction, more efficiency, lower turnover rate and a better alignment with the company mission and goals (Porter and Steers 1973; Christian, A. S. Garza and Slaughter 2011; A. B. Bakker, Demerouti and Sanz-Vergel 2014; Mäkikangas 2018).

1.2.2 Software Engineers

Historically, the concept of software engineer is relatively novel and, in fact, it is still developing from a science to an engineering discipline (Staff 2015). The ISO/IEC/IEEE (2010) formally defines software engineering in two parts:

1. "the systematic application of scientific and technological knowledge, methods, and experience to the design, implementation, testing, and documentation of software"; and
2. "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software".

This definition, in spite of its technical accuracy, fails to acknowledge the significance of the individual performing the tasks mentioned. In essence, the development of software continues to be a human endeavour which fundamentally not only requires human intellectual capital but also interpersonal activities (A. Garza, Lunce and Maniam 2003; Sumner, Yager and Franke 2005; F. Ahmed et al. 2015; Akgün et al. 2015; Yilmaz et al. 2017; Jiang et al. 2018).

Therefore, it is crucial to understand if the people developing software have particular characteristics that distinguish themselves from the general population. This is imperative for reliably determining how augmented reality can help develop the sense of belonging in software engineers working remotely, since that if software engineers have distinct characteristics from the mainstream population the manner in which augmented reality could develop their sense of belonging would arguably be different. Therefore, it is important to understand the typical features of software engineers working remotely so that a specific set of suggestions can be made to develop the sense of belonging with augmented reality which target this particular type of professional. In addition, it is important to clarify that the focus of this paper will be on software engineers that are staff members on a salary.

1.2.2.1 Remote Work

The number of people working remotely has steadily been increasing over the past decade (Thompson, Payne and Taylor 2015; GlobalWorkplaceAnalytics.com 2018; Perry, Rubino and E. M. Hunter 2018). As an example, in the last ten years the number of employees who say they usually work from home in the United Kingdom has increased by 19% (Trades Union Congress 2016). This results (Fig. 1.2) in 4.2 million people or 13.9% of those in the labour market working from home as of January-March 2014 (Office for National Statistics 2014). Furthermore, a global study by GlobalWorkplaceAnalytics.com (2018) concluded that since 2005 that the people that regularly work from home has increased 140%.

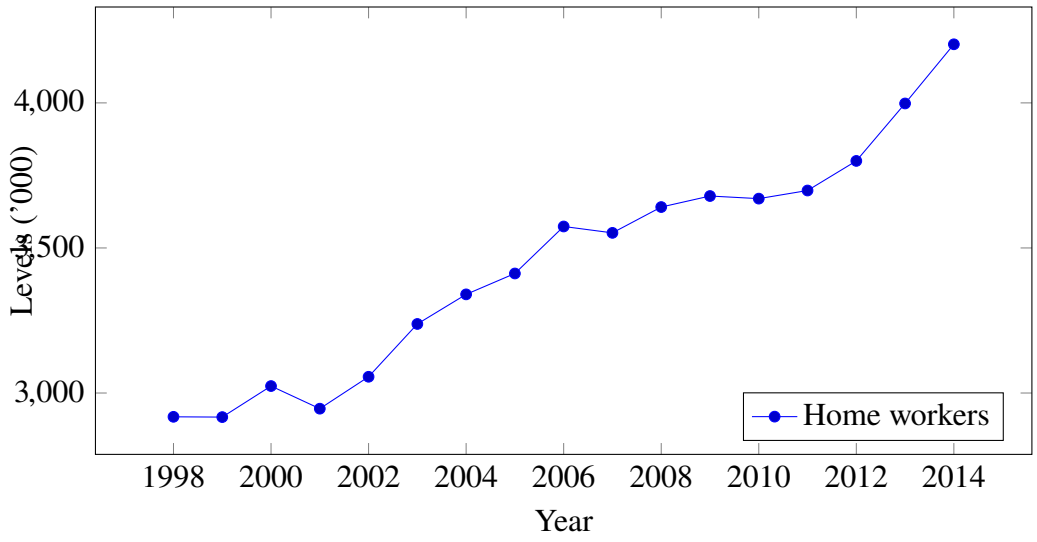

Figure 1.2: *Home workers who report they work from their own home or within the grounds of their home in the UK (Office for National Statistics 2014)*

This trend, in part due to the current technological revolution, is particularly noticeable in software engineers by virtue of the nature of their work (Thompson, Payne and Taylor 2015; Durward, Blohm and Leimeister 2016; Bentley et al. 2016; Perry, Rubino and E. M. Hunter 2018; Nash et al. 2018). In particular, the fact that the job of a software engineer is, in essence, to develop software and that is for the most part dependent upon a computer to be accomplished. Meaning that as long as the software engineers have access to a computer, they will be able to perform their task of developing software.

There are, at the same time, multiple issues with having a remote workforce. An early study by Golden (2006b) suggests that remote workers are less capable of managing

interpersonal relationships and interactions with others. These employees report feeling isolated and without the right time management skills and personal discipline they might become procrastinators and less productive. Furthermore, if the company is not 100% remote, there will be two different cultures within the organisation and that can cause further detachment for the employees working remotely. The fact that a minimum amount of consistent and fulfilling social interactions are needed by all human beings is generally seen as a factor strongly related to the loneliness reported by remote workers (Baumeister and Leary 1995).

Nonetheless, the topic of remote working is still being debated. A high-profile and controversial example of this is when Marissa Mayer, at the time CEO of Yahoo, requested that all the employees working remotely should relocate to Yahoo's premises. Her reasoning was that "some of the best decisions and insights come from hallway and cafeteria discussions, meeting new people, and impromptu team meetings" (Swisher 2013). Concluding that "[they] need to be one Yahoo! That starts with physically being together" (Keller 2013).

By contrast, Richard Branson, the founder of Virgin Group, referred to Mayer's views as "old school thinking" and making further comment stating "In 30 years time, as technology moves forward even further, people are going to look back and wonder why offices ever existed" (Branson 2013).

This inconsistency of opinions regarding remote working may be due to the lack of research regarding this topic which causes further uncertainties regarding the effectiveness of working remotely.

1.2.3 Augmented Reality

Historically, Augmented Reality (AR) started as a concept named 'virtual fixture' (Rosenberg 1993b). This technology was developed and introduced by the U.S. Air Force's Armstrong Labs in 1992 and is considered the world's first augmented reality system (Rosenberg 1992). In essence, the concept of this system was to add augmented sensory information upon a user's perception of the real environment. The augmented sensory information was also referred to as 'perceptual overlays' which consisted of a virtual fixture in the user's field of view (Rosenberg 1992; Rosenberg 1993a).

This concept of virtual fixture is better understood by using a real physical fixture, such as a ruler (Lawrence et al. 1997). The simple drawing of a straight line on a piece of paper is a task that most humans cannot perform quickly with a high level of

accuracy (Maddahi 2014). However, by using a ruler as a helping tool, the task can arguably be accomplished not only faster but with a considerably higher degree of accuracy. What is more, the execution of the task by using a ruler will reduce the cognitive load necessary to accomplish said task. This reduction occurs due to the fact that the operator will no longer require hand-eye coordination and constant visual feedback in order to draw the line. As a result, simplifying the task and increasing its precision (i.e. draw a straighter line). In essence, the ruler serves as a 'perceptual overlay' with the purpose of drawing a straight line on a piece of paper. Similarly, computer generated perceptual overlays are used in augmented reality environments to provide identical results. In essence, augmented reality adds to reality instead of fully replacing it (R. T. Azuma 1997).

The most cited definition in the literature regarding augmented reality systems is the one provided by R. Azuma, Baillot et al. (2001). They claim that an augmented reality system is defined by having three properties. These are:

1. The ability to combine virtual and real objects in the physical world;
2. The capacity to run in real-time and interactively; and
3. The capability of aligning virtual and real objects with one another.

A clear way to visualise where augmented reality systems stand is by looking at Milgram's 'virtuality continuum' (Fig. 1.3). In his diagram, augmented reality exists between the physical world (i.e. real environment) and completely Virtual Reality (VR). Thus, being part of a larger area of mixed reality within the continuum of real-to-virtual environments (Milgram and Kishino 1994). In other words, as soon as a single pixel is overlaid on the physical world this environment becomes mixed reality. Then, there is a continuum as reality is augmented with an increasing number of virtual elements (i.e. higher number of pixels) up to the point where it transitions to augmented virtuality where the majority of the environment is virtual with physical elements still present. Finally, there is a complete virtual environment without any objects from the physical world. Therefore, augmented reality permits virtual content to be seamlessly added or embedded in the physical world (Schmalstieg, Fuhrmann et al. 2002; R. Azuma, Billinghurst and Klinker 2011).

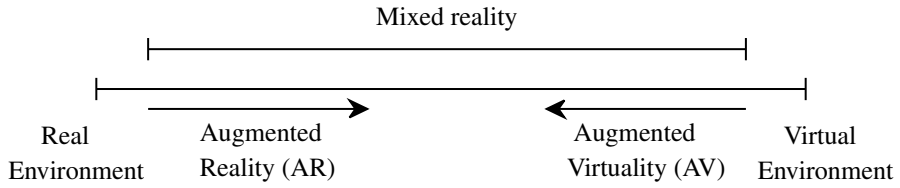

Figure 1.3 – *Milgram's simplified representation of a 'virtuality continuum' (adapted from Milgram and Kishino (1994))*

Augmented reality is therefore considerably different from virtual reality, in which the user is fully immersed in the artificial environment (Bacca et al. 2014). Furthermore, it is a technology that has recently been attracting a large amount of attention as it continues to move forward at an ever increasing rate (Fotaris et al. 2017; Pagés et al. 2018). In fact, mobile augmented reality is a technology that is rapidly rising as one of the most promising in the next decade (Alakärppä et al. 2017). This rise is supported by IDC (2017) whom forecast that the total expenditure on AR/VR products and services will reach $215 billion in 2021, a Compound Annual Growth Rate (CAGR) of 113.2% from just $11.4 billion in 2017.

Finally, if augmented reality helps develop the sense of belonging then companies have a clear path to add augmented reality as a tool for the benefit of not only the software engineers that are working remotely but also the other employees of the organisation that work with them. This will allow the organisation and their employees to ripe the benefits of an increased feeling of belongingness by the software engineers working at a distance.

1.3 Importance of the topic

The potential benefits of the use of augmented reality in order to develop the sense of belonging in software engineers working remotely is an important area of research for multiple reasons.

Firstly, as the trend to work remotely increases the social and psychological consequences for the individual are not yet fully understood (Bentley et al. 2016). In addition, on one hand the sense of belonging is a human need which needs fulfilment. On the other hand, if that need is not satisfied then loneliness can arise and as a result there might be ill effects to the human well-being (Baumeister and Leary 1995).

Secondly, as the competition for talent increases there is the need to gain a competitive edge (Farndale, Scullion and Sparrow 2010; E. Hartmann, Feisel and Schober 2010). In the event that augmented reality can develop the sense of belonging, that will have

a positive impact on sustaining a competitive advantage (Macey et al. 2011). This can potentially result not only in more productive and meaningful work but also a lower turnover rate (Harter, Schmidt and Hayes 2002).

Finally, recent developments in the field of augmented reality have heightened the need for studies that could suggest innovative ways to use this new technology (Orts-Escolano et al. 2016). Augmented reality is still a fairly new technology which did not yet prove its benefits in helping remote workers connect with their organisation and colleagues. Thus, the contribution to knowledge will be related to the effectiveness of augmented reality in developing the sense of belonging in software engineers working remotely.

1.4 Research Focus

As it was briefly discussed in the background information (Section 1.2) the topics of sense of belonging, software engineers, remote working and augmented reality are often researched, however, they are generally studied separately of one another. Thus, the goal of this paper is to address this knowledge gap by researching the connection between these seemingly distinct topics, in particular, the researcher seeks to determine how augmented reality could help develop the sense of belonging in software engineers working remotely.

1.5 Synopsis of the Research Design and Methods

The study was conducted in the form of a meta-synthesis literature review, also known as a qualitative synthesis of the literature (Slavin 1995; B. N. Green, C. D. Johnson and A. Adams 2006; Cronin, F. Ryan and Coughlan 2008; Dijkers et al. 2009; Grant and Booth 2009; Derish and Annesley 2011; Blackwood et al. 2015; Gastel and Day 2016; Noble and Smith 2018). In this type of review there is a broad synthesis of evidence in order to reach a higher level of understanding and provide a comprehensive perspective with regards to the main topics under investigation. The reason to pursue this type of research was due to the lack of primary research that investigated the use of augmented reality to develop the sense of belonging of software engineers working remotely.

1.6 Research Question and Objectives

In essence, the aim of this research is to critically analyse the current literature and produce a foundation for future research on how augmented reality can develop the sense of belonging in software engineers working remotely.

1.6.1 Research Question

The research question is, 'How could the use of augmented reality develop the sense of belonging in software engineers working remotely?'. The sub-questions that have to be answered in order to answer the research question include but not limited to:

1. What is the sense of belonging? Why is it important to develop it? What are the consequences of not fulfilling it?
2. What is a software engineer? What are the characteristics of software engineers? What (de)motivates them? Is the sense of belonging important to software engineers? How is the sense of belonging of software engineers affected by working remotely?
3. What is augmented reality? What types of augmented reality exist? What is the state-of-the-art technology? What is the correlation between augmented reality and the sense of belonging?

1.6.2 Objectives

The following objectives have been determined of importance:

Objective 1 Clarify the concepts of sense of belonging, software engineer working remotely and augmented reality.

Objective 2 Examine the impact of remote working on software engineers' sense of belonging;

Objective 3 Investigate augmented reality's correlation with the sense of belonging.

Objective 4 Synthesise the literature and present the findings with regards to the relation between the topics of sense of belonging, software engineers working remotely and augmented reality in order to provide background information for future research and also insights on how augmented reality could develop the sense of belonging in software engineers working remotely.

Objective 1 has the purpose of setting the scene and all the elements to consider towards answering the research question. Here, the aim of the researcher is to clarify the concepts required for the reader to fully grasp the research question and what is exactly the researcher attempting to answer.

Objective 2 is crucial to critically identify the consequences that remote working has on software engineers' sense of belonging. This is important to explore because the the correlation between these two topics should yield not only the levels of belongingness experienced by remote software engineers but also what factors in remote working are connected to the sense of belonging in a positive or negative manner.

Objective 3 will be essential in answering the research question. The intention is to attempt to ascertain the relationship between augmented reality and the sense of belonging. The primary purpose is to understand in what forms can augmented reality develop the sense of belonging. The researcher will focus on studies that have implemented the principle of transferability and have used thick description in order to transfer the knowledge from these studies' context to the remote working setting that is required in order to answer the research question.

Finally, once all the objectives have been critically investigated the researcher anticipates that the final objective can be fulfilled. Thus, Objective 4 has the aim of bringing together all the synthesised findings in the literature so that the research question can effectively be answered.

1.7 Value of Research

This research adds value to current research in a variety of ways.

Firstly, it addresses a gap in the literature with regards to the connection between the use of augmented reality by software engineers working remotely and the development of their sense of belonging. Therefore, providing critical investigation in this area which can be the foundation for future research.

Secondly, both the impact of remote working on sense of belonging and the correlation between augmented reality and the sense of belonging are still poorly understood and with this review of the literature an evidence based meta-synthesis of the literature could give the necessary background for further research in this area.

Finally, even though this qualitative synthesis review of the literature might be subject to biases, it is written from the standpoint of a researcher that has worked previously as a remote software engineer and experienced a perceived decrease in belongingness towards the organisation and colleagues. Thus, this paper could provide insights connected to the perspective of a remote software engineers for future research.

1.8 Guide to the subsequent chapters

The overall structure of the paper takes the form of six chapters, including:

Chapter 1; Introduction is the current chapter and it sets the scene for the following chapters. It covered the background, research focus, overall research aims, objectives and the value of this research.

Chapter 2; Research Methodology is the chapter which is concerned with the justification of the methods used for this research. This chapter explains the thought behind the research methods, ethical implications, limitations and validity of this study.

Chapter 3; Literature Review is the most extensive part of this paper since it is a review of the literature. The researcher decided to use subheadings in this chapter that are connected directly to the research objectives. The reason being so the focus is maintained in the research objectives with the final goal of answering the research question.

Chapter 4; Results & Analysis presents and examines the findings of this research. The researcher structured this chapter in an identical order to that of the literature review in order for the reader to be able to follow the development of the argument from the raw data to the interpretation of the findings in a logical manner. Furthermore, since this is a qualitative data analysis the results and interpretation are integrated with one another in order to provide a congruent discussion of the findings.

Chapter 5; Discussion describes the implications from the findings of this paper. This chapter includes an introduction section to remind the reader about the objectives and the research question that is being answered, the discussion section which covers both theoretical and practical implications of the findings, the research limitations where the weaknesses of this study are examined and suggestions for future work in which ideas for further studies are proposed.

Ultimately, *Chapter 6; Conclusions* is a summary of the main points of this research. The researcher attempts to avoid repetition and at the same time provide the reader with convincing takeaways from this paper.

Chapter 2

RESEARCH METHODOLOGY

2.1 Introduction

The overall aim of this research is to analyse how augmented reality could help develop the sense of belonging in software engineers working remotely. In other words, the researcher wants to explore the relationship between augmented reality, software engineers working remotely and the sense of belonging.

2.2 Philosophical Paradigm

Research philosophy is concerned with the manner in which knowledge is obtained, analysed and applied (O'Gorman and MacIntosh 2015; Sekaran and Bougie 2016). There are four kinds (Biedenbach 2015):

1) *positivism* where the researcher is neutral and independent of what is being researched, thus not appropriate for this study as the researcher wants to add value from his background as a software engineer;

2) *realism* which is related to scientific enquiry and accepts that reality exists independently of human behaviour, therefore, as human behaviour is being investigated this philosophical position was disregarded;

3) *pragmatism* is the philosophy where the research is initiated by a problem and the goal is to provide a solution, thus, as this is an exploratory type of research it does not apply; and

4) *interpretivism* which was the philosophical position chosen for this study due to the subjectiveness of the research conducted and the need to interpret the data from the point of view of those experiencing them, in particular with regards to the sense of belonging. Moreover, the researcher accepts the fact that both personal experience and the findings from the literature will have an influence in answering the research question and objectives.

The implications of this choice will be most noticeable in the manner in which the research findings will be analysed. As the interpretive paradigm has its main focus

on understanding and describing individual experiences (Fossey et al. 2002), the results that will be synthesised from the literature will inevitably be interpreted from the perspective of the researcher. As Denzin and Lincoln (2011, p. 5) remind us: "objective reality can never be captured. We know a thing only through its representations". In consequence, as the interpretivistic approach welcomes alternative explanations, these could potentially differ from the one of the researcher, thus, the researcher will need to acknowledge these other points of view and make them clear in order to increase the completedness of this study. Nonetheless, a possible limitation of this choice of paradigm is that the research could potentially be biased towards the researcher's opinions and beliefs.

2.3 Methodological Design

The methodological design chosen for this research project was a *meta-synthesis literature review*. This type of design, also known as *qualitative synthesis of the literature* (Oxman et al. 1994) is valuable in introducing a broad perspective on a specific subject often together with its history and development (Slavin 1995; Gastel and Day 2016). It has the goal of identifying and summarising the currently available literature, refrain from duplication, and pursue novel study areas that might not have been yet appropriately addressed in order for a higher level of understanding to be reached (Cronin, F. Ryan and Coughlan 2008; Grant and Booth 2009; Derish and Annesley 2011). Furthermore, this type of review is frequently thought-provoking (B. N. Green, C. D. Johnson and A. Adams 2006) which seems suitable to research a new technology such as augmented reality. Therefore, the aim of the researcher is to identify, critically evaluate and integrate relevant literature findings that focus on the research question and objectives.

After a reflective consideration of the research question and the objectives it is believed by the researcher that this methodological design is the one that best meets the requirements for this type of research for a number of reasons.

Firstly, an adequate literature review should bring together research evidence so that new and original information can be inferred (Seers 2015; Baumeister and Leary 1997). Moreover, considering that a potentially limited amount of knowledge will be available with regards to the practical application of augmented reality in a remote working environment, a qualitative study could conceivably work with proxy literature using the principle of transferability to uncover new knowledge and understanding (Korstjens and Moser 2017).

Secondly, on account of the subjectiveness of this study which was discussed in the philosophical paradigm (Section 2.2), it appears to the researcher that a quantitative study would not provide as much insight as the in-depth and holistic approach of a qualitative research. This view is supported by Moser and Korstjens (2017), whose research shows that in a qualitative study the goal is to "gain a deeper understanding of people's experiences, perceptions, behaviour and processes and the meanings they attach to them". As a result, providing a more adequate answer to the 'how' of the research question. Furthermore, the available literature with regards to the areas under investigation are mostly qualitative studies.

Thirdly, the research question and a number of objectives are mainly concerned with the sense of belonging and that is a social need (Maslow 1943; Baumeister and Leary 1995). Thus, qualitative research is favoured due to its link with the manner in which individuals perceive their social worlds (J. Green and Thorogood 2018).

Finally, with respect to practical considerations, there are two main reasons why it is believed that this type of design is best suited for this research:

1. The state of development of augmented reality which is still in its beginning, particularly in connection to developing sense of belonging;
2. The exceptionally sophisticated setup required to conduct a case study evaluating how augmented reality could affect the sense of belonging; and
3. The short time-frame to implement the research.

These reasons made it infeasible to carry a case study and for that reason, secondary research was the method chosen to answer the research question. However, in addition to the inability to collect primary data, there are a number of important limitations in using this method which will be discussed in the section 'Limitations and Potential Problems' (Section 2.8).

2.4 Logic of Research

Given the nature of this research, the choice for a qualitative systematic review of the literature (Section 2.3) was initially considered flexible, as during the research process it can be identified that another type of methodological design might be more suitable. Therefore, it was an 'emerging design' (Moser and Korstjens 2017) which resulted in that the logic of the research was also susceptible to research

findings. Nonetheless, the researcher mainly followed an *analytic induction* (J. Katz 2015; Brannen 2017) logic of research so that knowledge would arise from analysing concrete data. In other words, the research was conducted such that the data was used to develop theory (i.e. a 'bottom up' approach). The objectives (Section 1.6.2) that have been determined encouraged this type of logic because the research aim was to find the relationships among multiple variables such as augmented reality, sense of belonging and software engineers working remotely.

Furthermore, Noblit and Hare (1988) suggested that there were two approaches to conduct a qualitative systematic review of the literature: aggregate and interpretative. The former summarises the data and the latter interprets the data (Seers 2015). This research pursued the interpretative path due to the fact that the intention of the researcher was to understand the connections between the different subject matters so that the research question could be effectively answered.

2.5 Data Collection & Analysis Methods

Data collection and analysis methods in qualitative research are iterative processes that occur at the same time as the research advances (Moser and Korstjens 2017). Moreover, in the case of our qualitative approach and from the perspective of software engineers working remotely while using augmented reality, the goal was to gain a new understanding regarding how augmented could develop their sense of belonging. This logic that the data collection and analysis methods should be iterative processes and that it should be obtained from the perspective of the software engineers themselves is accepted by Vaismoradi, Turunen and Bondas (2013), whom state that the goal of a qualitative approach is to "arrive at an understanding of a particular phenomenon from the perspective of those experiencing it".

In terms of a concrete approach to data collection and analysis, the researcher followed the three-step approach proposed by Elo and Kyngäs (2008) consisting of:

1. *preparation*, which involved acquiring an overview of the studies in the literature by immersing oneself in the data. This first step which was part of the data collection occurred during the literature review and was the foundation for the data analysis that took place in the next step. In addition, the data was not collected in any particular pattern due to the fact that Moser and Korstjens (2018) have concluded in their paper that "data collection in qualitative research is unstructured and flexible". In other words, there were choices made regarding the collection of data during the actual data collection period;

2. *organising*, where open coding and the generation of categories were used to bring together the data. The coding process is concerned with determining themes, subject matters, similarities, differences and other types of grouping that are coherent with this research. This project was coded using LaTeX (LaTeX 2018) together with the features of the text editor Atom (GitHub 2018a) and the PDF reader and note-taker Skim (Amaxwell 2018). Furthermore, GitHub (2018b) was used as the version control system in order to manage this project and keep track of changes. The codes (i.e. data points) emerged from the interpretation of the researcher, which was discussed in the philosophical paradigm (Section 2.2), and are therefore susceptible to their understanding of the data. For example, the researcher may determine a theme or topic not because of its overall relevance but due to its frequency in the particular papers that the researcher has found (Holloway and Todres 2003). This would result in a bias towards the papers the research has encountered rather than an accurate depiction of the literature; and

3. *reporting*, which in the case of a meta-synthesis review of the literature is concerned with synthesising the evidence found in the studies investigated. Furthermore, it was thought at first that triangulation with different types of data would be possible in order to report the findings with increased confidence. However, when the research was being conducted it became clear to the researcher that the focus should be on the analysis of qualitative data due to the lack of quantitative studies with connection to augmented reality and the sense of belonging in software engineers working remotely.

The primary databases chosen for the literature search were: ScienceDirect (ScienceDirect 2018), Scopus (Scopus 2018), IEEE Xplore (IEEE Xplore 2018), Springerlink (Springer 2018), ACM (ACM 2018) and Google Scholar (Google Scholar 2018).

The document preparation system used for this dissertation was LaTeXwhich is "the de facto standard for the communication and publication of scientific documents" (LaTeX 2018). In addition, BibTeX was implemented as the reference and bibliography management system (BibTeX 2018).

2.6 Ethical Implications

The ethical implications are minimised since the research will analyse only secondary data, meaning that the study will not collect data directly from participants.

The first part of the ethical approval form was filled as required. A copy of the email stating that this dissertation does not require ethical approval is included in Appendix A.

2.7 Credibility, Dependability, Transferability and Confirmability

In a quantitative research the norm is to use validity, reliability, generalisability and objectivity to assess the quality of a study (Moskal, Leydens and Pavelich 2002). Nonetheless, these criteria are not appropriate for evaluating the quality of a qualitative research (Korstjens and Moser 2018). The reason being that in a qualitative study, the objective is to determine the trustworthiness of the study. In other words, Lincoln and Guba (1985) suggest that the question "Can the findings to be trusted?" is the primary concern when assessing the quality of a qualitative study. Furthermore, they have published the most common criteria used to evaluate the quality of a qualitative research, which are: credibility, dependability, transferability and confirmability.

The researcher has considered a number of factors for each of the criteria during the research process in order to synthesised the findings from the literature. In terms of credibility, the researcher assured that the research results came from a logical interpretation of the original data. In addition, as far as possible, the researcher attempted to abstain from biases or prejudgement of the data. On the question of dependability, its goal is to make certain that the research findings are stable over time and that they can be relied upon for future research. Unfortunately, it will not be possible to perform an inquiry audit on this research to establish its consistency and repeatability. Nonetheless, the researcher attempted to be as objective as possible in order to guarantee that the research findings were consistent with the raw data found. In the case of transferability, the researcher used "thick description" (Geertz 1973) to explain not only the behaviour but also the context in which said behaviour occurred. This is important so that another researcher, under conditions, can transfer the knowledge to another context. As regards confirmability, it was critical to guarantee that the research findings were undoubtedly be obtained from the data rather than a figment of the researcher imagination. In this case, the researcher used an audit trail to describe the method of data collection and analysis as well as the interpretation of that data itself. Finally, the researcher also critically self-reflected on their own preconceptions and biases that might have affected the interpretation of the results of this research. This is often referred to as the reflexivity criteria which might be important in determining the quality of a qualitative research (Palaganas et al. 2017).

Finally, the risk associated with the project execution was considered and effective risk management was applied. As an example, the decision to conduct secondary research was a mitigated risk due the inability to collect primary data as result of the inadequate state of development of augmented reality technology.

2.8 Limitations and Potential Problems

The flexibility discussed in the philosophical paradigm (Section 2.2) may create an inconsistent and incoherent research (Holloway and Todres 2003). This could be the case if the researcher is not consistent in the research methodology (Section 2.3) used. Therefore, it is critical that even using a flexible approach, the researcher remains coherent and, if need be, adapts an iterative procedure to synthesise the research findings.

Furthermore, the fact that this is a qualitative synthesis literature review (Section 2.3) might result in that not all the sources were found which could influence the quantity of knowledge available to report appropriate conclusions.

As the context is crucial in qualitative data, it might be the case that when the results of various studies are synthesised for this study, there might occur a "loss of explanatory context" (Atkins et al. 2008). The researcher will use thick description and maintain context awareness when performing the analysis and interpretation of the results of the original study in order to mitigate this problem.

Finally, as this is a relatively subjectivistic approach with an interpretative analysis, there could be the risk of a biased review since the selection of sources will be subjective due to the absence of explicit inclusion criteria. Nonetheless, the researcher is aware of these potential difficulties and will as far as possible attempt to mitigate them.

In summary, this chapter has justified the methods used in this research, explained the logic of the study and how the data collection and analysis will be executed. Moreover, it addressed the implications and limitation of the research and how the researcher will mitigate them. In the chapter that follows, the literature will be explored and synthesised in order for a higher level of understanding to be achieved.

Chapter 3

LITERATURE REVIEW

3.1 Introduction

The aim in this chapter is to present the state of research and review the current literature on the main subject matters of this study. This chapter is structured based on the research objectives.

Firstly, the topic of *sense of belonging* (Section 3.2) will be clarified and the relevant literature will be critically evaluated. The reason to start with the sense of belonging is due to the fact that it is crucial to understand its significance on the human mind before proceeding to critically evaluate how that can have a critical impact on individuals working remotely and how augmented reality could help develop it.

Secondly, the topic of *software engineers* (Section 3.3) is explained and the related literature critically evaluated. In this section there will be an evaluation of the characteristics of software engineers (i.e. what makes them unique), their motivators and demotivators in order to understand if the sense of belonging is meaningful for them, then the concept of remote working is discussed and its impact on software engineers' sense of belonging.

Finally, the researcher will investigate the literature regarding *augmented reality* (Section 3.4). As a brief introduction to augmented reality was already given in the introduction, this section will explore the current technologies used for augmented reality and essential concepts in order to lead the reader to Section 3.4.5 concerning the correlation between augmented reality and sense of belonging.

3.2 Sense of Belonging

In order to thoroughly comprehend the importance of the sense of belonging to a person it is necessary to initially cover the main concepts that play a role in understanding that notion and its connection to mental health.

Historically, the term mental health has been used to describe the absence of mental illness. However, this interpretation has developed substantially and currently the World Health Organization (2004) defines it as: "a state of well-being in which every individual realises his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to

her or his community". The World Health Organization (1995) complements the previous definition by stating that "health is [...] not merely the absence of disease or infirmity". Thus, it is imperative to maintain these definitions in mind when evaluating the impact of the lack of sense of belonging on the individual for the reason that even though they might not suffer from an illness they might not be experiencing well-being and their mental health might be in jeopardy.

The first serious discussions and analysis of interpersonal contact and belongingness emerged during the 1930s with Sigmund Freud (S Freud 1930). The idea that human motivation derived from a need was then born. Freud's theory postulated that sex or life instincts (i.e. *eros*) and aggression or death instincts (i.e. *thanatos*) are the most prominent drives of human motivation. On the other hand, multiple writers (P. A. Robinson and P. W. Robinson 1993) have challenged Freud's claims on the grounds that his views were excessively biased towards sex drive and filial bonds.

Nonetheless, it was not until a decade later that Abraham Maslow suggested in his article titled 'A theory of human motivation' (Maslow 1943) that humans were driven by needs unrelated to Freud's view. In fact, his theory was grouped among others in the literature (Turabik and Baskan 2015) as one of the most important 'content theories' (Fig. 3.1).

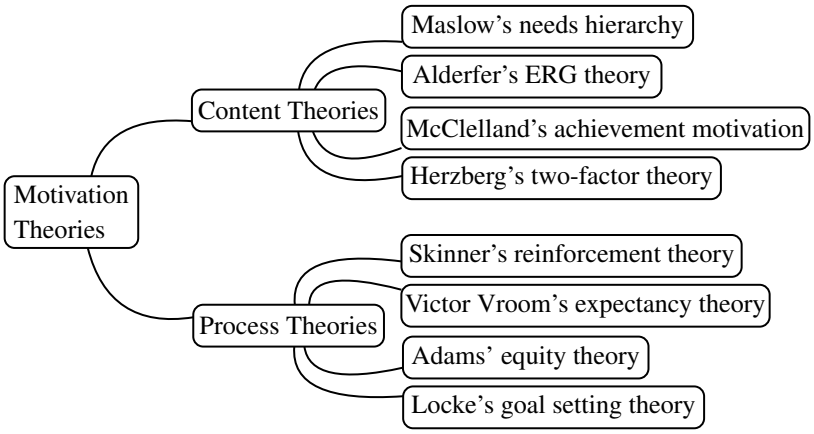

Figure 3.1: *Motivation theories*

The *content theories* aim attention at *what* motivates human behaviour, whereas *process theories* are more concerned with the *how* human behaviour is motivated (De Vito et al. 2018). In spite of the fact that these theories are some of the most well-known theories on motivation they are not exhaustive. In fact, Petri and Govern (2012) state that there are in excess of one hundred theories of motivation and that there is

not a single theory that fully illustrates how individuals are motivated. Nonetheless, every theory will expectedly yield new understanding into a very subjective and exceptionally intricate area (Beecham 2014). The fact is that motivation is necessary and individuals are not machines that can perform repetitive tasks endlessly (Beecham 2014). Accordingly, it is essential to understand people and what motivates them. Thus, the content and process theories offer an appropriate balance of theories to cover the main concepts of motivation.

3.2.1 Content Theories

In terms of content theories (Fig. 3.2) there are mainly four prominent researchers (Dinibutun 2012; Chowdhury, Alam and S. Ahmed 2014; Fallatah and Syed 2018). These are Maslow, Alderfer, McClelland and Herzberg.

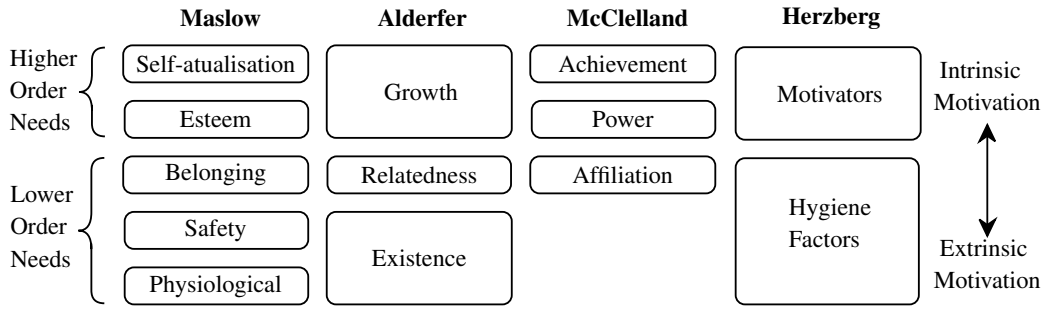

Figure 3.2: *Content theories (adapted from Zafarullah and Pertti (2017))*

The theory proposed by Maslow was described in Section 1.2.1 and is one of the most well-known and was built upon Freud's argument that needs drive human behaviour (Rasskazova, Ivanova and Sheldon 2016; Clark and Seager 2017; Schulte 2018). The main weakness with this theory is that there is insufficient empirical evidence to support it. In fact, Wahba and Bridwell (1976) questioned the 'uncritical acceptance' of Maslow theory and after evaluating 14 research studies they were unable to find unquestionable acceptance for the need of a hierarchy of needs. Furthermore, a limited number of studies (Daniels 1988; Neher 1991) have attempted to validate this theory but were inconclusive with regards to the need of a hierarchy. Instead, there was a general agreement that needs are inherited and that it would be difficult to elevate oneself and pursue other motivations if there are preoccupations concerning survival.

In addition, several studies have made an effort to redevelop Maslow's theory (Barnes 1960; R. Harrison 1966; Alderfer 1967). The most notable of these, according to

Wahba and Bridwell (1976), was the one of Alderfer due to the extensive evidence backing his ERG theory (existence, relatedness and growth). In his theory, the need to belong is grouped in the relatedness needs (C.-L. Yang, Hwang and Y.-C. Chen 2011). Thus, a theory that has substantial evidence that the need to belong is fundamental to humans.

Another prominent author to build on Maslow's theory was McClelland (1965). He proposed the 'Three Needs Theory' which described how the three needs (i.e. affiliation, power and achievement) impacted the behaviour of individuals from a managerial point of view. The main difference between McClelland's theory and that of Maslow and Alderfer is that McClelland posits that individuals learn the motivators of their needs over time, rather than the needs being inherent to the person and that the motivation is to satisfy them. Thus, his theory is often termed 'Learned Needs Theory' (Patanakul, J. K. Pinto and M. B. Pinto 2016; Wakabi 2016; Ferreira 2017). Nonetheless, the affiliation motivation compels the individual to seek love, belonging and relatedness (C.-L. Yang, Hwang and Y.-C. Chen 2011). Therefore, maintaining that the need to belong is inherent to a person and that this need also arises in the workplace.

Herzberg's theory states that there are factors that cause job satisfaction (i.e. motivating factors) and other factors (i.e. hygiene factors) that cause dissatisfaction (Herzberg et al. 1968). The key concept in this theory is that the opposite of satisfaction is 'no satisfaction', rather than dissatisfaction (DeShields Jr, Kara and Kaynak 2005). Herzberg et al. (1968) have classified interpersonal relationships as hygiene factors, therefore meaning that it is not a motivation factor but rather a factor that causes dissatisfaction if not satisfied. This is an important distinction since the lack of belongingness will cause dissatisfaction according to Herzberg in the job a person is doing and as a consequence they might seek reduce this dissatisfaction such as leaving the organisation (Holmstrom et al. 2006; Ebert, Murthy and Jha 2008; Hall et al. 2008).

Nonetheless, the principles in these renowned theories (i.e. Alderfer, McClelland and Herzberg) that form part of the content theories group are identical to Maslow's theory. In particular, the fact that humans have a need to belong has remained in all of them in spite of a slightly different grouping. Furthermore, the view that sense of belonging is a fundamental human need is also supported by Herney (1946), Sullivan (1953), Fromm (1956), Hogan (1982), De Rivera (1984), R. M. Ryan (1991), Max-Neef (1991), Epstein (1992), Guisinger and Blatt (1994) and Glasser (1999)

among others. As an example, Max-Neef (1991), in his matrix of fundamental human needs has placed the need to belong in the identity category meaning that it is connected to having reference groups and not only committing but also integrating oneself in these groups. In the same way, Glasser (1999) argued that there are five inborn needs which he identified as love and belonging, survival, power, freedom and fun.

Likewise, the theory that the need to belong is an essential part of psychological motivation was also accepted by Baumeister and Leary (1995). After performing a comprehensive review of the empirical literature in social and personality psychology they claimed that "human beings have a pervasive drive to form and maintain at least a minimum quantity of lasting, positive, and significant interpersonal relationships" (Baumeister and Leary 1995). A considerable amount of literature has been published on the importance of social relationships as a fundamental motivation aspect for a person. In essence, the literature derives from Erik Erikson's eight stages of psycho-social development regarding social relationships as an important aspect of human development (Erikson 1993), which are: 1) hope from 0 to 2 years; 2) will from 2 to 4 years; 3) purpose from 4 to 5 years; 4) competence from 5 to 12 years; 5) fidelity from 13 to 19 years; 6) love from 20 to 39 years; 7) care from 40 to 64 years; and 8) wisdom from 65 to death.

Each of these stages according to Erikson involve a settlement of a specific social relationship conflict. The resolution of these conflicts is what will allow for the capacity to create and maintain deep and significant relationships with others.

This idea is similar to that found in Bowlby (1972) who writes that attachment bonds are created in a person's childhood with their parents. Furthermore, Bowlby stresses that this initial social bond is crucial for the individual to form in the future the capacity of warmth and closeness. However, he argues that this first social bond needs to provide the child with a 'sense of warmth, intimacy, and security'. Additionally, Rokach (1989) states that individuals will strive for human contact due to the fact that its absence will cause painful experiences such as loneliness. Similarly, Mijuskovic (1988) is an advocate that social relationships are a driving force in human motivation. His argument is identical to other authors (Bowlby 1972; Rokach 1989) in that the fear of loneliness and the want to escape are elementary motivational forces. Equally important, Baumeister and Leary (1995) identified that there were personal differences in the intensity of this need, where certain individuals had a high need to belong compared to others where this need was lower.

In spite of their acceptance, there are limitations with these theories. The main limitations of the content theories are based around the fact that these theories are highly universal, lack research backing and have methodology issues. For instance, none of the theories makes a demographic distinction between the subjects studied nor support their findings with a reliable research methodology. Nonetheless, they all came to the conclusion that the need to belong is a fundamental human need which is present in all human beings and that it is a driver of human motivation.

3.2.2 Process Theories

With regards to process theories they analyse how motivational factors relate to behaviour (Steers, Mowday and Shapiro 2004). The most prominent theories include Skinner's reinforcement theory (Skinner 1945), Victor Vroom's expectancy theory (Vroom 1964), Adams' equity theory (J. S. Adams 1963) and Locke's goal setting theory (Locke et al. 1981).

In the case of the reinforcement theory by Skinner (1945), it posits that behaviour appears due to its consequences. It consists of four types of motivators (Fig. 3.3), these are: 1) positive reinforcement; 2) negative reinforcement; 3) punishment; and 4) extinction.

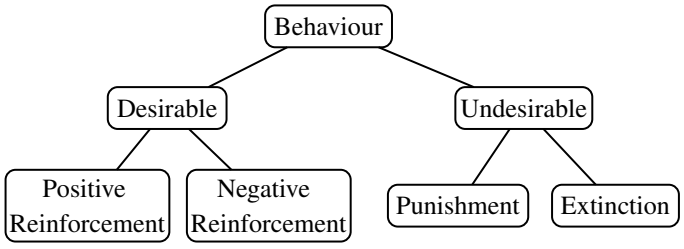

Figure 3.3: *Skinner's reinforcement theory (Skinner 1945)*

Regarding Vroom's expectancy theory (Vroom 1964) states that, in essence, behaviour occurs based on the assumption that a certain choice will lead to a desired outcome. He argues that each decision will be pondered against three factors (Fig. 3.4). These are: 1) expectancy; 2) instrumentality; and 3) valence.

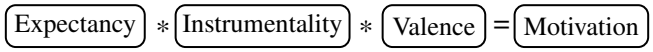

Figure 3.4: *Victor Vroom's expectancy theory (Vroom 1964)*

With respect to Adams' equity theory (J. S. Adams 1963), it is based on the comparison between the self and a reference individual. In particular, individuals will have in

consideration their input-output ratio which they will compare to that of a reference person and in the case of an imbalance they will become motivated to reduce the difference.

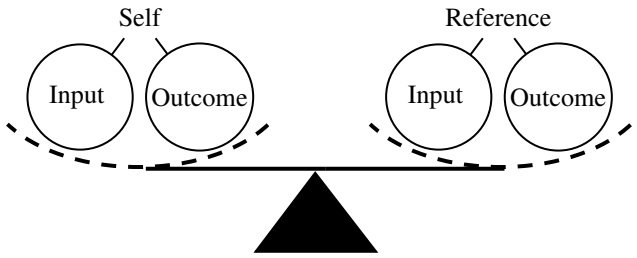

Figure 3.5: *Adams' equity theory (J. S. Adams 1963)*

With respect to Locke's goal setting theory (Locke et al. 1981), it postulates that defining a goal and pursuing it is a driver of behaviour (Fig. 3.6). However, the goals need to have the following main characteristics:

1) challenging, but not overwhelming; 2) clear and specific; 3) measurable; and 4) time-bound.

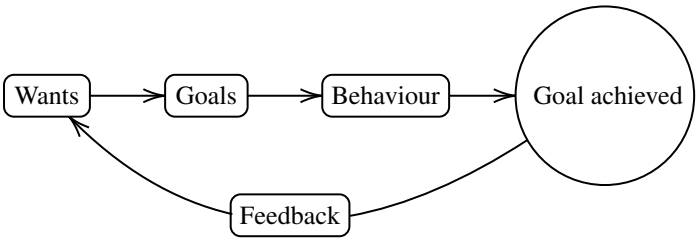

Figure 3.6: *Locke's goal setting theory (Locke et al. 1981)*

Overall, the process theories suggest that there is more to motivation than the inborn need to belong. However, with these theories it is important to bear in mind that they assume that people are rational in maximising their personal utility (Ogut and Attar 2015). Thus, they place responsibility for the lack of motivation on the person rather than on the circumstances. In addition, these theories over simplify the complexity of human behaviour and therefore are subject to issues with their reliability. As an example, cultural differences are not taken into consideration and that in the context of remote working — where the team is distributed — is a requirement. A further study could assess the correlation between augmented reality and these other theories of motivation, nevertheless, additional exploration of this falls outside of the scope of this paper.

In view of all that has been mentioned so far, one may suppose that the need for belonging is the force that drives human beings to pursue social interaction in order to avoid the pain caused by the lack or inadequate social relationships (e.g. loneliness) which several lines of evidence suggest that there it causes a considerable decrement to well-being (Baumeister and Leary 1995; Bonnie M Hagerty, R. A. Williams et al. 1996). In particular, the negative effects of the unfulfillment of the need to belong on the mental health of an individual include anxiety, poorer sleep quality, mental disorder, depression, poorer immune system functioning and increased risk of suicide (Kiecolt-Glaser et al. 1984; Leary 1990; Stravynski and Boyer 2001; Cacioppo, Hawkley and Berntson 2003; Heinrich and Gullone 2006; Cacioppo and Patrick 2008; Lam and Lau 2012; Holt-Lunstad et al. 2015).

Nonetheless, loneliness is a complex subject and although it is known that individuals that have insufficient human interaction more frequently experience loneliness (Yildirim and Kocabiyik 2010), the connection between social isolation and loneliness is often ambiguous (Coyle and Dugan 2012; Perissinotto, Cenzer and Covinsky 2012). In fact, Holt-Lunstad et al. (2015) argue that loneliness is purely the "perception of social isolation", in other words, it is based on the inner experience of being lonely rather than the amount of social interactions that an individual has. Additionally, Cutrona, Peplau and Perlman (1982) have described loneliness as the dissatisfaction caused by the disparity between desired and current social relationships. The implications of these studies are that in order to decrease loneliness the goal should be to assure the individual that their social relationships are adequate, rather than to try and create new ones and that loneliness requires subjective measurement.

3.2.3 Sense of Belonging in the Workplace

As a fundamental human need, the need to belong is also present in the workplace (Welch and Jackson 2007, p. 189). As noted by Mao (2006), there is an increase in psychological well-being when employees are able to form adequate relationships in the workplace. In the same vein, this benefit was also asserted by Stephens, Heaphy and Dutton (2011) stating that positive relationships between people at work are beneficial for the mental well-being of an individual. In addition, they argue that rather than relationships, connections and brief interactions between people in the workplace are crucial for employee's psychological well-being. Thus, the importance of belongingness in the workplace is centred on the perception of acceptance and threats of ostracism are rapidly recognised even if coming from an

inanimate object (e.g. computer) (Zadro, K. D. Williams and R. Richardson 2004; Fink et al. 2008; Andersson and Edberg 2010; Mohamed, Newton and McKenna 2014).

Moreover, in addition to the fundamental need to belong for the well-being of the individual, the sense of belonging is critical in the workplace for a number of reasons.

Firstly, it creates the feeling of *job security* (Hershcovis et al. 2017). In other words, if the individual perceives an increased belongingness then they will have a higher certainty about their job continuation. This job security has been linked with positive health effects due to reduced presenteeism (Virtanen, Mika Kivimäki et al. 2001; Virtanen, M Kivimäki et al. 2003; Noelke and Beckfield 2017) and anxiety (Gallie et al. 2017), increased motivation (Purohit and Bandyopadhyay 2014), productivity (Zameer et al. 2014; Olubusayo 2016), risk taking in searching innovative solutions (Mazzei, Flynn and Haynie 2016) and avoidance of active job seeking (Sortheix, Chow and Salmela-Aro 2015).

Secondly, a *positive attitude and commitment* in relation to the workplace (Mcdonald et al. 2016). On one hand, empirical research has shown that the lack of belongingness in the workplace diminished the amount of cooperation or help that the participants offered to colleagues (Hitlan, Kelly et al. 2006; Balliet and Ferris 2013). On the other hand, the effects of the lack of belongingness in the workplace include deviant work behaviours such as egotistic and dishonest (Thau, Aquino and Poortvliet 2007; Hitlan and Noel 2009; Poon, Z. Chen and DeWall 2013).

Finally, *personal fulfilment* which emerges from the development of the feeling of work as a meaningful activity for the individual (Lips-Wiersma and Morris 2009). Similarly, Hershcovis et al. (2017) argues that if the employee perceives the work to be meaningful then they will produce higher quality work.

In summary, this section has analysed the sense of belonging and has argued that the on one hand the lack of sense of belonging often causes loneliness among other ill effects and on the other hand when present it has a positive impact not only in the individual's well-being but also in the workplace. Moreover, in the literature regarding motivation and in spite of their limitations it could be argued that belonging is a human motivator for behaviour. Thus, if this need is not satisfied mental health issues might ensue. Nonetheless, in order to understand how augmented reality can develop the sense of belonging in software engineers working remotely it is necessary to investigate the topic of software engineer that work remotely. The next part of this

paper (Section 3.3) will clarify the concept of remote working software engineers, their specific characteristics compared to the general population and discuss the implications that remote working has on them. Therefore, the goal of the literature review is to understand how working remotely differs from working in an colocated office space, in particular with regard to the sense of belonging or lack of it and what distinguishes software engineers from the general population.

3.3 Software Engineers

As was pointed out in the introduction to this study (Section 1.2.2), one of the objectives of this paper is to examine the specific characteristics of individuals working as software engineers and determine if there are differences between them and the general population. In this section, a synthesis and evaluation of the literature with regards to that question is conducted. Furthermore, the researcher explores the factors that act as motivators and demotivators of software engineers in order understand the importance of developing the sense of belonging as a motivator factor for employees. Finally, there is a discussion and synthesis regarding the impact that remote working has on the sense of belonging of software engineers working remotely.

3.3.1 Characteristics

Software engineers have been determined to have particular traits that distinguish themselves from the general population. Figure 3.7 summarises a review of the literature (92 studies with 86% being empirical) that supports the finding that software engineers are a unique group of individuals by reporting that, in the papers reviewed, more than half (54%) have identified software engineers to be a “a distinct identifiable occupational group” (Beecham, Baddoo et al. 2008). In addition, that number could increase to 76% (54%+22%) depending on the context in which the software engineer is working. By contrast, only 24% of the papers reported that software engineers were not a distinct group.

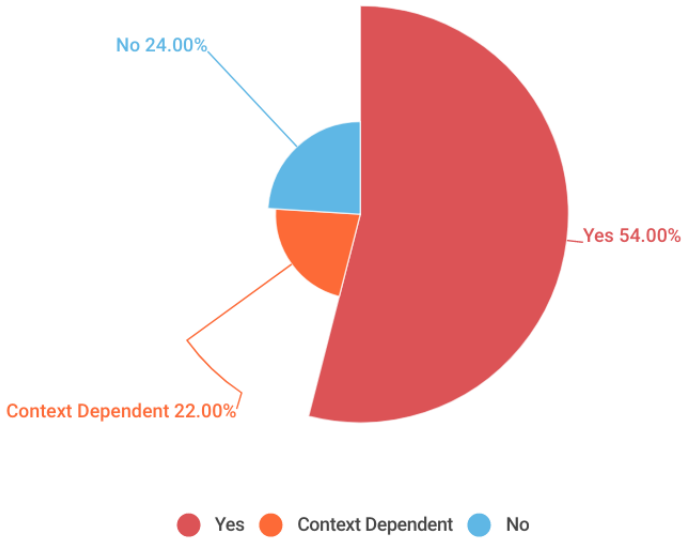

Figure 3.7 – *Software engineers as a distinct group (Beecham, Baddoo et al. 2008)*

This finding leads the researcher to pursue in more detail what it is that distinguishes software engineers from the general population in order to see how augmented reality could develop their sense of belonging. Thus, with respect to software engineers characteristics, Beecham, Baddoo et al. (2008) found that the two themes of variables (Fig. 3.8) that influence these characteristics are *control factors* (i.e. their own personality) and the *moderators* (e.g. job type and culture).

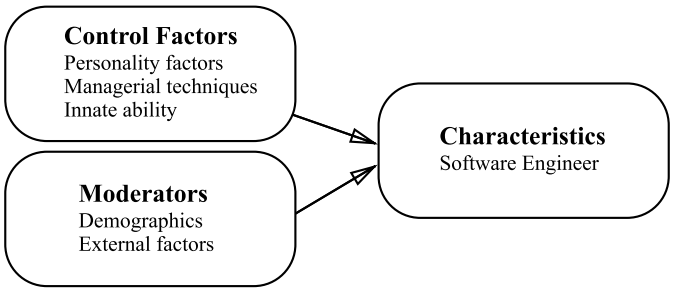

Figure 3.8 – *The influences of a software engineer characteristics (adapted from Beecham, Baddoo et al. (2008))*

In terms of *control factors*, these are mostly related to the individual personality of the person developing software. Ryckman (2012) defined personality as "the dynamic and organised set of characteristics possessed by a person that uniquely influences his or her cognition, motivations, and behaviours in various situations". Thus, in spite of the fact that each individual is unique there needs to exist a standardisation of personalities in order to conclude with a certain degree of dependability that software engineers can be grouped together as distinct from the mainstream population.

A systematic review by Cruz, Silva and Capretz (2015) that synthesised 90 articles from over 19,000 analysed using the Myers-Briggs Type Indicator (MBTI), which according to Furnham (2017) is "without doubt the most widely known and used personality test in the world", found that ISTJ[1] is the most common (24%) personality type among software engineers (Capretz 2003; Cruz, Silva and Capretz 2015). This represents approximately double of the general population (11-14%) (CAPT 2018) and shows that the majority of software engineers, due to their technical orientation, have a preference to work with reason and data instead of people. However, it is crucial to keep in mind that software engineers are still human beings and that even though they prefer to work with machines, the sense of belonging is still fundamental for their well-being.

With respect to *moderators*, they control the strength of the software engineers characteristics. These include demographics and external factors (Beecham, Baddoo et al. 2008). For example, a software engineer might have a characteristic, such as the need to be sociable, which will be contingent on control factors, such as their score on the Myers-Briggs Type Indicator (Furnham 2017). In turn, this need to be sociable will be moderated through contextual factors, for instance, the level of extroversion–introversion of the people in the country where the software engineer lives in.

Nevertheless, the most represented characteristics (Table 3.1) included:
a) introversion;
b) orientation for growth; and
c) autonomy.

The finding that introversion is a prevailing trait associated with software engineers has been corroborated by previous studies (Cruz, Silva and Capretz 2015). Furthermore, the introversion might give a reason for their deficient written and oral communication skills (Jazayeri 2004). However, Beecham, Baddoo et al. (2008) also found that in five studies two of the characteristics of software engineers were the "need to be sociable" and "identify with group/organisation/supportive relationships". This is congruent with the literature findings (Section 3.2) that state that individuals have different levels of social needs, in other words, some people will have the perception that they require more social interaction and therefore will report the need to be sociable as one of their characteristics. On the other hand, a person that has strong family relationships or that has the perception that their social interactions are

[1] ISTJ stands for introversion (I), sensing (S), thinking (T) and judgement (J)

adequate might not need as much social contact and for that reason will not report the need to be social or the identification with the organisation as meaningful from their point of view.

Software Engineer Characteristics	Frequency (# of studies)
Growth orientated	9
Introverted	7
Autonomous	7
Identify with group/organisation/supportive relationships	5
Need for stability	5
Technically competent	5
Need to be sociable	5
Achievement orientated	4
Need for competent supervising	4
Need for challenge	4
Need for variety	4
Need to make a contribution	3
Need for feedback	2
Marketable	2
Creative	2
Need for involvement in personal goal setting	1
Need for Geographic stability	1

Table 3.1: *Software Engineer Characteristics (adapted from Beecham, Baddoo et al. (2008))*

3.3.2 Motivators and Demotivators

The fact that software engineers form a distinct group of individuals (Section 3.3.1) moves the research forward in that it raises the question if the sense of belonging is a motivator for them. The answer to this question is crucial because the research question is concerned with how to develop the sense of belonging with augmented reality. It is important to state that the focus of the motivator factors for software engineers is regarding the work they perform in their organisations. In this case, motivation can be seen as a social process that will determine how software engineers join, stay and perform satisfactorily in an organisation (Huczynski and Buchanan 2010). Beecham (2014) argues that in spite of the fact that motivation is a comprehensively researched topic in the literature, the theories outputted have not been on par with the dynamic field that is software engineering.

Historically, motivation with regards to software engineers was simply seen as a link between the personality of an engineer and its job. This was supported by

the early *Job Characteristics Theory* (Couger and Zawacki 1980) which basically posits that the characteristics of a job will shape the state of mind of the employees which then causes job motivation (Bacha 2014; Kam, V. Shah and S. M. Ho 2017; Oerlemans and A. Bakker 2018). However, as with every human being, software engineers' needs and motivating factors are most certainly more complex than this early theory claims. In fact, a recent study by Beecham and Noll (2015) showed that the most important need for a software engineer is to "identify with their task". This means that when a task is given to a software engineer, it should be not only challenging but also its significance should be made clear so that the software engineer understands the objective of the task in connection to the whole software system that is under development. This is expected, as arguably people are often not motivated by performing meaningless tasks. Moreover, they also found that software engineers are motivated by "regular feedback, trust, appreciation, rewards, a career path and sustainable working hours" (Beecham and Noll 2015). What is more, the same researcher (i.e. Sarah Beecham) also determined in an earlier study (Beecham, Baddoo et al. 2008) that the sense of belonging together with 'working with others' were two of the most important motivators for software engineers (Table 3.2). In the same vein, Petri and Govern (2012) studied motivation and found that social interaction by its very nature could be motivating. The findings of these studies suggest that developing the sense of belonging in software engineers will increase their motivation levels.

Motivators	Frequency (# of studies)
Identify with the task	20
Employee participation/involvement/working with others	16
Good management	16
Career Path	15
Sense of belonging/supportive relationships	14
Rewards and incentives	14
Variety of Work	14
Recognition	12
Technically challenging work	11
Development needs addressed	11
Job security/stable environment	10
Feedback	10
Autonomy	9
Work/life balance	7
Making a contribution/task significance	6
Appropriate working conditions	6
Empowerment/responsibility	6
Trust/respect	4
Equity	3
Working in successful company	2
Sufficient resources	2

Table 3.2: *Motivators in software engineering (adapted from Beecham, Baddoo et al. (2008))*

Conversely, in terms of demotivators (Table 3.3), 'poor communication' (5) in particular with regards to either inadequate feedback or the fact of losing immediate contact with management were reported to be substantial demotivators (Beecham, Baddoo et al. 2008). Surprisingly, the 'lack of influence' was one of the least meaningful demotivators. This is in stark contrast with 'employee participation/involvement/working with others' (Table 3.2) which is reported to be the second most important motivator. There is a strong possibility that this indicates that having the opportunity to influence a decision does motivate the software engineer, but if that opportunity is not given then it will not demotivate them. In addition, this could be connected to the hygiene motivator theory by Herzberg, Snyderman and Mausner (1966) which postulate that removing a demotivator will not inevitably motivate employees. In fact, it will simply prevent dissatisfaction. In this case it will not be possible to completely remove the 'lack of influence' without giving the employee involvement in the decision making. Notwithstanding, currently the

software engineering field is dominated by procedures and a higher need for senior management authorisation (Beecham 2014). Thus, the software engineer might not expect to have influence on decisions which might lead to the result that the lack of influence will not demotivate them.

Demotivators	**Frequency (# of studies)**
Poor working environment	9
Poor management	7
Noncompetitive pay/poor pay/unpaid overtime	6
Lack of promotion opportunities	5
Poor communication	5
Stress	5
Bad relationship with users and colleagues	4
Unrealistic goals/ phoney deadlines	4
Inequity	4
Poor cultural fit/stereotyping/role ambiguity	3
Producing poor quality software	3
Lack of influence/not involved in decision making/no voice	2
Unfair reward system	2
Interesting work going to other parties	1
Risk	1

Table 3.3: *Demotivators in software engineering (adapted from Beecham, Baddoo et al. (2008))*

External signs that have a connection with motivated or demotivated software engineers are listed in Table 3.4. These results would seem to suggest that a motivated software engineer will not only be more likely to remain in the organisation but also that they will be more productive and deliver their projects on time more frequently. Taken together, the evidence from these studies suggest that the sense of belonging is a motivator for software engineers and that it is advantageous for the organisation to have motivated rather than demotivated engineers.

External signs	Frequency (# of studies)
Retention	12
Project delivery time	2
Productivity	5
Budgets	1
Absenteeism	1
Project Success	1

Table 3.4: *External signs of motivated and demotivated software engineers (adapted from Beecham, Baddoo et al. (2008))*

One criticism of much of the literature on software engineers' characteristics and what motivates or demotivates them is that they are subjective and it is not feasible to study every single software engineer. Nonetheless, the motivation theories and factors discussed are crucial to understand because they allow managers to know what motivates a software engineer and with that engage them in their tasks, raise their sense of belonging with the company and colleagues, increase their productivity and ultimately allow them to write higher quality software (Beecham, Baddoo et al. 2008).

3.3.3 Remote Working

The nature of software development is changing due to the advances in technology, in particular with regards to methods of communication, and that is propelling the growth in popularity of remote working (Beecham and Noll 2015).

Having defined and clarified what is a software engineer, the researcher will now move on to discuss the challenges that remote work brings to employees and organisations, the factors that motivate software engineers working remotely and importantly the remote software engineer as an element of a virtual team.

3.3.3.1 Challenges and Opportunities

Working remotely is, on one hand, creating new opportunities for organisations, such as:

1. Enabling workers to be unrestricted from geographic locations (Bayrak 2012);
2. Increase workers productivity by:

a) Preventing distractions and sources of irritation such as commonplace noises or overhearing conversations from others (Cole, Bild and Oliver 2012; Meijer, Frings-Dresen and Sluiter 2009; Sundstrom et al. 1994);

b) Providing additional privacy by allowing workers to not only control incoming stimuli but also restrict outgoing information (Ashkanasy, Ayoko and Jehn 2014);

c) Allowing the individual to control the working environment in order for them not to experience thermal displeasure or poor air quality (Pejtersen et al. 2006); and

d) Avoid open-plan workspaces which have been proven to result in higher levels of distraction, negative relationships and uncooperative behaviours (Morrison and Macky 2017) and are therefore not recommended (Kaarlela-Tuomaala et al. 2009) for professional workers.

3. Reduce costs related to office space (Breaugh and Farabee 2012; McCoy 2005);

4. Achieve greater employee satisfaction (Cole, Bild and Oliver 2012);

5. Access to a wider talent pool (Offstein, Morwick and Koskinen 2010; Miller 2016; McLaughlin 2017); and

6. Attract high-quality applicants (Allen, R. C. Johnson et al. 2013; Thompson, Payne and Taylor 2015).

Equally important, it is also providing benefits for the software engineers that work remotely. These include:

1. Spending more time with their families and have a lower work–family conflict (Rousseau, V. T. Ho and Greenberg 2006);

2. Having reduced or no commuting, saving on time and cost (Kossek and Thompson 2016; McLaughlin 2017);

3. An increased satisfaction, commitment and reduced turnover (Golden 2006a; Hunton and Norman 2010);

4. An eagerness to work harder (Kelliher and Anderson 2010; Gajendran, D. A. Harrison and Delaney-Klinger 2015);

5. An access the labour market if they are disabled (Trades Union Congress 2016); and

6. The ability to manage in a better way the requirements of long working hours (Duxbury and Halinski 2014).

However, on the other hand, this type of work arrangement will introduce new challenges (e.g. geographical distance, social-cultural distance and temporal distance) that were not as critical as when the software engineers are colocated (J. M. Verner, Brereton, B. A. Kitchenham et al. 2014; Ghafoor, I. A. Shah and Rashid 2017). Therefore, putting unprecedented and serious demands on both the software engineers themselves and on organisations that choose to support that type of work arrangement (Ghafoor, I. A. Shah and Rashid 2017). Some of the most critical challenges include:

1. *Ineffective communication* which was found by a recent systematic review of the literature by Ghafoor, I. A. Shah and Rashid (2017) to be the most crucial issue reported. In the 51 papers analysed, 43% of them stated that this was the main issue for software engineers working remotely. As an example, I. Richardson et al. (2012) found that when working remotely managers were incentivised to maintain the interaction between remote coworkers to as low as possible due to difficulties in communication which has negative consequences for team work such as misunderstandings, lack of trust, misalignment of goals, among other issues;

2. *Socio-cultural and language distances* which means that software engineers will have to communicate and work together with individuals that potentially have different culture, values and language (Noll, Beecham and I. Richardson 2010; H. Shah et al. 2012; Monasor et al. 2013; Beecham and Noll 2015). In addition, this communication is highly technical and complex due to the difficulty intrinsic to the development of software;

3. *Temporal distances* which will make the software engineers work in different time zone and that might impose limits on the capability to communicate effectively in real-time with other coworkers (Beecham 2014). This can cause frustration, delays and make the engineers perform their work at unreasonable and anti-social times. Furthermore, it can alienate the software engineers

because they will face the problem of not being able to voice their opinions appropriately since they are not physically present with their colleagues;

4. *Lack of appropriate technology* which causes remote workers to consume more time and effort in communicating with their colleagues (Rousseau, Tomprou and Simosi 2016);

5. *Lack of trust* which arises due to the fact that people might never have met face-to-face. This could pose issues on the quality of the software being developed or the speed of its development as for example engineers could doubt the validity of the code written by another engineer and spend time verifying it (Beecham 2014);

6. *High turnover* which is a probable result of the lack of motivation from the software engineers that work remotely (Holmstrom et al. 2006; Ebert, Murthy and Jha 2008; Hall et al. 2008);

7. *Excessive freedom* which can demotivate software engineers (Fernández-Sanz and Misra 2011).

Taken together, these results suggest that the main issue with working remotely is communication, this is not only because of the ineffectiveness to communicate due to socio-cultural, language or temporal distances but also the inadequate mediums of communication. Thus, it is likely that an improvement in communication can have a positive impact on remote working. In Chapter 3.4 these issues will be evaluated in connection to augmented reality in order to understand if this new technology can help mitigate them.

3.3.3.2 Motivation for Remote Software Engineers

The fact that software engineers are working remotely adds complexity to the motivation theories previously described. Noll, Beecham, Razzak et al. (2017) add that the *Self-Determination Theory* (R. M. Ryan and Deci 2006) is also applicable since remote software engineers are, for the most part, self-motivated. Thus, according to that theory they will need three essential psychological needs to be fulfilled. These are:

1. *relatedness*, essentially the sense of belonging not only to other employees but also the organisation itself;

2. *competence*, the possession of ability and know-how to perform the tasks required by the job; and

3. *autonomy*, the independence to decide and act on those decisions without having to require constant approval.

These were supported by a previous review (Farias Junior et al. 2012) that stated that software engineers that work remotely have to have the capacity for *recognition of cultural differences* and *individuality*. Furthermore, even though these new motivators are developing, the research to date has not been definite regarding the applicability of the already known motivator factors in this new work environment. In spite of that, El Khatib et al. (2013) has shown that if the software engineers working remotely are sufficiently motivated, they will have a crucial impact on the success of a project. By contrast, if the software engineers are demotivated that can cause a project to fail (J. M. Verner, Babar et al. 2014).

Another significant aspect of motivation in the workplace is being promoted, and with regard to this topic R. E. Johnson, C.-H. Chang and L.-Q. Yang (2010) stated that there exists a positive interconnection between affective commitment and being given a promotion. Alternatively, when a software engineer works remotely, they might be left unnoticed or have a lack of a clear career path (Beecham 2014). On the whole, there is a higher need in the remote work environment to give visibility to employees that are working remotely and have not only a clear career ladder for them in the organisation but also provide them with promotion chances.

3.3.4 Virtual Teams

As indicated previously, software engineers working remotely are not in their own silo but rather they work in a virtual team (Peralta et al. 2015). In other words, they work in a group of individuals that have basically a common goal. Additionally, these virtual teams are bound to a particular company rather than working together incidentally (Großer and Baumöl 2017).

Over the past three decades, the teamwork between individuals in a Computer Supported Collaborative Work (CSCW) environment has been examined in the literature (Conklin and Grief 1988). Early it was possible to connect virtual communities with supporting “a social contract” (Sproull and Faraj 1997), “sense of belonging” (Figallo 1998) and “an internal set of social norms” (Burnett and Bonnici 2003). Nonetheless, in a recent article in ScienceDirect, Großer and Baumöl

(2017) questioned the extent to which the virtualisation of work processes have been researched. They argue that the factors that determine the performance of virtual teams have neither been analysed nor structured as they should have been. Nonetheless, in the literature there appears to exist three main factors that influence the collaboration between team members working in a virtual context. These are:

1. *Individual properties* which are concerned with the skills relevant to virtual teamwork (Boughzala 2014; Riedl et al. 2015; Krumm et al. 2016);
2. *Culture* which can be different online and offline, but these differences can in reality lead to a superior performance of the team (Boughzala 2014; Magnusson, Schuster and Taras 2014; Riedl et al. 2015; Cheng et al. 2016); and
3. The extent of *virtuality of the team* (Riedl et al. 2015; Cheng et al. 2016; Krumm et al. 2016).

Frequently, the Computer Supported Collaborative Work is illustrated through a matrix (Großer and Baumöl 2017). This 2-by-2 matrix (Fig. 3.9) consists of two dimensions: (1) *Location* (rows); and *Time* (columns). More specifically, collaboration can occur in the same place (colocated) or in a different place (remote) and at the same time (synchronous) or at different times (asynchronous).

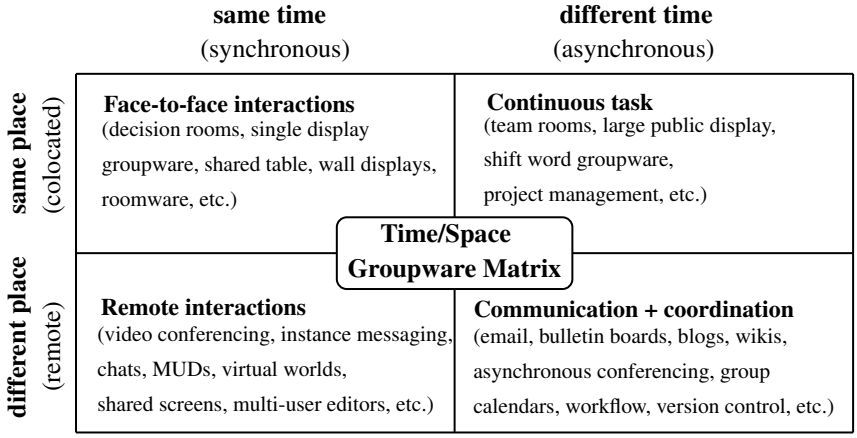

Figure 3.9 – *CSCW Matrix (adapted from Großer and Baumöl (2017))*

As an example, virtual teams are often used when an organisation attempts to cut costs (El-Sofany, H. M. Alwadani and A. Alwadani 2014). However, they expect the virtual teams to work virtually as well as if they are colocated but for the present workforce the face-to-face communication continues to be necessary (Sampath

2014). Furthermore, Großer and Baumöl (2017) in their systematic literature review discovered that the majority of individuals are not knowledgeable enough in order to work in a productive manner in a virtual context. Still, these findings possibly cannot be extrapolated to software engineers, as they more accustomed to work in a virtual environment and are a more tech-savvy demographics (Hong, Y. Kim and G. J. Kim 2017). They can nevertheless, with a fair degree of confidence, be applied to other professions within software development that will need to interact with software engineers (e.g. managers, product owners and stakeholders).

Accordingly, there are in the literature suggestions to best approaches when working in a virtual environment.

Firstly, *communication is complex*. That is, communication is not simply the exchange of words but a more intricate form of transmitting information that also involves nonverbal communication (Mehrabian 2017). In addition, this nonverbal communication is the most common way in which individuals convey feelings. For this reason, there needs to exist a more tolerant acknowledgement of different opinions (Peralta et al. 2015; Minas, Dennis and Massey 2016; Swaab, Phillips and Schaerer 2016).

Secondly, *guideline and conventions* are essential. That is to say, standards and routines have been identified as crucial for adequate communication and the processing of information (Bartelt and Dennis 2014; Morgan, Paucar-Caceres and Wright 2014; Cheng et al. 2016). Included in these standards and routines are the way or manner to communicate, the time to carry out this communication and the tools used to communicate.

Thirdly, *psychic distance*. This was discussed previously regarding the challenges of working remotely, it includes the culture, values, language and different verbal codes that each individual in the team possesses (Schuster 2013). Therefore, in a virtual context there needs not only to exist trust between the team members but also they should support and be open with each other (Hanebuth 2015; Peralta et al. 2015; Cheng et al. 2016). What is more, this perceived disadvantage can be leveraged to having a positive impact due to the fact that as coworkers become more aware of the differences between one another they will have higher awareness towards each other than in a traditional work environment (Magnusson, Schuster and Taras 2014). Thus, there will be an increase in the team performance which was a phenomenon studied by Schuster (2013) and termed the ‘psychic distance paradox’.

Fourthly, *alignment of goals*. When working remotely it will be more challenging to align every employee with the goals of the organisation and the path to achieve these goals (Maynard and Gilson 2014; El-Sofany, H. M. Alwadani and A. Alwadani 2014; Peralta et al. 2015). As a result, communication is essential to give each team member a clear overview of the roles, team structure, processes and details of the goals (Orhan 2014).

Finally, *management involvement*. Recommendations must be given to managers in order for them to be able to guide and facilitate the work of a virtual team. For example, training should be given so that a manager is capable of using the communication technology (Peralta et al. 2015; El-Sofany, H. M. Alwadani and A. Alwadani 2014; Politis 2014). Also, special attention should be given to socio-cultural skills that are substantially more required in the virtual context due to the nonverbal communication (Sampath 2014; Magnusson, Schuster and Taras 2014; Sivunen, Nurmi and Koroma 2016). In essence, the managers and individuals in leadership positions should be able to oversee the performance of the team and motivate them effectively (Dunn et al. 2015; El-Sofany, H. M. Alwadani and A. Alwadani 2014; Fuller and Harding 2015).

3.3.5 Impact of Remote Working on Sense of Belonging

The correlation between remote work and employee well-being has been studied over the last decade and the conclusion has mainly been that "it depends" (Gajendran and D. A. Harrison 2007; Michel et al. 2011; Allen, R. C. Johnson et al. 2013; Giberson and Miklos 2013; Perry, Rubino and E. M. Hunter 2018). There are simply too many factors (i.e. age, gender and virtual work experience) that moderate the level of well-being in software engineers working remotely (Raghuram et al. 2001). However, there are concrete results such as the fact that when employees are working remotely they are at a higher risk of being affected personally by isolation (Thatcher and Zhu 2006; Belle, Burley and Long 2015).

In the particular case of the need to belong, and as it was discussed in Section 3.2, Baumeister and Leary (1995) have found in their exhaustive review of the literature that people have the fundamental need to belong to a wider social group. Moreover, there is a large volume of published studies that state that the need to belong is also present in the workplace (O'Neill, Hambley, Greidanus et al. 2009; Belle, Burley and Long 2015; Colbert, Bono and Purvanova 2016; Perry, Rubino and E. M. Hunter 2018).

In addition, a survey by Raghuram et al. (2001) found that the majority of informants agreed with the statement that they were losing the sense of belonging to the organisation community which could provide them with support and information. This work was recently complemented by Colbert, Bono and Purvanova (2016), where they have stated that remote workers have weaker emotional ties to their colleagues and organisation than employees that work at the company's premises. As a consequence, remote employees will have their need to belong unfulfilled. This lack of belongingness could be associated to the findings of a recent case study by Dery and Hafermalz (2016) involving knowledge workers which found that employees reported (1) feeling 'invisible'; (2) considered it difficult to establish an identity; and (3) had problems having informal communication with colleagues.

3.3.5.1 Invisibility

The issue with invisibility has been raised by a number of studies (Raghuram et al. 2001; Belle, Burley and Long 2015; Dery and Hafermalz 2016). These studies give evidence to the common proverb "*out of sight, out of mind*" (Sewell and Taskin 2015) which illustrates the importance of being visible in order to be perceived. In fact, Belle, Burley and Long (2015) in their phenomenological study have concluded that one of the main issues with being remote was becoming invisible. These results are similar to those reported by Dery and Hafermalz (2016), whom added that not only technology was remarkably important in increasing the visibility of remote employees but also that these employees were keen in using new forms of technology to develop the sense of belonging towards their colleagues and organisation. That is, technology that would increase their visibility, give them a sense of identity and creative ways to communicate informally with their coworkers. Moreover, they stated that the development of sense of belonging was a crucial factor for the success of an organisation that has remote employees.

3.3.5.2 Sense of identity

The loss of the sense of identity is another issue that occurs when employees are physically distant from an organisation. This occurs due to the fact that there is a loss of "organisational referents" which result in a decrease in social support and in turn do not allow the person to form their identity within the organisation (Sardeshmukh, Sharma and Golden 2012; Belle, Burley and Long 2015).

This issue is accentuated by the fact that as a remote worker it is difficult to have

continuity of identity, in other words, others knowing you as you know yourself (Dery and Hafermalz 2016). As an example, one of the employees has reported: "'I don't remember everyone, I can't see them, no one knows me, because, previously being a crucial part of the team, then everyone knows you and respects you and knows your work ethic, but with new people, you have to begin again, you have to go, this is who I am within this organisation, and rebuild your identity, because you lose that". Thus, this person has lost their sense of belonging towards the organisation and her colleagues.

Another finding was that remote workers need a *visual display of identity* (Dery and Hafermalz 2016). These identities, for remote workers, are created with the use of technology, including: online forums, messaging apps and Skype. These are the tools available to not only do work connected communication but also to form social relationships with colleagues. In addition, the research by Dery, Kolb and MacCormick (2014) has determined that remote workers have the desire to create bonds with the organisation and fellow workers not only job-related but also in terms of social bonds. However, it was reported that when a person's online persona (i.e. avatar) is different in appearance to that of them in real life then further distance and disengagement is created between the coworkers.

3.3.5.3 Lack of informal communication

Finally, there was the necessity of having *informal communication* with coworkers. This was reported to be the most important way for remote workers to develop the sense of belonging with not only the company but also their colleagues (Dery and Hafermalz 2016). In fact, without the casual and more intimate forms of communication the sense of self and belonging in connection to the company decreased and conversely the risk of social isolation increased.

This lack of informal contact results in the loss of an intimate connection to the organisation (Belle, Burley and Long 2015). This view is supported by Heller (1989) who added that this type of communication is necessary in community to form "social ties that draw people together".

In addition, there is evidence that the fulfilment of the sense of belonging does not require face-to-face interaction and it can be satisfied outside of the workplace by strong family or friend ties (Perry, Rubino and E. M. Hunter 2018). Nonetheless, a decreased level of satisfaction and performance has been associated with a lack of

social relationships with colleagues at work (Golden 2006b; Golden, Veiga and Dino 2008; O'Neill, Hambley, Greidanus et al. 2009; Peters et al. 2016).

3.4 Augmented Reality

3.4.1 Technologies

The *hardware* for augmented reality consists in the majority of cases of a display, processor, sensors, input/output devices and software (X. Li et al. 2018). These systems might include (Chicchi Giglioli et al. 2015; Alakärppä et al. 2017): Global Positioning System (GPS); built-in cameras; accelerometers; solid state compasses; and internet connectivity. These components support the augmentation of the real-world with dynamic, context-aware, and interactive digital information (Alakärppä et al. 2017). In consequence, enabling the user to interact with virtual objects in the physical world and with that enhancing their perception of reality (Hugues, P. Fuchs and Nannipieri 2011; C.-H. Chen, Chou and C.-Y. Huang 2016). This results in an intuitive approach to give the user not only contextual but also location-specific perceptual overlay (Alakärppä et al. 2017). Moreover, augmented reality can be applied to multiple senses and sensations such as visual, auditory, haptic, somatosensory, olfactory and gustatory (R. Azuma, Baillot et al. 2001; Narumi et al. 2011; Schmalstieg and Hollerer 2016; Bermejo and Hui 2017; Roggeveen and Sethuraman 2018). As an example, in the figure 3.10 a user with an Head Mounted Display (HMD) with an integrated vision, olfaction and gustation system is tasting different augmented reality flavoured cookies whereas in reality he is eating a plain cookie. The result was that the users experienced a change in taste even though there was no change in the properties of the real cookie they were tasting.

Figure 3.10 – *User tasting augmented reality cookies (Narumi et al. 2011)*

In terms of *equipment*, Palmarini et al. (2018) in their systematic review of augmented reality applications grouped the hardware used for augmented reality into six types:

1. Head Mounted Display (HMD);
2. Hand Held Display (HHD) which includes mobiles and tablets;
3. Desktop PC;
4. Projector;
5. Haptic - through touch; and
6. Sensors.

Furthermore, figure 3.11 lists the state-of-the-art devices that are currently available in the market. From these, the Head Mounted Display are the most advantageous for augmented reality (Palmarini et al. 2018) due to their mobility and the capacity to overlay computer-generated information (i.e. virtual elements) before the eyes. However, they have the disadvantage of a limited Field of View (FoV) and might be uncomfortable to wear for long periods of time.

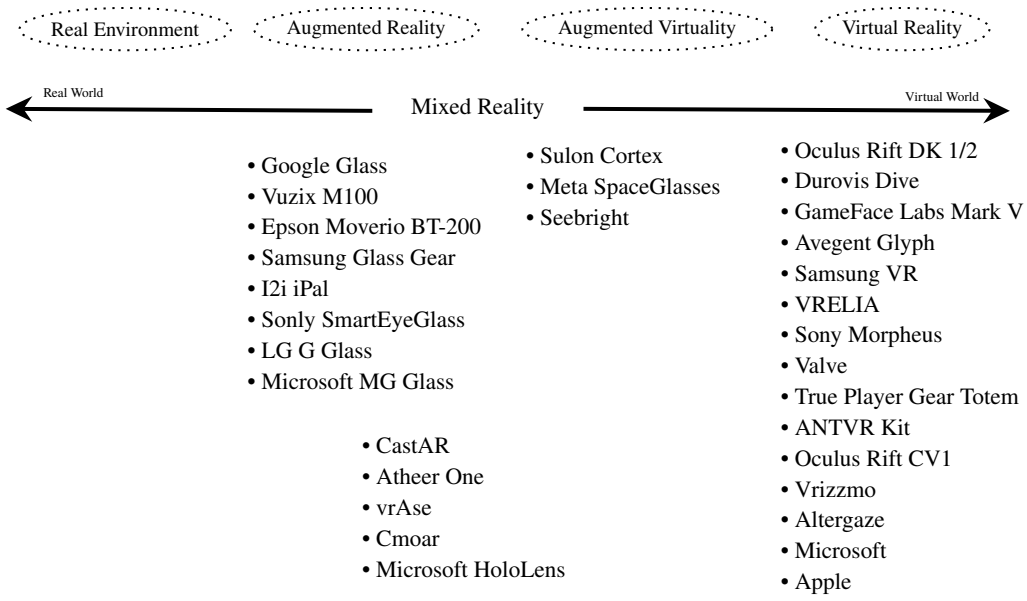

Figure 3.11 – *Off-the-shelf AR/VR Systems and Technology Providers (adapted from X. Li et al. (2018))*

With respect to *interaction methods* they can be divided into four types (Palmarini et al. 2018):

1. Text;
2. Audio;
3. Static 2D/3D; and
4. Dynamic 2D/3D.

As far as *software* is concerned, there are fundamentally two types of system used: marker-based and markerless systems (Chicchi Giglioli et al. 2015). On one hand, in the case of augmented reality using a *marker-based system*, it will use the camera to detect a black and white picture which will be overlaid with the virtual content (Fig. 3.12). On the other hand, the *markerless system* will use the positioning sensors (e.g. global positioning system, accelerometers and solid state compasses) to overlay the virtual objects in a precise position on the physical environment.

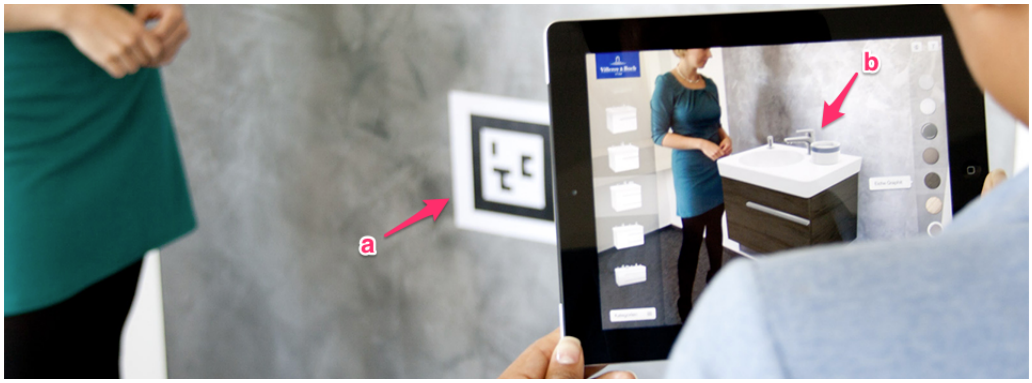

Figure 3.12 – *Marker-based system where a) the marker and b) the superimposed virtual object can be observed (adapted from Villeroy & Boch (2018))*

With regards to the *technological characteristics*, there are mainly three types of augmented reality (B. Kim, C. Kim and H. Kim 2011; Yeh, Tsai and Kang 2012; Dong, Feng and Kamat 2013; X. Li et al. 2018). These are:

1. *Tangible augmented reality*, which consists in the use of real world objects as interfaces in order to manipulate virtual elements (Dong, Feng and Kamat 2013);
2. *Collaborative augmented reality*, where users interact, in common with others, with real objects and virtual elements in a shared space (B. Kim, C. Kim and H. Kim 2011); and
3. *Distributed augmented reality*, which has the aim of allowing users in separate locations to engage in interaction with one another in an augmented reality environment by taking advantage of high-speed internet connection (Yeh, Tsai and Kang 2012).

With regards to the least possible capability of augmented reality systems in order to provide the user with an immersive experience there are basically three main characteristics that the system needs to possess (X. Li et al. 2018):

1. *High frame rate* of at least 95 frames per second. This is substantially higher than for example film cameras which have typically a frame rate of 24 fps (T. Ryan 2017; Benovsky 2017);

2. *Low latency* which in essence means that there should not be major delays in the whole system (e.g. processing data, overlaying virtual objects and update the user location); and

3. *Low pixel persistence* with an upper limit of 3 milliseconds. That is, the time that it takes the display to show the pixels should not be higher than 3 ms. The reason being that a pixel persistence higher than 3ms will result in motion blurring which in turn will cause motion sickness (Curcio, Dipace and Norlund 2016).

3.4.2 Applications

Augmented reality has been applied in multiple fields such as: entertainment (Ozbek, Giesler and Dillmann 2004; Dickinson et al. 2011), maintenance (Schwald and De Laval 2003; Henderson and Feiner 2011), architecture (Grasset, Decoret and Gascuel 2001; W. Zhou, Whyte and Sacks 2012), education (Kerawalla et al. 2006; Arvanitis et al. 2009; Sampaio et al. 2010), engineering (Bahn 2013), heritage and archaeology (Remondino and Campana 2014), medicine (De Buck et al. 2005; Cannon et al. 2014; Calle-Bustos et al. 2017), cognitive and motor rehabilitation (Assis et al. 2016; Hondori et al. 2013), and so forth.

Having listed the areas that have been using of augmented reality systems, let us now consider a few examples of current applications that are available in the market with augmented reality capabilities that could lead to conclusions regarding the development of the sense of belonging.

A useful example of a hand held display with a dynamic 3D interaction method and a markerless system is the iOS application *magicplan* (Sensopia 2018). It allows for the creation of professional floor plans using augmented reality (Figs. 3.13-3.14) and works by adding a perceptual overlay that allows the user to point to the corners of a room and with that create a floor plan.

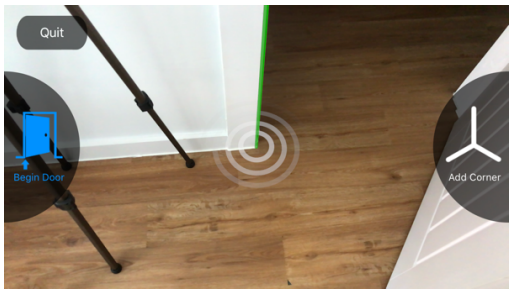

Figure 3.13 – *Magicplan app targeting a corner with an overlay indicator (Sensopia 2018)*

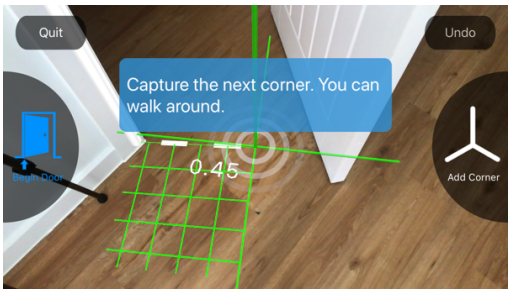

Figure 3.14 – *Magicplan app with the user moving away from the first corner with a grid overlay (Sensopia 2018)*

Another example of the application of augmented reality, that is currently being used, is augmented reality furnishing. IKEA has built an iOS application titled IKEA Place (IKEA Systems B.V. 2018) that allows the user to place virtual furniture in their real room environment (Figs. 3.15-3.16). In this example, the chair is a virtual object that is added as an overlay to the physical kitchen. The virtual chair remains in place even when the user moves the smartphone.

Figure 3.15 – *Augmented reality furnishing with IKEA Place iOS app (IKEA Systems B.V. 2018)*

Figure 3.16 – *Augmented reality furnishing with IKEA Place iOS app (IKEA Systems B.V. 2018)*

An exceptionally recent example is the project “Soccer On Your Tabletop” (Rematas et al. 2018a). This system uses a Head Mounted Display, in this case the Microsoft HoloLens, to render the players and football field in an interactive 3D visualisation 3.17. It is currently a prototype, but the demo (Rematas et al. 2018b) is already functional.

Figure 3.17 – *Project "Soccer On Your Tabletop" rendering from a YouTube video into an interactive 3D visualisation (Rematas et al. 2018a)*

This section so far has introduced augmented reality, its technologies and a number of applications being used. The fact that these applications shown are not related to the workspace is due to the lack of augmented reality solutions for collaboration between colleagues at work. The following section (Section 3.4.3) will discuss the concept of *presence* which emerged during the literature review as being promising in terms of developing the sense of belonging with augmented reality. Furthermore, an example of a possible workplace use of augmented reality will be given in Section 3.4.4.

3.4.3 Presence

It is practically certain that in order to develop the sense of belonging towards colleagues or organisations one has to be present in one way or another. As a consequence, it is imperative to assess the literature with regards to the formation of presence with augmented reality. Historically, and prior to the work of Minsky (1980), the concept of existing remotely in a location other than the one your body is present was largely unknown. In fact, Minsky has stated that his work was based in the prophetic science fiction novel "Waldo" (Heinlein 1942) which presented a primitive notion of this concept.

3.4.3.1 Telepresence and telexistence

Minsky termed *telepresence* the concept of a human having an immersive experience of 'being there' when operating a robot remotely. At the same time in Japan, S Tachi (1980) was introducing the concept of *telexistence*. Both these concepts are similar in their fundamentals with the exception that telepresence does not include the existence of a person in a virtual environment nor their existence in the physical world with the help of a virtual environment (Susumu Tachi 2015). That is, telexistence is the notion regarding the technology that allows its user to have a real-time sensation of being at a remote location (i.e. a place where their physical body is not present)

and at the same time enable them to interact with this remote environment. This interaction can take place in a remote context that can be a virtual, real or mixed environment (Susumu Tachi 2009).

In spite of the fact that these terms are still in use in the literature, the terms telepresence or telexistance will be simplified in this paper and referred simply as *presence* (i.e. sense of "being there" with others (Blascovich 2002b; Slater and Steed 2002)) in a remote context. This remote presence can, in addition, be divided into three components (Schubert, Friedmann and Regenbrecht 2001): (1) spatial presence, (2) involvement, and (3) realism. Each of these constituents will be discussed, among other concepts connected to presence, in the following paragraphs.

3.4.3.2 Copresence and social presence

The key issue with the previous explanations of telepresence or telexistence is that they lack the concept of social interaction. In other words, when presence was discussed in the literature it was, for the most part, the solitary experience of a single user interacting with a remote environment. This lead to the creation of the terms *copresence* and *social presence* which refer to the same concept of interacting in a remote context, but this time with other humans involved as well (Skarbez, Brooks Jr and Whitton 2017).

However, the concept of *copresence*, is not exclusive of technology and has existed in sociology since 1930s (Mead 1934; Cooley and Angell 1956; Erving 1963) where it was used to term people interacting with each other face-to-face in the physical world (Zhao 2003). Thus, copresence can be defined in any context as "a condition in which instant two-way human interactions can take place" (Zhao 2003). In short, "being there together" (De Greef and W. IJsselsteijn 2000; Schroeder 2002a).

On the other hand, the term *social presence* was introduced by J. Short, E. Williams and Christie (1976) in their book 'The social psychology of telecommunications'. It is a similar concept to copresence, in that it is connected to the interaction between humans in a remote context, but more with regards to "when one person feels another person is 'there"' (Bull 1983) rather than "being there together". More specifically, it can be seen as "the perception of a medium's ability to connect people" (Nowak and Biocca 2003) or "perceptual illusion of non-mediation" (Lombard and Ditton 1997). Nevertheless, social presence and copresence are terms frequently used interchangeably due to their considerable overlap (Blascovich 2002a; Bailenson et al. 2005; Skarbez, Brooks Jr and Whitton 2017). In fact, in a study investigating social

presence, Biocca, Harms and Gregg (2001) have determined empirically that there were three theoretical dimensions for social presence (Fig. 3.18). These were:

1. Copresence;
2. Psychological involvement; and
3. Behavioural engagement.

They have also complemented previous definitions of social presence by describing it as "the moment-by-moment awareness of the copresence of another sentient being accompanied by a sense of engagement with the other" (Biocca, Harms and Gregg 2001). That is, in order for a user to have the sense of social presence, they require more than simply copresence. In fact, psychological involvement reflected for example with empathy and behavioural engagement shown in the interaction between people in a remote context are crucial for the user to perceive social presence.

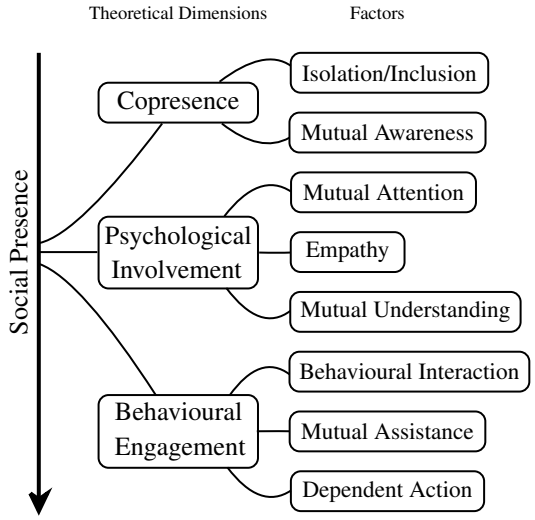

Figure 3.18 – *Factor structure of the Networked Minds social presence measure (adapted from Biocca, Harms and Gregg (2001))*

Finally, it is crucial to draw the line between a medium that supports the illusion of copresence and social presence but does not offer a quale of a person being in a different location. As an example, when speaking on the mobile phone with another person there exists "a strong sense of 'being with them' but not of being in the same place as them" (Slater, Sadagic et al. 2000).

3.4.3.3 Realism

Realism is defined by Alexander et al. (2005) as "the extent to which the virtual environment emulates the real world". This is a concept that at first glance appears vital for the sense of presence since it is thought that the higher the fidelity that a mixed reality environment can present the higher perception of 'being there' the user might have. However, it has been proven that in an unrealistic environment it is possible to create a strong feeling of immersion and also that in a environment with a high level of fidelity to have low immersion (Skarbez, Brooks Jr and Whitton 2017). In fact, Reeves and Nass (1996) stated that "fidelity of visuals have no impact on user attention, recognition, or subjective experience". This suggests that augmented reality would not need to provide high fidelity in order for the user to have the experience of presence. Thus, the main objective with realism will be to give the user just enough 'reality judgement' (i.e. belief that the user's experiences are genuine in existence) in order form them to have the sense of presence (Rosa María Baños, Cristina Botella, Alcañiz et al. 2004).

3.4.3.4 Embodiment and ownership

Several definitions of embodiment have been proposed. One of the earlier ones, in connection to mixed reality environments, was proposed by Benford et al. (1995) stating that it consists of giving a user a "body image to represent them to others (and also to themselves) in collaborative situations". This view is supported by Gabbard (1997), however, Blanke and Metzinger (2009) and Kilteni, Groten and Slater (2012) suggest that it is more than simply assigning an image of a body to the user in a virtual context, arguing that it is in fact a quale. That is, Blanke and Metzinger write that embodiment is "the subjective experience of using and 'having' a body". De Vignemont (2011) applied logical form to illustrate this perception in a clearer way: "E is embodied if and only if some properties of E are processed in the same way as the properties of one's body".

With regards to ownership, it is the "sense that a body (or body part) is one's own" (Skarbez, Brooks Jr and Whitton 2017). Ownership directly relates to embodiment, as without the subjective perception of having a body feeling that one owns it will not be possible (De Vignemont 2011).

3.4.3.5 Self-presence

Ultimately, the experience of having a body and feeling that one owns it should give rise to the sense that one is physically present in a remote context. Accordingly, Wirth et al. (2007) proposed that the experience of spatial presence is attained as a consequence of a two-level process. That is, (1) the user creates a mental model of the perceived environment (e.g. acknowledges that what they are perceiving is a space) and then (2) accepts that this space is in fact where they are situated (e.g. this space is their primary frame of self-reference). The study by Balakrishnan and Sundar (2011) offers probably the most comprehensive empirical analysis of this framework, confirming its validity and adding that the capacity to move in this mediated environment was essential for the user to experience the sense of presence. In addition, the survey by Skarbez, Brooks Jr and Whitton (2017) has found that the feeling of self-presence is directly connected to embodiment and ownership. Furthermore, Biocca (1997) has stated that this sense includes not only the body itself but also "physiological states, emotional states, perceived traits, and identity".

3.4.3.6 Involvement and engagement

Having discussed how to construct presence in a remote context, it is imperative to consider the implications that this has on the user. Involvement and engagement are two possible results, these are a psychological state that result of "focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (Witmer and M. J. Singer 1998).

Cummings and Bailenson (2016) conducted a meta-analysis of the effect of immersive technology on user presence which determined that on one hand a user might sense they are present in a virtual environment but at the same time be disengaged and not participating cognitively. On the other hand, there are cases where a user is cognitively involved but not present (e.g. reading a novel or watching a movie). Therefore, as Witmer and M. J. Singer (1998) pointed out, the level of involvement or engagement will depend upon the "degree of significance or meaning that the individual attaches to the stimuli, activities, or events".

3.4.3.7 Flow

In the case of a person being completely involved in a task or activity that ignores all other stimuli it is said they are in a state of flow (Csikszentmihalyi 2014). That is, an

optimal state of concentration to which Novak, D. L. Hoffman and Yung (2000) has found that presence is a contributing factor.

Having analysed presence and its most relevant components, the researcher will now move on to discuss the state-of-the-art technology that appears to bring this theory together: *holoportation* (Orts-Escolano et al. 2016).

3.4.4 Holoportation

This is a complete augmented reality presence system that attempts to give users the perception of presence with the help of the freedom to move in space, gestures, and body language (Orts-Escolano et al. 2016). In addition, they argue in their paper that even though the communication technologies have evolved they are still far from allowing for a person to perceive that they are physically 'there'.

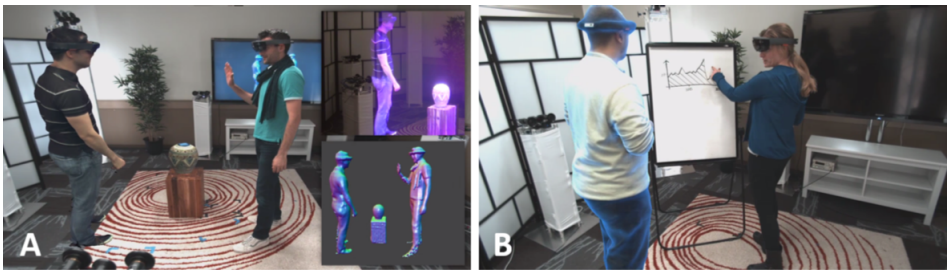

Figure 3.19 – *Applications of Augmented Reality using Microsoft's HoloLens; a) one-to-one communication and b) business meeting (adapted from Orts-Escolano et al. (2016))*

Holoportation is a technology that is an improvement in comparison to other attempts into an immersive 3D type of presence (Kuster et al. 2012; Beck et al. 2013; H. Fuchs, Bazin et al. 2014; Sime and Themelis 2018) for the reason that it provides a "new end-to-end immersive system for high-quality, real-time capture, transmission and rendering of people, spaces, and objects in full 3D" (Orts-Escolano et al. 2016). They were able to achieve this result by using the latest technology combined with software that allows for low latency, support true motion, real-time high-quality image capture and new interactive capabilities among other improvement. The mobility that holoportation offers is a key feature that other systems do not possess (Gibbs, Arapis and Breiteneder 1999; W.-C. Chen et al. 2000; Maimone and H. Fuchs 2011; Benko, Jota and Wilson 2012; Zhang et al. 2013; Pejsa et al. 2016) due to the manner in which the capture of the images occur. In spite of the fact that there were systems (Gross et al. 2003; Beck et al. 2013) that offered mobility, these had the limitation that would not allow for remote users to be in the same location as

the physical user due to working with stereoscopic projection (Orts-Escolano et al. 2016).

In addition to mobility, physical props are another crucial component of collaboration in a mixed reality environment (Luff and Heath 1998). Thus, in the holoportation system the researchers created the ability to add not only people in the augmented reality context but also furniture, props and even animals (Orts-Escolano et al. 2016).

Orts-Escolano et al. (2016) have reported, in their limited lab study with 10 participants, that on the whole the participants demonstrated a perceived feeling of colocation and social presence with the remote users, resulting in seamless interaction. As an example, one of the participants stated that holoportation was "way better than phone calls. [...] Because you feel like you're really interacting with the person. It's also better than a video chat, because I feel like we can interact in the same physical space and that we are modifying the same reality". Moreover, it was reported a strong perception of "interpersonal space awareness". This is exemplified by the fact that the people who took part in the study have demonstrated body language (i.e. non-verbal indicators) which are conventionally seen on physical face-to-face communication such as using body signs to communicate or leaning towards one another. One participant stated: "It made me conscious of [my own image]", while another reported "[the best thing was] being able to interact remotely and work together in a shared space". Therefore, having a common space and interacting with each other has allowed the participants to have an improved and more instinctive way of communicating. Further evidence was given by a participant explaining "I'm a dancer [...] and we had times when we tried to have Skype rehearsals. It's really hard, because you're in separate rooms completely. There's no interaction, they might be flipped, they might not. Instead with this, it's like I could look and say 'ok, this is his right' so I'm going to tell him move it to the right or towards me". In addition, the participants reported feeling the presence of another human being in the same room as them when using the augmented reality headset: "In the AR it felt like somebody was transported to the room where I was, there were times I was forgetting they were in a different room".

In addition, it is important to note that this study was conducted by Microsoft Research which is the company developing the HoloLens (Microsoft Research 2018) and took place under an extremely complex setup. Thus, unfeasible to reproduce in a real world scenario.

3.4.5 Correlation between augmented reality and sense of belonging

As indicated previously, augmented reality has multiple applications which are used to blend seemingly the physical with the virtual reality (Milgram and Kishino 1994). Notwithstanding, when it comes to psychological well-being, a very limited number of applications were developed (Baus and Bouchard 2014; Chicchi Giglioli et al. 2015). Regenbrecht et al. (2017) argues that in the majority of augmented reality applications, it would be beneficial for the person using augmented reality that they are unable to tell the difference between what is real and what is virtual. In other words, the immersive experience will be enhanced if the user perceives both virtual and reality to form a single reality.

On one hand, one manner in which this can be achieved is by producing virtual overlays that look realistic to the user. An example of this is BurnAR (Weir et al. 2012), a demonstration of augmented reality where the user sees through a Head Mounted Display that their own hands are burning (Figs. 3.20-3.21). In this instance, it is crucial that the virtual flames and smoke are merged seamlessly with the real hands of the user so that they are seen as one reality. Interestingly, it was reported that a number of users have reported that they felt their hands warming (Weir et al. 2013). Thus, the perceptual overlays in the mixed reality environment can induce an involuntary perception in other sensory pathways.

Figure 3.20 – *User with a head mounted display perceiving his hands burn (Weir et al. 2012)*

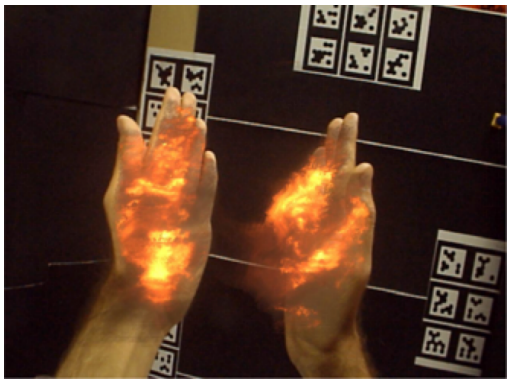

Figure 3.21 – *User's hands with the flames perceptual overlay (Weir et al. 2012)*

On the other hand, it is also possible to decrease the quality of the real world in order to match the quality of the virtual objects. Fischer, Bartz and Straber (2005) presented this novel approach (Figs. 3.22-3.23) more than a decade ago and concluded that users consistently regarded the stylized augmented reality system (Fig. 3.23) as having a higher level of immersion than regular augmented reality. What is more, they were

able to create mixed realities where the users were not capable of recognising real objects from virtual ones.

Figure 3.22 – *Regular augmented reality (Fischer, Bartz and Straber 2005)*

Figure 3.23 – *Applying 'cartoon-like' stylized augmented reality (Fischer, Bartz and Straber 2005)*

As an example, one of the first augmented reality applications with implications to the mental health was one conducted by C Botella, Banos et al. (2005). These researchers studied the effect of augmented reality in connection to microzoophobia (i.e. fear of small animals), in particular, spider and cockroach phobia. Since then a number of studies have broaden the scope of mental health issues under research including, for example, acrophobia (i.e. fear of heights) (C Botella, García-Palacios et al. 2007), anxiety disorders (B. K. Wiederhold and M. D. Wiederhold 2005), Post-Traumatic Stress Disorder (PTSD) (Rosa María Baños, Guillen et al. 2011; Cristina Botella et al. 2015), eating disorders (Perpiñá et al. 1999), tobacco addiction (Girard et al. 2009) and alcoholism (Bordnick et al. 2008). In addition to pathologies, mixed reality has also been investigate in connection to human well-being (A. Li et al. 2011; Rosa M Baños et al. 2013; Serino et al. 2014). A positive correlation was found in all the studies between the mixed reality exposure and higher efficacy of the treatments, resulting in benefits for the patients.

At the same time, a number of studies evaluated the level of presence that was achievable with an augmented reality system with the purpose of the treatment of mental health issues (Juan, Alcaniz et al. 2005; Juan, R. Baños et al. 2006; Juan and Pérez 2010; Bretón-López et al. 2010; Juan and Calatrava 2011; Juan and Joele 2011; Wrzesien et al. 2013). Respondents of these studies reported not only a high degree of presence but also a significant attribution of reality to their experiences (i.e. reality judgement). All these studies reviewed so far with regards to

augmented reality in connection to mental health, however, suffer from the fact that there was a small number of respondents and that the measurement of presence is subjective, i.e. mainly based on the questionnaire ITC-Sense of Presence Inventory (ITC-SOPI) (Lessiter et al. 2001). Nonetheless, Giglioli et al. (2015) stated that augmented reality had a higher level of sense of presence engagement in comparison to pictures.

Such approaches, however, have failed to address the development of the sense of belonging with the use of augmented reality. A relatively recent application that allowed to study the sense of belonging in connection with augmented reality was Pokémon Go (Niantic, Inc. 2016). This is a location-based game that overlays virtual Pokémons on the physical world and allows the players with the use of their smartphones to find, capture and collect them (Dorward et al. 2017). Vella et al. (2017) explored how the mobile game Pokémon GO facilitated social connectedness. The result was that, in fact, players developed a sense of belonging when using the augmented reality application. One major drawback of this study, however, was the limited number of people interviewed (N=15).

Nevertheless, most studies in the literature with regards to augmented reality in connection to the sense of belonging have mostly focused on the education sector. A positive correlation was found between augmented reality and sense of belonging in a learning environment (Wu et al. 2013; Bacca et al. 2014; Management Association 2018). In particular, it was reported that learners using augmented reality felt a sense of belonging when they collaborated with the other students. In addition, the respondents stated that they were mindful of the other people in the mixed reality environment as if they were sharing the same space with others (Bronack 2011; Khan and Umair 2017; Management Association 2018). These studies were built on previous studies which posited that the development of trust and sense of belonging were a necessity in order for the students to successfully learn in groups (Hudson-Smith 2002; Jakobsson 2002). In fact, in their systematic review of literature (32 studies), Bacca et al. (2014) found that the advantage of using augmented reality in education included motivation, interaction and collaboration between students. The limitations that they found were mainly technical (e.g. keep the virtual overlays in place) and the fact that augmented reality is an intrusive technology which lead to students giving an excessive amount of attention to the virtual elements.

Chapter 4

RESULTS & ANALYSIS

The following part of this paper moves on to present the results of this research. As this is a meta-synthesis review of the literature, the qualitative data analysis will develop from the raw data to an explanation, comprehension and interpretation of the results found in the studies investigated.

4.1 Sense of Belonging

This paper started by exploring the sense of belonging. The aim with the literature review regarding that concept was threefold. Firstly, understanding the origins of the sense of belonging. Secondly, explore the theories of motivation in order to ascertain if according to them the sense of belonging is a human motivator. Thirdly, determining the implications of that it has on the mental health of a human being.

4.1.1 Fundamental Human Need

It was found that the sense of belonging was part of to the lower order needs of the most recognised and reputable theories of motivation. Belonging in Maslow's theory (Maslow 1943), Relatedness in Alderfer's theory (Alderfer 1967), Affiliation in McClelland's theory (McClelland 1965) and Hygiene factor in Herzberg's theory (Herzberg et al. 1968). Hence, it could conceivably be hypothesised that the need to belong is a fundamental human need analogous to the need for food or shelter, albeit less powerful than those subsistence needs. That is, if an individual is lacking food, that need will take precedence over the need to belong.

4.1.2 Motivator

A positive correlation was found between the sense of belonging and motivation for behaviour. In fact, the most acclaimed theories of motivation have, in one form or another, belongingness as one essential pillar of human motivation.

4.1.3 Implications to Mental Health

With regards to the implications for the mental health, it was found in the literature that the lack of belongingness has considerable ill effects. These include a poorer sleep quality, anxiety, depression and a higher risk of suicide among others (Cacioppo,

Hawkley and Berntson 2003; Heinrich and Gullone 2006; Cacioppo and Patrick 2008; Lam and Lau 2012). One unanticipated finding was that loneliness is essentially the "perception of social isolation" (Holt-Lunstad et al. 2015). This finding has important implications for developing the sense of belonging, since it became clear that ultimately what needs to occur, for the individual to experience belongingness, is that they need to perceive it psychologically. In other words, augmented reality is only required to develop the perception of the sense of belonging in order for the individual to feel that they belong.

Overall, the results with regards to the sense of belonging indicate that it is not only a human need but also a crucial motivator for human behaviour. The next section, therefore, moves on to discuss the topic of software engineers,

4.2 Software Engineers

In the literature review regarding software engineers, this paper has focused on identifying their particular characteristics (Section 3.3.1), motivators and demotivators (Section 3.3.2) and the implications of software engineers working remotely (Section 3.3.3).

4.2.1 Characteristics

With respect to the software engineers' characteristics, the first objective was to determine if software engineers differ from the mainstream population. This was essential to discover, since in the case they were not then the research question could be expanded to include a wider group of individuals. Primary research conducted by Capretz (2003) (N=100) identified that software engineers were a separate group of people as a result of the a higher percentage of introverts in the field. This finding is consistent with that of Beecham, Baddoo et al. (2008) and Cruz, Silva and Capretz (2015) who conducted a systematic review of the literature with 92 and 90 studies respectively concluding that in the majority of papers reviewed software engineers were considered a singular group with similar needs. Nonetheless, they have acknowledged that the individual context, dependent on the control factors and the moderators of each person, will also have an influence in that conclusion. Thus, these results need to be interpreted with caution. However, they suggest that software engineers in general have a predominant personality type (i.e. introversion) and that should be taken into consideration when developing their sense of belonging with augmented reality.

4.2.2 Motivators and Demotivators

On the question of motivators and demotivators, it was decisive to determine if belongingness was a motivator for software engineers. For the reason that in the case of sense of belonging being a demotivator or simply not a motivator, then it would be futile to try and develop it with augmented reality because it would not benefit the organisation nor the employee. However, in the case of the sense of belonging being a motivator then it would imply that developing it would be beneficial since being a motivated software engineer is more desirable than being a demotivated one. Surprisingly, the sense of belonging was found to be one of the most important motivators for software engineers just second to the identification with the task (Table 3.2). This finding suggests that developing the sense of belonging is remarkably important if an organisation desires to increase the motivation level of their software engineers.

In terms of demotivators (Table 3.3), the results of the literature review indicate that poor communication and a bad relationship with colleagues are factors that demotivate software engineers. Thus, in the case that augmented reality being able to develop the sense of belonging it could also potentially improve the communication and connection to colleagues. As a result of the fact that by developing the software engineers' sense of belonging it will increase their affinity towards colleagues and the organisation, therefore, it could be assumed that as a consequence communication will also improve.

4.2.3 Remote Working

In order to assess the impact of remote working on software engineers' sense of belonging, it was necessary to understand this type of work arrangement. In particular, the challenges and opportunities that come with it, the factors that motivate software engineers in a remote context and how the collaboration occurs between software engineers and other team members in this virtual environment.

4.2.3.1 Challenges and Opportunities

As was pointed out in the literature review section concerning opportunities that remote working brings (Section 3.3.3.1), it was found that there were mutual benefits for both the organisation and the software engineers in this type of work arrangement. These benefits, served to confirm the fact that remote working is a viable type of work arrangement and there is a strong possibility that it will continue to gain popularity

as technology evolves.

However, the most significant findings in the literature relevant to answer the research question were the challenges that remote working creates. That is, it was found that the themes connected to distance were the ones that recurred the most throughout the data in the literature analysed. In general, these challenges could be grouped into geographical distance, social-cultural distance and temporal distance. Therefore, one possible implication of this is that technology (e.g. augmented reality) could help in reducing the perceived distance that remote worker have to their colleagues and organisation.

In addition, there were specific issues which the researcher suspects that the use of augmented reality could be a reasonable approach to tackle in order to develop the sense of belonging. These issue were:

1. Ineffective communication which has been found to be the most crucial concern when employees work remotely (Ghafoor, I. A. Shah and Rashid 2017). Since most communication is nonverbal (Martin and Nakayama 2013), augmented reality could be used to promote the use of nonverbal communication in order to make the communication more efficient;
2. Socio-cultural and language distances is another challenge that would benefit from not only nonverbal communication but also technology that would allow for the interpretation of body language or behaviours;
3. Lack of appropriate technology is a concern that could be solved by augmented reality if it is proven that it offers a better way of communicating;
4. Lack of trust could be address if augmented reality would provide the same perception to the user as if they were meeting face-to-face in the real world;
5. High turnover could be reduced if augmented reality was able to develop the sense of belonging of the software engineers; and
6. Excessive freedom is an issue that augmented reality could address if software engineers were working in a mixed reality context synchronously.

4.2.3.2 Motivation for Remote Software Engineers

In spite of the lack of literature with regards to the motivational factors of remote software engineers, it was possible to find that there were some studies that corroborate

the findings of a great deal of the previous work concerning the motivation of colocated software engineers (Beecham 2014). In particular, the fact that remote software engineers have the need of relatedness which needs fulfilment. These findings may be somewhat limited by the insufficiency of research in this area, thus, further research should be undertaken to investigate the motivating factors for software engineers working remotely.

A finding that was inferred regarding motivating software engineers working remotely was connected to progressing in the career ladder. That is, employees that work remotely lose their sense of belonging in the organisation due to their lack of visibility. Thus, an area where augmented reality can help is by increasing the visibility of the remote software engineers within the organisation and amongst their colleagues. By doing that, it could be argued that their motivation would increase along with opportunities for promotion.

4.2.3.3 Virtual Teams

In spite of the fact that virtualisation of work processes is needing further research (Großer and Baumöl 2017), it was possible to find in the literature that sense of belonging can occur in virtual teams (Figallo 1998). In addition, it was found in the data that working in a virtual environment is still problematic for the majority of people. Thus, one of the conclusions that emerges from these findings is that augmented reality would benefit from being intuitive so that the users could just work in the same manner as they do in real life.

Furthermore, it was possible to discover in the literature a number of key codes concerning team work in a virtual context.

The first one was connected to the *complexity of communication*, in particular with regards to the nonverbal communication. In fact, one important finding was this nonverbal communication was the most frequent way in which people expressed feelings (Mehrabian 2017). This is an area where augmented reality could aid since it is able to display virtual 3D people in real-time which allows for full body language and the expression of feelings. This would potentially then make the colleagues see the person working remotely in a more human dimension and include them in their social group.

The second theme was the *need for standards and routines* (Bartelt and Dennis 2014; Morgan, Paucar-Caceres and Wright 2014; Cheng et al. 2016). There exists,

however, a serious weakness with this argument which is that these standards cannot be transferred between teams. Consequently, it will not be possible to determine what exactly will work for a team as every team will work differently and will require different standards and routines. Nonetheless, it will be possible to give guidelines to the users of augmented reality in terms of the need to structure communication and discuss within the team possible standards and routines that could be implemented. These routines should be aimed towards fostering the sense of belonging which could include for example a virtual coffee break within the mixed reality environment.

The third result was the *psychic distance* (Schuster 2013). Augmented reality could be used in this case to create a more intimate connection with colleagues and with that increase trust and reduce the psychic distance. Therefore, making the remote employee feel more included in the organisation and accepted by their coworkers. As an example, the statement of Perry, Rubino and E. M. Hunter (2018) that working alongside other people was able to potentially satisfy the sense of belonging could be combined with that of the literature review which suggests that with augmented reality people working remotely could perceive the presence of another person in a mixed reality environment. In other words, the co-working space would not require to be in the real world and could rather be in a mixed reality context for people to develop their sense of belonging and reduce the psychic distance.

Lastly, there were the findings that the *alignment of goals* and *management involvement* were required for a productive virtual team (El-Sofany, H. M. Alwadani and A. Alwadani 2014; El-Sofany, H. M. Alwadani and A. Alwadani 2014; Dunn et al. 2015; Fuller and Harding 2015). These are issues that augmented reality could address since it would create proximity between software engineers and management, in particular, with the perception of being present together in the same mixed reality environment. This would create a higher sense of belonging from the software engineers towards the organisation. Furthermore, the increase in visibility that augmented reality would provide the remote person with a perception that they are known in the organisation and with that feel more included and have a higher sense of belonging.

Together these results provide valuable insights into ways in which augmented reality could help distributed teams work together and develop their sense of belonging not only towards their colleagues but also the organisation.

4.2.4 Impact of Remote Working on Sense of Belonging

The literature available regarding the impact that remote working has on the sense of belonging of software engineers is limited. Furthermore, as the sense of belonging is a subjective topic and there is an immense variety of individuals working remotely as software engineers it becomes difficult to reliably report the impact of remote working on the sense of belonging.

Nonetheless, there were in the literature a number of themes that have emerged in which augmented reality could aid in developing the sense of belonging. In particular, the findings by Dery and Hafermalz (2016) which state that there are mainly three issues that have a connection between sense of belonging and working remotely. These were (1) *the lack of visibility*, (2) *the inability to form an identity* and (3) *the scarcity of informal communication*. However, this data must be interpreted with caution because the authors state in their paper that the results found in their case study are not predetermined to be generalisable but they are, nonetheless, credible and relatively transferable. This is due to the fact that their study offered a preliminary insight into a topic that is lacking research.

In the case of *invisibilily* it was discovered that employees that work remotely feel invisible (Raghuram et al. 2001; Belle, Burley and Long 2015; Dery and Hafermalz 2016). In addition, it was found that employees were interested in using new technology for increasing their visibility. These findings appear to suggest that augmented reality would be welcomed if it would give software engineers a solution to increase their visibility within the organisation.

Regarding the the *inability to form an identity*, it was found that with the lack of organisational referents, remote employees would lose their sense of identity within the organisation (Sardeshmukh, Sharma and Golden 2012; Belle, Burley and Long 2015). Interestingly, it was discovered that remote employees need a visual display of identity which needs to be as close as possible to the person in the real world in order to not create further distance and disengagement. Thus, augmented reality would need to give its users a realistic avatar in the mixed reality context so that presence is established and identity formed appropriately.

If we now turn to the *lack of informal communication* which has been found to be the substantial developer of the sense of belonging, it would be reasonable to presuppose that a Skype video-conference call would not allow for such type of conversation as a casual meeting next to the water cooler in a real office (Belle, Burley and Long 2015; Peters et al. 2016; Dery and Hafermalz 2016). Therefore, augmented reality

should be able to promote opportunities for casual or informal encounters in a mixed reality environment in order to increase the amount of informal communication and with that the sense of belonging.

4.3 Augmented Reality

In the literature review of augmented reality it was found that there are various technologies capable of giving the user a mixed reality environment (X. Li et al. 2018). However, the Head Mounted Display provided the best user experience due to its mobility and the ability to overlay virtual elements before the user's eyes (Palmarini et al. 2018).

The most striking result to emerge from the data was that augmented reality can be applied to all five basic human senses, which are: hearing (audition), smell (olfaction), sight (vision), taste (gustation) and touch (somatosensation) (Narumi et al. 2011; Schmalstieg and Hollerer 2016; Bermejo and Hui 2017; Roggeveen and Sethuraman 2018). The senses of smell and taste could be stimulated by, for example, having a coffee break with colleagues in a mixed reality environment which would provide the employees with an opportunity to have exploratory communication. In fact, this diverges from the reasons given by Marissa Mayer to call Yahoo's software engineers that were working remotely to the office by claiming that they would not be capable of having the 'water cooler' conversation (i.e. informal communication) when working from home (Keller 2013).

4.3.1 Presence

Another significant finding was that presence was essential for the development of the sense of belonging.

Users need a visual display of identity which is the reason that embodiment and ownership are required in an augmented reality context to develop the sense of belonging (Skarbez, Brooks Jr and Whitton 2017). Augmented reality could help develop one's identity. As Max-Neef (1991) posited, the need to belong is in his identity category and connected to the involvement of oneself in reference groups. In addition, users would require not only the feeling of "being there", but also "being there together" (i.e. copresence and social presence).

4.3.2 Holoportation

Holoportation was found to be the latest and most advanced technology in the literature review with regards to the experience of perceiving another using augmented

reality (Orts-Escolano et al. 2016). In particular, due to the innovations with regards to mobility and the addition of physical props (Gibbs, Arapis and Breiteneder 1999; W.-C. Chen et al. 2000; Maimone and H. Fuchs 2011; Benko, Jota and Wilson 2012; Zhang et al. 2013; Pejsa et al. 2016; Orts-Escolano et al. 2016). Nonetheless, the findings from Orts-Escolano et al. (2016) suggest that even though the communication technologies have evolved they are still far from allowing a person to perceive that they are physically 'there'. In spite of that, augmented reality was reported to be superior to phone or video chats due to the strong perception of "interpersonal space awareness" or realistic feeling of interacting with another person.

In addition, the themes of awareness of self image and ability to use body language recurred throughout the case study (Orts-Escolano et al. 2016). One of the limitations found was that the HMD was blocking direct eye contact between users and that was important for them to connect with one another. A proof-of-concept prototype was developed but there were no studies published at the time of writing with this feature. Furthermore, they have stated that the algorithms for creating direct eye contact were very complex and as of now they were "not fully over the uncanny valley".

The main limitation of holoportation, however, is that even though it is the most technologically advanced augmented reality system, the quantity of sophisticated hardware necessary is still excessively high (Pagés et al. 2018). In particular, when it comes to the real-time rendering that is needed in an augmented reality environment. These constraints include the fact that the Random-Access Memory (RAM) of the hardware is very limited. This is the type of memory that stores data as it is currently being used (Åkerman 2005). Thus, essential to enable user to interact in real-time with the virtual objects. Equally important, in the case of displaying realistic virtual objects there is a need for multiple high-resolution high-speed cameras coupled with flawless calibration (Pagés et al. 2018). These will also need to be synchronised in order to produce high quality and realistic virtual objects. Moreover, the requirement for a 10 gigabit ethernet network for a reasonable latency makes this equipment inaccessible to the majority of people in most scenarios.

4.3.3 Correlation between augmented reality and sense of belonging

An initial objective of the project was to identify the association between augmented reality and the sense of belonging. In reviewing the literature, no data was found on the specific connection between the sense of belonging of software engineers working remotely and augmented reality. However, this was expected and the reason

to adopt a review of the literature as the type of research. Therefore, the researcher applied the principle of transferability to consider the findings obtained in different contexts for the case of software engineers working remotely.

The first findings were obtained in connection to the use of augmented reality for the treatment of mental illnesses (C Botella, Banos et al. 2005; B. K. Wiederhold and M. D. Wiederhold 2005; C Botella, García-Palacios et al. 2007; Bordnick et al. 2008; Girard et al. 2009; Rosa María Baños, Guillen et al. 2011; A. Li et al. 2011; Rosa M Baños et al. 2013; Serino et al. 2014; Cristina Botella et al. 2015). The results from these studies provide further support for the hypothesis that augmented reality can induce the feeling of presence and reality judgement which, as has been discussed previously, are essential to develop the sense of belonging.

Nonetheless, the most relevant findings were connected to the effects of augmented reality in the sense of belonging. One of the most recent examples came from the popular game, Pokémon Go (Niantic, Inc. 2016). This augmented reality game which uses a mobile device to overlay virtual characters in the real world, was able to develop the sense of belonging and social connectedness in the people playing it (Vella et al. 2017). In addition, a positive correlation was found between augmented reality and sense of belonging in a learning environment (Wu et al. 2013; Bacca et al. 2014; Management Association 2018). In particular, it was reported that learners using augmented reality felt a sense of belonging when they collaborated with the other students in a mixed reality environment (Bronack 2011; Khan and Umair 2017; Management Association 2018). It could be argued that these positive results with regards to augmented reality developing the sense of belonging could be extrapolated to other contexts (i.e. software engineers working remotely) since the underlying factors (e.g. collaboration between individuals, the perception of presence, development of trust and being in a mixed reality environment, among others) are similar. However, as was the case for holoportation, the major limitations were regarding the technology that is not yet capable of delivering a seamless experience.

Chapter 5

DISCUSSION

The primary goal of this study was to determine how augmented reality could help develop the sense of belonging in software engineers working remotely. In light of the pioneering nature of this objective, this study employed a meta-synthesis review of the literature to examine the currently available research with regards to sense of belonging, remote software engineers and augmented reality. Specifically, it explored how these independent topics could be linked together in order to answer the research question.

In this study, the objectives were to explore the concepts of sense of belonging, software engineers working remotely and augmented reality. In addition, it was important to examine the impact of remote working on a software engineer's sense of belonging and augmented reality's correlation with the sense of belonging. Once these relationships were discovered an argument could be made with regards to how augmented reality could help develop the sense of belonging in software engineers working remotely.

5.1 Achievements of the Investigation

In general, during the course of this study all the objectives were achieved. What follows is the identification of each objective and the evidence found for their achievement.

5.1.1 Clarify the concepts of sense of belonging, software engineer working remotely and augmented reality

The theory concerning sense of belonging, software engineers working remotely and augmented reality was explored in as much depth as it seemed relevant to answer the research question. In the literature these topics are well researched in isolation, however they lack studies that interlink them together.

5.1.2 Examine the impact of remote working on software engineers' sense of belonging

This study has found that generally software engineers working remotely do experience a diminished sense of belonging in comparison to software engineers that work

from the organisation's premises. This finding to a great extent supports the work of other researchers that reported that employees working remotely are at a higher risk of being affected by isolation, have poor emotional ties to their colleagues and organisation, feel invisible, have difficulty establishing an identity and lack informal communication (Thatcher and Zhu 2006; Belle, Burley and Long 2015; Colbert, Bono and Purvanova 2016; Dery and Hafermalz 2016). However, there are an unlimited number of variables to have in consideration for each individual, therefore, "it depends" was the most consistent finding in the literature (Raghuram et al. 2001; Gajendran and D. A. Harrison 2007; Michel et al. 2011; Allen, R. C. Johnson et al. 2013; Giberson and Miklos 2013; Perry, Rubino and E. M. Hunter 2018). These findings were expected and provide evidence that remote working, contingent on life circumstances, does have an impact on the sense of belonging of software engineers.

5.1.3 Investigate augmented reality's correlation with the sense of belonging

One of the more substantial findings to emerge from this investigation was that augmented reality helps develop the sense of belonging in fields such as education, gaming and treatment of mental health illnesses. Hence, it could conceivably be hypothesised that when the augmented reality technology reaches a level where it is feasible to use it in order to increase the sense of belonging of software engineers working remotely it should also have positive results. The limitation of the studies in these other fields, for example in the case of phobias, is that the current augmented reality technology allows for the generation of virtual spiders but generating a hologram of a human being is a much more complex task. Another potential limitation of those studies is that people with phobias are already in a disturbed state of mind, therefore, anything that resembles their fears will trigger a strong emotional response. As far as gaming and learning studies are concerned, they may help us to understand how to create an augmented reality environment where collaboration develops the sense of belonging. In addition, the work of a remote software engineer involves team work and collaboration with other people which is identical to the the process of collaboration whilst learning or playing a game.

Finally, the synthesise of the literature occurred throughout the study and the choice for a meta-synthesis review of the literature was appropriate for this type of investigation since it allowed the researcher to explore in depth the broad topics under analysis. Furthermore, the determinations made during this study were supported by the researcher's background as a remote software engineer experiencing a decreased feeling of belongingness towards the organisation and colleagues.

5.2 Implications of the Research

The following conclusions can be drawn from the present research:

a) the sense of belonging is not only a fundamental human need that needs to be fulfilled but also that it is a motivator for software engineers working remotely. Moreover, in the case that the sense of belonging is not satisfied there will be a number of ill effects to the individual;

b) loneliness (i.e. lack of belongingness) is not the actual absence of social interactions, but the personal perception of social isolation;

c) software engineers are a unique group of individuals with a higher percentage of introverts than the mainstream population;

d) software engineers working remotely experience a lack of belongingness towards the organisation and colleagues. The results of this study indicate that the feeling of being invisible is predominant in those working remotely;

e) the feeling of presence (i.e. 'being there' and 'being there together') are crucial for the development of the sense of belonging;

f) holoportation is the latest technology in terms of creating the perceived feeling of presence, however, it is still at an early development stage; and

g) augmented reality can develop the sense of belonging in comparable situations such as the treatment of mental illness and collaboration while learning. That is, the sense of belonging is a perceived psychological state which if not satisfied could develop into loneliness and its ill effects to psychological well-being.

Overall, this study strengthens the idea that the development of the sense of belonging in software engineers working remotely could be achieved through the use of augmented reality by giving the remote workers visibility, increase their feeling of 'being there together' and allow for opportunities for informal communication.

5.3 Research Limitations

In the case of research limitations, there were a number of weaknesses in this research.

Firstly, as is expected from a literature review, the sources and their selection were potentially biased, in particular through confirmation bias (L. Nguyen, Barton and L. T. Nguyen 2015). This is "the human tendency to search for, collect,

interpret, analyse, or recall information in a way that confirms one's prior beliefs or preferences" (Jorgensen and Papatheocharous 2015).

Secondly, the approach typically taken for this review of the literature might have resulted in that not all available literature was found. In spite of the fact that an exhaustive systematic review would have mitigated these issues, it would have not yielded the intended results that this study pursued because even though augmented reality is evolving it is still in its infancy and studies are just starting to match the advances in technology. Furthermore, a systematic review of the literature has been found to take on average 18 months (Duke University 2018) which is longer than the time allocated for this dissertation.

Thirdly, in the case of *reliability*, the main limitation is related to the fact that augmented reality is an evolving technology that changes and improves gradually. For this reason, the studies examined might have different results with newer forms of augmented reality. In addition, due to the subjectiveness of the sense of belonging and the perceived needs for social interaction in individuals with different personality types then findings might change. Also, due to the

Fourthly, even though a meta-synthesis review of the literature has the advantage of providing an overview of a broad area of research which often results in a qualitative synthesis with evidence-based arguments, the findings that it outputs might be considered less reliable due to not only biases but also the lack of a structured approach (Noble and Smith 2018). That is, the fact that a traditional review is less transparent comparatively to a systematic review in terms of the methods used to conduct the research might reduce the confidence in the results obtained. For this reason, in most cases a traditional literature review of the literature is not reproducible.

Finally, with regards to *validity*, the selection and interpretation biases that are typical of a traditional review of the literature might have impelled the researcher in a certain path that could have potentially been distinct from another researcher with a different background or point of view.

Despite its exploratory nature, this investigation offers some insight into an relatively unexplored set of topics. It could however have been more robust by applying some principles of a systematic review of the literature such as the elimination of bias through a structure approach, a more focused research question, a systematic search strategy and a more thorough assessment of validity and reliability of the findings.

Nonetheless, the value that the researcher was attempting to add was directly linked to a background overview of what is known regarding the main topics investigated and that was appropriately achieved.

5.4 Suggestions for future work

Having discussed the outcomes and limitations of this paper, a natural progression of this work would be to analyse how the latest augmented reality technology affects the sense of belonging of software engineers working remotely. As an example, Microsoft HoloLens could be provided to the software engineers working remotely which would have custom software in order to enable the creation of a visual identity (i.e. embodiment and ownership) and the feeling of "being there together". Nonetheless, as discussed previously, even the state-of-the-art hardware (i.e. HoloLens) has requirements that would not make it feasible to be used by the majority of software engineers working remotely. In particular, the complexity involved in creating the overlay of another person, the excessive cost of the equipment or the network capabilities to render the overlays with low latency. Thus, further research should also focus on solving these current obstacles by not only improving the hardware (e.g. sensors and haptic device) and reducing its costs but also developing algorithms that could mitigate the latency and information transfer issues.

The lack of literature on the effects of remote working on psychological well-being suggests that this is an area where further research should be conducted. In particular, a better understanding of the sense of belonging for those working remotely needs to be developed.

In summary, although extensive research has been carried out on augmented reality, sense of belonging and remote working software engineers as independent subject matters, no single study exists that which combines these three topics in order to evaluate how augmented reality could be used to develop the sense of belonging in software engineers working remotely. Thus, with the background and evidence found in this study, further research should be undertaken to investigate the effects that using augmented reality would have on software engineers working remotely.

Chapter 6

CONCLUSIONS

The aim of this dissertation has been to determine how augmented reality could develop the sense of belonging in software engineers working remotely. As a consequence of the broad scope of this goal, the researcher conducted a meta-synthesis review of the literature which analysed and synthesised the available research with regards to sense of belonging, software engineers working remotely and augmented reality. The intention was not to locate all the relevant literature but rather to have a discussion in order to provide future researchers with an adequate source of background information on these topics.

The importance of developing the sense of belonging was clearly supported by the current findings. In addition to belongingness being considered a fundamental human need that needs fulfilment, this study has also found that generally it is considered a motivator for software engineers working remotely. This motivation from belonging is directly connected with beneficial outcomes for both the organisation and employees.

With regards to remote software engineers, this study has found that generally individuals performing this job have a type of personality leaning towards introversion. This characteristic sets them aside as a unique group with that differs from the mainstream population. The research has also shown that as a consequence of software engineers working remotely they have reported a number of adverse outcomes. These include the inability to form an identity, the decline of visibility within the organisation and lack of informal communication. In addition, software engineers working remotely are also more prone to isolation which decreases their sense of belonging.

The investigation of augmented reality has shown that this is still an evolving technology which has the potential to develop the sense of belonging of software engineers working remotely in a number of manners. Firstly, it creates a feeling of presence as a result of embodiment and ownership which are crucial for the development of the sense of belonging. Secondly, it allows for nonverbal communication and collaboration with the use of gestures as it was demonstrated by the HoloLens project. Furthermore, shared physical props can be overlaid in the mixed reality context in order to enhance the perception of ‘being there together’. It can also be applied to all

five basic human senses which gives augmented reality application developers the ability to create the higher levels of feeling presence. Finally, it could add visibility to the employees working remotely by the means of holoportation. This visibility is essential due to the fact that it not only fulfils the need for a visual display of identity but also allows for the formation of continuity of identity which prevents the loss of organisational referents.

The future of augmented reality appears to be limitless, technology is advancing rapidly and, as it was suggested in this study, the evidence appears to support the assumption that it can be used to increase the sense of belonging of those working at distance from their organisation and colleagues. However, the adoption of augmented reality as a new technology for developing the sense of belonging of software engineers working remotely appears to be still a long way from the present for technical and economic feasibility issues.

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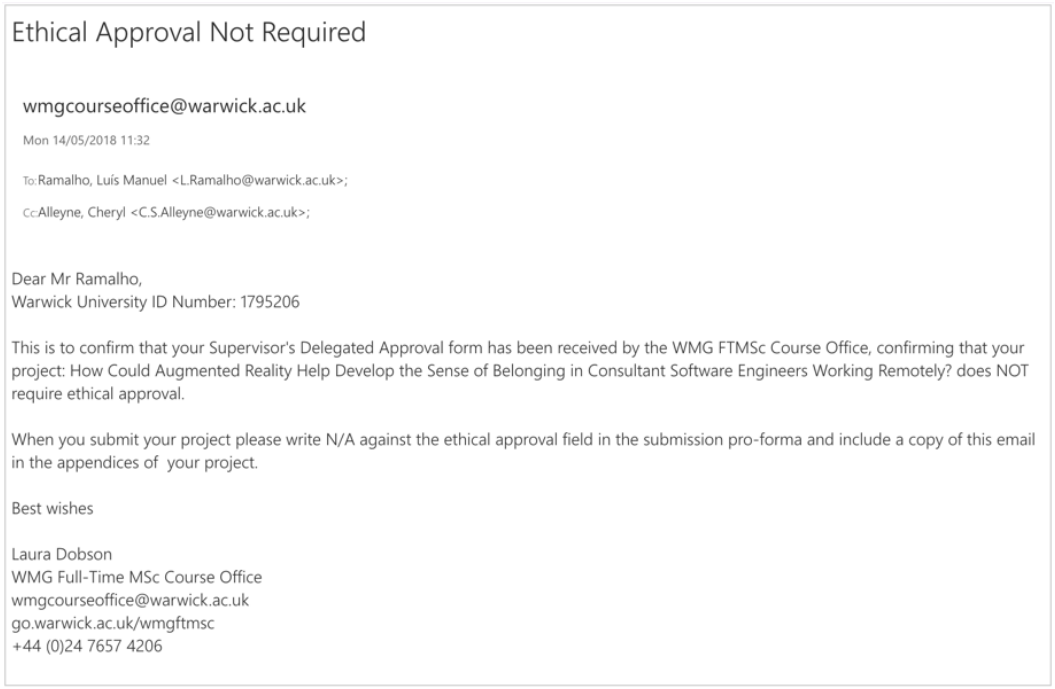
Appendix A

ETHICAL APPROVAL NOT REQUIRED



Ethical Approval Not Required

wmgcourseoffice@warwick.ac.uk

Mon 14/05/2018 11:32

To: Ramalho, Luís Manuel <L.Ramalho@warwick.ac.uk>;

Cc: Alleyne, Cheryl <C.S.Alleyne@warwick.ac.uk>;

Dear Mr Ramalho,
Warwick University ID Number: 1795206

This is to confirm that your Supervisor's Delegated Approval form has been received by the WMG FTMSc Course Office, confirming that your project: How Could Augmented Reality Help Develop the Sense of Belonging in Consultant Software Engineers Working Remotely? does NOT require ethical approval.

When you submit your project please write N/A against the ethical approval field in the submission pro-forma and include a copy of this email in the appendices of your project.

Best wishes

Laura Dobson
WMG Full-Time MSc Course Office
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go.warwick.ac.uk/wmgftmsc
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Figure A.1 – *Copy of the official WMG email stating that this project does not require ethical approval.*