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THE IMPACT OF AUGMENTED REALITY ON MOTIVATION AND THE ROLE OF SELF-EFFICACY

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ABSTRACT

HILLA KARI: The impact of augmented reality on motivation and the role of self-efficacy
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This thesis used a mixed method design and a field experiment to investigate the possible effects of augmented reality (AR) technology on motivation. The aim of this thesis was also to find out whether technological self-efficacy has an impact on motivation to finish an AR technology-based quiz. The sample included an experimental group (participants that used the AR application, n = 231) and a control group (participants that used the non-AR application, n = 71). The quantitative results were derived from a survey and an AR quiz game, and qualitative results were conducted from semi-structured interviews (n = 28). Pearson chi-square test was used to analyse, whether AR group had higher motivation to finish a quiz compared to the non-AR group. Binary logistic regression was utilised to examine whether technological self-efficacy contributes to motivation to complete an AR quiz-game. Finally, content analysis was used to investigate further, what factors in the AR condition possibly contributed to motivation. Contrarily to the expectations, the results showed that AR had no impact on motivation. The second hypothesis was supported as technological self-efficacy had a significant and positive association on motivation. It was found that especially search for the question marks, novelty towards new technology and curiosity were the most motivating factors in the AR quiz-game. In line with previous research on AR, the results from this thesis suggest future research on AR should acknowledge the possible challenges with the use of AR, such as usability issues and cognitive load. Based on the findings it is also recommended future research should continue to investigate ways on how to enhance efficacy beliefs in technology use particularly amongst older people.

Keywords: *AR technology*, *motivation, motivational theories, technological self-efficacy, affects, cognitive load*

TIIVISTELMÄ

HILLA KARI: Lisätyn todellisuuden vaikutus motivaatioon sekä minäpystyvyyden rooli
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Tässä opinnäytetyössä käytettiin monimenetelmällistä tutkimusotetta sekä kenttäkoetta tutkimaan lisätyn todellisuuden mahdollisia vaikutuksia motivaatioon. Opinnäytetyön tavoitteena oli myös selvittää, vaikuttaako teknologinen minäpystyvyys motivaatioon suorittaa AR-teknologiaan perustuva tietovisa loppuun. Otokseen sisältyi koeryhmä (osallistujat, jotka käyttivät AR-sovellusta, $n = 231$) ja kontrolliryhmä (osallistujat, jotka käyttivät ei-AR-sovellusta, $n = 71$). Kvantitatiiviset tulokset johdettiin AR-tietokilpailupelistä ja sen yhteydessä olleesta kyselystä. Laadulliset tulokset kerättiin puolistrukturoitujen haastattelujen avulla ($n = 28$). Pearsonin chi-neliötestiä käytettiin analysoimaan sitä, kokiko AR-ryhmä enemmän motivaatiota suorittaa tietokilpailu loppuun verrattuna kontrolliryhmään. Logistisen regressionanalyysin avulla tutkittiin, edistikö teknologinen minäpystyvyys motivaatiota suorittaa AR-tietovisa loppuun saakka. Lopuksi sisällönanalyysillä tutkittiin, mitkä AR-applikaation tekijät vaikuttivat motivaatioon. Vastoin odotuksia tulokset osoittivat, että AR-applikaatiolla ei ollut vaikutusta motivaatioon. Toinen hypoteesi sai vahvitusta tutkimustuloksista, sillä teknologisella minäpystyvyydellä oli merkittävä ja positiivinen yhteys motivaatioon. Sisällönanalyysin tulokset osoittivat, että etenkin kysymysmerkkien etsiminen, uuden teknologian viehätys ja uteliaisuus teknologiaa kohtaanolivat motivoivimpia tekijöitä AR-tietokilpailupelissä. Tämä tutkimus tukee aikaisempia havaintoja siitä, että tulevaisuuden AR-tutkimuksessa tulisi tunnistaa AR:n käytön mahdolliset haasteet, kuten käytettävyysongelmat ja kognitiiviset kuormitustekijät. Tulosten perusteella suositellaan myös, että tuleva tutkimus keskittyy sellaisten tapojen selvittämiseen, joilla voidaan vahvistaa tekniikan käyttöön liittyvää minäpystyvyyttä etenkin ikääntyneiden keskuudessa.

Avainsanat: *AR-teknologia*, *motivaatio, motivaatioteoriat, teknologinen minäpystyvyys, monimenetelmällinen tutkimusote, affektit*

Opinnäytetyön alkuperäisyys on tarkistettu Turnitin Originality Check -palvelun avulla.

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1 INTRODUCTION

Augmented Reality (AR) as a phenomenon offers a limitless number of applications, both useful and entertaining, and therefore research continues to explore its effects and applicability for different purposes. AR is defined as a 3D technology, in which the real world is supplemented with virtual (computer-generated) environments or objects (Azuma 1997, 356; Ibáñez & Delgado-Kloos 2018). In 2007, AR was noted as an emerging technology and it has been complemented as a new and exciting technology to improve human-computer interaction (Van Krevelen & Poelman 2010, 1). Due to the constant development of technology, AR use has become more accessible as its use no longer requires particular equipment and thus AR can be utilised on different devices, including smartphones. The accessibility of AR has also contributed to the increasing popularity of AR technology in scientific research. (Khan, Johnston, & Ophoff 2019, 2.) Unlike AR, Virtual reality (VR) has been a familiar tool in research for much longer and it has established more definite fields of application compared to AR (Cipresso, Chicchi-Giglioli, Raya & Riva 2018, 1–2). AR technology is still emerging in the scientific research, which is why it is also an interesting area of study in social sciences.

Despite the fact the impacts of AR have not been investigated as long as VR, it has been explored for adaptability, especially in different learning environments, such as schools, workshops and various types of training. AR has gained interest in numerous research areas such as architecture (Chun-Heng & Hsu 2017), entertainment (Orosz, Farkas & Pollner 2016), education (Bacca et al. 2014; Akçayır & Akçayır 2017), and medicine (De Buck et al. 2005). AR is showing its usefulness in various scientific scenarios and providing a unique way to collect behavioural data, for instance to support different kinds of learning and practice (Cipresso, Chicchi-Giglioli, Raya & Riva 2018, 13–15). AR technology is a useful tool in scientific research as it makes it possible to experience and understand phenomena that would not be otherwise possible. The use of AR enables to manipulate objects and observe phenomena in more varied ways because of its sensory enhancing properties. (Khan, Johnston, & Ophoff 2019, 5.)

Researchers have explained the effectiveness of AR technology in learning environments due to its immersing properties. The immersive and interactive aspects of AR may explain why integrating AR functionality with mobile games increases learning and motivation by engaging and providing a richer user experience (Barma, Daniel, Bacon, Gingras & Fortin 2015; Liu & Chu 2010, 633). Indeed, a number of studies show that AR has a significant positive association with motivation (Liu & Chu, 2010; Di Serio et al. 2013; Bujak et al. 2013; Chang et al. 2014). The impact of AR on motivation has been studied particularly extensively in the academic performance (Pribeanu, Balog, & Iordache 2017), language learning (Liu & Chu 2010), and in a variety of other learning environments (Ertmer & Ottenbreit-Leftwich 2010). Despite the studies showing a positive connection between AR and motivation, there are also research literature that indicates otherwise. For instance, some scholars suggest that factors such as poor usability and cognitive overload that are often associated with AR applications can decrease motivation (Akçayır & Akçayır 2017, 1; Chuttur 2009, 2). Due to inconsistent research results, the connection between AR and motivation needs further investigation.

A number of studies show self-efficacy plays a central role in impacting one's motivation, which can be seen in the efforts one will put in and how long he or she will persevere within a task. The concept of self-efficacy, originally defined by Bandura (1977, 1) as one's "perceived capability to perform a target behaviour", is an important construct and area of research in social psychology. Recent research on self-efficacy beliefs has expanded in areas of technological self-efficacy. The technological self-efficacy domains include computer self-efficacy (e.g., Alqurashi, 2016; Compeau & Higgins 1995; Simmering, Posey & Piccoli 2009; Celik & Yesilyurt 2013), internet self-efficacy (e.g., Lin, Liang, Yang & Tsai 2013; Kuo, Walker, Belland, Schroder & Kuo, 2014), information-seeking and online self-efficacy (Hill & Hannofin, 1997; Tang & Tseng, 2013). Due to the increasing reliance on technology in all areas of life, self-efficacy beliefs regarding technology use is an important and relevant research area.

This thesis aimed to explain the impacts of AR on motivation. Also, this thesis aimed to investigate whether technological self-efficacy has a positive effect on motivation. Specifically, this thesis aimed to examine self-efficacy beliefs in operating a mobile device, which can be considered as a domain of technological self-efficacy. Essential theoretical framework in this thesis are psychological theories on motivation and the self-efficacy theory. The research results from this study shed new light on the research on AR and it's impacts on motivation, as well as the effects of technological self-efficacy.

2 MOTIVATION

2.1 Motivation as a concept

Motivation is the primary variable of interest in this thesis. Motivation is a psychological force that enables and directs all human behaviour. The word motivation comes from the Latin word *motivus* ("a moving cause"), which refers to activating psychological processes, such as cognitive functions and behavioural regulation (Gorman 2004, 5; Ryan & Deci 2000, 69.) In addition to complex cognitive and behavioural processes, motivation includes autonomic bodily reactions, such as, maintaining homeostasis (Gorman 2004, 2). Even though there is no consensus across scientific fields on how motivation should be defined (Kleinginna & Kleinginna, 1981), researchers usually adopt the explanation in which motivation is viewed as the energy that initiates and directs all behaviour (Di Serio, Ibáñez & Kloos 2013, 587). James Sale (2016, 9) compares motivation to electricity – just like electricity, motivation is invisible but is detectable from its powerful effects. Even though motivation is an internal state and thus cannot be measured directly, motives become visible through behaviour, engagement, psychophysiology, brain activations, and self-report. The essence of motivation is energised and persistent goal-directed behaviour, as when people are motivated, they move and act. (Di Serio, Ibáñez & Kloos 2013, 587; Sale 2016, 4.)

Motivation is the energy behind essentially all human behaviour and therefore is necessary for maintaining, initiating, and staying engaged and committed to a certain task or activity. Motivation also governs how determined, intense and persistent action is. In addition to observable behaviours, motivation influences an individual's thinking and emotions during the action, which in turn influences decision making and choices an individual makes between alternative courses of action. Therefore, motivation also has a profound effect on a person's cognitive processes, perception and alertness. (Reiss 2004, 179.) Motivational states can be triggered by external events and contexts, which then act as antecedents to motives that trigger different motivational states. In addition to external events, motivational states can be triggered by internal or physiological needs, such as, hunger triggers a motive to eat. (Gorman 2004, 5–6.)

Motivation is a multifaceted construct, and varied approaches demonstrate aspects of this complexity (Dörnyei 1998, 117). One way to define motivation is to categorise it into different subcategories. Several various subcategories of motivation exist, including primary and secondary motives. Primary motivation refers to innate needs and reactions that have not been learned through socialisation processes. These include hunger, avoidance of pain, fear, and aggression. Secondary motivations are learned and can include goal pursuits and many other activities acquired through socialisation and learning. (Kleinginna & Kleinginna, 1981, 4–5.) Social motives are considered as secondary motives, which are achievement, affiliation, aggression, power and curiosity (Ryan 2017, 5─6). Social motivation measures aim to define subjects' willingness and interest in social contact (e.g. "In the past seven days, to what extent have you been interested in talking with others?" (Trémeau et al. 2013, 44).

Motivation is separated into intrinsic and extrinsic motivation. Intrinsic motivation means that an individual finds certain activity naturally satisfying without expectations of external consequences or rewards. An internally motivated individual experiences interest and enjoyment in the task, feels competent, autonomous, and has a strong internal locus of control (Deci & Ryan 1985, 8.) Internal control refers to an expectation that behavioural consequences are a result from his or her behaviour. External control, in turn, is the belief external consequences are beyond his or her control and not related to one’s actions. (Ahlin 2013, 2; Deci & Ryan 1985, 8.) External motivation, also known as outcome motivation, in turn, refers to activities that lead to consequences, such as concrete or verbal rewards. Extrinsic motivation is a desire to achieve an end state of a goal, for instance completing a university degree or making money (Kleinginna & Kleinginna, 1981, 6.) Hence, this type of motivation stems from the external expectations of rewards associated with task accomplishment instead of getting pure enjoyment or satisfaction from the action itself, but rather due to the external consequences acquired though a particular action (Britannica Academic 2019, 2; Georgiou & Kyza 2018, 174). Studies comparing intrinsically and extrinsically motivated individuals show that inherently motivated individuals experience more positive emotions, such as interest, excitement, and confidence. Intrinsic motivation is evidenced by both enhanced and sustained commitment to action. (Deci & Ryan 1985: Di Serio, Ibáñez & Kloos 2013, 537.)

Intrinsic motivation is considered as a type of perceived motivation (Trémeau, Goldman, & Javitt 2013, 44). Perceived motivation refers to a perception of one's motivation level, such as, an individual’s perception on how motivated and energetic he or she feels. Literature on perceived motivation proposes that perceived motivation cannot be easily measured with observational methods, and in order to evaluate it, self-reports are essential. (Trémeau, Goldman, & Javitt 2013, 43.)

2.2 Theories of motivation

Motivational theories aim to explain what drives individuals towards achieving a goal or an outcome. Motivational theories are useful to explain, for instance, why motivated individuals are more productive and more likely to produce results compared to unmotivated individuals. One of the most researched theories of motivation is the self-determination theory. The self-determination theory (SDT) has been primarily used to explain intrinsic motivation. According to SDT, humans are naturally curious, active, and profoundly social beings (Ryan & Deci 2000, 70.) SDT distinguishes between three primary motives or needs which are autonomy, competence and relatedness (Haukkala, Hankonen, Konttinen 2012, 401). The more an individual experiences autonomy, a sense of control, and relatedness to others, the more likely it is that the motivation for the activity is intrinsic (Reiss 2004, 183).

According to SDT, individuals' experience in any given situation is dependent on the type of motivational processes. Specifically, three types of motivation are distinguished: controlled motivation, autonomous motivation and amotivation. Controlled motivation (CM) makes a person pursue an activity to obtain a reward or avoid a punishment. Research has found that when individuals' actions are externally regulated, such as by other people, rewards or punishments, individuals experience pressure and obligation to act (Grant, Nurmohamed, Ashford, & Dekas 2011, 241.) In contrast to CM, autonomous motivation (AM) takes place when an activity is pursued out of personal interest. The fulfilment of the three basic needs of autonomy, relatedness and competence are elementary for the development of AM (van der Burgt, Kusurkar, Croiset, & Peerdeman 2018, 58.) CM is comprised of external regulation and is a type of extrinsic motivation, whereas AM refers to intrinsic motivation. Amotivation can be regarded as merely an absence of motivation and a lack of intention to engage in an activity (Gillet, Vallerand, Lafreniere, & Bureau 2013, 465.)

As expected, these different dimensions of motivation predict varying outcomes. Evidence indicates that AM predicts positive performance outcomes in diverse contexts, with participants across ages and with diverse measures of performance (e.g., cognitive tasks tasks) (Gillet, Vallerand, Lafreniere, & Bureau 2013, 467; van der Burgt, Kusurkar, Croiset, & Peerdeman 2018, 58). Gillet et al. (2010) found that AM positively influenced an athlete's performance in a judo competition. In line with this finding, results from Guay and Vallerand (1997) showed that AM predicted academic achievement at school in different subjects, such as Mathematics and Geography.

In contrast, CM, just like extrinsic motivation, has been found to reflect poorer performance outcomes, for example less time and effort prolonged amongst the activity. As an example, results of a between-subjects study found that participants who were instructed to focus on the experience of running on a treadmill (e.g., focus on their current exercising experience) spent more time on a treadmill compared to a group that was instructed to focus on the instrumental benefits of a workout (e.g., goals of losing weight). Additionally, the participants who were asked to focus on the external benefits felt significantly less energised than those who had focused on the workout experience itself. The results show that when people focus on external outcomes of exercising, it reduces the actual amount of time spent amongst the activity, possibly because such focus makes the activity more effortful and thus more challenging to sustain (Fishbach & Choi 2012, 96.) In line with this, a study that investigated similar impacts of external versus internal goals on performance found that participants who were instructed to focus on the outcomes of an activity experienced reduced motivation to continue the activity. Specifically, those participants who were asked to consider their external targets, while creating an origami, wanted to engage in the activity less than those who focused on the experience itself, (i.e., creating an origami is an enjoyable hobby as such and not because of the external benefits it might provide) while creating the origami. (Fishbach & Choi 2012, 99.)

Additionally, SDT proposes that intrinsic motivation, extrinsic motivation and amotivation exist at three different levels, which are situational, global and contextual. Situational motivation is the "here and now" of motivation, which can be regarded as the motivation people experience when they are engaging in a certain activity at a given time. It is the motivation that makes one to start and finish an action. For instance, low situational motivation often leads to impaired engagement in activities (Trémeau, Goldman, & Javitt 2013, 45; Gillet, Vallerand Amoura, Baldes 2010, 155). In situational motivation, a particular stimulus evokes a set of motives that elicit activity that is directed toward a specific goal. (Georgiou & Kyza 2018; Ruohotie 1998, 41). Research shows that external events such as competition (Reeve & Deci, 1996) and deadlines can decrease his or her intrinsic situational motivation for a specific activity. In addition to this, studies show that one's situational motivation is associated with positive outcomes such as positive emotions (e.g., Sheldon, Ryan, & Reis, 1996). Thereby, situational motivation can provide some useful insight into his or her current self-regulatory processes. (Guay, Vallerand, C´eline & Blanchard 2000, 176.)

Situational motivation is dynamic and influenced by the environment and social factors, whereas global motivation refers to more persistent behavioural patterns. Global motivation is therefore more of a general motivational disposition and can be measured with questions like: "In the past seven days, how much of the time did you feel energetic?” (Trémeau, Goldman, & Javitt 2013, 44). Global motivation impacts situational motivation by influencing a person to be, for instance, more confident in testing a new phone application and learning how to use them quickly. Hence, global motivation influences the direction and alertness of behaviour. Global motivation is very close to attitudes and personality traits as it is quite permanent and not so much affected by the environment. (Ruohotie 1998, 42, 3.) Contextual motivation concerns the motivational orientations that individuals develop toward each life context, such as, education, work and technology (van der Burgt, Kusurkar, Croiset, & Peerdeman 2018, 59).

Studies show that optimal challenges increase intrinsic motivation (Gillet, Vallerand, Amoura, & Baldes 2010, 465). An example of an optimal challenge could be a game played with a phone application. If the game is too easy or too demanding, players will either get bored or frustrated, leading to a loss of motivation for the game. However, it has been found that a suitably challenging game can lead to a "positive failure". Studies show that players can lose up to 80% of the game time but remain optimistic and continue to play enthusiastically. (Leiker et al. 2016, 327; Ravaja, Saari, Salminen, Laarni, & Kallinen 2006, 344). Expectancy theory of motivation explains that enhanced performance follows from increased effort, which is especially true in the positive affect condition (Parijat & Bagga 2014, 2). It has been found that positive affect increases expectancy for performance because people in positive affect have an improved ability to identify the connections between effort and performance (e.g., how much effort a task requires to perform well). Thus, people in positive emotional states should more clearly notice an association between their effort and needed performance, which lead to better performance. (Erez & Isen 2002, 1057; Fredrickson 2001). The link between performance, motivation and positive affective states will be further discussed in the chapter 2.3.

Social psychological theories on motivation assume that attitudes directly influence behaviour. It is believed that attitude towards a target impacts a response to it. According to the theory of reasoned action by Ajzen and Fishbein (1980), human behaviour is caused by a person's intent to perform actions. This intent is a function of two factors: the attitudes towards the behaviour and the norms. (Baqutayan & Mahdzir 2017, 429.) The latter refers to the person’s perception of the social demands placed on an individual to engage in a particular behaviour. If a conflict exists between the two factors, the persons considerations on importance of attitudinal and normative factors determines the final action. The theory of planned behaviour (Ajzen 1988) extends this model by adding an additional component to it, which is perceived behavioural control. The concept perceived behavioural control means the individual’s experience of ease or difficulty of performing the behaviour, such as perceptions of required resources to use a mobile phone application and potential obstacles (e.g., technological interferences) in using the application (Dörnyei 1998, 117–118). Performance can then be predicted from people's intentions to engage in the target behaviour and also from their perceptions to be able to control the behaviour. Based on the theory of reasoned action, intention alone is enough to explain individual's action if he or she has complete control over the behaviour. (Dörnyei 1998, 119.)

2.3 Different ways of measuring motivation

Some scientists argue that since motivation is a psychological construct it cannot be observed nor measured directly (Brehm & Self 1989, 110–111). Instead, it may be measured, for instance, through observable responses, such as, physiological (e.g., through brain activation) or behavioural responses (Touré-Tillery & Fishbach 2014, 329). Ultimately, motivation is the driving force behind any goal-directed behaviour and thus it makes sense that motivation is measurable through behaviour. Indeed, researchers often use behaviour as a measure when investing the strength or degree of motivation. Behavioural measures of motivation include an individual's choice to engage in each task, speed (i.e., duration of completing sub-goals to attain a bigger goal), or persistence that is exerted when pursuing a goal. Researchers often refer to the goal congruence of behaviour when wanting to explain someone's level or strength of motivation. Goal-congruent behaviour requires physical and mental effort. Factors such as performance, speed and persistence are evident in goal seeking behaviour and can thus be utilised to measure the state of one's motivation to pursue the goal. (Touré-Tillery & Fishbach 2014, 332.)

Performance measures of motivation include amount (i.e., how much has been achieved), accuracy and accomplishment. It can be argued that the more motivated people are over a specific goal, the more likely they are to exert effort to perform better in a specific task. (Touré-Tillery & Fishbach 2014, 330.) For instance, Bargh et al. (2001) investigated motivation through subjects' performance at five-word search puzzles. The results revealed that participants who primed with achievement type of words discovered more words compared to the control group. Additional dimension of performance is persistence, defined as the extent to which a person continues persistently to pursue a goal despite difficulties. For example, someone who is highly motivated over an augmented reality (AR) phone application may spend longer time trying to solve an AR-based phone application quiz despite being exhausted or intrigued by more stimulating activities. Persistence can be measured, e.g., in terms of the time an individual spends in an activity or the goal-related tasks one completes or with regards to the extent to which an individual pursues the goal without quitting. (Carver & Scheier 1998)

In many cases, motivation is measured in terms of speed: the amount of time an individual spends to pursuit a goal. Research has applied this duration measure to several aspects of behaviour to detect the depth of motivation. Speed can be measured in terms of how fast a person finishes a task or how quickly they proceed to the next task. (Touré-Tillery & Fishbach 2014, 331.) However, speed can also be a misleading measure because individuals who experience intrinsic motivation can also become absorbed in an activity and therefore may take longer to achieve a task. Sometimes a highly motivating activity can lead an individual to experience a flow state. Flow state can be described as a mental state in which an individual is completely absorbed and experiences energised focus, thorough involvement, and pleasure in the process of the activity (Hill, Van Boxtel, Ponds, Houx, & Jolles 2005, 430). The flow experience is associated with a loss of time and place, which is why people can spend longer times amongst the activity as they normally would (Hill et al., 2005 430). While speed measures the extrinsic motivation to complete a task, in addition to gaining external rewards, such as financial rewards, persevering amongst the activity might capture the motivation to engage in the internally meaningful and rewarding process and thus may more accurately measure intrinsic motivation (Touré-Tillery & Fishbach 2014, 334; Hill et al., 2013, 429). Hence, performance may be a more accurate measure to capture intrinsic motivation compared to speed.

Goal attainment is a relevant measure of the strength or the level of a motivational state. According to experimental social psychology, a goal is a cognitive representation of anticipated end state goals, which are organised in associative memory networks linking each goal to matching constructs (Fishbach & Ferguson 2007; Trémeau, Goldman, & Javitt 2013, 43). Goal-related constructs can be activities or objects that promote goal attainment (i.e., means of achieving a task), but also include objects that deter goal attainment (e.g., hindering temptation). Goal-related constructs may activate the pursuit towards the goal. For example, having a mobile phone available can activate a person's desire to play a game on a mobile phone application. When a goal becomes active, the motivational system prepares the person to take action by activating information related to the goal (Bargh, Gollwitzer, Lee-Chai, Barndollar & Trötschel, 2001, 1014). Consequently, motivation indicates how easily goal-related constructs are recalled or accessed (Trémeau, Goldman, & Javitt 2013, 43). Motivation can hence be measured though different speed and recognition tasks and recollection tasks. The greater the motivation is to achieve a certain goal, the more likely a person is to recall and notice concepts, objects or persons related to that goal (Trémeau, Goldman, & Javitt 2013, 43).

Research literature on motivation has some inconsistencies regarding how motivation should be measured. Motivation can be measured with self-reported questionnaires, the most common ones being The Motivation and Energy Inventory (MEI) and Intrinsic Motivation Inventory (IMI). MEI is a 27-item questionnaire that assesses mental or cognitive energy, social motivation, and physical energy (Shahid, Wilkinson, Marcu, & Shapiro 2011, 235). IMI assesses an individual's degree of intrinsic motivation with topics regarding interest, enjoyment and perceived competence (Touré-Tillery & Fishbach 2014, 331). These measures are validated by a number of research studies; however, some scholars argue that self-reports should be avoided due to their significant limitations.

Some limitations of self-reports include the lack of participant's own understanding of his or her psychological states. Also, social desirability concerns may further bias the results. Researchers in experimental social psychology recommend the use of cognitive and behavioural paradigms to evaluate motivation without the use of self-reports (Touré-Tillery & Fishbach 2014, 330). In contrast to this, some scientists argue that self-reports are essential in measuring certain types of motivation. For instance, perceived motivation cannot easily be derived by observing which is why self-reports are used for evaluation. (Trémeau, Goldman, & Javitt 2013, 43). Also, Van Der Burgt, Kusurkar, Croiset and Peerdeman (2018) found that observable methods should be used to measure situational motivation. Qualitative ethnographical methods were used, and data based on observation identified motivating and demotivating factors categorised into four themes that were found to be important for situational motivation construct (Van Der Burgt et al. 2018, 60).

2.4 Affective states and motivation

Affectivity is a closely related construct to motivation. Emotional states direct motivation and goal-congruent behaviour, and thus affective states are considered as an important influence on motivational states. Emotions direct individuals' interactions with the environment (Fredrickson 2001, 218), and different moods have been linked to increased or decreased motivation (Gillet, Vallerand, Lafreniere, & Bureau 2013, 465; Trémeau, Goldman, & Javitt 2013, 43). In addition to motivation, a number of research studies show that positive feelings influence performance in different ways. For example, research has shown that positive emotions or affects facilitate flexible and effective decision making and thinking (Proyer, Gander, Wellenzohn, & Ruch 2016, 4; Gillet, Vallerand, Lafreniere, & Bureau 2013, 467; Erez & Isen 2002, 1055).

Research on affects has shown that positive emotional states helps people to categorise items and situations more productively (Fredrickson 2001, 219). This is because people in positive affective states see more associations among uncommon situations and categories. This ability to easily find associations may indicate that positive emotional states increase ability to arrange and identify ideas and aspects in varied ways. (Touré-Tillery & Fishbach 2014, 336.) Studies have shown that arousing positive affectivity broaden the attentional scope, which may explain the improved problem-solving and positively impact motivation and persistence over a task (Friedman & Forster, 2010 875). In line with this, the broaden and-build theory of Fredrickson (2001) suggests that positive feeling states lead to beneficial and adaptive outcomes since in positive emotional states individuals tend to build resources more effectively. Indeed, number of researches indicates that people who experience positive emotions at a time of the activity often perform better (e.g., Hill, Van Boxtel, Ponds, Houx, & Jolles 2005, 433; Gillet, Vallerand, Lafreniere, & Bureau 2013, 474).

On the basis of past research on affectivity, motivation and performance, it is reasonable to assume that positive emotions have a likely contribution to a greater effort and motivation in finishing a given task. A study of Gillet, Vallerand, Lafrenieren and Bureau (2013, 475) found that autonomous motivation predicted positive emotions, whereas extrinsic motivation and amotivation positively correlated with negative affect. It was also found that positive affect predicted better performance, whereas the opposite was true for negative affect. On the basis of past literature and theories on affectivity and performance, it is assumed that positive emotions are likely to contribute to a greater effort and motivation in finishing a given task. Erez & Isen (2002, 1055) argue that research has placed relatively little consideration on how positive affects influence motivation and the relationship between these concepts should be further investigated.

3 SELF-EFFICACY

3.1 The definition of self-efficacy

In order to succeed, a person must have a resilient belief in his or her abilities to cope under challenging and trying conditions. Based on the self-efficacy theory, the concept of self-efficacy is defined as “a perceived capability to perform a target behaviour” (Bandura 1977, 1). Specifically, self-efficacy is a belief in one’s capacities to accomplish certain goals in various situations. Self-efficacy research indicates that efficacy beliefs impact one’s motivation, effort, and persistence (Bandura 1977; You, Dang, & Lim 2016, 221; Williams & Rhodes 2016, 115). Self-efficacy includes beliefs that tasks are achievable and such beliefs impact behaviour and expectations on quality of performance (Bandura 1997; Riggio, Weiser, Valenzuela, Lui, Montes, & Heuer 2011). According to research, self-efficacy beliefs are positively associated with positive relationships, adaptable coping and feelings of personal control. It is therefore no wonder that high self-efficacy correlates with a number of positive outcomes, including better physical and mental health, successful accomplishments, adaptive self-regulation, and efficient learning. (Avey, Luthans, & Jensen 2009, 679; Tilton & Hartnett 2016, 80; Bandura 2006, 2.) People with strong sense of efficacy consider failure as a consequence of lack of skill, knowledge or inadequate effort, which can be practiced and acquired. Consequently, when facing setbacks, persons who have high efficacy beliefs try harder instead of giving up. They approach challenging situations with a certainty that they have control over them. Thus, people with high efficacy beliefs experience personal accomplishments and reduced stress. (Bandura, Freeman, & Lightsey 1999, 2.)

In his early theories, Bandura (1977) proposed that self-efficacy was a fixed trait, meaning that efficacy beliefs were an inherent trait associated only with certain tasks or activities. However, it has subsequently been recognised, that self-efficacy is not only based on certain situations but is generalised across situations that share common features or similar activity domain (Bandura, 1997, 49). Self-efficacy is generalisable but also task-specific as efficacy beliefs differ across diverse life domains, such as, health, technology, academic beliefs and romantic relationships (Riggio, Weiser, Valenzuela, Lui, Montes, & Heuer 2011; Bandura 2006, 371). Nevertheless, self-efficacy is not a stable trait as previously assumed, but can be improved by mastery experiences, modelling and persuasion (Bandura, 1997; Avey, Luthans, & Jensen 2009, 680). Thus, self-efficacy develops through individual experiences across lifespan and self-referent processes across similar situations (Riggio, Weiser, Valenzuela, Lui, Montes, & Heuer 2011, 602).

3.2 The effects of self-efficacy on motivation and behaviour

As previously noted, self-efficacy affects the strength of motivation, which manifests in how much effort and preserving one will put in completing a task. Research on self-efficacy consistently indicates that strong self-efficacy beliefs contribute to greater and more persistent efforts. (Bandura, Freeman, & Lightsey 1999, 2; Bandura 2006, 307.) In contrast, people who doubt their capabilities give up on their attempts prematurely and settle for easy and convenient solutions when faced with more challenging tasks. Individuals with low efficacy beliefs see inadequate performance as a consequence of deficient ability and they easily lose faith in their capabilities when faced with setbacks. Contrarily, those with strong efficacy beliefs put in more effort to master or overcome challenges (Riggio, Weiser, Valenzuela, Lui, Montes, & Heuer 2011, 602; Bandura 1993, 120). Consequently, strong persistence often contributes to better performance and accomplishments (Doménech-Betoret, Abellán-Roselló & Gómez-Artiga 2017, 1193).

Self-efficacy also regulates motivation. According to Bandura, Freeman, and Lightsey (1999, 4), motivation is mostly cognitively generated since people are mostly motivated by their perceptions and beliefs on what they can do. A belief that actions can produce desired outcomes motivates action and behaviour because if one does not believe that he or she can produce any effect through actions, one often fails or will not exert the effort to try in the first place. (Bandura 1997, 2–3.) According to Bandura (2016, 365), people often avoid to engage in activities they believe will exceed their skill set, but they willingly accept challenges they believe they can successfully manage.

Self-efficacy beliefs function in three types of cognitive motivation which are outcome expectancies, causal attributions and cognised goals. The theories for these motivations are expectancy-value theory, attribution theory and goal-setting theory, respectively. (Bandura 1993, 118; Bandura, Freeman, & Lightsey 1999, 2.) According to attribution theory, people who deem themselves as capable in doing something, view (i.e., attribute) their failures to stem from inadequate effort. In contrast, people who deem themselves as unsuccessful with less capabilities, perceive their failures to follow from their low ability, such as a lack of skills or knowledge. Thus, attributions impact motivation and performance mainly through self-efficacy beliefs. The expectancy-value theory looks at motivation from social cognitive perspective. According to this theory, individuals' achievement expectations and the value they place on the task may predict the performance (Doménech-Betoret, Abellán-Roselló & Gómez-Artiga 2017, 1194; Bandura, Freeman, & Lightsey 1999, 2). In expectancy-value theory, motivation is determined by expecting that an action will produce certain outcomes. Expectancy and value beliefs predict task performance, choices between tasks and persistence (Trautwein, Nagengast, Lüdtke, Nagy & Jonkmann 2012, 763). As previously noted, individuals act on their beliefs about what they can accomplish. Therefore, the motivating impact of outcome expectancies is impacted by beliefs of self-efficacy.

Evidence supports that clear and challenging goals reinforce and maintain motivation. An optimal challenge can produce a strong memory imprint of beliefs related to self-efficacy. As a person overcomes a challenging goal, their confidence in their own abilities in similar situations increases. (Zimmerman 2000, 90; Schunk 2001, 1). Indeed, number of studies have found the most effective performance follows when goals are precise and challenging and when they are linked to receiving feedback on results to enhance commitment. Also, goals affect behaviour and motivation as people tend to pursue goal-congruent objects or situations which they consider positive and avoid such objects which might interfere with achieving a valued goal. (Lunenberg 2011, 5; Zimmerman 2000, 89).

Self-efficacy and motivation are closely related constructs and can be difficult to distinguish from one another. Several scholars have noted that what individuals state they can accomplish (i.e., self-efficacy rating) does not actually refer to self-efficacy (i.e., perceived capability), but rather measures the wider concept of motivation (Williams & Rhoedes 2016, 113). This is known as the self-efficacy-as-motivation argument. If the research aim is not to predict some behaviour but rather to understand it, then it is important that the researcher ensures responses to self-efficacy items measures perceived capability instead of wider concept of motivation (Williams & Rhoedes 2016, 116). It should be noted that motivation is a function of a broader range of sources which include affective states. Self-efficacy, in contrast, reflects one's assessment and perception on the capability to perform a task (Williams & Rhoedes 2016, 117). Self-efficacy impacts behaviour via internal beliefs in personal agency, which is why self-efficacy is considered as a cognitive factor (Bandura 1997, 2). Even though self-efficacy overlaps with other related constructs, it has shown discriminant validity to predict different outcomes. It has also shown convergent validity in predicting different motivational dimensions, such as choices, effort, persistence, and also emotional reactions. (Zimmerman 2000, 89.)

3.3. Sources of self-efficacy

Bandura (1993; 1997) proposed that self-efficacy beliefs develop from and can be fostered by four main factors, which are mastery experiences, vicarious experience (i.e., modelling from others behaviour), verbal encouragements and physiological states. Subsequently, more sources of efficacy have been identified and some research suggests that the sources vary depending on the task or context. However, some inconsistencies exist in the research literature regarding how self-efficacy beliefs develop and are enhanced. Lin, Liang, Yang, and Tsai (2013) investigated internet self-efficacy and identified performance encouragements, modelling, verbal or social persuasion, emotional and physiological states (e.g., fearful or a joyful state) and personality factors as the main sources. In contrast, Bates and Khasawneh (2007) suggested that self-efficacy in online learning is impacted by previous success in online learning, previous training, feedback from the instructor and anxiety regarding technology use. The research of Lin et al (2013, 2734) suggested that the sources of technological self-efficacy should be further investigated, for instance, weather the sources vary depending on age used measures (e.g., self-report questionnaires versus qualitative methods).

According to Bandura (1986; 1997) efficacy beliefs are mainly impacted by mastery experiences. Mastery beliefs follow from perceived results of past performance. Mastery experiences are enactive or actual experiences that follow from successfully accomplishing a given task, and create a strong efficacy belief to accomplish similar tasks in the future. (Zeldin & Pajares 2000; Bandura 1997.) Mastery experiences are also viewed as the most powerful influence on technology-related self-efficacies (Ertmer & Ottenbreit-Leftwich 2010, 261). In line with this, Tilton and Hartnett (2016) found that teachers' mobile digital technology self-efficacy beliefs were foremost enhanced by mastery (or actual experience). Frequent achievements lead to strong efficacy expectations that reduce the negative affect regarding failure, such as giving up in the face of setbacks (Alqurashi 2016, 46).

As noted previously, strong efficacy beliefs and sense of accomplishment transfer not only to similar circumstances, but are generalised across a wide area of activities (Bandura 1997, 195). In line with this, Simmering, Posey, and Piccoli (2009) found that efficacy beliefs in computer use correlated with previous practice in online learning and internet use. Interestingly, computer self-efficacy has a negative correlation with motivation to learn (Simmering et al. 2009, 113). The results were explained to be due to invalid measurement of self-efficacy as the ratings of computer self-efficacy were thought to be related to actual computer skills and not the confidence of the learner (Simmering et al. 2009, 114). Similarly, other studies have also found that better computer skills lead to less learning motivation. It can be that a highly skilful individuals lack motivation as they may feel that they do not need to learn much. (Burke and Moore 2003, 37–38).

In a vicarious experience, people build their self-efficacy by observing others performing an activity successfully (Bandura 1997, 5). Modelling someone can inspire the observer to try similar tasks if they believe they could also accomplish similar goals. However, the observer's self-efficacy beliefs can be diminished if they see the model fail in their attempts. Self-efficacy can also be negatively impacted by unhelpful or discouraging feedback or messages. (Tilton & Hartnett 2016, 80; Alqurashi 2016, 45.) Verbal persuasion or coaching, for example, encouragement to use particular mobile applications can have positive impacts on motivation to try new tasks. (Tilton & Hartnett 2016, 80).

Additionally, physiological arousal contributes to self-efficacy. People with strong self-efficacy often view their emotional states and affective arousals as energising, which can positively predict performance. In contrast, those with low self-efficacy beliefs can interpret their physiological symptoms (e.g., heart rate or sweating) to indicate lack of skills or ability. (Tilton & Hartnett 2016, 83.) Reluctance about using technological devices may be due to anxiety about low efficacy beliefs in technology use. Avoidance of using technological devices may disguise low self-efficacy beliefs in technology use (Celik & Yesilyurt 2013, 149).

In addition to vicarious learning and physiological states, studies suggest that mood affects how people perceive their personal efficacy. Specifically, positive mood may enhance self-efficacy whereas low mood may reduce these beliefs. (Bandura 1993, 119). It has been found that when people have positive moods, their self-efficacy typically increases. In line with this, Vries (2017) found that teachers who experienced positive emotions, such as joy, when teaching reported higher scores of efficacy beliefs. In contrast, those who felt stress experienced a drop in their self-efficacy levels (Vries 2017, 20). However, the sample size only consisted of five teachers, so the generalisation of the results is questionable. Nevertheless, it can be stated that positive emotions lead to more positive self-assessments and optimistic self-evaluations and therefore better performance outcomes.

Self-efficacy beliefs can also be boosted in a group environment. Collective efficacy is expectations of a group to succeed in certain situations (Bandura 1997, 1982). Collective efficacy helps with problem-solving because the mutual efficacy beliefs of a group can be stronger compared to an individual's own beliefs (Bandura, 1997). Research suggests that collective efficacy predicts positive group motivation and performance (Ertmer & Ottenbreit-Leftwich 2010, 262; Tilton & Hartnett 2016, 83; Lee & Ko 2010, 839). For instance, a descriptive correlational study investigating collective self-efficacy of Korean hospital nurses found that collective self-efficacy was linked to increase in performance of a sample of nurses (Lee & Ko 2010, 839). The study suggested that hospital administrators should provide more resources in strengthening teambuilding to improve the quality of care in hospitals (Lee & Ko 2010, 843). Similar results were found on mobile and collective technology efficacy between teachers and students. The collective efficacy between students and teachers enabled and encouraged teachers with lower self-efficacy to continue to use technical devices (Tilton & Hartnett 2016, 87). Kopcha (2012) also suggests that practising in a team can have a positive influence engagement with new initiatives.

3.4. Technological self-efficacy

As previously noted, self-efficacy is not a stable trait but varies across different fields. Bandura (2006, 307) noted that self-efficacy beliefs are multifaceted and “the efficacy belief system is not a global trait, but a differentiated set of self-beliefs linked to distinct realms of functioning”. Technological self-efficacy refers to an individual’s confidence levels and beliefs about his or her abilities to use technology (Compeau & Higgins 1995, 189). Technological self-efficacy impacts individuals’ interests toward technology and their willingness to use different technological devices. When facing difficulties in technology-related tasks, a person who has strong self-efficacy beliefs is ought to conquer the difficulties. (Compeau & Higgins 1995, 190.)

Technological self-efficacy includes different domains, such as online (or internet) self-efficacy or specific device (such as smartphone) efficacy or even a new device that utilises augmented reality (Tilton & Hartnett, 80). Ayub, Zaini, Luan, & Jaafar (2017, 369) define mobile self-efficacy to individual beliefs on his or her abilities and capabilities to get involved in the learning and teaching activities in the class. A number of studies have investigated computer self-efficacy (e.g., Alqurashi, 2016; Compeau & Higgins 1995; Simmering, Posey, & Piccoli 2009; Celik & Yesilyurt 2013), internet self-efficacy (e.g., Lin, Liang, Yang & Tsai 2013; Kuo, Walker, Belland, Schroder, & Kuo, 2014) and information-seeking and online self-efficacy (Hill & Hannofin, 1997; Tang & Tseng, 2013). Due to the increasing need to use technology in education, technological self-efficacy has been identified important especially amongst teachers. Studies have been interested about the role self-efficacy plays in teachers’ personal and professional acceptance of new technologies. Technological self-efficacy has a central role in defining the teachers’ capability and willingness to use technology as teaching device. (Vries 2017; Tilton & Hartnett 2016, 79; Ayub, Zaini, Luan, & Jaafar 2017, 371.) Not many studies exist on technological self-efficacy in an AR environment.

Technological self-efficacy is in the interest of research due to the increasing value of technology use in different fields, such as science, education, agriculture, commerce, transportation, communication etc. (Celik & Yesilyurt 2013, 148; Chuttur 2009, 1; Tilton & Hartnett 2016, 79). Technological self-efficacy is regarded central to an individual’s abilities, as efficacy beliefs influence the choices one makes concerning new matters and situations, such as using new technology (Tilton & Hartnett, 79). Self-efficacy is also heavily connected to beliefs about value and usability of devices, so it closely impacts how to the accept and absorb new technology (Shea & Bidjerano 2010, 1722).

Strong self-efficacy beliefs related to technology are not the only contributing factor to meaningful technology use (Ertmer & Ottenbreit-Leftwich 2010, 262). Based on the study by Wozney et al. (2006, 173), confidence levels regarding technology use and perceived value on technology use were important for successful use of technology. Ertmer and Ottenbreit-Leftwich (2010, 262) proposed that a good knowledge base for technological devices is also important, indicating that self-efficacy beliefs as such might not be enough to explain willingness to engage in technology use. Technological Acceptance Model (TAM) suggests that user's motivation can be rationalised by three factors: perceived usefulness, attitudes toward using the system and perceived ease of use (Chuttur 2009,1). According to TAM, the easier the handling of the technological device is perceived to be, the higher the efficacy beliefs associated with its use (Chuttur 2009, 2).

Also, Bandura (1982, 124) proved in his study the relevance of considering both the perceived ease of use and the perceived usefulness in predicting behaviour and engagement. Given this, the perceived ease of use and usefulness should also be considered as central factors in explaining technology usage and adaptation in different situations (Chuttur 2009, 2; Ertmer & Ottenbreit-Leftwich, 262). Being familiar with a digital device is also considered important for building self-efficacy and engagement with the device (Mueller, Wood, Willoughby, Specht, & Deyoung 2005, Ertmer & Ottenbreit-Leftwich 2010, 262). In addition, individual readiness is an important component in adopting new technology such as mobile apps (Ayub, Zaini, Luan, & Jaafar 2017, 366). Technology readiness towards mobile apps means the need to assess and consider the awareness of and acceptance of mobile phone use. Abas, Peng and Mansor (2009) proposed technology readiness means the readiness to be a mobile phone learner. Individuals who are not ready with new technologies, will find their acceptance of technology are affected (Ayub, Zaini, Luan, & Jaafar 2017, 366).

4. AUGMENTED REALITY

4.1 Phenomena of Augmented Reality

Augmented reality is an emerging phenomenon in the scientific research field but is gaining continuous interest in various research disciplines. AR is 3D technology, in which real images and virtual objects interact in the space (Azuma 1997, 356; Ibáñez & Delgado-Kloos 2018). In more extensive definitions, AR provides a live environment that enables heightened visualisation of real images combined with virtual objects. Added virtual objects can include texts, photos, audio, videos and 3-dimensional models. (Sirakaya & Cakmak 2018, 2.) Sense of presence, realism, and reality signify the main features of AR, which are regarded the main instruments of the quality of user experiences. A highly realistic experience joints together the user's expectation and the interaction within the AR surroundings, and allows deeper feeling of being immersed in the environment physically, cognitively, and emotionally (Cipresso, Chicchi - Giglioli, Raya & Riva 2018, 4). This enhancement that AR offers allows users to experience and sense more than they would normally sense via the sensory organs (Sirakaya, 2016).

Azuma et al. (2001) proposes AR has three main features. Firstly, it combines virtual and real objects in a real environment and then expands the user's perception by adding contextual layer of information to the real world (Ibáñez & Delgado-Kloos 2018). According to Bujak et al. (2013, 536), AR combines the physical and virtual, drawing on the strengths of each. Unlike virtual reality (VR), AR technology enables users to interact simultaneously with both virtual objects and the real environment, which is the second main feature of AR. Compared to VR, AR technology is closer to reality, with AR graphics bringing digital graphics and sound to the real world. VR technology, in turn, consists of a fully controlled, digital experience. (Yip, Wong, Yick, Chan, & Wong 2019, 89.) Therefore, AR complements reality without entirely replacing it (Azuma 1997). Azuma's (2001) third AR feature is real-time interactivity, resulting in virtual objects appearing in the same time dimension as the real world (Azuma et al., 2001). Not only does AR enhance the real world taken by the camera, but also it enables users to perceive the environment in real time (Chung, Lee, Kim & Koo 2018, 628). AR enhances a user's senses (e.g., vision and tactile) with virtual or naturally invisible information that is transformed into visible format by digital means (Azuma et al., 2001).

AR offers environments that are not possible to be created in real-world conditions due to many inconveniencies (Shelton & Hedley, 2002; Yuen et al., 2011). AR enables safe experimentation of potentially unsafe experiments, and some teaching methods are possible to conduct safely and ethically with the use of AR. That's one of the reasons why AR use is increasingly studied in psychological health and in treating different psychological disorders (Cipresso, Chicchi-Giglioli, Raya, & Riva, 2018, 14). It has been identified that AR systems can be effective in teaching. The ability of AR to merge virtual objects, for example 3D models and abstract concepts, together with real-world images makes AR an essential tool to improve educative methods. (Sirakay & Cakmak 2018, 3–4.) For instance, Baird and Barfield (1999) found that AR was a more useful tool in teaching motherboard assembly than original teaching materials. Moreover, students who utilised AR finished tasks faster with less errors. However, it was found that AR system was not as suitable as traditional methods what comes to usability. (Baird & Barfield 1999, 250.)

AR technology has been considered one of the most advanced technologies to improve user experience. AR technology has become more accessible since it can be used without specialised equipment and because it can be easily used utilising different appliance including a mobile phone. The accessibility of AR has also contributed to the popularity of AR technology in scientific research. (Khan, Johnston, & Ophoff 2019, 2.) AR technology has been explored for adaptability, especially in different learning environments, such as schools, workshops, and different types of training. Number of studies indicate that AR technology affects learning positively and thus is potential for educational outcomes. (Liu & Chu 2010, 632; Bujak 2013, 536.) AR technology is particularly useful for learning because it creates an effective and engaging environment. Studies suggest that AR provides a non-traditional learning space, which can increase attention, improve understanding of abstract concepts and create possibilities for collaborative learning, ultimately facilitating personally meaningful experiences. (De Souza E Silva & Delacruz 2006; Liu & Chu, 631; Bujak 2013, 540; Di Serio, Ibáñez, & Kloos 2013.)

Researchers have explained the popularity of AR technology by immersing its users in an enhanced real world. It is suggested that the immersion, defined as becoming part of the experience, experienced through AR encourages users to engage in different activities, which may improve motivation, such as, towards learning (e.g., Di Serio, Ibáñez, & Kloos 2013, 588; Khan et al. 2019, 3; Chiang, Yang, & Hwang 2014). Immersion includes both the physical features of the setting and the condition by which individuals are absorbed by an activity (Di Serio, Ibáñez, & Kloos 2013, 588). Immersive learning helps to engage the learner holistically, that is, cognitively, emotionally and physically. The immersive and interactive aspect of AR may explain why integrating AR technology with mobile games increases learning and motivation by engaging and providing richer user experience. (Barma, Daniel, Bacon, Gingras & Fortin 2015; Liu & Chu 2010, 633).

Different display and tracking technologies support various levels of immersion (Georgious & Kyza 2018, 173; Khan, Johnston, & Ophoff 2019, 3). Immersive technologies, for example head-mounted displays, support a high degree of immersion in contrast to mobile devices, which do not enable immersion to the same degree. An example of light AR would be applications that are used in smartphones, such as, the Pokemon Go mobile application (Khan et al. 2019, 3; Di Serio, Ibáñez, & Kloos 2013, 587). If the digital information is poorly aligned with the real objects, it can contribute to a less authentic feeling of immersion and consequently, a lack of engagement (Di Serio, Ibáñez, & Kloos 2013, 587).

In more recent years, the research literature on AR technology has been expanding, including research results on the benefits, limitations, efficiency and affordability of using AR technology (Bacca, Baldiris, & Fabregat 2018, 2). Bacca, Baldiris, Fabregat, Graf, and Kinshuk (2014) analysed 32 studies on AR technology that addressed the advantages, disadvantages, challenges, and limitations of AR technology applications in different educational contexts. According to the meta-analysis results, AR technology specifically influences learning gains (43,7 %), such as higher grades and more effective learning, and motivation (31,2 %) (Bacca et al.). In addition to learning, many research studies show that AR positively contributes to motivation.

4.2 The impacts of AR on motivation

Studies show that AR has a significant positive association with motivation (Liu & Chu, 2010; Di Serio et al., 2013; Bujak et al., 2013; Chang et al., 2014). The association of AR technology on motivation has been investigated in the fields of academic performance (Pribeanu, Balog, & Iordache 2017), language learning (Liu & Chu 2010), and in a variety of other learning environments (Ertmer & Ottenbreit-Leftwich 2010). Gutierrez and Fernandez found that engineering students (n = 25) with a degree in mechanical engineering who utilised AR technology in graphic design assignments ranked statistically significantly higher compared to a control group that used standard learning tools (n = 22). Motivation and learning were measured by an experiment and two questionnaires in which students gave feedback on the learning material, its effectiveness and their own satisfaction with the learning experience. (Gutierrez & Fernandez 2014, 626). In addition, results from another experimental study showed that students learning with an AR technology approach demonstrated measurably higher motivation in the attentional, trust, and meaning dimensions compared to the group using conventional learning techniques (Chiang, Yang, & Hwang 2014, 352).

Liu and Chu (2010) examined the effect of AR technology on motivation in a context of ARCS motivation theory in a sample of 13–14-year-old Taiwanese students learning a second language. The ARCS theory consists of four concepts: attention, relevance, confidence, and satisfaction, which reflect how people are motivated and remain motivated by something (Keller 1987, 3; Liu and Chu 2010, 630). The results showed that the AR group (n = 32) scored significantly better on the questions that measured different areas of the ARCS motivation theory compared to the control group (n = 32). The follow-up interviews also revealed that students in the experimental group found the AR game interesting, which is why they also thought the game as a useful and meaningful learning tool. (Liu & Chu 2010, 639).

Results of a mixed-methods design showed that AR technology had a positive effect on the motivation of high school-aged visual arts students (Di Serio, Ibáñez, & Kloos 2013, 586). Motivation was measured with a motivation survey based on the ARCS motivation model. The study consisted of three parts, in which students first attended a lecture using standard slides (TS1) and then an augmented reality enhanced lecture (TS2) presenting 3D model works that included text, audio, and video files. Students independently explored the AR learning environment in the laboratory room. The study also included a qualitative analysis section that looked at students as they interacted with AR technology. Afterwards, post-experience interviews were carried out with students. According to the quantitative results, students were more motivated in TS2 compared to TS1. It was found that subjects in the AR condition experienced more engagement and enjoyment. Participants also described the AR environment as appealing. (Di Serio, Ibáñez, & Kloos 2013, 586–588)

In the same study, students commented they experienced the AR environment as pleasant due to having a sense of control over exploring the topics in the order they wanted. In addition, the interviews revealed that, in TS2 condition, students achieved a higher degree of concentration and attention compared to the regular lecture. Participants reported it was easier for them to recall what they were learning in the AR environment compared to the normal lecture. It was also found that after the TS2 learning session, students randomly formed discussion groups in which they described in detail materials they found particularly interesting. (Di Serio, Ibáñez, & Kloos 2013, 589). The results indicate that AR influences students' motivation in many levels, one of which also appears to be group sharing. However, the appeal of the novelty associated with AR technology could have contributed to the particularly high motivation scores (Di Serio, Ibáñez, & Kloos 2013, 588).

Rasche, Schlomann and Mertens (2017) used a web-based survey to investigate the motivational effects of a popular AR game, Pokemon Go. The results of the study showed active players and former players differed in what they found particularly motivating in the game. Specifically, more active players stated features related to Pokemon Go, such as catching the Pokemons and attaining more advanced levels in the game as the most motivating factors. Former users highlighted the game quality, such as improved AR and more challenges to be the most motivating features. It was also found important reasons for stopping to play the game were boredom, technical difficulties, diasappointment and difficulties in attaining higher levels. (Rasche, Schlomann & Mertens 2017, 1–4.)

In addition to motivation, research has found that AR can contribute to the psychological state of flow. Study of Giasiranis and Loizos (2017) compared two groups (N = 42) that consisted of students, who were divided into a control group (n = 20) and an experimental group (n = 22). The control group utilised web technology, whereas the experimental group used tablets with an AR application. Findings indicated that both technologies positively impacted performance and enabled the experience of flow, with statistically significantly better results with the AR experimental group. (Giasiranis and Loizos 2017, 85.) It was suggested that AR contributed to the interest of students, which in turn motivated them to participate more actively and enthusiastically in learning activities. The findings also showed that students in the AR condition were more concentrated and comprehended teaching material better (Giasiranis and Loizos 2017, 86).

Despite a number of studies highlighting the benefits of AR on learning and motivation, there are some inconsistencies in the research literature regarding opportunities and challenges of AR usage. For instance, research has indicated that applying AR often requires multitasking because users often need to engage both with large amounts of information and several technological devices to sometimes complete complex tasks (Wu, Lee, & Liang 2013, 46). Multitasking can cause an excess cognitive overload, which contributes to feelings of being overwhelmed and confused (Khan, Johnston, & Ophoff 2019, 5). Moreover, AR applications are reported to be difficult to use, which can decrease motivation due to the poor usability (Akçayır & Akçayır 2017, 1; Chuttur 2009, 2). Nevertheless, according to Khan, Johnston and Ophoff (2019, 6), there is a lack of proof to propose that usability matters are related to AR technology directly but rather possibly are caused by other factors, including insufficient technology experience of the user, errors in design and programming, technical problems, or negative attitudes towards AR and/ or technology. In conclusion, the impacts of AR on motivation need to be further explored in a variety of settings to form more accurate conclusions regarding the topic.

5. AIMS OF THE RESEARCH STUDY

This thesis aimed to expand the research literature on AR and its potential effects on motivation. The general aim was to get a picture of the processes and outcomes of AR on motivation from a social psychological perspective. Based on previous theoretical literature and research evidence, AR technology could potentially have positive effects on motivation. Also, according to previous research literature on technological self-efficacy, self-efficacy is likely to affect motivation increasingly. Thirdly, this thesis aimed to expand the understanding on what particular features in the AR environment motivate people. Based on these research questions, this study has the following hypotheses:

H1. AR technology increases motivation

H2. Higher technological self-efficacy contributes to higher motivation

To answer the first hypothesis, AR and non-AR groups were compared in regards to finishing AR based quiz game. Motivation was measured by the number of participants who finished this quiz. In this thesis it is assumed that the more intrigued and interested (i.e., motivated) the participants are towards AR technology, the more motivated they are to complete the quiz. Motivation is essential in maintaining, initiating and sustaining any activities. Therefore, it was assumed, that motivation depends on how determined, intense and persistent action, i.e., finishing the quiz.

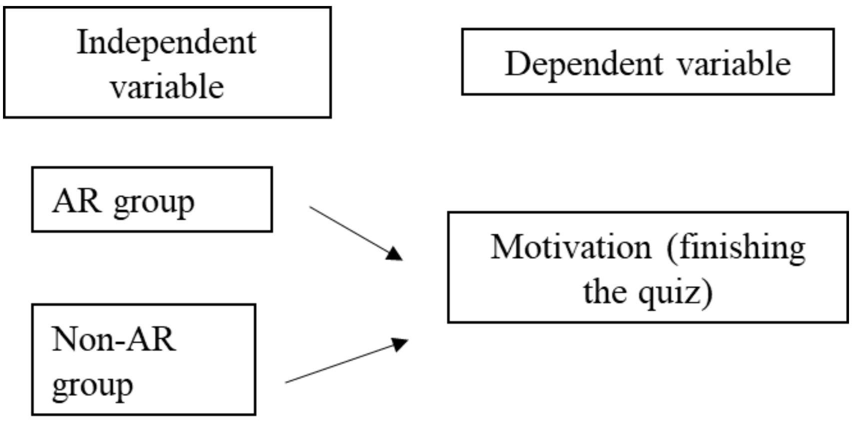

Figure 1. Design for the first hypothesis

The second hypothesis was investigated with a binary logistic regression analysis. The second hypothesis was only investigated amongst the AR group. This was because the particular interest of this thesis is to investigate whether self-efficacy contributes to motivation in the context of AR.

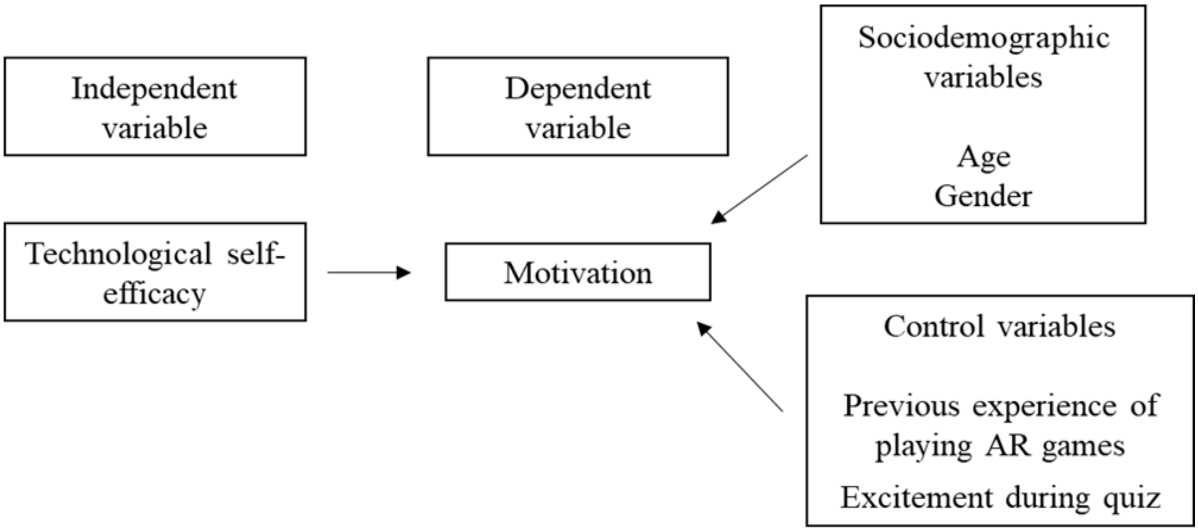

Figure 2. Design for the second hypothesis

As the initial purpose of the study was not to investigate motivation, the concept of motivation was further explored with interview data and content analysis. The purpose of content analysis was to provide further understanding of the effects of AR technology on the dependent variable under investigation, which in this thesis was motivation.

6 METHODS

This chapter introduces the procedure, participants, measures and variables of the study. The main aspects of the study design are also summarised, with a more detailed account of the methodology available from Savela, Oksanen, Kaakinen, Noreikis & Xiao (2020).

6.1 Procedure and participants

The data for this thesis was collected from a research project called *Social Dynamics of Augmented Reality* implemented by a social psychology professor Atte Oksanen and an assistant professor Yu Xiao from Department of Communications and Networking, Aalto University. The project was an unfunded collaborative research project implemented in cooperation with Aalto University and Tampere University. The data was collected between August and October 2018 at the Finnish Science Museum Heureka. The aim of the research project was to examine the potential effects of AR in public places. More specifically, the study examined how AR technology influenced users' sociability, entertainment and learning in shared space. (Savela, Oksanen, Kaakinen, Noreikis, Xiao 2020, 1; Noreikis, Savela, Kaakinen, Xiao & Oksanen 2019, 148111.)

An AR game, developed by the staff members from Aalto University, was used to study the effects of AR. AR-based quiz game, named ARQuiz, used the Heureka science center's quiz. All the quiz questions were in relation to biotechnology topics. The quiz was established for the AR application, non-AR application and pen-and-paper questionnaire (Savela, Oksanen, Kaakinen, Noreikis, Xiao 2020, 2). The original sample (N = 372) included participants from experiment group (participants that used AR app) and two control groups (i.e., non-AR app and pen-and-paper group). This thesis was mostly interested to investigate the effects of technology, which is why only AR and non-AR groups were included in the analyses (n = 302). The second hypothesis was only investigated amongst the AR group because the thesis was interested in investigating whether self-efficacy contributes to motivation in the AR condition.

The main feature of the AR game was to find quiz questions from the exhibition area using the AR application. Participants looked for floating virtual question marks dispersed around the main exhibition area. When a participant approached a question mark, the quiz question appeared on the phone screen. Subjects were able to choose their answer by tapping the phone screen. (Noreikis et al. 2019, 148112). One question had four possible answers. There was a total of 15 questions located in eight different places. Participants needed to explore the whole exhibition room to find all the questions. The participants earned points by answering the questions correctly. The goal of the game was to answer all questions, however, if a participant decided to quit the quiz, he or she was presented with a total quiz score. The AR game also had a social feature as it enabled the participants to interact with others by leaving messages and by replying to messages left by others. Other users were immediately able to see the posted messages, read and reply to them. (Savela et al. 2020, 4).

The non-AR app contained similar functionality as the AR app but the non-AR group solved a quiz on the smartphone without AR function. The non-AR app users could directly look through the quiz questions so they did not have to explore the exhibition space to find the questions marks. There were no differences in the scoring system or quiz questions. Similarly, to the AR group, non-AR app users could also write and read comments. (Savela et al. 2020, 4).

Participants were recruited to the study by asking all the visitors who arrived at the main exhibition area to participate in the study. Before commencing the survey, the participants were given instructions for completing the quiz and they were told they would be playing a quiz game.

Participants were also instructed that they had to answer survey questions prior and after the quiz game. Participants were advised that participation was completely voluntary. Participants were randomly allocated to one of the two different experimental groups (AR or non-AR). Participants were not aware of the details of the study including the different conditions and which condition they were assigned to. There was no timeline to finish the quiz, and therefore non-AR and AR players could interact in the space at the same time. Participants were given a small candy as a reward after they completed the experiment. (Savela et al. 2020, 4.)

The study was restricted from participants under 15 years of age. Participants of the final sample (N = 302) were aged 15–73 (M = 36.19, SD = 11.73), and 55.95% of them were female. The subjects were divided into an experimental group (AR group; n = 231; 62.10%) and a control group (non-AR app users; n = 71; 19.09%). The main interest of the thesis was to investigate the possible effects of AR technology, which explains a larger number of participants in the AR group.

There were no major differences between the experimental and two control groups in terms of age, gender or previous experience playing AR games. This means that the randomisation was successful considering the background variables. There were 53,7% females in the AR group (n = 124) and 56% of females in the non-AR group (n = 40). The mean age for AR group was 35.76 (SD = 11.63; range = 15–73) and non-AR group 37.59 (SD = 12,04; range 15–72). For the question *Do you use your mobile phone for playing games that use augmented reality (AR)?* AR group had 75.8% (n = 175) no answers and non-AR group 81.7% (n = 58).

In order to estimate the representativeness and generalisability of the sample, the descriptive statistics of the sample were compared to the population of Finland, i.e. the entire study population. In 2018, the age structure in Finland was following: 62.13% were between 15 and 64 years old and 21.72% were 65 years and older (M = 42.5 years). (Official Statistics of Finland 2018.) The mean age of the sample in this thesis is approximately 6 years less compared to the population in Finland. Visitors of Heureka are mostly families with children, which can explain the lower mean age. Women accounted for slightly more than half of the country, 50.72% of population, which is fairly similar distribution to the sample of the current thesis.

In addition to the quantitative data that was collected with the survey, a total of 28 face-to-face semi-structured interviews were gathered (57.14% women; M = 31.07 years; SD = 7.42). The semi-structured interviews consisted of only AR users to further explore AR user behavior and to gain a better view of the participants' experiences. The qualitative data was mostly gathered from the last interview question: *Did you complete the quiz? In your opinion, did augmented reality technology play a role in your motivation to complete the quiz (or complete the survey)?* Participation to the interviews was voluntary. All participants gave their informed consent for inclusion before they took part in the study. The interview form contained a total of 10 questions regarding the experiences in relation to the AR.

6.2 Measures

When doing research, it is critical to know about the types of variables in order to evaluate the appropriateness of the used statistical techniques. Unless the type of variables that are used in obtaining the data are specified, it is not possible to know whether the conclusions derived from the data are valid. (Field 2013, 8). Variables are measured to test study hypotheses. Variables are roughly dichotomised into two major types, independent and dependent variables. Independent variables (IVs) are the differing conditions (treatment vs. placebo) to which the participants are exposed. An IV may influence the measurement of the dependent variable (DV) and the value of DV is thought to be affected by the IV (Watson 2015, 1; Tabachnick & Fidell 2013, 1). In other words, IVs are usually considered predictor variables because they predict the DVs, also known as the response or outcome variables (Tabachnick & Fidell 2013, 2). The outcome variable of this study measured motivation and the main predictor variable measured technological self-efficacy. Other sociodemographic and control variables, which were relevant to include due to the research design and literature review, were: age, gender and experience of playing AR-games.

In statistical methods, the scale of the variables should be considered, meaning whether the variables are categorical or continuous (Tabachnick & Fidell 2013, 5–6). Categorical or discrete variables can have only limited values on the scale. Examples of discrete values include categories (group A and group B) and gender (male or female). (Tabachnick & Fidell 2013, 5–6). The discrete variables of this thesis were motivation, gender and playing AR games. These discrete variables can also be considered as binary because they have only two categories (no or yes, man or a woman). (Field 2013, 11).

The main predictor of this thesis, technological self-efficacy, was measured on an ordinal scale. In ordinal data, responses can be ranked or placed in an order but no measure of distance cannot be done (Field 2013, 11). Technological self-efficacy was measured on a seven level Likert scale, which is deemed to reach the upper limits of reliability (Allen & Seaman 2007, 63). Generally, scientists recommend using a Likert scale as wide as possible (Allen & Seaman 2007, 63). Likert scales are commonly used to measure data in surveys. Often Likert scales can be treated as interval data due to the contention that parametric tests are statistically more robust and provide more information compared to nonparametric ones. However, there are issues with treating ordinal data as interval because it can misrepresent the findings of a survey and lead to wrong conclusions. (Allen & Seaman 2007, 63.)

The continuity of a variable means that the variable of interest is being measured on a scale that changes values smoothly. Continuous variable can have unlimited number of values between any two values, in other words, it can obtain any values within the range of the scale. Some examples of continuous variables are time, age and distance. (Nummenmaa 2004, 30). Age of the participants was the only continuous variable of this thesis.

Motivation

Motivation was measured by the number of participants who finished the quiz. The values of the variable were encoded in the following manner: 0 indicates that a participant did not complete the quiz and 1 stands for completing the quiz. Table 1 shows the differences between the experimental and control groups for finishing and not finishing the quiz.

Table 1. *Descriptive statistics for participants who finished and did not finish the quiz for the AR and non-AR groups (n = 302)*

The AR group	*n*	%
Motivation to finish the quiz		
0 = Did not finish the quiz	182	78.8
1 = Finished the quiz	49	21.2
Total	231	100
The non-AR group		
0 = Did not finish the quiz	18	25.4
1 = Finished the quiz	53	74.6
Total	71	100

The descriptive statistics from Table 1 show that most participants, nearly 75% in the non-AR group completed the quiz. The descriptive results show that most participants in the AR condition did not complete the quiz: only approximately 21% of the participants completed the quiz. These results will be further explored in the results section.

Technological self-efficacy

This survey data included self-reported smartphone application self-efficacy, which is a part of the larger construct of technology self-efficacy. In this thesis, this operationalisation will be referred to as technology efficacy, which was the main independent variable of the study. Technological self-efficacy was measured with a question "*I am confident that I will learn to use new smartphone applications*". The variable was measured on a Likert-scale from 1 to 7, 1 indicating "Strongly disagree" and 7 indicating "Strongly agree". The technological self-efficacy question was adapted from computer/technology/mobile self-efficacy questions and modified to measure mobile application self-efficacy (Compeau & Higgins 1995).

Sociodemographic variables

Age and gender of the respondents were the controlling sociodemographic background variables. Gender was encoded as a dummy variable so that the value of 0 stands for women and the value 1 for men. There were 56% of females in the non-AR group (n = 40) and 53.7% females in the AR group (n = 124). The mean age of the respondents was 35.76 ranging from 15–73. Table 2 sums the descriptive statistics of the independent and background variables of the study.

Table 2: *Descriptive statistics for the independent variable, socio-demographic variables (age, gender) and the control variables, Descriptive statistics n = 302*

Variable	*M*	*SD*	Range	*n*	%
AR group				231	62
Technological self-efficacy	5.97	1.27	1–7		
Gender			0–1		
0 = woman				124	53,7
1 = men				107	46,3
Age	35,76	11.63	15–73		
Non-AR group				71	19
Technological self-efficacy	5.80	1.23	2–7		
Gender					
0 = woman				40	56
1 = men				31	44
Age	37,59	12,04	15–72		

Note: M = Mean
SD = Standard deviation
Note: Medians for self-efficacy: AR = 6.0 and non-AR = 6.0

6.3 Analysis methods

Three different methods of analysis were used to investigate the research questions. The first two research questions were investigated with quantitative analyses and the third one with qualitative methods. The first hypothesis was studied with a Pearson´s chi square test. The second hypothesis, higher self-efficacy will contribute to higher motivation to finish the quiz, was investigated with logistic regression analysis. The second hypothesis was only investigated amongst the AR group. Both quantitative analyses were performed using IBM SPSS 25. The third research question utilised content analysis to further investigate the aspects of AR that might have contributed to the motivation of participants.

6.3.1 Quantitative research, statistical significance, validity and reliability

Quantitative research can be used to test theories with hypotheses and applying statistical analyses. Quantitative research includes a variety of methods which are applied to investigate a phenomenon with the use of numerical or statistical data. Quantitative research enables to measure the phenomena under investigation and to analyse data for relationships. (Watson 2015, 1). Quantitative research is deductive, meaning that statistical analysis is applied and conclusions are drawn from the data (Tabachnick & Fidell 2013, 6–7).

Quantitative data is often presented in percentages, central tendency (i.e., mean, median, mode), standard deviation and range. Usually, quantitative analyses are done using inferential statistics. Inferential statistical techniques are used to test whether differences exist in populations based on measurements done on samples. (Tabachnick & Fidell 2013, 7). With the use of inferential statistics, a researcher makes inferences about collected data, such as, to investigate the differences between the mean values in the experimental and control groups and to examine the associations between variables, such as motivation and self-efficacy (Watson 2015, 4). Descriptive statistics, in turn, is used to summarise and describe data, such as, describe samples of subjects in terms of variables and are used to provide estimations of central tendency in the population (Tabachnick & Fidell 2013, 7).

In inferential statistics, the statistical significance of the findings is always assessed. Statistical significance is usually expressed in terms of probability (p), which measures the possibility of an event occurring by chance. (Tabachnick & Fidell 2013, 11). In social sciences, p is considered low (i.e., statistically significant) when it falls below 0.05. With low enough probability it be concluded that a finding is statistically significant at this probability. Statistical significance suggests that the observed events are likely to have occurred due to the experiment and not because of external factors. Statistical significance includes probability that certain effects have a chance of producing statistical significance in the data analysis and that the observed association between variables is real. (Watson 2015, 5; Field 2013; 4–5).

It is important that instruments of measurement are designed in a way that they have good reliability and validity. In quantitative research, measurement error cannot be completely eliminated; however, human error can be minimised in different ways. (Watson 2015, 5). One way to ensure the random error is kept to a minimum is to determine properties of the measure, which are validity and reliability. A valid instrument measures what it is designed to measure and a reliable measure can be interpreted consistently across different conditions (Field 2013, 12). Important types of validity are criterion validity (i.e., the results correspond to a different test of the same phenomenon), concurrent validity (i.e., data is recorded concurrently using the new instrument and existing criteria), predictive validity (i.e., data from a measure are used to predict future observations) and content validity (i.e., the test fully represents what it aims to measure). Reliability can be assessed, for instance, by testing the same experimental group twice: a reliable instrument is expected to show similar results at both times in time, known as test-retest reliability. (Field 2013, 12–13).

Quantitative research design is often divided into two broad categories: experimental and survey designs. Experimental designs are the best for explaining causality because in experimental research, the researcher has control over the conditions of at least one IV to which a subject is exposed to. In experimental design, researcher has the power to determine the levels of IV, how they are implemented, and how and when cases are assigned and exposed to the participants. The researcher also randomly assigns subjects to conditions of the IV and controls all other influential variables by holding them constant or randomising their influences. (Tabachnick & Fidell 2013, 2.) The use of a complete experimental design ensures the use of randomised experimental design and allows to draw firmer conclusions about the effects of the experiment (Caplan, Vinokur, Price, & Van Ryn 1989, 765.) This research utilised field experimental design that is a type of experimental design, which is done in a natural environment of the participants and not in a laboratory. The experimenter still manipulates the IV, but cannot control extraneous variables (i.e., other variables than IV, which affect DV) in the same way as if the research took place in a controlled laboratory environment. (Ochieng 2009, 14.)

Nonexperimental research includes surveys, which are suited for studying people. Most surveys are cross-sectional, but more reliable survey designs are longitudinal. Longitudinal studies enable to study long-term changes in populations. (Watson 2015, 4). The biggest limitation of nonexperimental design is that it is challenging to attribute causality to an IV. For instance, IV and DV are assumed to be related if there is a change in a DV related with levels of an IV. However, in nonexperimental design the cause of the relationship is unclear (due to the researcher has not manipulated IV), and therefore no causal association cannot be implied. (Tabachnick & Fidell 2013, 3; Field 2013, 7). If a researcher wants to draw conclusions regarding cause-and-effect relationships, experimental designs should be used.

6.3.2 Qualitative research

The qualitative approach was used as a method of analysis to study the second hypotheses. Qualitative research was chosen to better understand and explain the phenomena of motivation and to analyse participants experiences of motivation in the AR environment. Qualitative research is always analysed from a certain theoretical-methodological point of view. When analysing qualitative data, the researcher always focuses on what is relevant to the theory of the research. (Hirsjärvi & Hurme 2011, 59.) In qualitative research, the data is often reduced to a more manageable level by focusing on extracting material relevant to only to the research problem. Data can be reduced by combining observations and by finding common denominators or themes. The pooling of findings illustrates the researcher's endeavour to look at individual cases more generally. Available clues are used to interpret the phenomenon under study (Alasuutari 2011, 39–44; Hirsjärvi & Hurme 2011, 60).

Often when qualitative research is used as a method of analyses in social sciences, the goal is to explain phenomena and understand some reality. Qualitative research makes no attempts to establish whether the event is "correct". Berger and Luckmann (1967), for example, refer to qualitative research as "social construction of reality". Qualitative research can be applied when a more in-depth understanding of sometimes complex phenomena, for instance, attitudes, behaviour and motivations, is required. (Alasuutari 2011, 55–56; Barnham 2015, 836.) Contrarily, in quantitative research, the goal is to measure phenomena and at least within the constraints of a given sample, can be presented as "facts". (Barnham 2015, 837–838.)

Other distinction of quantitative and qualitative research is the types of research questions they provide answers to. For instance, quantitative research normally seeks answers to 'what?' questions (e.g. what factors impact motivation in an AR environment). In contrast, qualitative research is primarily used to answer "why?" questions with an aim to gain deeper levels of analysis. Qualitative research aims to understand why participants think or behave in certain ways, but it also aims to identify what participants think about a certain phenomenon. (Barnham 2015, 837–838). Ultimately, the aim of qualitative research is to make the phenomenon understandable in the temporal and cultural context in which it occurs. (Hirsjärvi & Hurme 2011, 50.)

There are number of different research methods available to the qualitative researcher. The most well-known methods are narrative psychology, grounded theory and content analysis. Each of these methods provide opportunities for data collection applicable to different purposes of the research study. (Arora & Stoner 2009, 275.) If the research goal is to study an individual's experiences and meanings about a certain phenomenon, then it is relevant to only select subjects who have actual experience of the particular phenomenon and can thus define the experience in detail and the setting in which the experience occurs. (Arora & Stoner 2009, 274.) In line with this, this thesis only aimed to explain the phenomena of motivation experienced in the context of AR, and therefore it is relevant that only AR participants were interviewed.

The common limitation of qualitative research is ambiguity inherent in language. For instance, a participant and a researcher can talk about motivation, but really motivation could mean very different things to the participant and researcher. The main limitation of qualitative designs is that their findings cannot be confidently applied to wider populations because the qualitative findings are not tested to determine statistical significance or whether the findings are due to chance. (Ochieng 2009, 15; Arora & Stoner 2009, 275.)

6.3.3 Mixed methods design

This thesis used the mixed methods design to enable a more complete utilisation of data. Mixed methods design was used for a further analysis of the findings than what is possible when solely using quantitative and qualitative analyses. In mixed methods designs, both quantitative and qualitative methods are used, which helps to mitigate disadvantages in relation to limitations of quantitative and qualitative designs and offers the needed depth of understanding of the given phenomenon (Arora & Stoner 2009, 279; Creswell & Plano Clark 2006, 528). As noted in the previous chapter, quantitative and qualitative analyses are used for different purposes and the research methods can be used to answer different research question (i.e., to measure or explain phenomenon). Qualitative data can offer a deeper analysis of the research question and findings (Barnham 2015, 837), but the qualitative research is a generally preferred method by social scientists to analyse data for relationships and draw conclusions. (Srnka and Koeszegi 2007, 30; Watson 2015, 1).

Mixed methods research was originally mostly used in social sciences but has subsequently extended into other scientific fields. The procedures of mixed methods design are suitable to investigate many different research questions and the methods can be used for different purposes. (Creswell & Plano Clark 2006, 528; Wisdom & Creswell 2013, 3.) This thesis utilised mixed methods design to explain some of the quantitative findings with qualitative data, known as explanatory sequential design. Explanatory sequential design has a quantitative phase and a qualitative data collection phase. This means that qualitative data builds on the findings from the quantitative findings so that the quantitative findings can be analysed more closely through the qualitative data. (Wisdom & Creswell 2013, 4; Palinkas et al. 2011, 45.)

In addition, the purpose of using mixed methods design was to use qualitative data to supplement quantitative findings of the thesis. In an embedded design, the qualitative data can be included into the study during the intervention (e.g., to explore how participants experience AR environment); and after the intervention (e.g., to help explain the results of quantitative analysis). (Palinkas et al. 2011, 45–46). Findings from quantitative data about the differences between AR and non-AR groups regarding motivation to finish a quiz can be explored further with qualitative focus group (AR) to gain a better understanding how the individuals' experiences correspond to the quantitative results. In this way, mixed methods design is utilised to explain qualitatively how the quantitative mechanisms might work.

6.3.4 Pearson's chi-squared test

When the aim is to compare independent groups, independent t-test is primarily chosen as the method of analysis (Delacre, Leys, Mora, & Lakens 2019, 1). Sometimes, however, the data does not fit the assumptions regarding parametric tests. Parametric tests cannot be used if the data does not have a normal distribution (normality assumption); data from groups do not share the same variance (homogeneity of variances) and if the data is not linear. The data should also be independent (i.e., values for variables for different groups are independent of each other). (Delacre, Leys, Mora, & Lakens 2019, 2–3). If one or more of these assumptions are not met, the non-parametric methods should be used as an alternative method of analysis.

As noted above, independent t-test could not be used as a method to investigate the first hypothesis because the parametric assumptions were not met: the two study groups, AR and non-AR groups, had different sample sizes and different standard deviations, which violates the assumption of homogeneity of variance (McHugh 2013, 143). A non-parametric option to the t-test is Mann-Whitney test. However, Mann-Whitney test was not an option here because the variables being investigated (i.e., the experimental groups and motivation) were categorical. Therefore, the only suitable method to examine the first hypothesis was Pearson's chi-squared test. (McHugh 2013, 143).

The Chi-square test is used to examine the distribution of categorical variables and the possible dependencies between them (Nummenmaa, Holopainen & Pulkkinen 2017, 194). The test also provides information regarding the performance of the variables or groups being studied (McHugh 2013, 143.) The Chi-square test (also known as the Pearson chi-square and independent chi-square test) provides information on which categories explain any possible differences between the categorical variables or groups (McHugh 2013, 143). The initial purpose of Pearson chi-square test is to compare the numbers or frequencies in certain categories to the numbers expected to get in those categories by chance. Expected frequencies refer to the distribution of observations that would occur if two groups (i.e., AR and non-AR groups) would have the exact same completion rates for finishing the quiz (Nummenmaa, Holopainen & Pulkkinen 2017, 197). Pearson's chi-squared test reveals whether the categorical variables are related, such as, whether there is an association between the study group (experiment and control) and the participant finishing the quiz (yes or no answers). In other words, the Pearson's chi-squared test is used to assess whether two variables are independent from each other. If the p-value is below 0.05, it can be assumed that the variables are related in some way. (Field 2013, 742).

When interpreting the significance of the findings, the significance value should be less than 0.05 ($p < .05$). Standardised residuals can be added to the analysis to further assess the significance of the findings. Standarised residuals are z-scores and can be interpreted the same way as z-scores: the value is regarded as significant at $p < 0.05$ if it falls outside of +/- 1.96. If the value falls outside of +/- 2.58, it is significant at $p < 0.01$. A value outside of +/- 3.29 is significant at $p < 0.001$. (Field 2013, 744). Cramer's V can be used to measure the strength of association (i.e., effect size) between the categorical variables. Values closer to 1 (0–1), indicate stronger association. Finally, odds ratio (*OR*) can be calculated to get a better idea of the effect size and help with the interpretation of the results. (Field 2013, 744). In addition to Cramer's V, *OR* can be used as an additional indication of an effect size for categorical data. (Field 2013, 744).

Non-parametric tests make fewer assumptions compared to parametric tests. The chi square-test makes two central assumptions concerning the independence and the expected frequencies: the groups being studied must be independent from one another and the value in expected cells should be at least 5 in at least 80% of the cells. Also, none of the cells should have an expected count of less than one (Field 2013, 735; McHugh 2013, 144).

6.3.5 Binary logistic regression

Binary logistic regression analysis was used to study the second hypothesis. Logistic regression is useful when the dependent variable is dichotomous, such as whether a participant finished or did not finish a quiz. The outcome in binary logistic regression is binomial, meaning that there can be only two possible outcomes, for instance, the outcome occurred or did not occur (Mayers 2013, 441; Keith

2013, 213.) The outcome is expressed in binary terms, where in this thesis 0 represented that an outcome did not occur (i.e., a participant did not finish the quiz) and 1 represented that an outcome (i.e., a participant finished the quiz) did occur (Mayers 2013, 441). Binary logistic regression was used because an outcome variable was categorical (i.e., participants finished or did not finish a quiz), which violates the assumption of linearity in normal regression (Field 2009, 315). Logistic regression overcomes the problem of linearity assumption by expressing the linear equation in logarithmic terms, called the logit (Field 2013, 762).

The regression coefficient (*B*) is in an essential role when interpreting the results of a logistic regression. *B* is the change in the outcome variable (i.e., logit of the outcome) that is associated with a one-unit change in the predictor variable (Field 2013, 784). The logit of the outcome is also known as Y, is the odds of an outcome occurring. For each predictor, the expected change in the log odds of belonging to the target group (i.e., normally the binary term 1) per one unit increase on the predictor. A positive *B* indicates a probability of belonging to the target group as a result of increases on the predictor variable. Contrarily, a negative coefficient demonstrates that the probability of target membership decreases with increases on the predictor. (Field 2013, 785; Mayers 2013, 442.)

In logistic regression, the way in which predictors change the likelihood of an outcome is being investigated. In other words, logistic regression answers to what are the odds of finishing or not finishing the quiz given a particular set of values for the independent variables. (Field 2013, 786.) For instance, higher technological self-efficacy might increase the likelihood of finishing the quiz, while being female might decrease the likelihood of finishing the quiz. That likelihood can be expressed in terms of an odds ratio (Mayers 2013, 447). Odds ratio (*OR*) is useful when interpreting the results of logistic regression. *OR* expresses the likelihood the outcome will occur according to changes in the predictor variable. *OR* indicates the change in odds that are followed by a unit change in the predictor variable. Simply, *OR* can be interpreted as follows: values that are greater than 1 indicate a greater likelihood of finishing the quiz whereas a value that falls below 1 show that as the predictor increases, the odds of the outcome occurring decrease. (Field 2013, 786; Mayers 2013, 455.) When interpreting the results, it should be noted that *OR* is not quite the same as probability even though it is calculated the same way (Keith 2013, 219).

The model should adequately "fit" the data. This can be measured by looking at the differences in the observed and expected frequencies. The observed outcomes are what actually occurred; the expected frequencies are what researcher predicted. The observed and expected frequencies should be similar. Hosmer and Lemeshow is a chi-squared test but it tests the fit of the model using a non-significance to indicate the goodness of fit. Hosmer and Lemeshow test examine if the observed and expected frequencies are significantly different. A non-significant test for Hosmer and Lemeshow indicates that a model is a good fit for the data. (Mayers 2013, 445–446.) Nagelkerke R Square (R^2) is a pseudo-coefficient of determination. In this thesis, Nagelkerke R^2 value was used to interpret the effect size for the model (Field 2013, 786). Nagelkerke R^2 can be interpreted as the equivalent to R^2 in linear regression. In other words, Nagelkerke R Square is an indication of the total variation in the outcome variable explained by the model (from 0 to 1). (Field 2013, 786; Mayers 2013, 454).

Finally, when interpreting the results of logistic regression, confidence intervals (*CI*) for the odds ratio should be considered. *CI* values can be interpreted in the following way: if the *CI* contains 1, then that IV does not have any impact on the odds and there is inadequate evidence to conclude that the outcome and predictor are statistically significantly different (Field 2013, 786). If both *CI* values include a number greater than 1, then as the IV increases, so do the odds for finishing the quiz. Values that are less than 1 indicate the opposite: as the IV increases, the odds of finishing the quiz decrease. (Field 2013, 786).

Assumptions and restrictions

In logistic regression, fewer assumptions and restrictions are made compared to linear regression. Normal distribution assumption does not apply because logistic regression only deals with categorical outcomes. The main assumption of the logistical regression analysis is that the outcome variable must be categorical with two possible outcomes, coded as 0 and 1. (Mayers 2013 447; Nummenmaa 2004, 319). The predictor variables can be continuous or categorical. Logistic regression has no restrictions on the number of categories for the predictor. In addition, logistic regression makes no assumptions about the scale of the variables to be explained meaning that they can be of whatever kind. In addition, there are no assumptions about the relationships of variables, but they can be, for example, logarithmic (Nummenmaa 2004, 320; Field 2013, 764).

In logistic regression, it is important that the predictor variables do not have high correlations with one another. If the correlation between variables is too strong, it will cause problems in terms of the accuracy of the results and makes independent predictions impossible. This issue is known as multicollinearity, which is a problem in the data that can cause difficulty regarding the reliability of the model parameter estimates. (Alin 2010, 370.) Multicollinearity is not an issue, unless there are large linear dependencies between the predictor variables (e.g., the correlation coefficient exceeds 0.9). Various multicollinearity indicators have been developed to indicate the problem (i.e., the variance inflation factor, VIF). (see Appendix 1). It should be noted that the tolerance data should not be below 0.2 and the VIF figure not to exceed 10. (Mayers 2013, 452).

Building a model and parsimony

When building a model, it is important to strive for parsimony. This means that models should be kept simple. According to the idea of parsimony, simple models are preferred because simpler explanations regarding a phenomenon are preferable to complex ones. If associations between the outcome and predictors is found, it is recommended to simplify the model by removing some predictors while still maintaining a strong prediction. In other words, there is no need to include predictors to the model unless they have explanatory value. Goodness-of-fit tests are utilised to select the model that does the best job of prediction with the smallest number of predictors. (Tabanich & Fidell 2013, 441; Field 2013, 768.)

Prior to the actual logistic regression analysis, different models should be compared to find a model that is the best fit for the data. This can be done with comparing the block chi squares of different models with different predictor variables. In this way, the researcher identifies whether, for instance, model 3 is an improvement over model 2. The block chi-square test indicates change in the model chi-square resulting from adding a predictor or several predictor variables. The values for the block chi square are obtained by calculating the difference between the model chi-square for two models (e.g., the χ^2 value of Model 1 subtracted from the χ^2 of Model 2). If the block chi square test is nonsignificant, it can be concluded that adding an extra predictor did not improve the model (i.e., it had no effect on the fit for the data). In this manner, the final and best fitting model can be decided with comparing block chi squares to choose the most parsimonious model that is the best fit for the data. (Field 2013, 790).

The simplest model includes only the constant and none of the predictors. The model that includes all predictor variables is normally referred to as the full model. The goal is to evaluate whether the full model is the best model and if it isn't, the researcher should choose a simpler model. (Tabanich & Fidell 2013, 441; Field 2013, 778–779.) In SPSS, predictors can be entered into the model in different orders. However, unless there is evidence to justify the order of the predictors, they should all be entered simultaneously using the Enter method (Mayers 2013, 459).

6.3.6 Content analysis

Content analysis was used as a method to further explore AR application users' motivational experience about the AR environment. Content analysis is a wildly used qualitative research method to analyse and explore meaning of a content of text. Content analysis can be utilised to interpret text data through identifying themes or patterns in the text (Hsieh & Shannon 2005, 1279). The objective of content analysis is to present knowledge and understanding of a phenomenon that the research aims to explain, which in this thesis was motivation. (Hsieh & Shannon 2005, 1277.) The specific type of content analysis approach depends on the theoretical and practical research interests and the research question in question.

Content analysis is a versatile method as it can be utilised for many types of research. Content analysis is applicable not only as a single method, but also as a loose theoretical framework that can be incorporated into different combinations of analysis. (Tuomi & Sarajärvi 2018, 114.) In line with this, this thesis utilised content analysis in a more flexible manner to further explain the quantitative results of the first research question. Specifically, content analysis was used to gain a better understanding on which factors impacted or did not impact motivation in the AR condition.

Content analysis can be data- or theory driven. Data-driven analysis seeks to examine the data as objectively as possible, without any prior knowledge or assumptions about the topic guiding the analysis or its outcome. The challenge with data-driven analysis is that the concepts, research design, and other factors of the research can influence and bias the outcome of the analysis. In this thesis, theory-driven content analysis was used. Theory-driven approach was used because there was already existing knowledge of the motivational themes that should be analysed in the answers. Motivational theories and previous literature on motivation guide the analysis. In theory-driven content analysis, the process starts under the terms of the material. What is essential is that the analysis is not based directly on theory but serves as a support for the analysis. Advocates on qualitative research have proposed the perspectives and language of participants experiencing a phenomenon should guide theory development (Arora & Stoner 2009).

In theory-driven analysis, the theory or prior research on the topic guides the analysis of findings. Categories or themes identified in the study can either offer a supporting or an opposing view of the phenomenon or might refine, expand, and enrich the existing theory and add on the current research literature (Hsieh & Shannon 2005, 1283). The findings offer supporting and/ or contrary evidence for a theory. There are different ways to present the evidence, such as, by presenting codes or descriptive evidence. Also, rank order comparisons of code frequency can be used (Curtis et al. 2001,43; Hsieh & Shannon 2005, 1281). The use of coding and descriptive evidence is optional but not necessary when presenting the results. In this thesis, the data was presented according to motivational themes that raised from the interviews.

Typical to content analysis is the organisation of the material according to different categories, themes, or types (Tuomi & Sarajärvi 2002, 93–95). This thesis applied content analysis to identify factors that participants acknowledged to contribute to their motivation. These factors were categorised into themes. Theme designing can be categorical in principle, but it emphasises what is said about each theme. All in all, it is a matter of splitting and racking up material according to different topics, which makes it possible to compare the occurrence of specific themes in the data. Before looking at the actual themes, the content can be grouped according to sociodemographic variables, such as gender and age. If the material was collected through a theme interview, then different views are easy to categorise into themes.

Some scholars argue that the absence of firm definitions and procedures limit the application of content analysis (Hsieh & Shannon 2005, 1277). However, existing theory or research may facilitate focusing the research questions, and they can predict associations among variables. (Hsieh & Shannon 2005, 1281).

7 RESULTS

This section explores the results for the three research questions. The first research question of whether AR environment contributes to a greater motivation was explored with the Pearson's chi-squared test. The binary logistic regression analyses were used to answer, whether technological self-efficacy contributes to higher motivation for finishing a quiz in an AR environment. Lastly, content analyses were used to further investigate the effects of AR on motivation.

7.1 AR environment's effects on motivation

Pearson's chi-squared test was used to examine the difference in motivation between an AR-group and a non -AR group. The main results are presented in Table 3. The value of the chi-squared test was 69.328. The significance value is less than 0,01 (p = 0.00) for the row labelled χ^2 (Pearson's chi-squared test), which indicates a significant relationship for finishing the test and the study group (i.e., non-AR and AR group). This significant finding supports that there is a relationship between the study group (i.e., control or experiment group) and whether the person completed or did not complete the quiz. This finding shows that there is a significant difference in the rates for finishing the quiz in the experiment and control conditions. It can be concluded that when participants used an AR application, approximately 21% of the them finished the quiz and 78.8% did not, whereas when a non-AR application was used, the opposite is true (25% did not finish the quiz and 75% finished).

Table 3: *The number of participants who completed the quiz in two different study groups, standardised residuals, the value of χ^2 and effect size (Cramer's V)*

		Finished the Quiz		Total
Experimental group		No	Yes	
Non-AR				
	n	18	53	71
	%	25	75	100
	Standardised Residual	- 4.20***	5.90***	
AR				
	n	182	49	231
	%	79	21	100
	Standardised Residual	2.30**	-3.90***	
Total	*n*	200	102	302
χ^2 (df =1)		69.33***		
Cramer's V		0.48		

Note: 0 cells have expected count less than 5. The minimum expected count is 23.98.
*p < .05, **p < .01, ***p < 0.001

Table 3 shows four residuals: one for each type of experiment group and whether the quiz was finished. All of the standardised residuals are statistically significant and can be interpreted as follows: in the non-AR condition, significantly more participants than expected finished the quiz (z = 5.9) and significantly fewer participants than expected did not finish the quiz (z = - 4.2). In the AR condition, however, significantly more participants than expected did not finish the quiz (z = 2.3) and significantly fewer participants finished the test (z = -3.9). This means that both groups (experimental group and the control group) significantly influenced the participants either finishing or not finishing the quiz.

Cramer's statistic is 0.48, which can be interpreted as a medium to high association between finishing the quiz and the experiment and control groups. This significance (p < .001) indicates that a test values were unlikely to have occurred if there were no association in the population.

OR was calculated in the following way: First, the odds that a person finished a quiz given that they belonged to a non-AR group was divided by the odds that a person belonged to a non-AR group and did not finish the quiz. Next, the odds for belonging to AR group and finishing the quiz, was divided by the odds for belonging to AR group and not finishing the quiz was calculated. Afterwards the first was divided by the latter.

		Non-AR	AR
Completed	Yes	53	49
the quiz	No	18	182

$$OR = \frac{53/\,18}{49/\,182} = 10.94$$

The OR tells that if a person was in the non-AR group, they were 10.94 times more likely to finish the quiz compared to if they were in the AR group.

In conclusion, there was a significant relationship between the type of group (experiment and control) and whether participants finished the quiz: χ^2 (1) = 69.33, p <.001. Based on the *OR*, the odds of the non-AR group finishing the quiz were 10.94 times higher than the odds for the AR group finishing the quiz.

7.2 The effects of technological self-efficacy on motivation

Prior to the actual logistic regression analysis, three models were compared to see which model is the best fit for the data. Model 1 included an outcome variable, the main predictor variable and the sociodemographic variables age and gender. Predictors were included using the enter method. In model 2, the control variable of playing AR games was added. This model was significant, χ^2 (3) = 15.73, p = .003. To find out whether model 2 was an improvement over model 1, the chi square test for block was looked at. This value was taken by calculating the difference between the model chi-square for the two models (here, 15.73 - 14.94 = 0.79). This change in the chi-square test was nonsignificant, χ^2 (4) = 0,790, p = .374, which indicates that adding playing AR games to the model had very little effect on the fit. In model 3, a control variable of excitement during the quiz was added.

Model 3 was a significant fit of the data (χ^2 (5) = 15.74, p = .008), however, model 3 was not an improvement over the previous one, (15.742 - 15.73 = .013). This change in the chi square test is again non-significant, χ^2 (1) = .013 = p =.911, indicating that adding "Excitement during the quiz" to the model did not have any effect on the fit of the model. (see Attachment 2).

Based on these comparisons, model 1 was chosen as the most parsimonious and best fitting model, and the analysis was proceeded with the Model 1. The main results of logistic regression for the Model 1 are presented in Table 4.

Table 4. *Summary of Logistic Regression Analysis for Variables Predicting the likelihood of participants finishing the Quiz*

Predictors	*B*	*SE B*	OR	95% *CI*
Gender	-0.72	0.54	0.49	0.18–1.40
Age	-0.06**	0.025	0.94	0.89–0.98
Technological self-efficacy	0.62*	0.29	1.86	1.06–3.27
Constant	-3.97	1.39	0.02	
Model 1				
χ^2	14.94**			
df	3			
Nag. R^2	0.23			

Note: OR = Odds Ratio
*p < .05. **p < .01. ***p < .001
Gender: Male = 0, Female = 1
Nag.R^2 – Nagelkerke's pseudo coefficient of determination

Table 4 shows that the model is a significant improvement of fit compared to the null model. The chi-squared test is statistically significant, which means that the model is a significant fit of the data χ^2 (3) = 14.94, p = .002. The model was found to fit the data adequately (Hosmer and Lemeshow's χ^2 = 8.06, p = 0.43). Nagelkerke's pseudo coefficient of determination of 0.23 means that the model explains 23% of the variance for finishing the quiz.

The fourth column in Table 4 includes the values for regression coefficients (*B*). Technological self-esteem is a positive and significant (*B* = 0.62, *SE* = 0.29, p = 0.030) predictor of the probability of completing the quiz. Positive coefficient indicates, that as scores increase on self-efficacy, the probability of falling into a target group 1 (i.e., finishing the quiz) increases. More specifically, for technological self-esteem the log odds of belonging to a target group are increasing by 0.62. Age, in turn, is a negative and significant (B = -0.06, SE = 0.025, p = 0.007) predictor for finishing the quiz. For every unit increase in motivation, (i.e., finishing the quiz) there is a decrease of 0.06 in the log odds of finishing the quiz. In other words, as the age is increasing, the probability of finishing the quiz is decreasing. Non-significant B value for the gender indicates that gender is a non-significant predictor for finishing the quiz.

OR value of 1.86 for technological self-efficacy means that the odds for finishing the quiz are being multiplied by 1.86. The participants who scored higher on self-efficacy were 1.86 times more likely to finish the quiz compared to not finishing the quiz. For age, the *OR* value is less than 1, which means the odds are decreasing for every unit increase on the predictor variable. For age, the odds are decreasing by a factor of 0.94. In other words, the older participants were 0.94 less likely to finish the quiz.

The confidence interval for self-efficacy predictor is between 1.06–3.27. Both values are greater than 1, which means that as self-efficacy increases, so do the odds of finishing the quiz. For age, the *CI* is 0.89–0.98, which means that as the participants age increase, their odds of finishing the quiz decrease. The *CI* for gender is 0.18–1.40. In can be concluded that since this interval contains 1, the predictor has no impact on the odds for finishing the quiz.

7.3 The effects of AR on motivation further explored

From the 28 interviewees, 19 subjects answered that they completed the quiz. Four participants replied they did not finish the quiz and five people were not sure whether they completed the quiz. The participants who finished the quiz mostly commented that AR had a positive impact on their motivation. It was found that one major theme in the interview data was the AR application made the quiz more interesting. For instance, "I finished [the quiz]. If the quiz was a typical quiz, it would have been less interesting. The question marks and searching for them maintained [my] interest" (Interviewee 1). Indeed, trying to find the question marks was a common theme for interest and motivation: "I completed the quiz. If it would have been paper-based quiz I would have done it anyway, but the [AR] application was nicer because I had to look for the question marks. I don't think it would have worked the same way on paper. [The app gave] an immediate response and encouragements helped and motivated me". (Interviewee 2). Others reported competitiveness of wanting to find the questions marks. Some said the AR application was fun and thus contributed to their motivation.

Others said they believed that AR application increased their concentration: “[The app] made it more interesting. If it was a normal quiz without the camera it would have been more boring. I believe that AR [application] helped me focus on the quiz” (Interviewee 6).

Some suggested that curiosity towards new technology helped to increase and maintain motivation: “I finished the quiz. Well, maybe AR had an impact on my motivation because I had to find all the question marks there, just like in Pokemon Go one have to search for Pokémons. I'm not sure if I was able to see how many question marks were left. Of course [I believe the app] increased motivation, and it was also nice to try new technology” (Interviewee 12). In addition to this, some participants said the novelty of AR was motivating but wondered if they would have felt the same way if AR was not new for them: “I completed the quiz. It probably did yeah [have an impact on my motivation], because it was interesting as it was new. But then again, if the use of this kind of applications were everyday life, then I don't know if it would have had such a meaningful impact [on my motivation]” (Interviewee 17). Similarly, one participant said they finished the test but did not believe that AR impacted their motivation: “I don't know if AR had an effect [on my motivation]. However, it was interesting to see what came next in the application. I was more curious towards the app” (Interviewee 3).

Table 5 presents the common themes that raised from the interviews. Table 5 only summarises, which main factors contributed to motivation. Some participants identified more than one motivating factor and therefore some participants are presented in a number of different categories.

Table 5: *Themes for the common motivating factors* (*n* = 20)

Interviewee (X)	Themes for motivating factors
X1, X2, X12, X16, X20, X23, X26, X27,	A: Search for the question marks
X1, X2, X3, X4, X9, X25, X28	B: Interest and curiosity
X12, X17, X18	C: New technology (novelty)
X7, X9, X25	D: Fun
X2	E: Encouragements (thought the smartphone application)
X23	F: Competitiveness
X6	H: Concentration and focus

Note: This table presents themes participants found motivating in the AR environment.

It should be noted, however, that some of the participants finished the quiz but did not believe AR was a motivating factor. For instance: "I completed the quiz [but] the augmented reality didn't make a difference [regarding finishing the quiz]. I participated in the research, so I wanted to complete the task". (Interviewee 5). Others said AR could have possibly contributed to their motivation if the quiz questions were more closely related to the exhibition. A common theme that was brought up in the interviews was that the quiz questions were not related to the exhibition itself, which was confusing for some of the participants. In addition, some AR users reported exhaustion due to having to focus on both the virtual and physical world.

One participant indicated he or she experienced a state that resembled immersion while engaging with the AR application: "I feel like I don't necessarily notice other people, that I could even walk over someone. I was there at the phone, but still it felt as if I wasn't here in this space" (Interviewee 11).

Interestingly, the same participant also stated, that they finished the quiz but did not believe that it was due to his or her motivation, even though he or her enjoyed searching for the question marks.

Even though the state that the participant described is in line with the definition of flow and immersion, the participant reported they did not experience the state as pleasant or

Some participants commented that the experiment was a bad experience for them: “This particular AR app was a negative experience indeed. Perhaps otherwise AR could have added to my motivation” (Interviewee 14). Others reported technical difficulties and user interferences, such as phone heating up and finishing the test by accident. Some indicated, the questions were too long and experienced the quiz as effortful to complete: “I finished [the quiz]. It probably did add on [my] motivation, the fact of trying to find the last question marks influenced the motivation. Questions could have been shorter so you wouldn't spend so much time reading. It seems like it took too much time to understand the question. The answers were several sentences long. If it had been more dynamic and faster paced, but this one felt too heavy to be an extra thing in the exhibition” (Interviewee 16). Some participants who had a more negative experience reported conflict and disorientation in trying to pay attention to their surroundings and to other people while navigating the room and advancing in the quiz.

8. DISCUSSION

This thesis used a mixed method design to investigate whether AR contributes to increased motivation. This thesis also investigated whether technological self-efficacy increases motivation to finish an AR-based quiz-game. This study had two hypotheses, which were AR increases motivation (H1), and higher technological self-efficacy has a positive effect on motivation (H2). The first hypothesis was not supported by the findings but contrarily to expectations, the non-AR group was significantly more likely to complete the quiz compared to the AR group. The second hypothesis was supported as technological self-efficacy was significantly and positively associated with finishing the quiz. Despite the high number of participants in the AR group not completing the quiz, the content analysis revealed that several interviewed participants experienced AR as motivating. Notably, the results showed that search for the question marks, interest and curiosity towards new technology were the most motivating aspects of the AR application. Some participants stated that they did not find the AR application as motivating due to, such as, technological interferences and the use of the application, in general, being a bad experience. These results are further discussed in the following paragraphs.

8.1 Main findings and comparisons to previous literature

The first hypothesis that AR contributes to greater motivation was not supported by the findings from Pearson's chi-squared test. In contrast, the non-AR group was significantly more likely to finish the quiz compared to the AR group. A number of research studies have shown that AR has a positive impact on motivation (e.g., Ertmer & Ottenbreit-Leftwich 2010; Pribeanu, Balog, & Iordache 2017; Liu & Chu, 2010; Di Serio et al., 2013; Bujak et al., 2013; Chang et al., 2014). Differently to most of the previous research, the results of this thesis suggested otherwise.

This finding could be explained with motivational theories and the past research based on AR. The settings of the field experiment may have not been ideal for creating intrinsic motivation for the participants. According to the self-determination theory (SDT), controlled motivation (CM) makes a person pursue an activity to attain a reward or to avoid a punishment. In this experiment, individuals might have felt that their behaviour (i.e., participating in the study and using the AR app) were externally regulated by outside factors, such as the researchers asking them to participate in the experiment, rewards (e.g., candy reward after the experiment) or punishments (e.g., the disapproval of a researcher for not participating in the study). Due to these reasons, participants may have experienced a sense of pressure and obligation to participate in the study, which may have decreased their intrinsic motivation. (Grant, Nurmohamed, Ashford, & Dekas 2011, 241.)

Autonomous motivation (AM), which refers to intrinsic motivation, occurs when an activity is pursued out of person's own interest. According to the SDT, the fulfilment of the three basic needs of autonomy, relatedness and competence are needed for the development of AM (van der Burgt, Kusurkar, Croiset, & Peerdeman 2018, 58). Unless the participants engaged in the experiment out of true interest, such as a willingness to try out new technology, it would have been difficult for them to experience intrinsic motivation, which could explain the high number of participants in the AR group not finishing the quiz. In other words, it could be that participants in the AR group experienced more CM than AM, which could explain why they did not have the energy to complete the quiz. Indeed, number of previous studies on motivation have shown that AM positively predicts performance outcomes. CM, in turn, has been found to be related to poorer performance outcomes, such as, less time and effort prolonged amongst the activity (e.g., Guay & Vallerand 1997; Gillet, Vallerand, Lafreniere, & Bureau 2013, 467; Fishbach & Choi 2012, 96).

According to the SDT, the more an individual experiences relatedness to others, the more likely it is that the motivation for the activity is intrinsic (Reiss 2004, 183). Some of the aspects of this field experiment supported social interaction, such as the opportunity to leave and reply to the comments of other participants, and thus offered and opportunity to relate to others. However, as reported in the interviews, the quiz game was mostly a solitude activity that required concentration and hence social interaction with other participants might have been experienced as disrupting. The finding of Savela, Oksanen, Kaakinen, Noreikis and Xiao (2020, 10) supports this proposition as their results showed that subjects in the AR condition were less likely to socially engage with other participants compared to the control groups. It is possible that if the experiment better supported opportunities to relate to others, the intrinsic motivation to finish the AR quiz game could have been higher.

Some of the participants reported technical difficulties with using the AR application, which may have led to a loss of motivation to finish the quiz game. According to the theory of planned behaviour, attitudes, subjective norms and perceived behavioural control explain motivation. In line with the theory of planned behaviour, it has been found that AR impacts motivation through the feeling of having control over the activity. The SDT also proposes, that sense of control is necessary for the development of intrinsic motivation (van der Burgt, Kusurkar, Croiset, & Peerdeman 2018, 58). In this experiment, participants had some control over the activity because they were able to discover the question marks in order of their own choosing. For instance, participants could freely explore the exhibition space while playing the AR quiz game, which may have added to feelings of control and autonomy. However, there was a lack of freedom in regards to choosing the topic that was explored in the quiz game. Evident in the interviews, some participants reported difficulties in using the application, such as phone heating up or accidently ending the quiz. This may have negatively impacted their perceived behavioural control, in other words, how easy or difficult they perceived the activity (e.g., perceptions of required resources and potential obstacles), and thereby lowered their motivation to finish the quiz. Also, some participants reported the application being too difficult to use, which may have contributed to the participants either getting bored or frustrated, and hence not finishing the quiz.

Further examination of the motivating and non-motivating factors of AR via content analysis revealed, that despite the high number of participants not finishing the quiz, most of the subjects who participated in the interview commented that AR had a positive impact on their motivation. Participants reported searching for the question marks, interest toward new technology, fun, encouragements (through the app), and competitiveness as motivating factors in the AR experiment. Some of these findings are supported by the previous research literature. The findings of Rasche, Schlomann and Mertens (2017) proposed active Pokemon go players are mostly motivated by features of the AR game, such as aiming to catch all Pokemons and accomplishing higher levels in the game. Similarly, interview data in this thesis indicated searching for the question marks was the most motivating aspect of the AR quiz game. In line with the results of this thesis, Di Serio, Ibáñez, & Kloos (2013, 586) found that their participants felt more engaged with in the AR environment, and the participants described it as enjoyable.

Also, previous studies have found that AR games has been experienced as more interesting than original games (Liu & Chu 2010, 639). The results from this thesis also suggest that AR has potential in helping individuals to engage and remain interested in learning activities as a result of the motivating factors of AR. One participant also stated, that AR impacted his or her concentration levels. Similarly, Giasiranis and Loizos (2017) found that participants in the AR condition were more focused compared to the control group, and hence comprehended teaching material better. Supported by the previous research, it can be assumed that AR enhances the interest of subjects, which in turn can motivate them to engage in activities as well as enhance their concentration in, such as, learning. In addition to interest, satisfaction regarding usability has been found important in the willingness to engage with AR applications (Di Serio, Ibáñez, & Kloos 2013, 586). In line with this, Savela et al. (2020, 9) found that higher satisfaction of the participants was positively associated with the likelihood of completing the quiz.

AR related research shows that AR can contribute to the psychological state of flow by immersing its users in an enhanced world. It is suggested that AR can lead to immersion, defined as becoming part of the experience. Studies show that the state of immersion facilitates positive outcomes, for example better focus and engagement in activities, and improves motivation. (e.g., Di Serio et al. 2013, 588; Khan, Johnston & Ophoff 2019, 3; Chiang, Yang, & Hwang 2014; Giasiranis & Loizos 2017.) Similarly, in this thesis, one participant indicated he or she experienced a state that resembled immersion while engaging with the AR application. For instance, the participant described that he or she did not pay any attention to other people and felt one was not present in the physical space. Interestingly, the same participant also stated, that he or she finished the quiz but did not believe that it was due to one's motivation, even though he or she enjoyed searching for the question marks. Rather than immersion, this particular participant likely experienced cognitive overload with having to divide one's attention with the AR game and reality. Indeed, many studies have concluded that applying AR technology often entails multitasking, as users need to engage with technological devices that they are not familiar with (Wu, Lee & Liang 2013, 46). Nevertheless, this finding indicates that even mobile devices can support some degree of immersion, even though mobile devices are not considered as high immersive technologies like head-mounted displays (Khan et al. 2019, 3).

Some participants stated that the novelty of AR was a motivating factor for them. One participant said it was nice to try out new technology. The appeal of the novelty associated with the AR technology could, however, merely measure situational and short-lived, temporary aspects of motivation (Di Serio, Ibáñez & Kloos 2013, 560). Accordingly, one of the participants stated that even though he or she experienced the AR application as motivating, one suspected that if he or she had the chance to use AR applications more often, the motivational impact of AR could be less significant. In line with De Serio et al (2013), this thesis also suggests similar experiments ought to be carried out over a long period of time to explore the possible confounding novelty effect.

The interviews also revealed some reasons why the AR application was not a positive experience. Participants made comments that referred to the experience of cognitive overload; for instance, a few AR users reported that it was inconvenient having to divide their attention between the physical world and the virtual world. One participant said that the questions in the quiz could have been shorter, and they felt it time-consuming to understand the questions. The participant specified that the quiz felt too "heavy" to be an extra thing in the exhibition. Evident in the past literature, the use of AR often requires multitasking, as users have to absorb a lot of information and handle many technological devices sometimes to perform various tasks (Wu, Lee & Liang 2013, 46). Multitasking can cause cognitive overload, which contributes to feelings of being overwhelmed and confused (Khan, Johnston & Ophoff 2019, 5). In line with the results of this thesis, previous research also suggests that AR applications are reported as difficult to use, which can decrease motivation due to the poor usability (Akçayır & Akçayır 2017, 1; Chuttur 2009, 2).

The second hypothesis was supported, which was consistent with the majority of other research literature on self-efficacy. That is, technological self-efficacy had a positive and significant relationship with motivation, which suggest self-efficacy is a major determinant in one's level of motivation, which is reflected in a person's effort and perseverance to perform a task. In line with the self-efficacy theory, it can be explained that participants with lower self-efficacy beliefs had less motivation (i.e., persistence) to finish the quiz. As pointed out by the previous research on self-efficacy, people who have doubts about their own capabilities lower down their efforts, give up prematurely and quicker settle for easier solutions when faced with more challenging tasks (e.g., Bandura 1993, 120), whereas the more one believes in his or her capabilities, the more persistent and stronger are his or her efforts (Bandura, Freeman, & Lightsey 1999, 2; Bandura 2006, 307).

The finding that technological self-efficacy predicted the probability of finishing the quiz can also be explained with the expectancy-value theory. According to the theory, individuals' expectations of accomplishment and the value placed on a task predict performance, in other words, by one's beliefs about the ability to carry out a certain task and the extent to which that certain task is valued (Doménech-Betoret, Abellán-Roselló & Gómez-Artiga 2017, 1194; Bandura, Freeman & Lightsey 1999, 2). Expectancy-value theory proposes that motivation is determined by the expectation that an action leads to certain outcomes (Doménech-Betoret et al. 2017, 1194). In other words, people act on their self-efficacy beliefs about what they can do. Therefore, it can be concluded that participants with higher beliefs in their technological abilities had more positive outcome expectancies for completing the quiz, which also contributed to better outcomes for finishing the quiz.

Results from logistic regression indicated that younger participants were more likely to finish the quiz compared to older participants. It can be that younger individuals were more confident in using the application and therefore had higher motivation to finish the quiz. Gender or previous experience for playing AR games did not have impact on the likelihood for finishing the quiz. Previous literature on the sources of self-efficacy indicates prior practice and training in certain activities may enhance efficacy beliefs (e.g., Ertmer & Ottenbreit-Leftwich 2010; Tilton and Hartnett 2016). This thesis, however, did not find any association between prior experience playing AR games and likelihood for finishing the quiz. A number of studies shows that people tend to perform better when they experience positive emotions (e.g., Hill, Van Boxtel, Ponds, Houx, & Jolles 2005, 433; Gillet, Vallerand, Lafreniere, & Bureau 2013, 474). In this thesis, however, excitement during the quiz did not predict the likelihood for finishing the quiz.

8.2 Evaluation of the study

The instruments of measurement, reliability and validity, are considered when assessing the quality of the study. As previously noted, reliability refers to the reliability of the measurement and validity to the chosen methods to measure exactly what the study aims to measure (Field 2013, 12). In addition to reliability and validity, each study has its own strengths and limitations depending on the study design and chosen instruments and methods of analyses.

The current study was a field experiment. The strength of field experiment is that behaviour of participants is likely to reflect reality because it occurs in a natural setting. Therefore, the ecological validity of field experiments is higher compared to experimental studies that are conducted in laboratory. Due to the experimental nature, conclusions can be confidently drawn regarding cause-and-effect relationships. The limitation of field experiment is that there is less control over confounding factors that might bias the findings. Thereby, the full replication of the study is also problematic for another researcher, which means that the reliability of the study is decreased since the instruments cannot be interpreted consistently across variety of different situations. (Tabachnick & Fidell 2013, 5–6; Caplan, Vinokur, Price & Van Ryn 1989, 765; Field 2013, 12). Also, the used methods in experimental research can affect the findings. Sometimes participants can put too much emphasis on trying to please the researcher. Additionally, it is possible that participants are often not aware of their true feelings and behaviour, so they cannot respond to a questionnaire or interview accordingly. In these ways, the behaviour of participants can decrease the content validity of experimental studies. (Ochieng 2009, 15.)

Survey was used to gather quantitative data. A typical limitation for surveys is reliability factors related to cognitive processes of the participants. Based on the satisficing theory, reliability of the study and its validity can be distorted when subjects use minimal mental processing when responding to the survey. This behaviour is known as satisficing. In contrast, reliability of the study is enhanced when respondents carefully consider their answers, known as optimising. (Hamby & Taylor 2016, 912.) Satisficing cannot be eliminated, but it can be minimised with offering a limited number of alternatives and keeping the survey length to optimal (Hamby & Taylor 2016, 913). The survey in this research had a total of 26 questions (and the quiz) and took about 10 minutes to complete. Also, many questions only offered yes or no answers or self-evaluations on a scale of 1 to 7. The interview data showed, however, that some participants felt the survey and quiz game felt effortful to complete. Also, the environment of the science museum could have partly distorted the attention capacity of the participants because of the noise and other available activities around the exhibition area. These factors could have enhanced the satisficing behaviour of the participants and could potentially limit the findings.

External rewards can increase survey completion rates and times. External incentives can encourage respondents to complete the survey but with the cost of providing quick answers without carefully considering and reflecting their answers. Thus, external rewards can contribute satisficing behaviour and motivate the participants to rush through a survey. (Barge & Gehlbach 2012, 182.) In this thesis, participants were offered chocolate as a reward for participating to the study. Chocolate reward may have been a motivator for some to participate in the study. On the other hand, it can be assumed that visitors of science museum would have been interested to try out new technology and participate in the study out of their own interest.

A self-report scale should have both strong convergent and discriminant validity. Mobile application self-efficacy was adopted from Compeau and Higgins (1995) computer self-efficacy questionnaire. This is a validated measure to assess computer self-efficacy and can be applied to measure other forms of technological self-efficacy (Compeau & Higgins 1995, 189). Technological self-efficacy was measured on a seven level Likert scale, which is deemed to reach the upper limits of reliability (Allen & Seaman 2007, 63). Generally, scientists recommend using a Likert scale as wide as possible (Allen & Seaman 2007, 63). When measuring self-efficacy, providing a neutral response (i.e., choosing the middle option from 1–7) yields to more reliable answers than forcing non-neutral respondents to choose positive or negative option. On the other hand, offering the middle option can be encouraging, as non-motivated or tired respondents are likely to choose a neutral option without considering other opinions. (Krosnick & Presser 2010, 271.) There were no missing cases for the self-efficacy question or any of the other variables that were used in the final model, meaning that the statistical power of the research was not impacted by any missing cases. The missing data can bias the estimation of parameters and can decrease the representativeness of the samples, which however was not a problem in this thesis (Kang 2013, 402).

Pearson chi-square test was used to study the first hypothesis. Often parametric tests are more robust and have more statistical power compared to nonparametric tests (Nummenmaa, Holopainen & Pulkkinen 2014, 200). According to Hunter and May (1993, 386) parametric tests are more robust compared to nonparametric tests if all the assumptions underlying the parametric test hold and the nonparametric test is based on a measurement scale lower than interval. The use of parametric statistical tests based on their hypothetical statistical advantage can lead to false analyses and potentially to inferences that are invalid (Hunter & May 1993, 385). In this thesis, the use of parametric tests was not possible due to the normality assumptions not being met. However, all the Pearson chi-square assumptions were met and therefore inferences from the analyses should be valid.

Binary logistic regression was used to answer to the second hypothesis. The strength of binary logistic regression is that it can be used to make predictions and to describe relationships between variables (Nummenmaa, Holopainen & Pulkkinen 2014, 236). Results showed that Nagelkerke's pseudo coefficient of determination explained 23% of the variance for finishing the quiz. In social sciences, this value is considered as adequate value (Mittlbock & Schemper 1996). The test result from Hosmer and Lemeshow's goodness of fit were non-significant, and thereby the model is considered a good fit for the data, which makes it possible to derive valid conclusions from the findings (Mayers 2013, 453, 458.) Assumption for multicollinearity were satisfied. Some correlations existed between the variables, but according to multicollinearity measurements, this is not a problem.

When measuring self-efficacy, it is argued that semi-structured interviews help participants to interpret their experience and confidence levels more fully, which in turn helps to explain the concept of self-efficacy more efficiently than only self-report questionnaires (Zeldin and Pajares 2000, 219). Some researchers argue that quantitative methods do not provide possibilities for detailed explanations of a research question, and therefore deeper insights are only available through qualitative research (Zeldin & Pajares 2000 219; Schunk 2001, 3). It is argued that using qualitative methodologies, for example interviews and observation, for exploring the sources of technological self-efficacy could possibly contribute to the theory more thoroughly (Schunk 2001; 1991). This thesis only used quantitative analysis to investigate the impacts of technological self-efficacy. It is advised that future studies should utilise mixed methods to examine the impacts of self-efficacy to draw firmer conclusions.

The common limitation of qualitative research is ambiguity, that is inherent in human language (Arora & Stoner 2009, 279). For instance, a participant and a researcher can talk about motivation, but motivation could be perceived in very different ways to them. The main limitation of qualitative designs is that the findings cannot be confidently applied to a wider range of populations with the same extent that quantitative analyses can. (Ochieng 2009, 15; Arora & Stoner 2009, 275.) The strength of this thesis is that it used mixed methodologies to help mitigate some of the issues in relation to the validity and reliability of both quantitative and qualitative designs. Also, this thesis used two different statistical analyses to provide a more thorough understanding of the concept of motivation.

The ways motivation was operationalised and measured in this thesis is somewhat limited. Motivation was operationalised in terms of performance, specifically, persistence. Persistence, or the extent to which a person continues to pursue a goal despite challenges, here was measured with the number of goal-related tasks (i.e., the quiz questions) the participants completed. Motivation was also defined as the extent to which one continues to engage in the task without quitting it, (i.e., finishing the quiz). (Carver & Scheier 1998; Reed & Aspinwall 1998). It was assumed that if the AR quiz game was experienced as motivating, then participants would put extended effort in completing the AR-based phone application quiz despite becoming tired or wanting to pursue more exciting activities available in the museum. Motivation is, however, a multifaceted and complex psychological construct, which makes it difficult to measure accurately. The validity of the findings could have increased if this thesis had utilised a wide range of other measures to capture motivation, such as, speed, accuracy and amount (e.g., how many questions participants answered to depending on AR and non-AR conditions).

The strength in regards to how motivation was measured was the use of behavioural measures. Number of scholars studying motivation recommend the use of behavioural measures over self-ratings or questionnaires because they believe self-ratings are biased by the participants incapability to accurately recognise their internal states (e.g., Touré-Tillery & Fishbach 2014, 340). However, in addition to behavioural measures, The Motivation Energy Inventory and Intrinsic Motivation Inventory (IMI) could have been used to help to distinguish different motivational dimensions and better capture intrinsic motivation specifically (Shahid, Wilkinson, Marcu, & Shapiro 2011, 235). Motivation could have also been explored with observable methods that are particularly important when measuring situational motivation (Van Der Burgt et al. 2018, 60). Situational Motivation Scale could have been used to further investigate aspects of situational motivation (Trémeau, Goldman & Javitt 2013).

8.3 Conclusions and generalisability of the findings

This thesis shed new light on the AR research and questioned some of the literature on the positive impacts of AR on motivation. The results of this thesis also illustrate some of the limitations of AR, which are recommended to be addressed in future research. The results are in line with previous studies with regards to the positive impacts of self-efficacy on motivation, confirming a significant relationship between technological self-efficacy and motivation. The results of this study show that younger age is essential in predicting motivation regarding AR technology use, which adds to the AR related research. The results indicate that despite the high number of participants not finishing the AR quiz game, number of participants still commented that AR was a motivating factor for them due to novelty, interest, curiosity towards new technology and AR adding to their feelings of competitiveness.

It is recommended that future studies utilise different ways to measure motivation that were not possible in the constraints of this thesis. In line with Touré-Tillery & Fishbach (2014), this thesis suggest that future researchers should employ multiple measures to help differentiate between the types of motivations. Future research on motivation should take note on what kind of a motivational dimension the study is aiming to explain, and utilise the motivational measures (e.g., observation, surveys) accordingly. Due to the complexity of motivation, it is recommended to use more than one measure to increase the validity and reliability of findings (e.g., Touré-Tillery & Fishbach 2014, 328).

The results of this thesis support that technological self-efficacy is a central factor in understanding individual's use and engagement with new technology. Especially, the results show that older people were less likely to complete the AR-based quiz, which is likely to have been due to their lower efficacy beliefs in their abilities to use the technology. It is recommended that future research will further investigate how individuals' beliefs in technological abilities could be enhanced so that people would more willingly use and engage with technology. Thereby, further research is yet needed because the society is becoming increasingly reliant on technology. Previous research on self-efficacy has already identified that mastery experiences, modelling and verbal persuasion impact self-efficacy beliefs. Not much research exist about how self-efficacy can be enhanced, especially in the field of AR-related research. Also, future research should employ both qualitative and quantitative methods to measure self-efficacy more accurately.

Future research should more closely investigate whether negative experiences related to AR are due to the AR use itself or other factors. This thesis was unable to identify whether lower rates for completing the AR game was due to AR technology itself or due to other reasons. The results from content analysis showed, however, that some of the participants did not experience AR to "be their thing" and would have rather completed the experiment with pen and paper. In line with this, previous research indicates that usability issues may not be directly related to AR technology but could possibly be caused by other factors, including insufficient experience in using technology or negative attitudes towards AR (e.g., Khan, Johnston and Ophoff 2019, 6). Indeed, future studies could more closely investigate the impacts of attitudes in relation to AR use. It would also advance the research field to find out whether personality factors have an impact on willingness to use AR technology.

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ATTACHMENTS

Attachment 1. Results from multicollinearity

Predictors	VIF values	Tolerance
Age	1.006	0.994
Gender	1.025	0.976
Technological self-efficacy	1.027	0.974
Dependent variable: Motivation		

Attachment 2: Results for logistic regression: comparison of the models

	Model 1	Model 2	Model 3
χ^2	14.940**	15.730**	15.742**
df	3	4	5
Block chi-square test (*p*)		0,790	0,911

Note: Note: *p < .05. **p < .01. ***p < .001

The chi square test for Block for models 2 and 3 are non-significant, indicating that extra predictors do not add any effect on the fit of the model.

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