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Motivating students to increase their metacognitive awareness

An exploratory app development study

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Abstract

One might expect the people who succeed in college to be those who are deemed the most intelligent. However, metacognitive awareness predicts academic success better than intelligence and through developing metacognitive awareness, learners have the ability to compensate for differences in IQ. Metacognition is the awareness, understanding and control that someone has over their learning. On the meta level of cognition learners determine their goals and sketch a plan to achieve them. The plan is executed by lower level cognitive functions, being monitored on the meta level. Through monitoring, the learner can verify whether their actions are bringing them closer to their goal or whether they need to adjust their actions. We developed an app which trains metacognitive awareness through explicit goal setting, planning and evaluation of learning activities. Since it requires extended effort to repeat these steps, a motivational incentive was incorporated in the form of a game. By playing the game, users acquired learning strategies. By utilizing and reflecting on these strategies, users earned gold that could be spent in the game. The app was tested with 3rd year college students at the university of Groningen, with weekly interventions to guarantee usage and provide support. The game was considered to be motivating by our participants, but the game itself was too hard which limited the amount of learning that was done. Participants were forced to earn learning strategies through the game, which several participants found limiting of their autonomy as a learner. Another limiting factor was that the available learning strategies were not always usable within the learning plan of our participants. Whether the app leads to increased metacognitive awareness remains inconclusive, but the utility of the app was widely recognized by our participants. The current app provides a framework which can easily be extended, to allow for quick adaption based on the lessons learnt from this study and to continue testing in future studies.

Contents

Chapter 1

Introduction

"*If you know you are on the right track, if you have this inner knowledge, then nobody can turn you off... no matter what they say.*" - Barbara McClintock

Barbara McClintock was a female scientist working in the field of cytogenetics. She was responsible for the discovery of genetic transposition in the 1940s, which was met with a lot of resistance at the time. However she kept believing in her theories as she was sure that she was on the right track. In the 1960s her theories eventually became generally accepted, for which she was rewarded with the Nobel Prize in Physiology or Medicine in 1983.

This inner knowledge of being on the right track, or not being on the right track, emerges through metacognitive awareness. High metacognitive ability has been shown to be able of compensating for differences in IQ and has been noted to have more predictive value for academic success than intelligence (Swanson, 1990). Metacognition, as the term 'meta' suggests, essentially operates on a level above cognition while still being a part of cognition. This is described in the metacognitive model by Nelson & Narens (Nelson, 1996) which divides cognition into two levels: A meta level which regulates higher order functions and an object level on which lower order functions are carried out. The meta level contains the goals that one wishes to achieve, through which it determines a course of action. These actions are then carried out on the object level. The meta level is responsible for monitoring and evaluating the processes on the object level, to determine whether the chosen action is suitable for reaching the intended goal.

Metacognitive awareness starts to develop around the age of three, at which point children start to develop theory of mind. Theory of mind is the ability to recognize mental states and allows one to reason about the minds of both others and yourself, which is crucial for being able to reason about yourself and your knowledge while also realizing that your knowledge may be false (Kuhn, 2000). As you then grow older you will develop metacognitive theories, which formulate beliefs about yourself as a learner. These theories are generated through experience (e.g. "*I am inherently smart because I never had any trouble in high school*") but they can also be acquired through peers, teachers, culture or stereotypical ideas (e.g. "*I am a woman and therefore I am bad at science*") (Schraw & Moshman, 1995) (Schmader, Forbes, Zhang, & Berry Mendes, 2009).

It is important to note that these theories are beliefs and that they are not necessarily correct. These theories can also be picked up unconsciously, which can be troublesome since it will then influence the learning process without the learner being aware of this (Schraw & Moshman, 1995). For this reason it is important to make students aware of metacognition, hence the term metacognitive awareness. The current study will therefore opt to develop an app through which students can improve their metacognitive awareness and consciously form metacognitive theories.

Training metacognitive awareness is in itself however not something that is immediately rewarding, since it requires extended practice and reflection in order to be effective (Kuhn, Schauble, & Garcia-Mila, 1992). Expending effort into monitoring and reflection or learning will have to be continued in order for the learner to be able to reap the benefits, thus we need to incorporate an element to keep our users motivated. Since video games have shown to be remarkably effective in motivating users and their ability to keep them engaged (Sailer, Hense, Mayr, & Mandl, 2017), researchers have started to incorporate video game elements to learning tasks in order to motivate students and facilitate learning.

This study will do the same, as we will incorporate game elements to motivate students to train their metacognitive awareness. The game elements will serve as a means of providing immediate gratification for putting in initial effort. By handing out rewards based on effort we aim to keep students engaged, so that they remain motivated and increase their metacognitive awareness in the long term.

1.1 Outline

Through the introduction it has become clear what is the problem area, and what are the opportunities of the current study. The next chapter will serve to present the contextual environment of this research. We will therein present our working definitions of the relevant concepts, and will determine the scope of this research. From the literature discussed in the theoretical framework, we will derive the most important design principles in section 2.4. Chapter 3 then presents how these principles have been used in the design of our application. Chapter 4 will discuss how the first iteration prototype of our application was tested, and will discuss some adjustments that were made to the design thereafter. Chapter 5 discusses how the second, and in this study, final iteration of our app was tested and whether or not working with the app has led to the intended outcomes. Finally, in chapter 6 we will discuss guidelines that other researches can use to further improve the design of such an application in future iterations.

Chapter 2

Theoretical framework

Before we can begin to design our learning tool, it is important to have a firm understanding of metacognitive awareness as well as understanding how we can motivate users through gamification. Section 2.1 will dive deeper into what exactly is metacognitive awareness and of which subcomponents it is constituted. Self-regulated learning will also be discussed since this is often tangled with metacognitive awareness in scientific literature. Section 2.2 will discuss motivational processes relevant to learning. This allows us to identify specific principles that we can use in our design, so that we can motivate users to the best of our ability. Section 2.3 will discuss the state of the art on gamification research, through which we will determine the properties that our game needs to have.

2.1 Metacognitive awareness

Metacognition emerged in the late 1970s from the field of educational psychology as a construct to refer to the awareness and understanding of one's own thoughts. The term refers to higher order thinking processes that evaluate and monitor cognitive processes, which the word meta refers to (Flavell, 1979).

The metacognitive model by Nelson & Narens (Nelson, 1996) emphasizes the distinction between higher order and lower order functions of cognition as it recognizes two different levels of cognition organized in a feedback loop (see Figure 2.1). The meta level contains knowledge about oneself as a learner, personal goals and knowledge of different strategies that can be employed for reaching these goals. When for example the goal is to acquire a specific piece of information, the meta level can send instructions to the object level to first utilize the strategy "Seeking information online". This is carried out at the object level, which would in this case be the learner opening their web browser and entering a query in their favorite search engine. The query results are all read and understood at the object level, whereas the meta level monitors whether the results are relevant to the goal. Upon detecting conflict between the search results and the expected outcome, the meta level sends instructional feedback to the object level which aims to resolve this conflict.

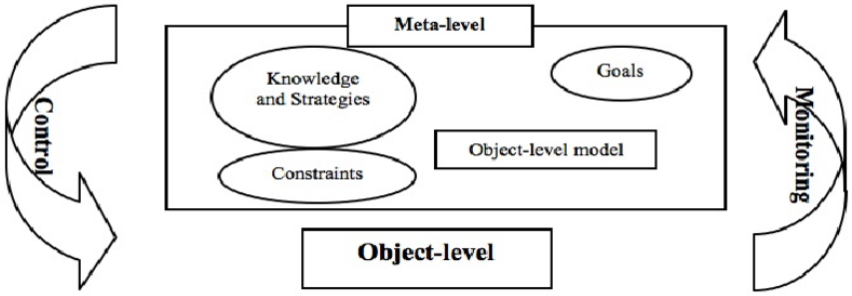

Figure 2.1: Visual representation of Nelson & Narens' metacognitive model (Van Overschelde, 2008, p. 48)

The meta level is thus responsible for directing the strategies at the object level whereas feedback on the effectiveness is derived back to the meta level through monitoring of performance at the object level. This leads to enhanced awareness at the meta level, and can lead to revisions in strategy selection to achieve a better outcome (Kuhn, 2000).

Such strategy revisions will not always immediately lead to better outcomes, but for the enhancement of awareness at the meta level it does not appear to matter whether the change in strategy was effective or not. Learning from mistakes as well as successes is both considered to be valuable. Mistakes in this regard can lead to the learner avoiding inferior strategies in the future, whereas successes can lead the learner to subsequently use and develop superior strategies (Kuhn et al., 1995). Both of these situations are thus considered to be valuable and can lead to better learning outcomes on the long run. Through this constant monitoring a person will repeatedly be judging their own learning performance, from which they will consequently develop metacognitive theories about their strengths and weaknesses as a learner (Schneider, 2008). Such theories are personal and describe how learners see their own cognitive abilities and how they believe these can effectively be employed and regulated.

Schraw & Moshman noted the distinction between tacit and explicit metacognitive theories (Schraw & Moshman, 1995). Tacit theories are formed implicitly, meaning that a person is not aware of themselves forming or even applying the theories. Explicit metacognitive theories are further divided into formal theories and informal theories, both are theories of which an individual will be aware to some extent. The awareness and understanding of informal theories is often fragmentary. For example, let´s say that someone was working on an assignment and had to leave for soccer practice. When they come back and return to their assignment, they notice that they are working much more efficiently than before. This might lead to suspicions: was it that sports drink that made me more efficient? Was it the exercise? Or was it simply taking a break? Either of these suspicions can be seen as informal metacognitive theories. Through empirical testing informal theories can be developed into formal theories. When the suspicion is then confirmed, the learner will have a formal strategy which they are aware of and fully understand. These formal theories can then actively be utilized to the advantage of the learner.

However, implicit and tacit metacognitive theories also impact learning performance. This can be dangerous, since tacit metacognitive theories can hamper the learning process without the learner being aware of it (Schraw & Dennison, 1994). This can lead learners to believe that they are (not) capable of achieving their goals without knowing why this is the case, or it can lead to learners attributing their success or failure to the wrong reasons. This consequently leads to a lesser amount of control that they have over their learning which, in case of repeated failure, can lead to self-learned helplessness (Diener & Dweck, 1978). This hampers learning performance as learners will perceive their efforts to be futile, they do not believe they can succeed whatever they may do. Such a scenario can be prevented through training metacognitive awareness. The next segment will identify the different components of metacognitive awareness and how they can be trained in order to empower the learner and increase their learning performance as a result.

2.1.1 Components of metacognive awareness

Metacognitive awareness can be divided into two different subcomponents:
Metacognitive knowledge and metacognitive skills (Veenman, Kerseboom, & Imthorn, 2000).
Metacognitive knowledge refers to the knowledge that someone has of learning. This includes both knowledge about oneself as a learner as well as knowledge about different learning strategies. Metacognitive skills refers to what learners do about their learning. This refers to the skills that someone uses to exert control over their learning process, such as explicit planning and periodic evaluation. Training metacognitive awareness must address both of these components in order to be successful in increasing performance. Lack of development from either component can lead to the learner experiencing trouble to achieve a satisfactory level of performance.

When someone has developed proper metacognitive skills but is lacking in metacognitive knowledge they are said to have a knowledge deficiency. These people might detect that their approach is not working out, but will not have the awareness of other strategies through which they can set out an alternative approach that might be more successful. For training metacognitive knowledge it is suggested that a summary matrix, such as the strategy evaluation matrix, can be an effective tool. Such a matrix contains information on different learning strategies and provides the learner a concise list which they can refer to and choose strategies from (Schraw, 1998).

In case a learner is aware of different learning strategies but is unable or unwilling to regulate their cognitive processes they are said to have a production deficiency. This will lead to a scenario in which the learner does not become aware that the work that they are doing will not lead to the intended outcome. Such issues have been shown to be solvable by providing the learner with hints or cues which explicitly prompt them to carry out their regulatory cognitive skills. (Lin, Newby, & Foster, 1994) (Veenman, Kok, & Blöte, 2005).

2.1.2 Metacognitive awareness & Self-regulated learning

Metacognitive awareness and self-regulated learning have emerged from educational psychology as predictors for academic achievement. Although both are seen as important aspects for successful learning, the terms have become somewhat nested and are sometimes used interchangeably (Kaplan, 2008) (Dinsmore, Alexander, & Loughlin, 2008). To avoid any such confusion within this paper we will start off by explicitly distinguishing between these two concepts and determining our view on how they relate.

Metacognitive awareness was introduced as a construct by Nicolas Flavell as a way to refer to a higher order of cognition. Metacognitive awareness is required for executing the higher order functions of cognition, it serves to monitor and regulate cognitive processes based on personal goals and beliefs (Flavell, 1979).

Self-regulated learning (SRL) is the degree to which one is able to dynamically adapt how one engages in a learning task. SRL consists of a series of steps, which are all inherently metacognitive in nature (Winne, 1996). The first step consists of planning the learning task. At this stage prior knowledge that one may have in relation to the current task is reactivated, and the learning goals are set. Possible obstacles as well as resources that can help to overcome these obstacles are also identified at this stage. The second step is initiated when the learning process starts, the learner monitors their progress and forms self-generated feedback. Based on this feedback the learner can adjust their strategies where necessary. The final step evaluates the learning process as a whole and determines whether the goals that were set have been reached (Zimmerman, 2000). These three steps together form the self-regulated learning cycle.

We can thus say that SRL is learning guided by metacognitive awareness. Effective self-regulated learning requires the learner to self-generate feedback about one's self in relation to the learning task, which is reliant on metacognitive awareness. Therefore we consider metacognitive awareness to be a prerequisite for effective self-regulated learning (Ridley, Schutz, Glanz, & Weinstein, 1992).

2.2 Motivation

The word motivation finds its roots in ancient Latin and refers to what it is that makes people move and engage in certain specific behaviors (Eccles, Wigfield, & Schiefele, 1998). We will distinguish between intrinsic motivation (motivation that comes from within a person, such as inherent interest or enjoyment of a task) and extrinsic motivation (motivation that comes from outside sources, such as recognition by others) (Ryan & Deci, 2000). The tasks that a person will carry out and the amount of effort that they are willing to put into these tasks can be determined by either form of motivation.

This section will discuss three ways in which motivational beliefs influence and shape the behavior of individuals when they engage in a learning task. This happens through the following factors: Self-efficacy, task-value beliefs and goal orientation. These factors form the basis of judgments that one will make on the level of ability that they have, the gains that there are to completing the task and the likelihood that they will be successful.

2.2.1 Self-efficacy

Self-efficacy is the perception of personal competence in a certain domain, it determines the confidence that an individual has in their ability to successfully complete a certain task. It also influences the amount of effort that an individual is willing to put into a task and for how long an individual is willing to persist. (Bandura, 1986).

Self-efficacy is influenced by a number of factors: Performance achievements, emotional arousal, vicarious experience and verbal persuasion (Bandura, 1977). Performance achievements refer to the previous failures and successes that the learner has experienced in the given domain. When a student has repeatedly been successful in math, they will become more confident in their mathematical abilities and will gain self-efficacy in this domain. They will then also be more likely to pursue math related courses in the future, whereas failures will lower self-efficacy and can lead to avoidance of related tasks. Emotional arousal is also a relevant factor, with high levels of arousal typically leading to lower self-efficacy and performance (Fisk & Warr, 1996). Success is usually more likely to be expected when someone is in a calm and neutral state compared to when someone is tense and experiencing aversive arousal. Vicarious experience is the perception of others seeing completing a task that is perceived as threatening, without experiencing negative consequences. Through such experiences one can become less aversive to the task and can learn that they too can carry out similar tasks to improve their performance. Finally, verbal persuasion can also be a means of raising self-efficacy and reducing anxiety towards certain tasks.

Through listing these factors we have now identified multiple ways in which we can attempt to raise self-efficacy in our learning tool. Through raising self-efficacy we can improve the confidence of the learner and can diminish an initial fear response that students may have towards certain tasks, which is expected to lead to more persistence and better learning outcomes (Fisk & Warr, 1996) (Yusuf, 2011).

2.2.2 Task-value beliefs

The beliefs that someone has about a certain task will influence the amount of effort that a person is willing to put in. Task-value beliefs, according to Eccles *et al.*, can be divided into four components: Cost, expected utility, interest-enjoyment value and attainment value. These four factors together determine the subjective view of the costs and gains that there are to successfully completing a task (Eccles & Wigfield, 2002).

Cost refers to a personal estimation of the negative aspects of engaging in a task. The costs that one perceives are influenced by numerous factors: The expected stress and anxiety that a task is expected to bring, the fear of consequences of failure (loss of self-worth) and also the possible negative sociocultural consequences that there may be to succeeding at a task (fear of rejection of one's parents or peers) (Eccles et al., 2005).

Expected utility is referring to how useful someone perceives a task to be, which is determined through how well the gains of success are fitting into an idividuals' future plans. The task itself may not be enjoyed per se but it serves as a means to an end in order to achieve a certain goal, therefore this is more a measure of extrinsic motivation.

The interest-enjoyment value on the other hand refers to the intrinsic motivation and the enjoyment that one experiences when performing a task. Allowing children to freely pursue the things they are inherently interested in has been shown to have positive effects on their learning performance, whereas controlling children undermines their feelings of autonomy and hampers their performance (Fei-Yin Ng, Kenney-Benson, & Pomerantz, 2004). When a choice is made autonomously, the motivation behind it is entirely self-determined which is beneficial for persistence, performance and mental health (Vallerand, 2000).

Finally, attainment value refers to the value of a task in relation to the personal identity of the subject. An in-depth discussion of identity goes beyond the scope of this paper, but to provide an example of attainment value imagine someone who considers himself to be masculine. Any task that confirms this self-obtained view of masculinity will then have high attainment value to this individual. In similar fashion attainment value can contribute to females avoiding science related subjects because it does not correspond with the stereotypical perceptions of what a female should be (DeBacker & Nelson, 2000).

2.2.3 Goal orientation

In the context of this study we distinguish between two different forms of goal orientation: Performance goals and mastery goals. Which type of goals an individual has, is thought to be determined by their belief on intelligence (see Figure 2.2) (Dweck, 1986). The belief that intelligence is fixed will lead to performance goals, associated with a behavioral pattern in which one is seeking external rewards that show approval of their ability. The belief that intelligence is malleable will lead to mastery goals, which are associated with a behavioral pattern revolving around intrinsic rewards and gaining competence for personal reasons (Pintrich, 1999).

Theory of intelligence	Goal orientation	Confidence in present ability	Behavior pattern
Entity theory (Intelligence is fixed)	**Performance goal** (Goal is to gain positive judgments/avoid negative judgments of competence)	**If high**	**Mastery-oriented** Seek challenge High persistence
		but	
		If low	**Helpless** Avoid challenge Low persistence
Incremental theory (Intelligence is malleable)	**Learning goal** (Goal is to increase competence)	**If high** or **low**	**Mastery-oriented** Seek challenge (that fosters learning) High persistence

Figure 2.2: Intelligence beliefs and their subsequent behavioral patterns (Dweck, 1986)

Besides determining what type of goals the learner is after, their goal orientation will also frame how they perceive challenge and effort. Performance oriented individuals will tend to avoid challenge and are preoccupied with failure. They perceive having to put in effort as an indication of a personal lack of ability. In the face of challenge with uncertain outcomes especially they will be less likely to persist in an attempt to save face and prevent the potential failure that is coming up. Due to this preoccupation with failure, performance

orientation is also associated with reduced psychological well-being and a higher likelihood of depression (Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004).

Mastery orientation on the other hand is associated with being less fazed by challenge and failures, leading to a greater persistance and better learning performance. Mastery goals have also been shown to positively correlate with metacognitive activity, meaning that mastery oriented individuals have a higher tendency to engage in actively regulating their learning process by using metacognitive skills (Ford, Smith, Weissbein, Gully, & Salas, 1998). Of all the motivational aspects listed, mastery goal orientation has been identified as the most important one for predicting metacognitive activity (Sungur, 2007).

2.3 Gamification

The use of gamification for educational purposes has become increasingly popular in the last few years, with apps such as duolingo having millions of users. Duolingo is an example of a learning tool for language acquisition which also contains rewards and achievements to motivate their users. It has also been utilized in a classroom environment and students reportedly preferred the use of the app over the typical book based learning (Munday, 2016).

This section will provide background information on gamification and will clarify why and how it can effectively be employed. We will first discuss the principles of gamification, to determine the reasons behind its effectiveness. Second we will discuss previous research on gamification, so that we can understand which game elements are likely to be successful for motivating users and which elements are not. Finally, we will discuss the incentive system which determines for which actions the users shall be rewarded. This is combined with a brief discussion on reinforcement learning, since this is the core concept behind inducing changes in behavior through rewards and punishment.

2.3.1 The Principles of gamification

Gamification refers to the implementation of game design elements in the context of applications that serve a different purpose than to solely entertain (Deterding, Dixon, Khaled, & Nacke, 2011). The idea for utilizing concepts from gaming comes from the popularity of video games especially, which appear to be very effective in engaging and motivating players to learn and perform complex and time consuming tasks that would most likely be considered to be mundane outside of the context of the game.

There are several ways in which the design elements from games can provide motivational benefits to ordinary non-game tasks. These core game concepts include having a clear goal directedness, which is established by having clear win conditions and objectives. The goal theory of Edward A. Locke states that people will be motivated by clear goals (Locke, 1968) and that the setting of such goals helps an invididuals' self-regulation by providing a specific definition of what is considered to be an acceptable performance that they can work towards (Latham & Locke, 1991). The goal of a game is usually delivered to the player through some form of narrative. This is the storyline within the game that provides contextual information and creates an incentive for players to advance the game in order to see how the storyline progresses. Narration has a strong

motivational function, it can induce emotions in players and contributes to the desire for people to return to the game (Plass, Homer, & Kinzer, 2015).

Another way of motivating users comes from achievements, which reward the player for completing certain levels or tasks. This is a way of providing gratification to the user and serves a motivational function through the recognition of the players' ability, providing them with a sense of achievement. Striving for achievements can also be a reason for users to carry out tasks which they would otherwise not engage in (Fitz-Walter, Tjondronegoro, & Wyeth, 2011). Achievements can thus also provide the user with a goal to work towards, which can lead to users coming back or putting in more effort in order to unlock these achievements.

Games usually also have a reward system that consists of either points or an in-game currency, which serves to reinforce certain behavior. The incentive system of a game will determine the behavior that is rewarded. Awarding points is a way of positive reinforcement, which makes it more likely for the rewarded behavior to reoccur. Negative reinforcement is also a tool which can be utilized, which is the punishing of certain behavior in order to decrease the chances of repetition of the behavior (Linehan, Kirman, & Roche, 2015).

Competition is a natural element in most games, as there is often an opposing force that needs to be defeated in order to win the game. Besides competition between the player and computer controlled entities, one can also choose to incorporate competition between the players. This can be realized through tracking points and achievements on a leaderboard which displays the best performing players. The leaderboard is a way for players to show off their ability and earn fame and pride amongst fellow competitors. This can lead players putting in extra effort in order to strive for a spot on the leaderboard and get the recognition they deserve.

These are all ways in which motivation for the execution of learning tasks can be increased. In educational context it might not always be possible to change the task itself to something more enjoyable, but through the addition of the aforementioned elements a fun and challenging environment can still be realized. The next segment will discuss previous research on the effectiveness of these elements.

2.3.2 Previous research on gamification

Since video games have a strong ability of engaging players, a large body of research has gone into the utilization game elements to enhance motivation and performance on serious tasks in business and education. The typical game elements being used in such studies include leaderboards, achievements and point systems. Findings on the effectiveness of these elements are varied, as will be discussed in this segment. What further complicates this research is that most studies do not limit themselves to just one of these elements, making it harder to identify their individual effects.

Incorporation of points, leaderboards and achievements in applications can lead to an increase in the amount of responses that are generated compared to vanilla versions without gamification. This does not automatically mean that the response quality increases as well (Mekler, Brühlmann, Tuch, & Opwis, 2017) (Landers, Bauer, & Callan, 2017). The study of Landers *et al.,* further investigated the effects of a leaderboard and concluded that it essentially serves

the same purpose as goal-setting. A leaderboard will provide a goal for the player to achieve similar scores in order to show up on the leaderboard (Landers et al., 2017). Since a playerbase (as well as a classroom) is likely consisting of players with various levels of ability, the goal of getting on the leaderboard is not a reasonable goal for all players involved. While challenging and specific goals can foster achievement (Latham & Locke, 1991), unreasonably high goals will lead to failure and can cause maladaptive behavioral patterns (Dweck, 1986). This is supported by the findings of Jagušt *et al.*,, who developed a gamified approach for learning math in primary school. Generally this led to increased motivation, but it was noted to demotivate players who were unable to achieve a high ranking (Jagušt, Boticki, Mornar, & So, 2017).

Hanus & Fox (2014) also advocate to be cautious with implementing game elements in traditional education because gamification is reliant on providing external rewards. Their study incorporated achievements and a leaderboard, with their results indicating this led to lower intrinsic motivation and consequently worse performance (Hanus & Fox, 2015). Besides reducing motivation, the emphasis on performance can also result in students becoming more careful and anxious of making mistakes (Hakulinen, Auvinen, & Korhonen, 2013). In accordance with this idea, students with a performance-avoidance approach characterized by the intention to avoid failure and mistakes, appear to not be effectively motivated by achievement badges (Hakulinen & Auvinen, 2014).

Underlying this problem is the emphasis on performance orientation, since points and achievements are usually handed out solely on the basis of someone's display of ability. This is a consequence of the design of the incentive system, which will be discussed in the next segment.

2.3.3 Incentive structures & Reinforcement learning

The incentive structure of a game determines for what the player is rewarded, and can shape player behavior by reinforcing certain behavior while ignoring or even punishing bad practices. A successful gamification implementation is accomplished when desired outcomes are being repeated by the player (Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2015). Through these reinforcers the behavior of the player is essentially shaped via operant conditioning, which has been well established in psychology as a successful way of modifying behavior. This approach has shown that reinforcement can be a successful tool in shaping the behavior of both animals and humans. By rewarding a specific action it consequently becomes more likely for this action to be repeated in the future. It is also possible to punish certain behavior, for example by deducting points or having the player character die within the game. This will in turn decrease the likelihood of that action being repeated.

Grade systems commonly used in education can be effective reinforcers for changing student behavior, as was shown in an experiment with primary school children whose in-class behavior was found to improve after receiving grades explicitly based on their behavior (Williams & Anandam, 1973). This can be considered an elementary form of gamification, since it provides the students with an incentive to change their behavior in order to achieve a high score. By explicitly having a contract signed by the students containing the conditions on which the grading is based, it becomes very clear and specific that they need to change their behavior.

Typically however grades are only awarded for performance on an essay or exam. When this leads a student to believe that their school is performance oriented by emphasizing high grades, external rewards and competition through a valedictorian award for example, this can lead to students adopting performance goals and its corresponding maladaptive behavioral pattern (Gonida, Voulala, & Kiosseoglou, 2009).

Although this can be effectively motivational for high achievers who repeatedly receive positive reinforcement, it can be perceived as off-putting by low performing students who repeatedly become negatively reinforced. These students might, as a result, become anxious and preoccupied with failure. Low performing students can in turn thus develop a behavioral pattern corresponding to the fixed mindset of intelligence which, as discussed in the section on goal orientation, is less than ideal.

To instead promote the growth mindset of intelligence, studies have been carried out within gamified approaches to learning algebra. Instead of rewarding performance, these studies decided to reward effort and exploration. Results from these studies indicate that this approach led to low achieving students developing higher persistence compared to a control group (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014). This is thought to be because the approach of focusing on effort instead of ability promotes belief in the entity theory of intelligence, leading to higher persistence and a healthier behavioral pattern overall (O'Rourke, Peach, Dweck, & Popovic, 2016).

The current study will attempt to take advantage of these findings and adopt a similar incentive structure. This and other design principles that we intend to use in our design will be summarized in the next section.

2.4 From theory to practice

This section will bridge the discussion of the theoretical framework and the design of our app, which we have called Learn2Conquer (L2C). This name was chosen to emphasize that it consists of 2 different aspects: A learning element and a game. The game was initially planned to be a strategy game in which the player could literally conquer different regions. This was later changed to space invaders, but the name Learn2Conquer remained as a legacy of that initial idea.

We will introduce the main concept of L2C and explain how we intended to design it in a way that allows learning of a wide variety of contents. We will then summarize the most important hypotheses that were derived from literature and thereby establish our intentions. The chapter will be concluded by presenting our research questions.

2.4.1 Learning across various domains

We have mentioned duolingo earlier in this chapter as an example of a popular learning tool. Duolingo is specific for learning languages, as such it only contains information related to language and can solely be used for learning within this specific domain. What we intend to do is develop a tool that generalizes learning, so that it can be used across various domains. This would mean that our app can be used to learn virtually (or virtually learn - pun intended) anything, no matter the subject. We do this by shifting our focus from what knowledge is acquired,

to how knowledge is acquired. Although the majority of research approaches metacognitive awareness from within a singular domain, there is some evidence that indicates metacognitive awareness in itself is inherently domain-generic (Derry & Murphy, 1986) (Schraw, 1998) (Veenman, Wilhelm, & Beishuizen, 2004).

The advantages of adopting a domain-generic approach is that L2C can be used and tested by students everywhere, no matter in what field. This would also mean that students are not limited to using L2C for just one of their classes, but that they can keep using it for their entire curriculum. A third advantage is that by focusing on how knowledge is acquired, students are also expected to learn how they can become more able and efficient at acquiring knowledge.

The downside to this is that no learning contents can be embedded in the app, users will thus have to be provided with learning materials and learning will have to happen outside of the app. This consequently means that we cannot directly monitor the behavior and performance of our users, nor can we verify whether they are indeed acquiring the intended knowledge. The user therefore has a substantial amount of responsibility: Users need to actually be studying while using the app and need to take the metacognitive skills of planning and reflection seriously, they will be learning little to nothing by trying to fool the app and will thereby end up fooling themselves.

To overcome these difficulties we will test the app in a classroom setting, as a supplement to an existing course. This means that course materials will be provided and that a teacher is present to determine the performance on the assignment. L2C will serve as a tool to guide and motivate students throughout the learning process, after which the verification of whether enough knowledge was acquired will happen externally.

2.4.2 Design hypotheses

L2C consists of two different aspects: Learning and gaming. Learning requires detailed planning and evaluation, which are metacognitive skills. The game serves the purpose of engaging and motivating players to repeatedly exercise these skills, through which we aim to increase metacognitive awareness. Learning and gaming are intertwined through rewards that can be acquired. Learning offers rewards which can be used for the game, whereas the game offers rewards that can be used for learning.

Through the incorporation of a game we aim to spark interest and hope to be able to motivate our users. The game is supposed to have interest-enjoyment value, meaning that we expect our users to be intrinsically motivated to play the game. The game rewards users with learning strategies, that are randomly selected from a pool of carefully chosen learning strategies. This adds extra utility and provides external motivation for winning the game. Additionally we expect this to increase metacognitive knowledge.

When it comes to learning, users can be using L2C to study any subject. We will therefore allow our users to determine their own learning goals. By displaying these goals on the homepage we provide the user with goal-directedness. This is further emphasized in the agenda, which asks users to determine a purpose for each activity they plan. Every single activity in the agenda will thereby also have a clear goal.

Rewards will be offered for both learning and reflection as a means of providing additional utility for these tasks, which serves to provide external motivation for carrying out metacognitive skills. By repetition of these steps we aim for the user to not only increase their metacognitive awareness, but also for them to recognize the value of these tasks and become more confident in their learning ability. Over time we thus expect the user to increase in self-efficacy and task-value beliefs, thereby gradually switching from external motivation to internal motivation.

Finally, by rewarding effort we aim for the user to keep using the app. When it comes to the learning that is being done in the app, there is no distinction between success or failure because both are valuable for increasing metacognitive awareness. We thereby try to increase persistence and to promote a mastery orientation rather than a performance orientation.

2.4.3 Research questions

Since this is an exploratory study, we are most interested in the usability and motivational aspects of the app. The end goal is still to increase metacognitive awareness and consequently learning performance, but we cannot expect to find conclusive evidence on the first attempt. It is more important to identify whether students appreciate the current setup, so that we can learn whether this is an approach worth pursuing and refining in the future. The main research questions we have are as follows:

- How can a learning tool be developed that is easy to use across various domains?
- How can users be motivated to repeatedly exercise their metacognitive skills?
- How can a tool be developed that facilitates the development of metacognitive awareness?

The next chapter will discuss the design of L2C, which proposes our hypothetical solutions for achieving the goals that have been defined in our research questions. The chapters thereafter will serve to discuss the testing and evaluations on whether the design of L2C was successful in achieving these goals.

Chapter 3

Application design

Learn2Conquer is a web application built in React. The choice for a web app was made because this allows our participants to work with the app on their own devices, regardless of which operating system they use. For additional convenience all user data is stored in a database, which allows users to work in different sessions without losing progress. All user actions will also be logged in this database, which allows the researchers to see exactly what users are doing within the app.

The app is designed to closely follow the self-regulated learning cycle (see Figure 3.8) and mainly focuses on making metacognitive theories more explicit. In order to do this, the app asks students to create a detailed learning plan. Through gamification elements we opt to motivate students to try new strategies and to reflect on all their learning activities. The application also keeps track of all activities and reflection logs for users to review and learn from.

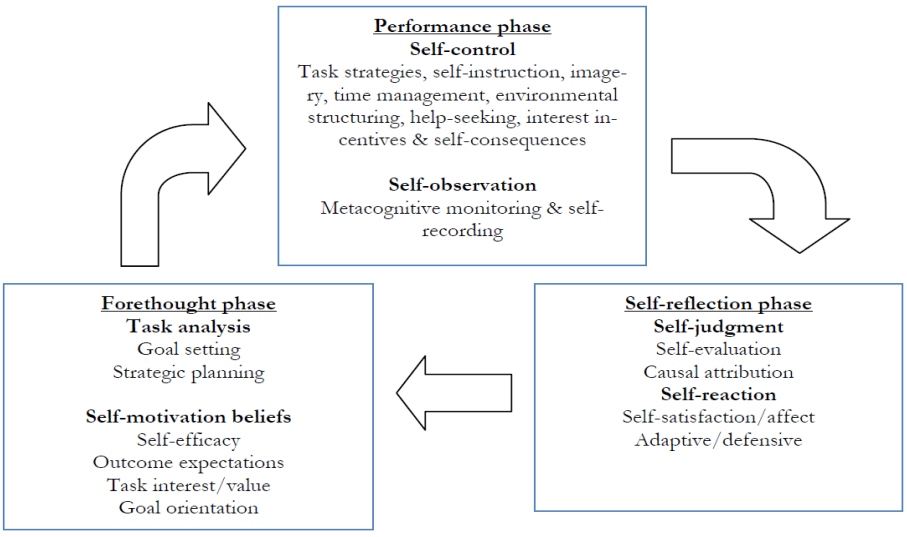

Figure 3.1: Overview of self-regulation (Zimmerman & Moylan, 2009)

3.1 Homepage

Figure 3.2 shows the homepage of Learn2Conquer. Here the user can see their learning goals (a), their agenda (b), the leaderboard (c), game instructions and a button to start playing (d), the current gold and a button to access the shop for upgrades (e) and the current stats of the ship that is used in the game (f).

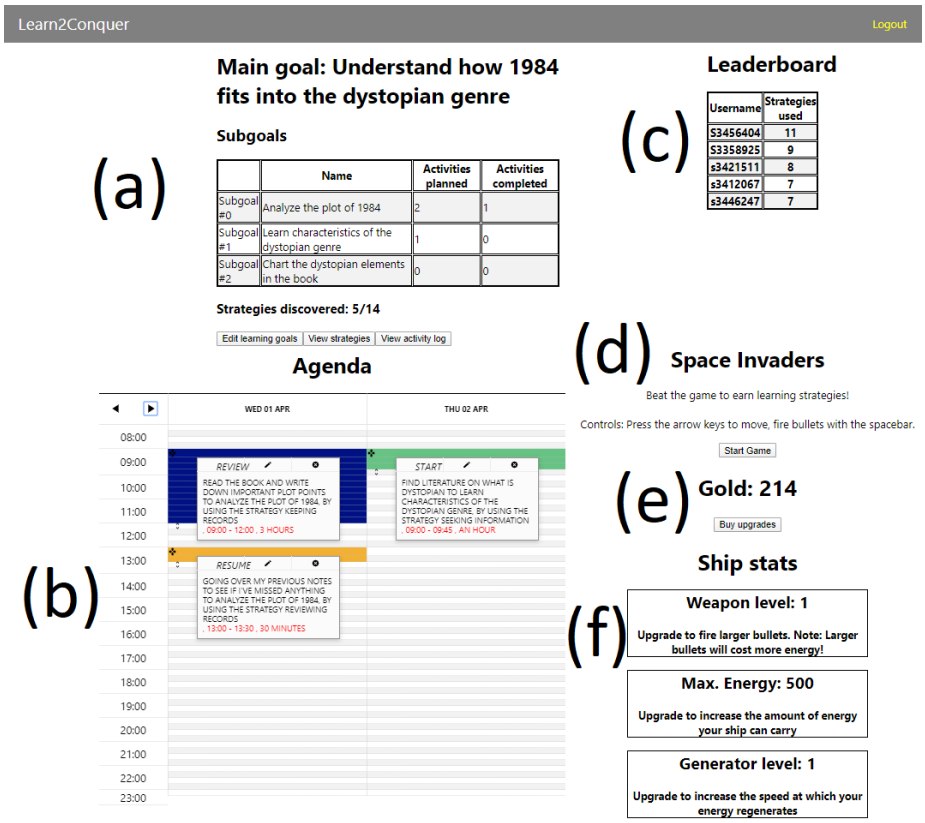

Figure 3.2: Homepage of Learn2Conquer

3.2 Application flow

The app is set up to motivate users to repeatedly go through the path as displayed in Figure 3.3. This path consists of acquiring a learning strategy, bringing it into practice and reflecting upon its effectiveness and thereby adheres to the self-regulated learning cycle. The app consists of four different elements: planning, learning, reflection and motivation. The remainder of this chapter will describe these elements in this order, to create a detailed understanding of how the app was designed.

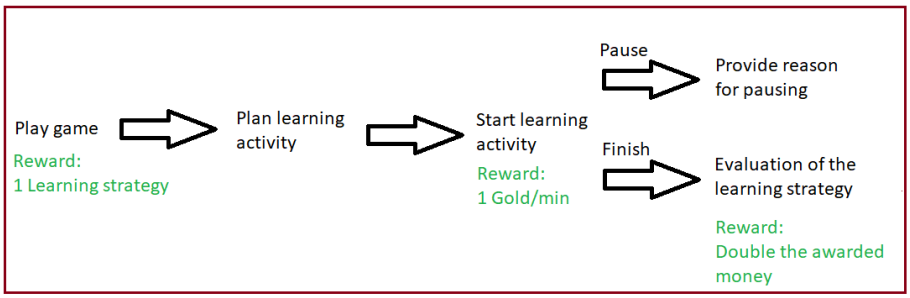

Figure 3.3: The intended flow of learning and reflection

3.3 Goal setting & Planning

The first step of the learning process is for the learner to plan what they intend to achieve and how they think that they will manage this. Since this starts by setting learning goals we will first describe how this is handled, the agenda will be described thereafter.

3.3.1 Goal setting

New users are first asked to specify their main learning goal and are then asked to break this down into a number of subgoals, which should ideally form a complete overview of all tasks required for completing the main goal.

Instructions and examples of proper learning goals are to be given in an introductory presentation, which was supplemented by written instructions that can be found in Appendix E. This setup keeps the app domain-generic, while allowing teachers and tutors working with the app to emphasize what is important in their course by providing content-specific examples.

3.3.2 Agenda

An agenda is embedded in the app in which users can plan all their activities. The menu used for planning is displayed in Figure 3.4). This requires the user to be rather detailed about what, when and why they will be doing things. All of the information in this menu combined forms what we refer to as a learning activity. This consists of a title chosen freely by the user, a subgoal chosen from the current list of subgoals, a time and a learning strategy chosen from the inventory of the user. The title provides a general description of what the user will be doing, whereas the subgoal determines the purpose of this activity. Time indicates when and for how long the user expects to start and complete the activity. Finally, the learning strategy determines how the user expects to be working.

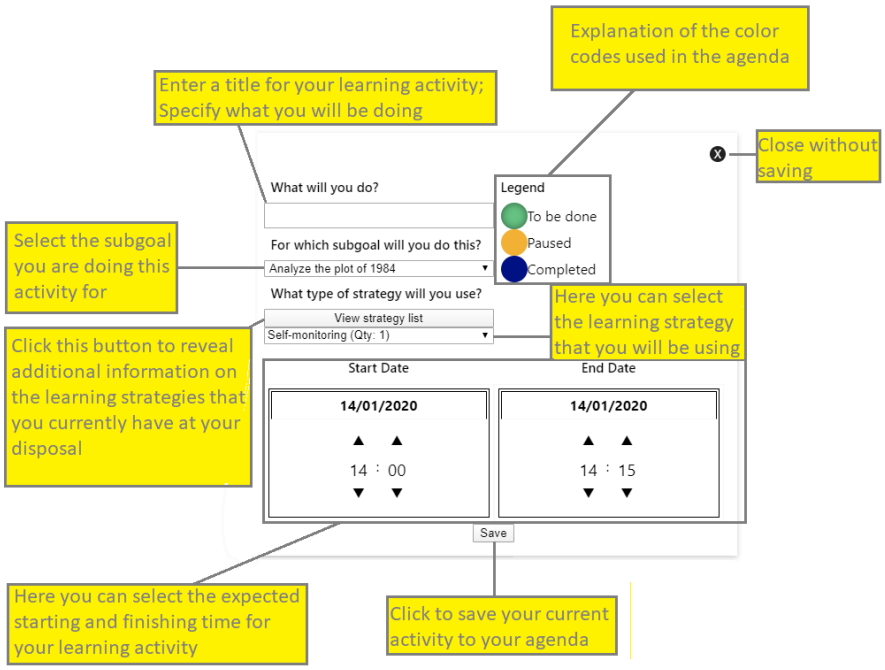

Figure 3.4: Menu for planning activities in the agenda

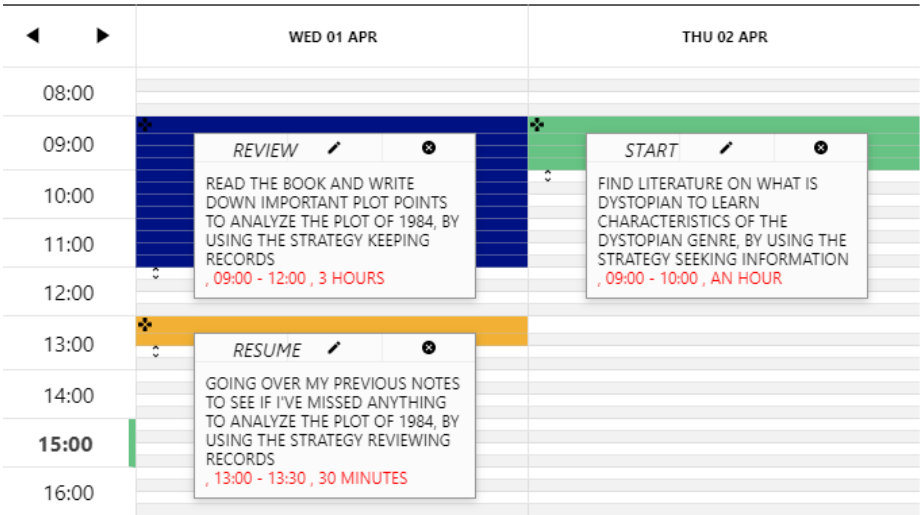

Figure 3.5: Agenda as embedded in the app

3.4 Learning

Once a learning activity has been planned, the user can start the activity from the agenda (see Figure 3.5). After a learning activity has been completed, it will remain visible for the user to review and learn from. While learning, a timer

is shown which helps users keep track of the time they spent on their learning activity. This feature will be described below, the available learning strategies will be listed and discussed thereafter.

3.4.1 Time management

When the user starts a learning activity, the screen changes to display only the information of the current activity (see Figure 3.6). The game and agenda are hidden on this page, to eliminate distraction as much as possible and to allow the user to focus solely on the work at hand. During this time, the user is expected to do the work as they have planned. Since learning materials are not included, the learning activity is executed outside of the app. Users should still keep the tab open so that they can time themselves while they are working.

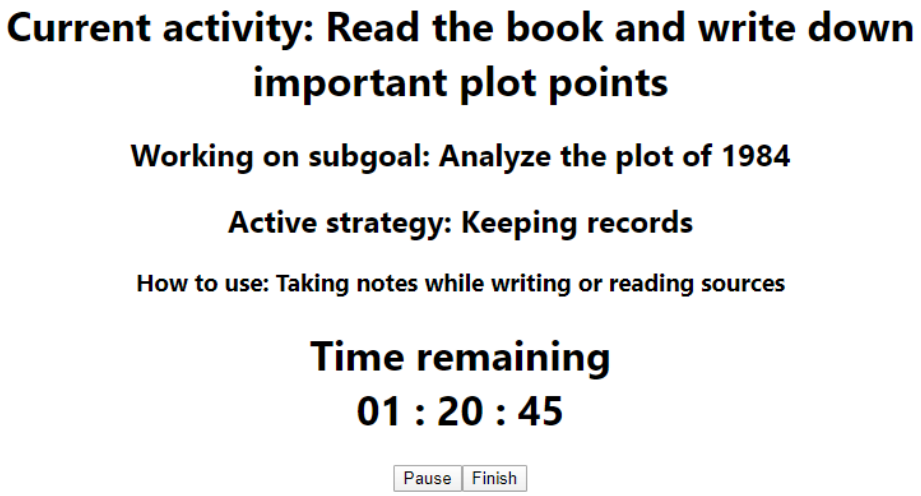

Figure 3.6: Learning page

Since every learning activity includes an estimated time, users are forced to think about the time they expect to be needing for a certain activity when they plan it. By also having a timer run while doing the activity, users can easily monitor whether their estimate was accurate. Additionally the timer can serve as an incentive to maintain interest and to keep focused on the current task in order to finish the activity on time. In case users find themselves having underestimated the time, the option to add more time is provided after the timer has run out. Users are not penalized for doing this because this might lead to discouragement or a consistent overestimating of the time required in order to avoid penalty.

3.4.2 Learning strategies

Since all available learning strategies come from within the app, it is important to maximize the chance that every strategy resonates with the users. To this end the app has been set up to allow easy adjustments of available learning strategies. This allows teachers working with the app to customize the available

strategies and to make sure that they are all relevant to the task at hand. A complete overview of all learning strategies can be seen in Appendix A. These strategies consist of cognitive strategies (e.g. repeatedly writing something down to help you remember), metacognitive strategies (e.g. going over your work to make sure that it is up to standards), motivational strategies (e.g. rewarding yourself after you finish a task) and management strategies (e.g. finding a quiet place to study). All strategies were taken from scientific literature. Due to differences in learning content between the pilot and final study, we have used different strategies in both studies. The choice of strategies for both experiments will be discussed further in the following chapters.

3.5 Reflection

Reflection is the part that is most emphasized in the app, since reflection is a fundamental aspect to increasing metacognitive awareness. Reflection is also heavily rewarded, since it doubles the gold reward for the time spent learning (see Figure 3.3). The intended flow of the app has users self-reflect after each activity they complete which will be discussed first. Second we will explain how all activities and reflections are logged in the app, which allows users to review this information for later analysis. Third we will explain how progress tracking is embedded in the app.

3.5.1 Self-evaluating

Each time a learning activity has been finished, the user is asked a series of reflection questions (see Figure 3.7). These questions are aimed at generating insight into whether and why a certain strategy was useful. Questions on whether the user actually used the selected strategy are also present, since learning happens outside of the app and cannot directly be monitored.

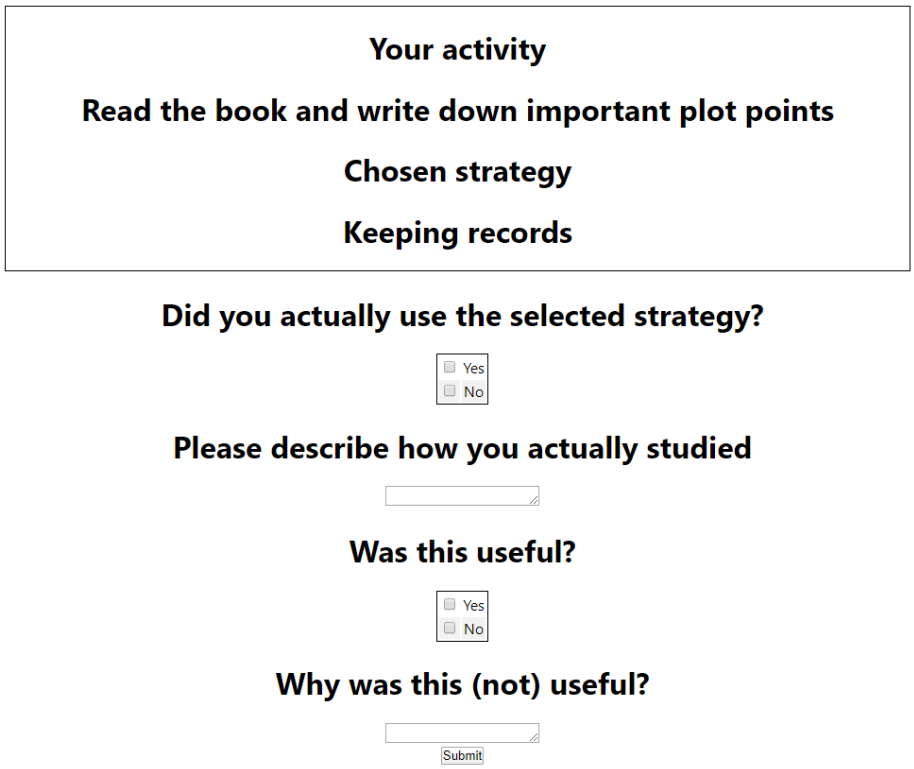

Figure 3.7: Reflection questions after completing a learning activity

Self-recording

The app keeps a log of all learning activities that are done. This allows users to easily see what they have done, whether they found an activity useful and why they thought so. Users can review these logs either by clicking on a completed item in the agenda, or by viewing the activity log which shows a table of all completed activities. Additionally, the app calculates a usefulness score for each strategy used. This score is based on the reflection questions that users are asked every time they finish a learning activity. This includes a question which directly asks the user whether the strategy they have just used was deemed useful or not. The usefulness score is calculated by taking the amount of times that a strategy was deemed useful, divided by the total amount of times that this strategy was used. The strategy list displays all usefulness scores and thereby provides the users with a clear overview of all strategies and how useful they are to that specific user. The activity log additionally displays the reason why each activity was found useful or not, which provides additional feedback. All answers to the reflection questions are also visible when reviewing a completed activity in the agenda.

3.5.2 Progress tracking

The main goal and subgoals are displayed on the homepage of the application (see Figure 3.2). Displaying the main goal serves to remind the user of what

they want to achieve, it provides a focused target for them to work towards and can be motivational (Locke, 1968). By displaying the subgoals we aim to provide the user with an overview of all the things that need to be done in order to complete their main goal. Also a record is kept of the number of activities planned and completed for every subgoal, to provide the users with a more clear indication of the progress on every aspect of the task.

3.6 Game

A game is incorporated to trigger users to expend initial effort, rewards serve to motivate users to keep putting in effort. Through rewards we also create an interplay between gaming and learning, since rewards for completing the game can be used for learning and vice versa. This section will present the game design, the incentive system and the leaderboard.

3.6.1 Game design

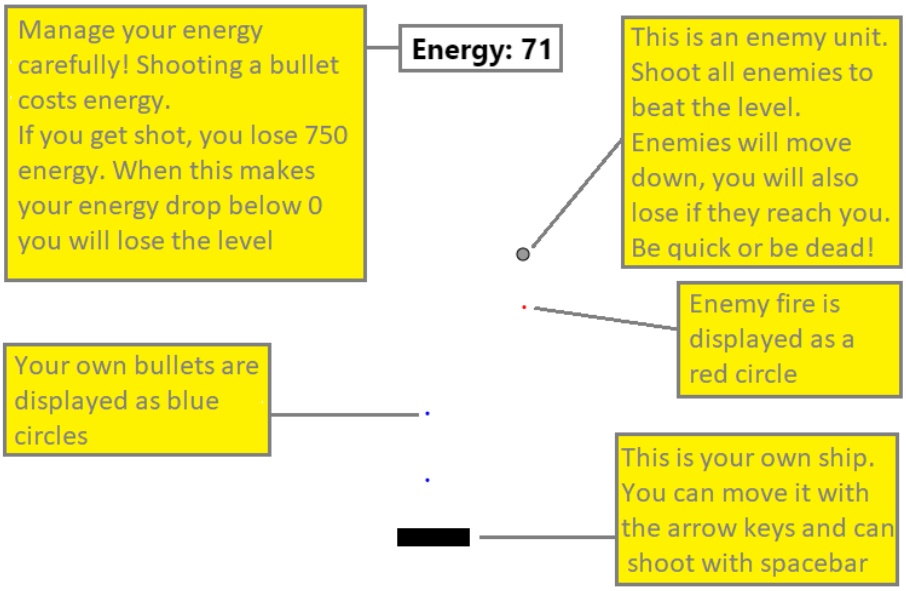

Figure 3.8: Overview of the game in the app

The game embedded in the app is an adaptation of the 1978 arcade game space invaders (see Figure 3.8). Different from the original is the inclusion of energy, which is used to determine whether the player is alive and whether they are allowed to shoot. Energy depletes by shooting or getting shot and automatically regenerates over time. When the player is shot, they will lose 750 energy. In case this makes their energy drop below zero the player will lose the level. The game is won by eliminating all enemies. The enemies in the game only move horizontally, but will move down when they touch the border of the screen. As soon as an enemy reaches the bottom of the screen the game is also lost. In the

first level of the game there is one enemy to be defeated, for each consecutive level an extra enemy is added to make the game more difficult. There is always a 1 in 30 chance that an enemy will fire, regardless of how many enemies there are. This was done to create a linear increase in the difficulty of the game. To keep the game interesting, a special enemy is added on every 5th level which is outlined in red. These enemies start to move diagonally after having hit the border and will thus reach the bottom faster than typical enemies which is something to look out for. To cope with the increase in difficulty, upgrades are available so that users can upgrade their ship and can thereby make sure that they can keep beating the game as it progressively gets harder.

Upgrades

There is a store embedded in the app which provides users with the opportunity to buy upgrades. Gold is the currency in the app, which is awarded for learning and reflection (see Figure 3.3). The user can increase the amount of energy their ship can carry, the speed at which their energy regenerates and their weapon. Initially the user will start off with 500 energy, a level 1 generator and no weapon. A weapon (level 1) will have to be bought with the starting gold awarded for setting learning goals. This is designed as such to ensure that all users are aware of the fact that they can use their gold to buy upgrades. Upgrading the weapon increases the size of the bullets that you fire, but also makes your bullets cost more energy. The amount of energy that a bullet costs is determined by multiplying the weapon level by 25.

3.6.2 Incentive system

After beating a game of space invaders, users are rewarded with a learning strategy. Each time there is the option to choose one of three different learning strategies. The chosen strategy will be added to the inventory of the user. Details of all learning strategies have to be revealed before they are allowed to be chosen, so that users understand all strategies and can make an informed choice.

The app is thereby set up to spark initial interest through the game, which should be fun to play and be motivating in and by itself. Learning and reflection are rewarded with gold, thereby creating motivation for these tasks. It is expected that users start to see the benefits of these tasks through repetition. When users recognize these task to be useful, it should add to their motivation to keep using the app.

3.6.3 Leaderboard

A leaderboard is present in the application, which is based on the amount of different learning strategies that users have tried. This serves to provide a social feature, as well as an incentive to try as many strategies as possible. Additionally, the number of strategies that have been discovered is displayed on the homepage (see Figure 3.2). This serves to spark curiosity on the strategies that have not yet been discovered and provides feedback on the progress of the user in terms of discovering all available strategies.

Chapter 4

Pilot study

4.1 Introduction

A pilot study was conducted to get an idea of how students respond to the app and to find flaws that needed to be addressed before conducting the final experiment. Main topics of interest were whether the application was motivating for students and whether use of the app could provide insights to potentially spark a change in their learning behavior.

4.2 Methods

4.2.1 Participants

Data for the pilot study was collected from a total of eight people. All participants were recruited from the Hanze university of applied sciences and the university of Groningen, since we aimed to gather participants with experience in higher education. All but one participant was enrolled in higher education at the time of the experiment, the one exception being a participant who had just finished their bachelor and was between studies at the time. Overall experience in higher education ranged between 1 and 5 years (m=3.375, s=1.60), age ranged from 20 to 25 (m=23.25, s=1.58). All participants received and signed a paper form of informed consent prior to the start of the experiment.

4.2.2 Materials

The pilot study was conducted in a computer lab, to provide all participants with a means of accessing our web app L2C. Participants provided their own study materials. By conducting the pilot during an exam week, it was guaranteed that all participants had an upcoming assignment or exam that they could study for. Since participants used the app to work on a variety of different tasks, a variety of learning strategies needed to be available so that L2C could be used for any learning task. In order realize this, a wide variety of learning strategies taken from (Zimmerman, 1989), (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013) & (Schraw, 1998), were included. Strategies revolving around planning and goal setting were excluded, since these steps are a crucial part of the app

design and any user will automatically be applying these strategies as they use the app. The complete list of strategies used can be seen in Appendix A.

A beta version of L2C was used in the pilot study, contrary to the description in chapter 3 this version did not contain a leaderboard. In the beta version it was also not possible to change learning goals or to continue an activity after running out the timer.

4.2.3 Measures

Personal data and study experience of participants, as well as their opinions on the app, were recorded trough a custom questionnaire (see Appendix C). This questionnaire was designed to gather information on four different aspects: Learning strategies, motivation, usability & usefulness. Each of these categories consisted of five statements with answers being recorded on a 5-point likert scale. The questionnaire served to provide quantitative data on the app appreciated. This was supplemented by qualitative data gathered through an interview, which provided more in-depth information on why certain elements were appreciated, or not appreciated. Through this evaluation we aimed to identify whether there were any problems that needed to be addressed before conducting the final experiment.

Based on user logs recorded by the app, behavioral patterns of users could be identified. This provided information on how often the cycle of gaming, planning, learning, reflection and gaming (as seen in Figure 3.3) was repeated. Ideally our participants would repeat this cycle multiple times, so that they repeatedly exercise metacognitive skills through which they can increase their metacognitive awareness.

4.2.4 Procedure

The study started off with an introduction, during which participants received guidance on setting up their accounts. This lasted for half an hour and aimed to familiarize our participants with all the different functions of the app.

Next, our participants were given one hour in which they could freely use the app. It was stressed that all learning activities in which subjects engaged should be logged in the application. During this time there was no interference from the experimenter. Nevertheless the experimenter was present during the whole session, but only to answer any questions and to provide assistance where needed.

To conclude the study, a final evaluation was scheduled. This consisted of our questionnaire and an interview, each lasting for about 15 minutes.

4.3 Results

The questionnaire contained 20 statements, divided into 4 blocks of 5 questions, with answers being recorded on a 5-point likert scale. We calculated the mean score on each of the categories for a rough idea on how well each aspect of the app was received, to help us identify roughly how well each aspects was appreciated. Scores were transformed to numerical values on a scale between 0 and 4, with "Completely disagree" being transformed to zero and "Completely agree" being transformed to the maximum value of four.

Table 4.1 shows the average scores for all the categories. It can be seen that usefulness scored highest, closely followed by motivation. Usability and learning strategies receive lower scores, but still appear to be between neutral (2) and positive (3).

Table 4.1: Mean scores on the questionnaire per category

Category	**Mean score**
Learning strategies	2.5
Motivation	3.0
Usability	3.1
Usefulness	2.5

4.4 Discussion

The pilot study has provided valuable insight into how students experienced working with the app. Since all categories of the questionnaire on the app scored well above average (see Table 4.1), the app was deemed to be ready to be tested on a larger scale. Nevertheless, some interesting points came forward during the interview which led to some changes being made to the final version of the app. The next segment will highlight the most important topics per category and will support the changes made to the app.

4.4.1 Learning strategies

Of all the categories in the questionnaire, learning strategies received the overall lowest scores. Analysis of the user logs has shown that our participants used an average of two different strategies during the pilot experiment. The questionnaire indicated that out of our eight participants, only two had tried a new learning strategy. What may have contributed to this is that the pilot study was scheduled amidst the exam week. This means that participants were already half way in studying for the upcoming exam and likely had an idea on how they wanted to approach this, before participating in the experiment. Second, the experiment lasted an hour which may have been insufficient time to try many different strategies. Nonetheless it was deemed viable to promote the use of different strategies. Since it was brought up in the interview that some participants would have liked to see a social feature, a leaderboard was added. By basing the leaderboard on the number of strategies used, we were able to include a social feature as well as an extra incentive to try different strategies in order to climb the leaderboard.

4.4.2 Motivation

The game initially appeared to be enjoyed by most participants, seeing as cheers could be heard after a level had been beaten. The questionnaire further showed that none of our subjects disagreed on the game being fun to play, although three subjects indicated being neutral towards the game. When the interviewer asked for the reason why, one of our participants commented finding it difficult to hit enemies. Others then added finding it unfair that enemies would sometimes immediately fire after the game had started, without them being able to prepare. The game was therefore adapted to prevent enemies from firing in the first second. This gave users some time to prepare and dodge incoming bullets, making the game more fair.

Apart from the game we tried to motivate our users by incorporating rewards for both learning and playing the game. When asked in the interview, one participant pointed out feeling motivated by the congratulatory popup after beating the game. She continued to note the omission of a similar popup after having completed a learning activity, to which others agreed. To create more consistency, we chose to add an additional popup that shows up each time a learning activity has ended. This displays a message that congratulates the user, while also indicating exactly how much gold was earned for their efforts.

4.4.3 Usability

During the experiment it became apparent that some participants experienced trouble with setting their learning goals, and that some had in hindsight wanted to have different goals. One participant had therefore resorted to creating a new account, since it was not possible to edit learning goals in the initial version of L2C. This was designed as such to make sure that students would only use the application within a single course or project. Since this led to problems, we decided to provide the opportunity of resolving such problems by adding the option to edit learning goals.

Some participants had also noted experiencing trouble with the layout. In particular, subjects who were working in split screen, with one browser window for running the app and another window to study, found that reducing the screen size caused difficulties as elements of the app started to overlap. This mostly caused problems with readability and interactivity of the agenda. In the final version of the application the layout was therefore reworked to prevent overlapping to ensure that all elements could be interacted with, regardless of screen size.

Finally, a third usability issue came forward which revolved around the estimated time for a learning activity. Two participants indicated having underestimated the time it took to complete their activity and finding it silly to not be able to continue learning without having to play the game first. To address this issue, the option to add more time and continue using the selected strategy was added to the final version. By having this option, users are no longer penalized by underestimating the time it will take to complete an activity by having to change their approach or play the game until again receiving the desired strategy. This consequently provides the user with more comfort and control over the planning of their learning process.

4.4.4 Usefulness

Usefulness scored the best out of all the categories. The questionnaire indicated that half of our participants strongly agreed to finding it useful to plan their activities, as well as finding it useful to have their reflections logged. The interview further revealed that the timer was also appreciated, mostly because it provides the user with a deadline which helps to keep them focused on completing the task in time.

Chapter 5

Final study

5.1 Introduction

The final study had students work with L2C over a period of four weeks. L2C was used to assist students with writing a scientific essay, as part of the course "Controversial Literature and Literary Controversy" taught at the university of Groningen. Students were divided into two groups, having lectures on either Tuesday or Friday. During these weekly lectures, an hour was reserved for our study. All students were instructed to only use L2C to work on their essay assignment, the available learning strategies were adjusted to be more specifically applicable for writing an essay. The article of Graham & Harris (2000) describes a series of self-regulated learning strategies specifically for writing (Graham & R. Harris, 2000). These strategies formed the basis of the strategies used in the final experiment. As in the pilot experiment, the strategies goal setting and planning were excluded since the app is set up in a way that forces users to use these strategies anyway. A complete overview of the available learning strategies used can be found in Appendix A.

In the current study it is mainly of interest whether students are motivated by L2C, which will be measured by the amount of games and learning activities that participants log. Second, we are interested in whether use of L2C over a longer period of time will lead to increased metacognitive awareness.

5.2 Methods

5.2.1 Participants

Participants were all bachelor students at the university of Groningen, their ages ranged from 19 to 25 years (m=21.8, s=1.6). 42 students were enrolled in the course and were asked to participate, 41 agreed to participate by giving their informed consent. Participants spent an average of 2.8 years in higher education and thus this sample can be considered to consist of experienced students.

5.2.2 Materials

During the final study we have used the full version of the app as was described in Chapter 3. Subjects were allowed to use their own laptops or devices to access the app. The only requirement was that a keyboard was necessary in order to be able to play the game.

5.2.3 Outcome measures

To measure metacognitive awareness we used the Metacognitive Awareness Inventory (MAI), which has the advantages that it can easily be administered online and that it scores multiple different facets of metacognitive awareness. The MAI was both administered at the start and the end of the study, as a means to investigate whether use of L2C affected metacognitive awareness.

For evaluation of the app, a questionnaire was used (see Appendix D) which was similar to the one used in the pilot and included the same four categories. One extra category was added which consisted of 5 extra questions on the effort it took to work with the app, to provide a better understanding of whether participants think L2C is worth the effort. Additional open questions were added which directly asked what participants thought was the best and worst thing about the app, as well as which learning strategies they did and did not find useful. To investigate whether L2C successfully induced variation, a final question was added which asked whether participants had used a different approach than usual.

Logs recorded by the app allowed further investigation of how many, and which, strategies were used by our subjects. These logs also provide data on how long users spent on the app and how much of this time they spent learning or gaming. Finally, the difficulty of the game will also be evaluated by analyzing the win/loss ratio found in these logs.

5.2.4 Data analysis

To answer the question how the usability of L2C was appreciated we gathered quantitative data in our questionnaire, supported by qualitative data provided by open questions in the questionnaire. These questions include asking the user what they think is the best and worst part about L2C, asking them whether L2C led them to use a different approach than usual, and asking which of the strategies they encountered they found to be most, and least, useful.

Motivation will be tested through recording quantitative data provided by the log files that L2C keeps. We are interested in both the number of games played and the amount of learning that is done, with high frequencies of either expecting to reflect high numbers of motivation. The game difficulty will also be evaluated through calculating the win percentage gathered from these logs. To see whether L2C improves metacognitive awareness we compare pre-test scores and post-test scores on the MAI, which are tested for significance through a paired t-test.

Missing data

During the study it happened 20 times that the outcome of the game was not logged and therefore remained unknown. This may have occurred due to a

server error in logging the outcome, or the game simply being aborted by the user. Since only 0.3% of the total number of games played had an unknown outcome, these missing values do not substantially impact the reliability of the win percentages that will be calculated later on.

5.2.5 Procedure

During the first lecture an introduction was provided, during which participants were meant to fill in the MAI so that we had a baseline measurement of their metacognitive awareness. The introduction also provided examples of learning goals and explained the concept of L2C. During the in-class introduction participants were expected to create an account, set their learning goals, purchase a weapon and earn their first learning strategy by winning the game. After this introduction they were free to use L2C at their own discretion, as it was assumed that participants were now fully capable of working with the app individually and without supervision.

The second and third lectures provided participants with the opportunity to work on their essays through L2C. Participants were encouraged to use the app and were encouraged to ask questions if they encountered any problems. Participants were also encouraged to climb the leaderboard as a way of tempting them to explore new strategies. At the end of each lecture, participants were encouraged to keep working with L2C outside of the lectures. This was deemed important since users get the most out of L2C if they register all of their activities in it, mainly because L2C then provides a complete overview of all efforts. This makes it possible to reflect on all that has been done and optimizes progress tracking. Finally, the fourth lecture was scheduled to go through the post-test MAI and evaluation questionnaire.

Procedure infractions

During the first week of experimenting L2C had some downtime due to issues with the server on which the app was hosted. Because of this, the Friday group was not able to create their accounts during the first week. To provide the Friday group with a treatment equal to the other group, the introduction was repeated in the second week.

Due to the outbreak of COVID-19 and the precautionary measures taken by the university, all classes were cancelled halfway into the study. This meant that the Friday group had only received two out of the four aforementioned lectures, and that the Tuesday group had only received three.

5.3 Results

Data from 6 people was excluded from further analysis because they did not complete the introduction. This left 35 participants whose logs will be investigated in order to find how much they played the game, how many learning strategies they acquired through winning the game, and how many of these strategies they have put into practice.

The post-test MAI was limited to 14 respondents. Each of these respondents has completed at least 1 learning activity, meaning that they have planned,

executed, and reflected on it. It will then be investigated whether the use of L2C has had an effect on their metacognitive awareness.

First we will however discuss the app evaluation, since proper usability is a prerequisite for the ability of users to accomplish their goals within any application. This section will also discuss how participants perceived the usefulness and effort of working with L2C, so that its costs and benefits can be clarified. The app evaluation will be discussed based on results from the questionnaire, to which 19 participants responded.

5.3.1 App evaluation

Quantitative data on the usability was gathered through a series of five statements in the questionnaire (see Figure 5.1). This data revealed that 64% of respondents agreed or strongly agreed that the design of L2C was user-friendly. 85% of our respondents agreed or strongly agreed on finding L2C easy to use.

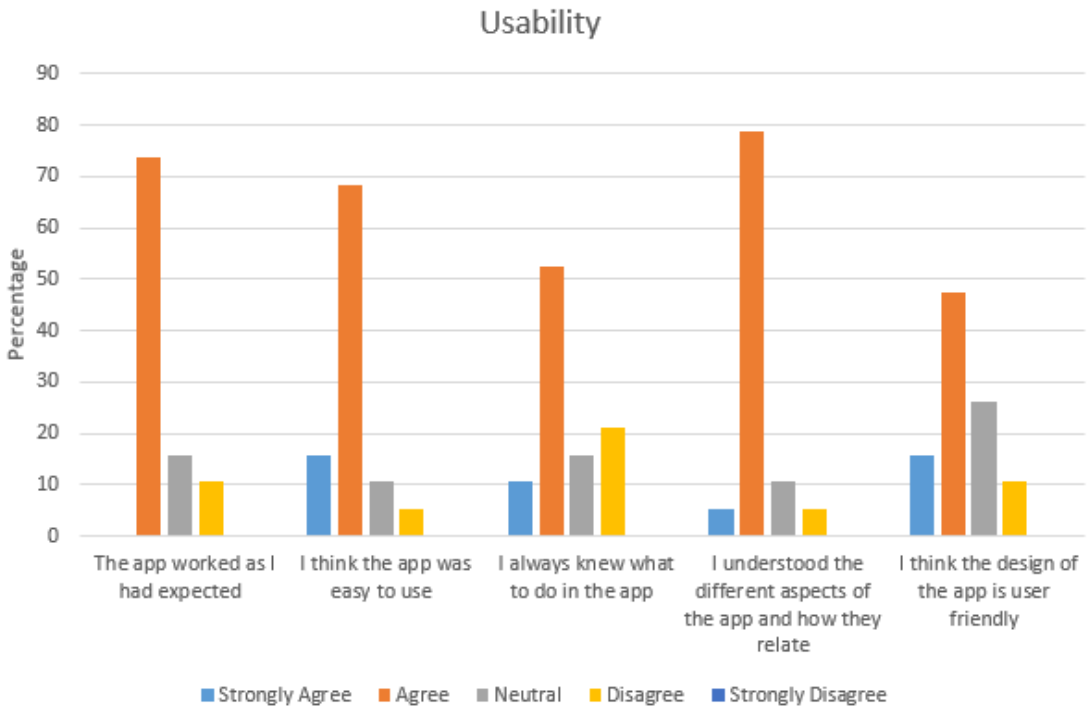

Figure 5.1: Questionnaire results regarding usability

On the open question as to what was the best part about L2C, one participant remarked: "*It's simpleness, it was easy to use. Looked nice, the planning table was very clear*". Another participant commented on the usability in response to the question on what was the worst thing about L2C: "*I felt like the design, aesthetic and compatibility with different screens kind of made it less pleasant to use*".

To provide insights into the perceived effort and utility that participants attributed to L2C, we will investigate the results from the questionnaires' statements on usefulness and effort.

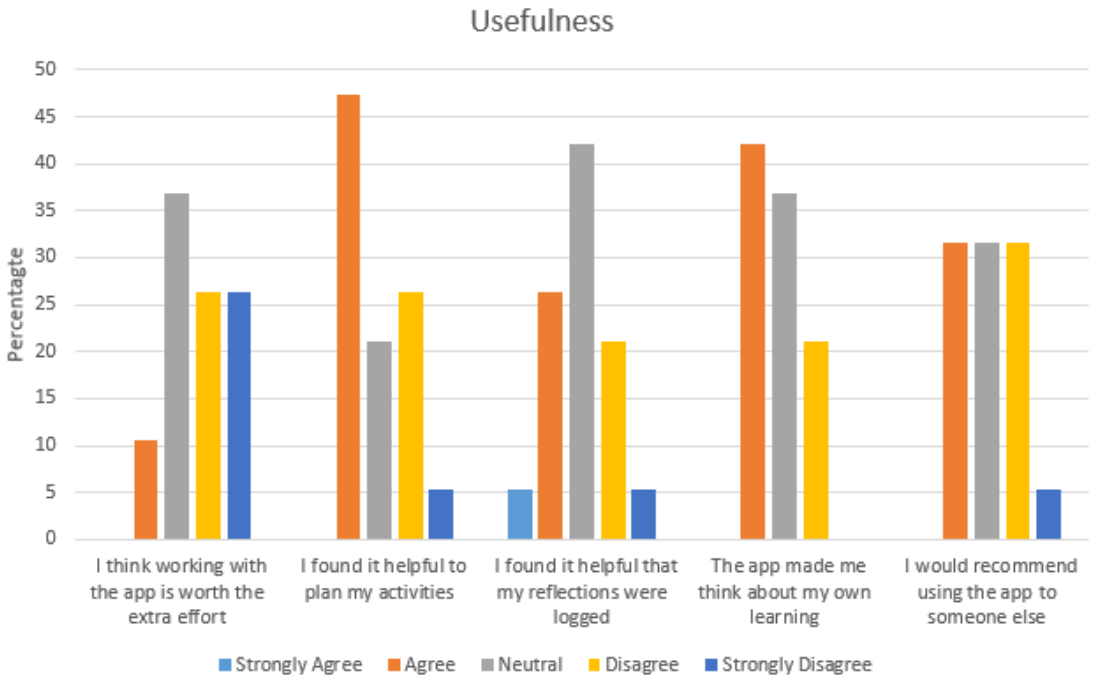

Figure 5.2: Questionnaire results regarding usefulness

Figure 5.2 shows that 47% of respondents found the planning of activities in L2C a helpful feature. 42% of respondents was led to think about their learning, indicating metacognitive activity. 31% of respondents would recommend L2C to someone else, but only 11% believe it to be worth the effort for themselves.

Qualitative data from the questionnaire reveals more insight into why this is the case, as the following quotations serve to illustrate:
"*I think this would have been very helpful at the start of my studies but I'm about to graduate so I've established a study system that works well for me*".
"*It is not very suitable for people who already have learning strategies and it does not work that well for essay-writing. However, I would have found this app very useful when I was a first-year for my linguistics courses*".

Now having evaluated the benefits that participants perceived L2C to have, we will next investigate the costs of using L2C. This will be done by discussing the data that the questionnaire has gathered on the effort that it takes participants to work with L2C.

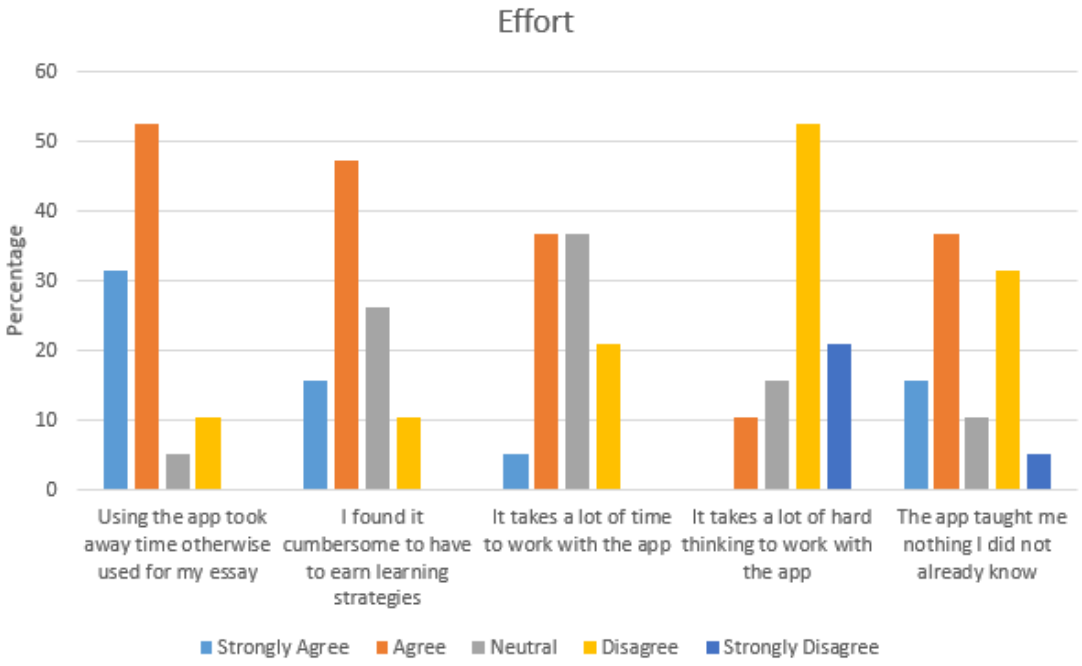

Figure 5.3: Questionnaire results regarding effort

The quantitative data in Figure 5.3 shows the questionnaire results on the effort it takes to work with L2C. Contrary to the other categories, here we would like to see little portions of agreement.

73% of respondents disagreed or strongly disagreed with the statement that L2C required hard thinking. 47% of respondents agree or strongly agree that L2C does take a lot of time to work with. A large majority of respondents also indicate that using L2C has taken away time otherwise spent on the essay itself. These findings are corroborated by quotations from the questionnaire, in response to the question what the worst part about L2C was: "*For me, it felt as doing something "extra". I've been writing essays for almost three years and personally didn't feel the need to break down every part of essay writing (choosing a strategy, set learning goals, etc.) via an app, since I already do that for myself when writing an essay*". "*I think that the app would be helpful for first year students that are starting to write academic essays. For a third year student, the app makes essay writing, which I find easier to do now, a bit more tedious. I didn't like having to log what I was doing, I just wanted to do it*". Several respondents explicitly named having to earn strategies the worst thing about L2C, which the following quotations will illustrate: "*I did not like having to earn learning strategies, and I also did not like that I had to earn the strategy again after every time I used it*". "*Having to earn all the strategies was a bit impossible for me and I had to use strategies that I wouldn't actually use while writing my essay*". These quotations are supported by the quantitative data in Figure 5.3, which shows that having to earn learning strategies is considered to be cumbersome by 64% of respondents.

Next we will discuss the responses on statements regarding the available learning strategies, displayed in Figure 5.4, to determine whether they were usable and interesting for our participants.

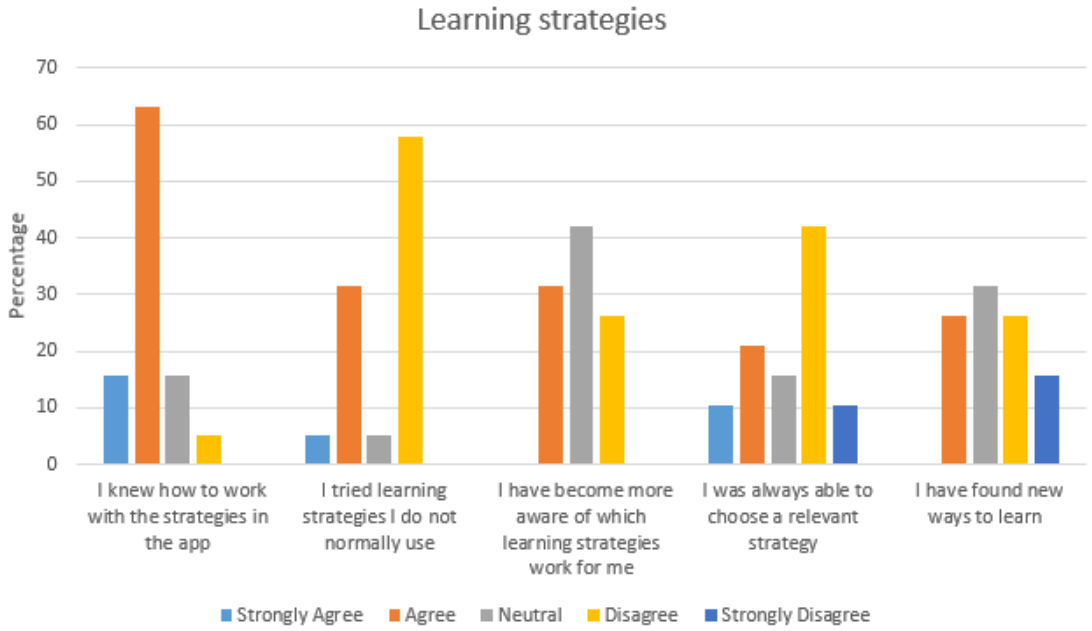

Figure 5.4: Questionnaire results regarding learning strategies

The majority (77%) of our respondents reportedly knew how to work with each of the strategies, as they agreed or strongly agreed with this statement. Only 26% of respondents agreed to having encountered learning strategies that were novel to them. 36% of respondents indicate also having tried strategies that they would have not used without L2C. On the question which strategies were found useful, one respondent commented: "*The strategies I did use - having a silent environment without distractions, gathering information, and taking notes - were useful, but I was already aware of them and using them in my learning process*". This quotation appears to be representative of the total sample since from the 19 people having filled in the questionnaire, 16 indicated having used the same approach to writing the essay as they normally would.

Another thing to note is that 52% of respondents indicate not always having a relevant strategy to choose from. This is corroborated by quotations from the questionnaire: "*It is not that they - the learning strategies - were not useful, they just weren't useful for the part of the essay writing process that I was in at that moment*". "*Quite a lot of the times strategies came up that I could not use at that moment and a lot of the same strategies came up*".

5.3.2 User logs

This section will discuss the quantitative data gathered from the user logs of 35 participants. We will determine whether they were motivated by L2C by reporting the total usage statistics. First, we will discuss the number of games that were played. Second, we will discuss how many of these games were won and how many learning strategies were thus acquired. Third, we will look into how many of these acquired strategies have been used.

Game statistics

A total of 6854 games were played, with a mean number of 190 games played per person. The standard deviation is 576, which is mostly caused by a single participant who was responsible for playing as many as 3423 games whereas most participants played less than 100 games. Although it is extraordinary that one participant has played such a high number of games in comparison to the rest of participants, the choice was made to not exclude this data point. The reason for this is that it will not lead to a loss of statistical power, since there is no formal statistical test that will be carried out on this data. We are only interested in the frequencies of gaming and learning in L2C.

Figure 5.5 displays the frequency distribution of the games played per person, which shows that the data is right-skewed. A majority of 27 participants played between 1 and 90 games, but there is a group of 9 participants who have played over 100 games. The variability in the data is high, which reflects large individual differences in engagement towards the game. Due to this high variability the median is a more reliable measure of the central value in this data, which amounts to 33 games played per person.

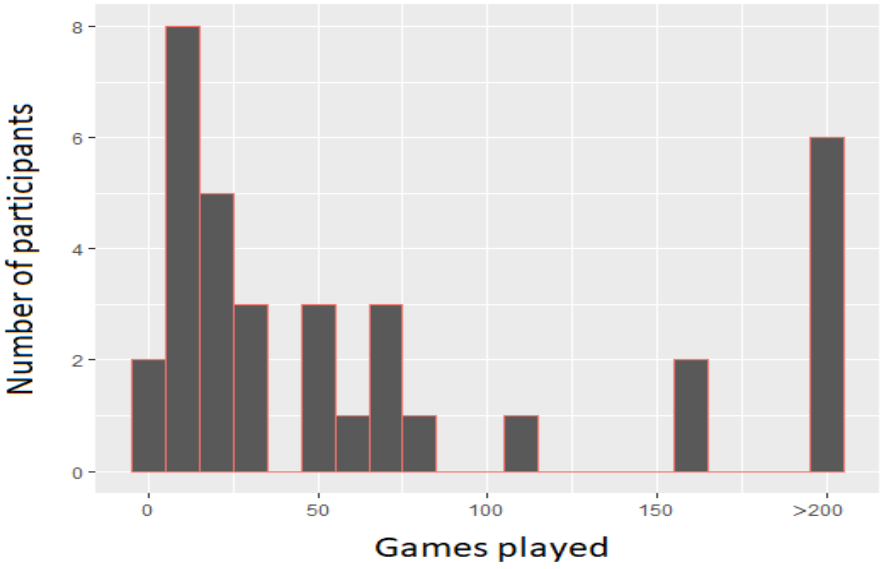

Figure 5.5: Frequency distribution of amount of games won per user.
The figure uses a bin width of 10, with the exception of the last bin that represents all remaining values ranging from 201 to 3423

To evaluate whether the game was appropriately difficult and to what extent participants were able to beat the game, we will now investigate the number of games that have been won. The number of games won equals the number of learning strategies that have been acquired, which is a necessity in order to be able to do learning within L2C.

The number of games won per participant is displayed in Figure 5.6, which shows that the distribution is right-skewed. The median of games won per participant is 4 whereas the mean amounts to 8.6. This difference is caused by a few users who played the game very fanatically, with one of them even reaching as far as level 61. This was the same participant who had played 3423 games, meaning that their win percentage was 1.7%.

The absolute number of games won is 309 (4.5%), whereas an absolute number of 6525 games were lost (95.2%). This data is skewed by the participant with 3423 games played, exclusion of this participant increases the win percentage to 7.5%. When however taking the mean of wins and losses across all of our participants, who admittedly varied a lot in the number of games that they played, the win percentage rises to 18.6%

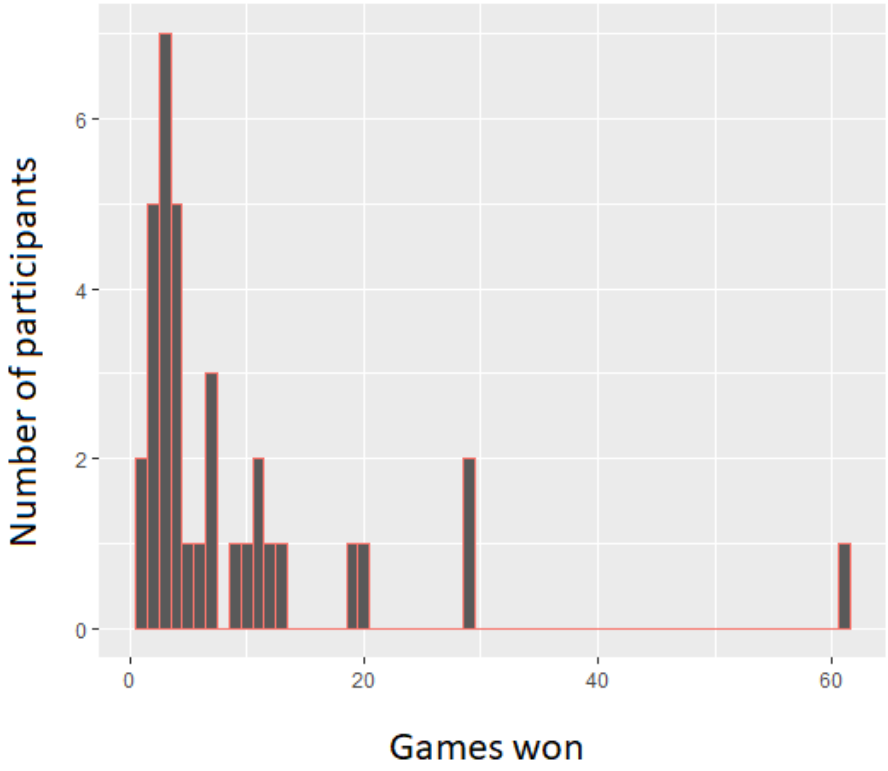

Figure 5.6: Frequency distribution of the amount of games won per user. Bin width = 1

As Figure 5.6 shows, all participants have beaten the game at least once and have thus been able to acquire at least one learning strategy. Next, we will investigate how many learning strategies have been used.

Learning activities

The process of planning, performing, and reflecting on a learning activity has been completed 98 times in total. In 82 of these cases (83.7%) the user indicating actually having used the strategy that he or she selected. These 82 cases were further inspected, to extract information on the usefulness of the available strategies. This analysis showed that all strategies, apart from seeking social assistance, have been used. All of the used strategies were deemed useful in 60% or more cases. A detailed overview of which strategies were used and how they were appreciated can be found in appendix B.

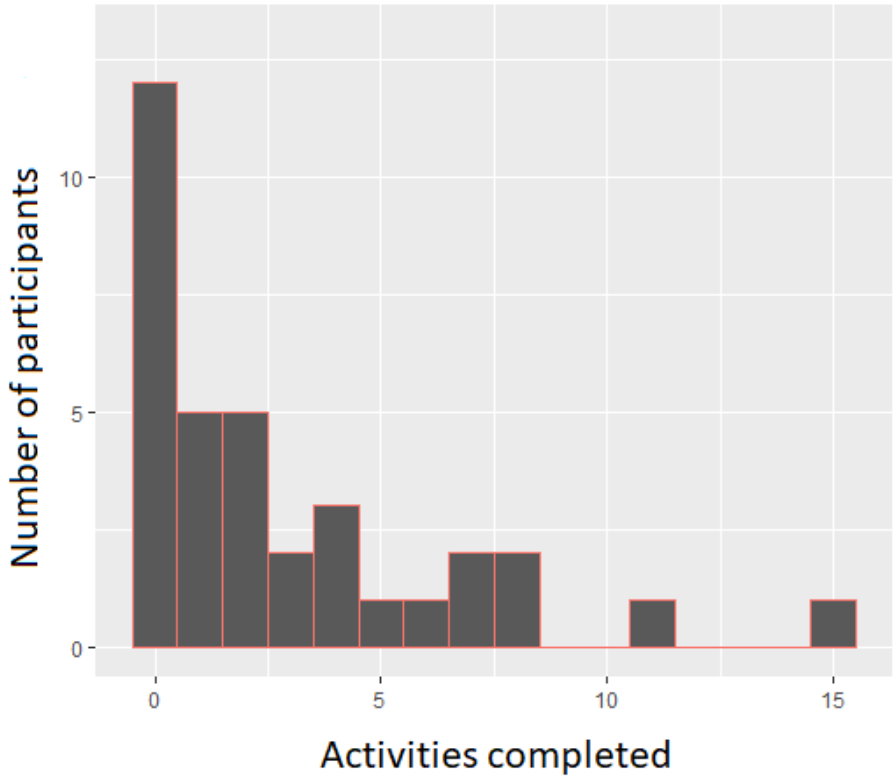

Figure 5.7: Frequency distribution of completed learning activities per user. Bin width = 1

Figure 5.7 displays the frequency distribution of completed learning activities, which is right-skewed. The median herein is 1.5 whereas the mean number of learning activities completed per person is 2.7. 13 Participants (36%) did not complete a single learning activity, despite 12 of them having at least one learning strategy available to use.

Now having determined the number of learning activities that have been completed, we will next investigate whether this repetition of metacognitive skills has had any effect on the metacognitive awareness of our participants.

5.3.3 Metacognitive awareness

To examine the effects of L2C on metacognitive awareness, we compared the mean baseline score on the metacognitive awareness inventory (MAI) to the mean score gathered at the end of the study (see Figure 5.8). This figure indicates that half of our participants score higher on the MAI after using L2C, whereas the other half scores lower on the MAI after using L2C. It can also be seen that one participant received a mean score of 34 on the pre-test MAI, which is relatively low since the other 13 participants received scores of $\geq$57. This participant was not excluded since it can not be said that this is an erroneous measurement. It might be the case that this participant really has a low metacognitive awareness, but that they have always been able to succeed in their education despite their metacognitive awareness being mostly tacit.

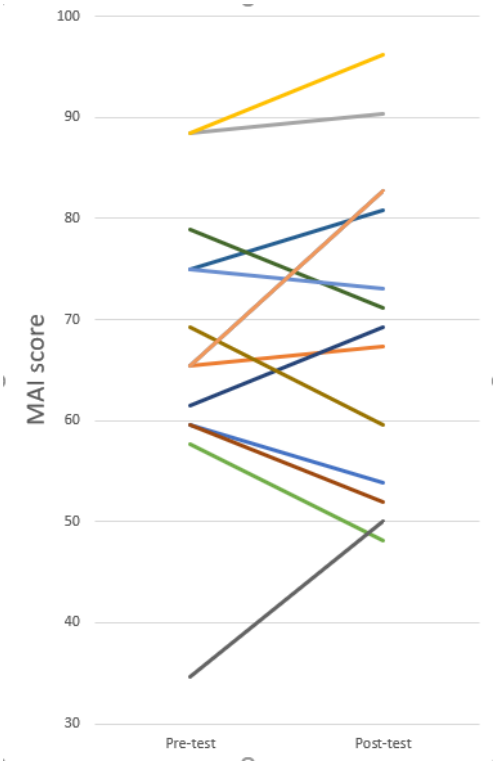

Figure 5.8: MAI scores before, and after the study. Results displayed per participant, with pre-test scores on the left and post-test scores on the right.

For our statistical analysis, we first tested whether the differences seen in Figure 5.8 were normally distributed. A Shapiro-Wilk test showed that these differences were not significantly divergent from normal distribution (W=0.90, p=0.13). Since there was no violation of the normality assumption, we next ran a paired t-test. The results from the pre-test (m=67.4, s=13.8) and post-test (m=69.8 s=15.5) MAI indicate that the use of L2C did not result in an improvement in metacognitive awareness (t(13)=0.89, p=0.39).

To provide a more detailed understanding of the effects of L2C, the scores on all the specific categories measured by the MAI are displayed in Figure 5.9. The last bar in this graph displays the mean total score which did increase, although this difference was not significant as the aforementioned analysis revealed.

Apart from the categories "Conditional knowledge" and "Information management strategies", all mean scores for the individual categories appear to marginally increase. A relatively large increase is found in the categories "Planning", "Evaluation" and "Procedural knowledge". Post-hoc analysis revealed that none of these increases were significant.

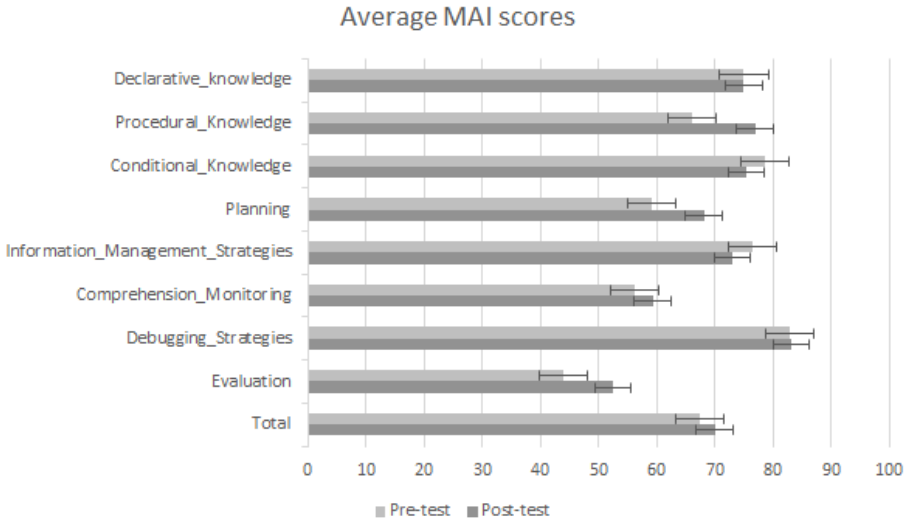

Figure 5.9: Average MAI scores per category, measured before and after the final study.
Error bars are shown to provide an indication of the uncertainty in this data.

5.4 Discussion

In this study, we have developed a web app with the purpose of motivating people to increase their metacognitive awareness. By incorporating a game we aimed to spark initial interest in the app, which revolves around trying different learning strategies and keeping personal logs and reflections of their effectiveness. Over time the idea is that users start to see the benefits of these tasks which is thought to increase motivation through heightened task value beliefs.

By having users repeatedly going through the cycle of planning, learning and reflection we intended to facilitate the development of metacognitive skills. Through repeated reflection the user is also expected to develop explicit metacognitive theories, which contributes to a better understanding of their personal strengths and weaknesses as a learner. This should consequently aid the learner in setting learning goals that are challenging yet reasonable, while also providing them with the means necessary to reach these goals.

From the current results we can not definitively conclude whether our app was successful in increasing metacognitive awareness. Overall MAI scores showed an upwards trend, but no significant effect could be measured. While participants generally recognized the benefits that use of the app can yield, some indicated that there was little for them to gain and felt like the app held them back. Making the app more adaptive to the user and decreasing the effort that has to be put in are key points that need to be reworked in order to allow all students to get the most out of the app.

5.4.1 Usability & Usefulness

Judging from the current results, it can be concluded that the app overall was found to be easy in use. 83% of participants reported that the app was easy to use and 90% of participants agreed that the app worked as they had expected (see Figure 5.1). One problem on usability was however encountered with the timer that showed while participants were learning. Multiple participants did report finding this timer helpful to keep them focused, however some participants occasionally forgot to start their timer. This resulted in them completing their activity without earning gold for it. To further increase usability the timer should perhaps start automatically, or the user should be given a reminder to start the timer.

Overall, it would appear that the app provides a user-friendly platform in which students can explore different strategies and make a detailed learning plan with relative ease. The usefulness of logging all activities and having a detailed overview is something is generally recognized, although more so for less experienced students. This is indicated in numerous quotations from the questionnaire, and is supported by the data in Figure 5.2. This figure shows that 11% of participants find the app to be worth the effort for themselves, while 31% would still recommend the app to someone else. As participants in the current study had 3 years of study experience on average, some participants indicated that they already had a clear idea of how to approach their essay. They reported to already be breaking down this process in their minds and did not feel the need to log this.

This is supported by Figure 5.3, which shows that over 70% of our participants did not believe that using the app required hard thinking. For less experienced students it might be harder to break their learning down into the required amount of detail, yet there might also be more to gain in terms of metacognitive awareness and awareness of different learning strategies.

5.4.2 Gaming & Learning

With 36 people having played close to 7000 games, the game overall appears to be engaging. The distribution of games played and won is however skewed, as can be seen in Figure 5.6. This shows a pattern where some participants have both played and won the game in high frequencies, whereas most participants win the game only once or twice. One might suspect that people who won the game repeatedly were also the ones who won the game more easily, yet this does not appear to be the case. For instance the person responsible for winning 61 games had a win percentage of only 1.8%, meaning that this person alone has played 3423 games. Other participants showed higher win rates, but

stopped playing at an earlier stage. This shows that engagement to the game does not come from the ability of winning, suggesting that individual interest in the game's mechanics and its expected utility are more important factors.

All participants did beat the game at least once and thus had the opportunity to start learning. However this is where a large portion of participants lost interest, seeing as 12 participants (34%) did not actually engage in learning despite having earned one or more strategies. This is a consequence of the acquired strategies not always being applicable to the approach that a user has in mind, which was too often the case in the current experiment. Due to their study experience, 75% of participants was already familiar with the learning strategies that L2C offered. Most participants also had an idea of how to approach their assignment prior to the study, and the questionnaire revealed that 16 out of 19 respondents (84%) stuck to their usual approach.

Based on these findings, it becomes clear that the game may have been lacking utility. When the game offers learning strategies that are already known or not applicable, there is little reason for participants to keep putting effort into the game other than to enjoy it. The good thing is that most participants did enjoy the game, as 6 respondents (31%) name it the best thing about L2C. However 7 respondents (37%) find the game to be the worst part about L2C due to its difficulty and lack of utility. The rigidness of having to beat the game before participants could start learning is also something which was critiqued.

To alleviate these issues, learning strategies need to become more readily accessible and users should be given the opportunity to freely engage in learning. Whether participants could engage in learning in the current study was determined by their ability in the game space invaders, which was especially troublesome since the game proved to be difficult for most participants.

However trying to induce variation in the way that users approach their learning, which was the underlying reason for this design choice, should perhaps still be kept. Otherwise students might stick to a learning pattern which they think works well, whereas in reality this is not the case. This is a consequence of the Dunning-Kruger effect, which describes the failure of recognizing that ones performance is poor: someone thinks they are doing great, when in reality they are not (Dunning, 2011). Due to this lack of awareness, such drastic measures as forcing variation may be necessary for else there is no reason for the learner to adjust their allegedly superior approach. The downside to this is that forcing people can reduce their intrinsic motivation (Deci, Koestner, & Ryan, 2001), making this a risky endeavour that future studies might want to avoid.

5.4.3 Metacognitive awareness

From the current results we can not definitively conclude whether the learning and reflecting done in the app has led to increased metacognitive awareness. Overall we did see a marginal increase of 2% on MAI scores (see Figure 5.9), although statistical analysis revealed that this was not significant. What could have contributed to this, is that there may have been a ceiling effect. In five of the categories that the MAI measures, there was a participant who achieved the maximum score on both the pre-test and the post-test. Since the maximum score was already achieved in the pre-test, this consequently limits the room for growth in the overall scores. This ceiling effect is likely due to the experience of participants in the current study.

A relatively large increase can be seen in the categories "Planning" & "Evaluation", which are also the metacognitive skills that are emphasized in L2C. This can be seen as an indication that there may have been some benefits to training these skills with L2C, although the increase was not significant. The category "Procedural knowledge" also sees a relatively large increase, which can potentially be traced back to the goal-directedness within L2C. Since users have to specify a purpose and specific strategy for each of their activities, it is made very clear how and why each activity will be carried out.

The category "Conditional knowledge", referring to knowledge about when a specific strategy is most useful, decreases in overall scores. This could be explained by how learning strategies are acquired. L2C offers random strategies, selected from a pool of carefully chosen strategies. Because of this randomness, and the difficulty that some participants had with acquiring learning strategies, participants might have sometimes felt like they had to just had use a strategy simply because it was the only one available. Therefore L2C in its current form does not facilitate, and might even hinder, the development of conditional knowledge.

The category "Information management strategies" also decreases overall. This category measures the awareness of skills and strategies to process information more efficiently. Although strategies such as "Imagery" and "Organizing" were present in the final study, some participants might have not been able to acquire these strategies. This could be solved by giving the user more freedom of choice in which strategies they want to use, as well as incorporating more strategies of this type.

Finally, in overall scores we can see that half of our participants increase in metacognitive awareness over the course of the study, whereas the other half appears to decrease in metacognitive awareness (see Figure 5.8). The explanation for this might lie in the rigidness of the app, since it forces the user to always reflect, even on established concepts. Reflecting on known strategies should perhaps be limited or made optional, since there is a point at which nothing new is to be learnt and reflection becomes all effort and no utility. Constant reflection on the same concept might even lead to people starting to doubt their established patterns, which could explain the decrease in MAI scores that we see for some participants.

5.5 Limitations

The current study tested L2C with a sample of experienced students, which was in hindsight not ideal. Experienced students might have already formed metacognitive theories that are largely true, and which have been subconsciously stored. By forcing such students to again reevaluate these established concepts, they are not only held back but they can also start to doubt or deteriorate their established theories.

An additional drawback is that most of our participants had already developed a detailed approach to writing an essay, and wanted to stick to that. While their approaches could have perhaps been approximated in L2C, acquiring the appropriate strategies and logging every activity would cost additional effort and was not always found useful. Because of this, a relatively low number of learning activities has been recorded in the final study. Most participants recorded

around 2 activities, which is unlikely to be the full amount of activities done to complete their essays. With a limited number of activities logged, the benefits that L2C may yield remain somewhat inconclusive. It also remains inconclusive whether L2C influences learning performance, since it was not possible to collect the grades that our participants had acquired on their essays.

Furthermore, essay writing might also not have been the ideal domain to test in. Multiple participants reported to not find L2C that suitable for writing a scientific essay, which can be attributed to the learning strategies that mostly revolved around the acquisition of knowledge. The writing aspect, where the acquired knowledge is put into practice, was underexposed in the current experiment.

As a final limitation, the cancellation of lectures during the study may have contributed to a lesser amount of data that could be used in our analyses. It is mostly the evaluation questionnaire and post-test MAI that have suffered from this. Less than half of our participants responded, which may have been different if we were able to do this evaluation in-class as was intended.

5.6 Future work

The current study had participants working with L2C while writing a scientific essay, thus in one specific domain. Whether L2C can yield benefits over different domains is something that has to be tested in future studies.

In its current form, L2C provides a framework which allows for convenient extension and customization in future studies. The current study identified some adjustments that should be made, in order to resolve some of the problems that currently still exist. In future studies, it is most important that it should become easier to start learning through various different strategies. Doing this should increase the number of times that users repeat the cycle of planning, learning and reflection. The more this cycle is repeated, the more increase in metacognitive skills is to be expected.

By expanding the list of available strategies, users can be offered a wider variety of approaches which should make sure that there is something new to explore for everyone. This should also increase the number of different strategies that users come across and try, which should lead to further increase of metacognitive knowledge. Users could also be given the option to add their own custom strategies, which would guarantee that they always have access to relevant strategies, which was not always the case in the current experiment. Through sharing these strategies with all users, a social learning environment could also be created in future studies.

Further testing with a group of less experienced students is the logical next step to take, which is promising especially since multiple participants from the current study explicitly stated that they would have found such a tool useful in the first year of their studies. An additional benefit of testing with inexperienced students, is that they are less likely to have developed a strong preference towards one specific approach. This might make them more willing to deviate from their initial plan and to try different strategies as well. Through experimenting with different strategies, detailed planning and constant reflection, L2C can potentially help these students to develop good habits and can provide them with the means necessary to achieve academic success.

Chapter 6

Conclusion

In the previous section we have discussed the most important findings of the current study. Overall we have seen that engagement in L2C was skewed, with a limited number of participants being engaged and recording lots of activities whereas others appeared to be less interested and gave up early in the process. To make L2C more engaging and have it appeal to a broader audience, L2C should become more adaptive to cater to the needs and wishes of individual users. Additionally, the effort it takes to learn and explore different strategies should be decreased.

This chapter will serve to discuss the lessons learnt in terms of designing a domain-generic app to motivate learners to increase their metacognitive awareness. By discussing these lessons we hope to inform future researchers with some guidelines that should help the realization of an effective and appealing platform to motivate students to increase their metacognitive awareness.

6.1 Learning strategies

The main problem with learning strategies in the current app is that they had to be earned before they could be utilized, while users in reality will already have strategies at their disposal. This discrepancy is something that needs to be resolved in future versions since it may lead to user dissatisfaction. **Users need to have access to learning strategies from the start.**

Making all available strategies readily available is optional, but the risk of this is that users stick to only using the strategies that they are accustomed to whereas there might be superior alternatives that remain unknown to the user. We do believe that variation needs to be induced in order for students to get the most out of the experience. Forcing people to do this as was attempted in the current study is in retrospect not the best way to achieve this. By controlling users in this manner, autonomy and self-determination are taken away which consequently hampers motivation and can lead to feelings of helplessness. **Incentivizing students to use various strategies could work, but the choice to do so should always come from the user.**

Adaptation of rewards based on strategy use can be a way to achieve this, so that use of unfamiliar strategies yields larger rewards than strategies that have been used repeatedly. This can be combined with achievements that can

be unlocked for using many different strategies, which would only be acquired if a user is self-determined to strive for this particular reward. Note that this is not an exhaustive list of possibilities, these are only some examples of ways to tempt users to explore while ultimately leaving the user in charge of this decision.

Finally, externally providing all learning strategies will in practice always mean that there is a limited list of strategies to choose from. One can also choose to not restrict users to the available strategies in order to mitigate this. **The autonomy of the user can be increased by allowing users to add their own personal strategies.** By adding these custom strategies to a public pool that is accessible to all users, one can create a social environment in which users can actively benefit from the knowledge of others on how to best tackle a problem and achieve optimal learning performance.

6.2 Game

The current app forced users to play the game in order to be able to learn, which as discussed is not an optimal approach because it reduces the users' autonomy. The difficulty of the game was also hard to balance due to the incorporation of more (types) of enemies and upgrades. This resulted in the game being hard to complete by the majority of users, whereas it did provide interesting mechanics for more adept gamers. Some of our participants in the current study appeared to really enjoy the game, judging from the high number of games that they played. Following this, we should perhaps not write this approach off immediately. **Comparing the current L2C to a version without gamification could provide important insights on whether incorporating external motivation is necessary at all.**

Another way to continue the efforts from this study would be to change the purpose of the game. Having users play the game to earn learning strategies as rewards is risky, since the strategy needs to be viable for the user at all times. An additional problem is that, with strategies being consumed upon use, playing the game can easily become a chore which is always required to be completed before one can start learning. Providing indefinite access to unlocked strategies solves this, but that poses a different problem since the game will lose its purpose the moment all strategies have been acquired. To solve this problem, one could choose to have the option of playing a game be the reward that has to be earned through learning. This has the advantage that it shifts the emphasis more strongly towards learning, through which users can earn the option to play a game. **Users could earn tokens by learning and performing metacognitive skills, which they can spend on playing some kind of game if and whenever they desire.** This is essentially taking the proven concept of arcades and slot machines, but dressing it up in a way that revolves around learning and increasing metacognitive awareness.

Finally, the game could also be made more relevant to learning. Space invaders might be action packed and enjoyable, but it has nothing to do with learning. **By incorporating a puzzle game, it might be possible to activate problem solving skills that could foster learning performance.**

6.3 Utility & Usability

The majority of our participants thought it was clear what they needed to do in the app and how they could do this, the benefits that could be gained through the app were also widely recognized by our participants. There are however still changes that we envision will improve the utility and usability of the app, which revolve around the app adapting itself to the user. For example, a timer is shown while users are doing a learning activity which was appreciated, but a problem is that it now has to be manually started. Although the timer was appreciated by our users, some users forgot to start the timer and ended up not being rewarded for their efforts. This can be avoided by either automatically starting the timer, or through showing a notification to the user which indicates that they might have forgotten to start the timer. Such a solution would indicate that the app is thinking with the user rather than being rigid, which can even be perceived as the app working against the user.

By gathering more information on a user, through their behavior and perhaps introductory tests on their learning behavior, it may become possible to create more personalized rewards. This would also allow one to realize more personalized notifications that show to a specific user what they could gain from the app (utility), and could show them how to achieve this (usability). **By having the app adapt itself based on the behavior of a user, we can create a more personalized experience which benefits both usability and utility.**

Rewards could also adapt based on user behavior, which could provide a subtle way of reinforcing specific behavior. If a user engages in different learning activities for hours on end without taking breaks, the rewards that are gained for each consecutive activity could be diminished. This would be a subtle way of indicating that a user should take breaks and spread out their learning, in order to get more efficiency out of their learning activities. When rewards are offered for gaming, a similar approach can be utilized. This would then imply that the utility for the game is mostly for taking your mind off learning for a certain amount of time. Although it might be fun to reach level 1000, at the end of the day this is not useful.

6.4 Final thoughts

Overall we can say that L2C may have potential, but that changes are required for users to get the most out of using L2C. The utility was recognized by our participants, but due to the game difficulty and rigidness of the app not all participants were able to get something useful out of it. Whether use of L2C actually has led to increased metacognitive awareness could as of yet not be confirmed. We did however learn important lessons that can help us overcome the current issues, based on which we can find specific solutions on how we can make L2C appeal to a larger audience. We hope that this contributes to the further development of digital solutions that can motivate and empower students in any domain, so that we can reduce dropout rates in our schools and facilitate academic achievement.

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References

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, *84*(2), 191.

Bandura, A. (1986). Social foundations of thought and action. *Englewood Cliffs, NJ*, *1986*.

DeBacker, T. K., & Nelson, R. M. (2000). Motivation to learn science: Differences related to gender, class type, and ability. *The Journal of Educational Research*, *93*(4), 245–254.

Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of educational research*, *71*(1), 1–27.

Derry, S. J., & Murphy, D. A. (1986). Designing systems that train learning ability: From theory to practice. *Review of educational research*, *56*(1), 1–39.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining gamification. In *Proceedings of the 15th international academic mindtrek conference: Envisioning future media environments* (p. 9-15). New York: ACM.

Diener, C. I., & Dweck, C. S. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement cognitions following failure. *Journal of personality and social psychology*, *36*(5), 451.

Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review*, *20*(4), 391–409.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58.

Dunning, D. (2011). The dunning–kruger effect: On being ignorant of one's own ignorance. In *Advances in experimental social psychology* (Vol. 44, pp. 247–296). San Diego: Elsevier.

Dweck, C. S. (1986). Motivational processes affecting learning. *American psychologist*, *41*(10), 1040.

Eccles, J. S., et al. (2005). Subjective task value and the eccles et al. model of achievement-related choices. *Handbook of competence and motivation*, 105–121.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual review of psychology*, *53*(1), 109–132.

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In

Handbook of child psychology (5th ed., Vol. 3, p. 1017–-1095). New York: John Wiley & Sons Inc.

Fei-Yin Ng, F., Kenney-Benson, G. A., & Pomerantz, E. M. (2004). Children's achievement moderates the effects of mothers' use of control and autonomy support. *Child Development*, *75*(3), 764–780.

Fisk, J. E., & Warr, P. (1996). Age-related impairment in associative learning: The role of anxiety, arousal and learning self-efficacy. *Personality and Individual Differences*, *21*(5), 675–686.

Fitz-Walter, Z., Tjondronegoro, D., & Wyeth, P. (2011). Orientation passport: using gamification to engage university students. In *Proceedings of the 23rd australian computer-human interaction conference* (pp. 122–125). Canberra: ACM.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American psychologist*, *34*(10), 906.

Ford, J. K., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, E. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. *Journal of applied psychology*, *83*(2), 218.

Gonida, E. N., Voulala, K., & Kiosseoglou, G. (2009). Students' achievement goal orientations and their behavioral and emotional engagement: Co-examining the role of perceived school goal structures and parent goals during adolescence. *Learning and Individual differences*, *19*(1), 53–60.

Graham, S., & R. Harris, K. (2000). The role of self-regulation and transcription skills in writing and writing development. *Educational psychologist*, *35*(1), 3–12.

Hakulinen, L., & Auvinen, T. (2014). The effect of gamification on students with different achievement goal orientations. In *Proceedings of 2014 international conference on teaching and learning in computing and engineering* (pp. 9–16).

Hakulinen, L., Auvinen, T., & Korhonen, A. (2013). Empirical study on the effect of achievement badges in trakla2 online learning environment. In *Proceedings of 2013 learning and teaching in computing and engineering* (pp. 47–54).

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & education*, *80*, 152–161.

Jagušt, T., Boticki, I., Mornar, V., & So, H.-J. (2017). Gamified digital math lessons for lower primary school students. In *2017 6th iiai international congress on advanced applied informatics (iiai-aai)* (pp. 691–694).

Kaplan, A. (2008). Clarifying metacognition, self-regulation, and self-regulated learning: What's the purpose? *Educational Psychology Review*, *20*(4), 477.

Kuhn, D. (2000). Metacognitive development. *Current directions in psychological science*, *9*(5), 178–181.

Kuhn, D., Garcia-Mila, M., Zohar, A., Andersen, C., White, S. H., Klahr, D., et al. (1995). Strategies of knowledge acquisition. *Monographs of the society for research in child development*, i–157.

Kuhn, D., Schauble, L., & Garcia-Mila, M. (1992). Cross-domain development of scientific reasoning. *Cognition and instruction*, *9*(4), 285–327.

Landers, R. N., Bauer, K. N., & Callan, R. C. (2017). Gamification of task performance with leaderboards: A goal setting experiment. *Computers in Human Behavior*, *71*, 508–515.

Latham, G. P., & Locke, E. A. (1991). Self-regulation through goal setting. *Organizational behavior and human decision processes*, *50*(2), 212–247.

Lin, X., Newby, T. J., & Foster, W. T. (1994). Embedding metacognitive cues into hypermedia systems to promote far transfer problem solving. In *Proceedings of selected research and development presentations at the 1994 national convention of the association for educational communications and technology.* Nashville: ERIC.

Linehan, C., Kirman, B., & Roche, B. (2015). Gamification as behavioral psychology. In *The gameful world: Approaches, issues, applications* (pp. 81–105). Cambridge: MIT Press.

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational behavior and human performance*, *3*(2), 157–189.

Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior*, *71*, 525–534.

Munday, P. (2016). The case for using duolingo as part of the language classroom experience. *RIED: revista iberoamericana de educación a distancia*, *19*(1), 83–101.

Nelson, T. O. (1996). Consciousness and metacognition. *American psychologist*, *51*(2), 102.

O'Rourke, E., Haimovitz, K., Ballweber, C., Dweck, C., & Popović, Z. (2014). Brain points: a growth mindset incentive structure boosts persistence in an educational game. In *Proceedings of the sigchi conference on human factors in computing systems* (pp. 3339–3348). New York: Association for Computing Machinery.

O'Rourke, E., Peach, E., Dweck, C. S., & Popovic, Z. (2016). Brain points: A deeper look at a growth mindset incentive structure for an educational game. In *Proceedings of the third (2016) acm conference on learning @ scale* (pp. 41–50). New York: Association for Computing Machinery.

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International journal of educational research*, *31*(6), 459–470.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist*, *50*(4), 258–283.

Ridley, D. S., Schutz, P. A., Glanz, R. S., & Weinstein, C. E. (1992). Self-regulated learning: The interactive influence of metacognitive awareness and goal-setting. *The journal of experimental education*, *60*(4), 293–306.

Robson, K., Plangger, K., Kietzmann, J. H., McCarthy, I., & Pitt, L. (2015). Is it all a game? understanding the principles of gamification. *Business Horizons*, *58*(4), 411–420.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, *25*(1), 54–67.

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design ele-

ments on psychological need satisfaction. *Computers in Human Behavior*, *69*, 371–380.

Schmader, T., Forbes, C. E., Zhang, S., & Berry Mendes, W. (2009). A metacognitive perspective on the cognitive deficits experienced in intellectually threatening environments. *Personality and Social Psychology Bulletin*, *35*(5), 584–596.

Schneider, W. (2008). The development of metacognitive knowledge in children and adolescents: Major trends and implications for education. *Mind, Brain, and Education*, *2*(3), 114–121.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional science*, *26*(1-2), 113–125.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary educational psychology*, *19*(4), 460–475.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational psychology review*, *7*(4), 351–371.

Sungur, S. (2007). Modeling the relationships among students' motivational beliefs, metacognitive strategy use, and effort regulation. *Scandinavian Journal of Educational Research*, *51*(3), 315–326.

Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. *Journal of educational psychology*, *82*(2), 306.

Vallerand, R. J. (2000). Deci and ryan's self-determination theory: A view from the hierarchical model of intrinsic and extrinsic motivation. *Psychological inquiry*, *11*(4), 312–318.

Van Overschelde, J. P. (2008). Metacognition: Knowing about knowing. *Handbook of metamemory and memory*, 47–71.

Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. M., & Deci, E. L. (2004). Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of personality and social psychology*, *87*(2), 246.

Veenman, M. V., Kerseboom, L., & Imthorn, C. (2000). Test anxiety and metacognitive skillfulness: Availability versus production deficiencies. *Anxiety, Stress and Coping*, *13*(4), 391–412.

Veenman, M. V., Kok, R., & Blöte, A. W. (2005). The relation between intellectual and metacognitive skills in early adolescence. *Instructional Science*, *33*(3), 193–211.

Veenman, M. V., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and instruction*, *14*(1), 89–109.

Williams, R. L., & Anandam, R. (1973). The effect of behavior contracting on grades. *The Journal of Educational Research*, *66*(5), 230–236.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and individual differences*, *8*(4), 327–353.

Yusuf, M. (2011). The impact of self-efficacy, achievement motivation, and self-regulated learning strategies on students' academic achievement. *Procedia-Social and Behavioral Sciences*, *15*, 2623–2626.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology*, *81*(3), 329.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In *Handbook of self-regulation: Theory, research, and applications* (p. 13-39). San Diego: Academic Press.

Appendices

Appendix A: Pool of learning strategies

Name	Description	Version
Skim	Looking over a text to get a general overview of the material	Pilot
Highlighting	Reading through a text while marking the important information	Pilot
Rehearsing	Practice the learning materials, e.g. repeatedly writing down a formula to help you remember	Pilot
Practice testing	Test how many of the learning materials you actually know by making assignments or taking a practice exam	Pilot
Keyword mnemonics	Making a rhyme, song or an acronym out of the information to make it easier to remember	Pilot
Summarizing	Writing a summary of the learning materials	Pilot
Elaborative Interrogation	Question yourself on why an explicitly stated fact or concept is true	Pilot
Self-testing	Ask yourself questions about the learning materials and try to answer them without looking at the answers	Pilot
Self-consequentiating	Think of ways in which you can reward or punish yourself for success or failure during the learning process	Both
Self-evaluating	Going over your work to check the quality	Both
Seeking information	Gathering information pertinent to the topic you study	Both
Seeking social assistance	Asking another person for help, either online or in real life	Both
Keeping records	Taking notes while writing or reading sources	Both
Reviewing records	Rereading notes or the text you have produced so far	Both
Outlining	Making an outline of the main points, as preparation for writing a paper or detailed reading of a text	Both
Imagery	Draw a picture, diagram or a flowchart to visualize the information that you want to understand or transfer	Both
Environmental structuring	Finding a quiet place to work by isolating yourself from anything that may be distracting	Both
Organizing	Ordening your notes or your source materials	Final
Revising	Modifying your text or plans for writing	Final
Self-monitoring	Checking to see if your writing goals are met, to verify whether you are on track	Final
Self-verbalizing	Saying dialogue out loud while writing or articulating what needs to be done	Final
Self-selecting models	Emulating the tactics or style of writing of a more gifted author	Final

Appendix B: Appreciation of learning strategies

Name	**Times used**	**Times found useful**	**% Useful**
Seeking information	12	12	100
Organizing	10	10	100
Keeping records	8	8	100
Reviewing records	4	4	100
Self-evaluating	4	4	100
Self-monitoring	2	2	100
Self-verbalizing	2	2	100
Self-selecting models	2	2	100
Outlining	13	12	92.31
Environmental structuring	11	9	81.82
Revising	5	4	80
Self-consequentiating	4	3	75
Imagery	5	3	60
Seeking social assistance	0	0	N/A

Appendix C: Pilot study questionnaire

Personalia
What was your username in Learn2Conquer?
What is your age?
What is your gender?
What do you study?
What year are you in?
Statements - Learning strategies
I knew how to work with the strategies in the app
I tried learning strategies I do not normally use
I have become more aware of which learning strategies work for me
I was always able to choose a relevant strategy
I have found new ways to learn
Statements - Motivation
I was motivated to find new learning strategies
The app motivated me to continue learning
I enjoyed working with the app
I think the game was fun to play
I wanted to get as far in the game as possible
Statements - Usability
The app worked as I had expected
I think the app was easy to use
I always knew what to do in the app
I understood the different aspects of the app and how they relate
I think the design of the app is user friendly
Statements - Usefulness
I think working with the app is worth the extra effort
I found it helpful to plan my activities
I found it helpful that my reflections were logged
The app made me think about my own learning
I would recommend using the app to someone else
Open questions
What topic did you study during the experiment?
Which learning strategies did you find useful?
Which learning strategies did you find useless?
What did you learn by using the app?
Do you have any comments about the app, or ideas on how it can be improved?

Appendix D: Final study questionnaire

NB: The MAI questionnaire included background questions, thus what study participants were enrolled in and for how long they had been studying was already known. Therefore these questions were omitted in the evaluation questionnaire.

Personalia
What is your student number?
Statements - Learning strategies
I knew how to work with the strategies in the app
I tried learning strategies I do not normally use
I have become more aware of which learning strategies work for me
I was always able to choose a relevant strategy
I have found new ways to learn
Statements - Motivation
I was motivated to find new learning strategies
The app motivated me to continue learning
I enjoyed working with the app
I think the game was fun to play
I wanted to get on the leaderboard
Statements - Usability
The app worked as I had expected
I think the app was easy to use
I always knew what to do in the app
I understood the different aspects of the app and how they relate
I think the design of the app is user friendly
Statements - Usefulness
I think working with the app is worth the extra effort
I found it helpful to plan my activities
I found it helpful that my reflections were logged
The app made me think about my own learning
I would recommend using the app to someone else
Statements - Effort
Using the app took away time otherwise used for my essay
I found it cumbersome to have to earn learning strategies
It takes a lot of time to work with the app
It takes a lot of hard thinking to work with the app
The app taught me nothing I did not already know
Open questions
Which strategies from the app did you find useful?
Which strategies from the app didn't you find useful?
How much time did you spend on your essay?
Which general strategy did you use for your essay?
Did you approach your essay other than usual?
Are you satisfied with how you approached your essay?
How much time did you work with the app?
What did you like most about the app?
What did you like least about the app?

Appendix E: Guidelines for setting learning goals

Defining your learning goals can help you study more effectively. By defining your learning goals you will create a focused target for you to work towards, this helps you know what to aim for and can help you to identify the progress you are making towards this goal. Learning goals are most helpful if they are specific and contain information about the subject at hand, they can also contain the level of expertise you wish to achieve at the end of your work. Don't be afraid to challenge yourself and to set high goals, but don't be unreasonable and try to keep in mind what is realistic.

Choosing your main goal

Your main learning goal should contain the subject that you are studying and what you want to achieve. The main goal will later be split up into subgoals so you don't have to include all the different aspects in your main goal, the main goal should however contain the general scope of what you want to achieve. It is best practice to ask yourself what you want to get out of the course or project that you are currently doing, and to take that as your main goal.

- Please don't say anything like "I want to pass my course", try to be specific!
- Your learning goal is personal, and should contain what you specifically want to achieve through doing the work that is at hand.
- Ask yourself: what do I want to be able to know or do at the end of this course?
- When writing scientific papers, you can often derive your main learning goal from your main research question.
- In a project for creating an app to motivate people to exercise more, your main learning goal could be something like "Find out how we can motivate people to exercise through an app".

Choosing your subgoals

Next, we will divide your main goal into a series of more specific subgoals. These will serve as an overview of all the different things you need to do in order to complete your main goal. The application will keep track of how many activities you have done for each subgoal, to give you an indication of the progress you are making. The more specific you are with your subgoals, the easier it is for you to see that you are making progress.

- Think of all the different things you need to know in order to accomplish your main goal
- Be as specific as you can; Instead of writing "Doing background research", try to split this up into different topics that you need to learn about.

- When your essay is on how you can motivate people to exercise through an app, you should probably find out how you can motivate people (Subgoal 1), you need to figure out how to build an app (Subgoal 2), and you may need to learn about exercise and/or health (Subgoal 3).
- If you also need to write a report or have to do a presentation, you could add these things as additional subgoals.
- In general, the idea is that you should be able to look at your subgoals and immediately have an idea of all the different things that need to be done. The application will keep track of the amount of activities that you plan and complete, to help you identify the progress on each of your subgoals.