ONLINE SUPPORT SYSTEM OF PERSONALIZED LEARNING STRATEGIES

An application to promote self-regulated learning

Bachelor of Science thesis Creative Technology

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“Tell me and I will forget, show me and I may remember; involve me and I will understand”

- Confucius, 450 B.C.

ABSTRACT

Becoming self-regulated is one of the key aspects of maturity, which is also the case in the educational fields as students have to become self-regulated. To do so, one must possess several self-regulated learning (SRL) skills. These SRL skills can be taught through formal education, such as education as offered by (research) universities. This is also endorsed by the University of Twente (UT), as SRL is included as one of the core pillars of their education policy called the Twents Education Model (TOM). It was found that a quality stroke was possible to be made to facilitate SRL in the Creative Technology (CreaTe) bachelor curriculum at the UT, aiming to improve the study results of the users. The main research question was formulated as; how can the principles of SRL be used in an online study support system to improve study efficiency among CreaTe bachelor students? Through a literature research and a human-centered design (HCD) process, a final prototype was designed, realized and eventually evaluated. The prototype consists of two subsystems, both using the user interface of Google Sheets. Through Google App Script, a JavaScript integrated script-editor, the system was realized and automated. Subsystem I aims to strategically support the users to approach a learning process in a more systematic way. This was done by developing a time-tracking system, enabling the users to compare their scheduled time-investment to a norm, such as the mean expected time-investment norm as set by the European Credit and Accumulation System (ECTS). Furthermore, a self-reflection functionality was added to enable students to reflect on their own planning. Subsystem II aims to support students in a subject-matter way by providing study tips on courses that were considered as difficult and by facilitating a task-analyser that enables the user to walk through a learning task before it is actually performed. The system was eventually tested on 5 users, with an overall user-satisfaction of $M = 3.4$ on subsystem I and $M = 3.5$ on subsystem II, both based on a 1-5 Likert scale (1 = strongly unsatisfied, 5 = strongly satisfied). A qualitative research was conducted as well on 2 educational experts and 3 students. From this qualitative and quantitative data, it was concluded that the system is an added value in the sense of supporting first-year CreaTe students with their planning behaviour, mathematics and programming courses, and studying in general. This implicated that usage of the system will contribute to an improvement of meeting the SRL core pillar of TOM within the curriculum and that the system will improve study efficiency among CreaTe students.

Acknowledgements

Many people have supported me during the graduation project who I am very grateful for. I would like to thank some of them in particular. First of all, I would like to thank my supervisor dr. ir. E.J. Faber for the support, feedback, brainstorm sessions and most of all, the great advises you gave me many times. Secondly, I want to thank all the people that were willing to make time for me to conduct interviews and brainstorms sessions with. Karen, Eddy, Thea and of course my fellow CreaTe students, many thanks. The last group that I would like to thank who supported me indirectly on the project are my family and friends, in particular my parents, house and club.

Table of contents

List of abbreviations

BSA: Bindend studieadvies (*English:* Binding study advice)

CreaTe: Creative Technology - a bachelor's programme at the University of Twente

ECs: European Credits (*Dutch:* Studiepunten)

ECTS: European Credit Transfer and Accumulation System

EduCie: Education committee of a study association

EEMCS: Faculty of Electrical Engineering, Mathematics and Computer Science

(G)UI: (Graphical) user interface

HBO: Hoger beroepsonderwijs (*English:* University of Applied Sciences)

HCD: Human-centered design

IQR: Interquartile range

LMS: Learning management system

LTI: Learning tools interoperability

S.A.: Study Association

SDL: Self-directed learning *or* student-driven learning

SRL: Self-regulated learning

UT: (research) University of Twente

VWO: Voorbereidend Wetenschappelijk Onderwijs (*English:* Pre-university Secondary Education)

TELT: Technology enhanced learning & technology (team)

TOM: Twents Onderwijs Model (*English*: Twents Education Model)

Part I

Self-regulated learning; related work and relevance

1. Introduction

The need of metacognitive guidance

In order to introduce this topic and demonstrate its relevance, some important findings of Chapter 2 will be summarized here. Creative Technology is a study which uses technology to solve issues from society, by keeping an eye on the changing needs of the society and thinking of corresponding solutions. The aim of this graduation project fits within this description. Briefly said, the issue to be solved is that respectively many students do not (learn to) master sufficient study techniques during their first semester at the university. This is quite strange, as the gap between education offered in high school and university is widely acknowledged; academic education is considered as more cumulative and more freedom is given to the student to plan in his/her own time in compared to high school. This requires some metacognitive guidance. Currently, this guidance is not always present as part of the curriculum of academic education. Of course, one can justly state that students will acquire these skills during the three-year lasting bachelor program by self-exploration. But still, this does not justify to keep the providence of resources that can catalyse this learning process limited.

An elaborated problem analysis will be provided first, which is based on different exploratory interviews with students, teachers, educational experts and literature research. The relevance of this topic will also be discussed, as this is necessary to understand the decisions that will be or are made. Subsequently will the aim of this graduation project be distilled out of this analysis. To make it possible to create a comprehensive solution to the problem that will be stated, different research questions will be formulated. The chapter will end with the outline of the rest of the thesis.

1.1 Elaborated problem analysis and relevance

Naturally there exist a difference in study behaviour between first-year and third-year students, which is also observed at students who follow the bachelor program of Creative Technology (CreaTe) at the University of Twente (UT) (Educational Scientist, personal communication, 2017). This is explainable as third-year students have learned to work in a disciplined and structured way by planning learning activities and stick to this planning. The urgency of possessing these skills can partly be devoted to "natural selection", as students who were not able to acquire these skills on time are expected to fail (parts of) their study. Otherwise, if they do not, the curriculum is probably too easy for them. According to the education committee of the study association - which consists of six members who represent the entire population of CreaTe students - the first two quartiles are easy to complete whereas students start failing at the third one (EduCie S.A. Proto, personal communication, 2017)

The two causes of this failure that have been identified by this committee, are the lack of study skills and the lack of study discipline, which interrelate with each other. These lacks are also endorsed by interviewed study advisors and teachers (Study advisor, personal communication, 2017; Supervisor, personal communication, 2017). The lack of study skills is partly attributed to a lack of urgency of these skills on high school. According to a survey that has been conducted among first-year CreaTe students, most of them only planned their study behaviour during tests weeks and exam periods. This planning was sufficient enough for their way of education. According to this same survey, many of the students did not earlier experience this way of education in this cumulative way and tempo, and some of them were not used to this level of difficulty.

The other cause that was identified was the lack of study discipline of the students, including the lack of self-study to still acquire these necessary skills. Of course, students can do something about it to increase this discipline, but it is not fair to point the finger entirely to the student. A research conducted at the UT revealed that a major reason of the dropouts was that students were not able to keep up with the study materials as they considered it as too much workload and failed in their time-management and proper planning (Bearda, 2011), which confirms the "natural selection" aspect. The way of learning required in academic education quite differs from the education offered in secondary school as more freedom is offered to the student. This demands knowledge about and proper regulation of typical such to speak self-regulated learning (SRL) skills, such as planning and self-monitoring (Desmedt, 2004; Zimmerman, 2001). Besides, the learning tasks are more difficult as they demand a higher level of thinking in comparison to the earlier experienced education (Desmedt, 2004). It makes sense that these differences lead to study progress problems among students who have recently left secondary school. These learning problems can be caused by different reasons. Some of the students are simply not aware of the differences between this different way of learning until they encounter them by themselves. According to professionals in the field, such as teachers, student psychologists and study advisors that were interviewed, in some cases this moment of realization comes too late or students did not have a clue how to anticipate on this (Study advisor, personal communication, 2017).

The first question that arises is whose problem this lack of study skills and study discipline and thus whose responsibility it is to provide a solution. The Dutch universities offer education on an academic level, which simply requires study discipline, including the necessary self-study skills. According to critics about the current student population, many students who currently visit university do not belong on this level. This debate goes far beyond the scope of the CreaTe curriculum and is still actual. Recently, former rector magnificus of the University of Utrecht prof. dr. Van der Zwaan spend his sabbatical travelling around other universities to learn more about their form of government. His conclusion; there are too many students on the Dutch (research) universities who do not belong there, which is a result of the current social thought and political choice that citizens should be as highly educated as possible (Trouw, 2018b). Another problem that comes along is that, while the number of students increases rapidly, the corresponding governmental financial support to the educational institutions does not. Although this is a major issue for universities, this will not be further discussed in this analysis.

The result of this public thought is that too many talented students do not possess their optimal learning environment (Trouw, 2018a; 2018b). Van der Zwaan pleads that the government should enable universities to conduct a stricter selection procedure, even (or particularly) in the bachelor admission. Although Van der Zwaan claims that study success can be statistically estimated by taking a look to the grades of mathematics and English achieved at high school as well as the achieved grade of the first exam conducted at the university, someone's motivation and thus study attitude should also be taken into account. The experience teaches that formation of the final goal (and thus an answer on the "why question") of following a study on academic level comes over the years, which is inherent to intrinsic motivation to achieve high grades to achieve such a goal as well as possible. From this point of view, it is hard to select someone who is potentially talented to become a high-performing academic student pure on statistics and one interview at the start of the first year. All together can it be concluded that Van der Zwaan has a strong point that some students who currently go to university do not belong there as they are not intrinsically motivated in scientific education, e.g. conducting research and solving complex issues or simply do not have the capacity. Furthermore, it is very important that the social discussion about the current prevailing thought that educating people on a higher level is always the best will be continued. First of all, the current expectation of quality and the corresponding financial support is not in line with each other. A second important argument provided by Van der Zwaan that reveals the relevance of this discussion, is his concern whether the labour market is resilient enough to house all these people. Yet, it should not be forgotten that a huge part is potential academically talented. Assuming that educating scientific talent is one of the core responsibilities of a university, it is the responsibility of both the university and the student to act proactively on this topic.

The second question is how the universities, in this case especially the UT, currently set up their policy to act to this responsibility. The study facility of the UT is based on a concept called the Twents Educational Model (TOM), which divides the three-year lasting bachelor program over 12 project-based modules. One of the three core aspects of this model is to educate students by *student-driven learning* (SDL), which means that “students take control over their own learning process” (University of Twente, 2018). The corresponding policy is fairly liberal; the modules are aimed to let students make their own choices such as planning and educational activities while being closely consulted by teachers who actually act as mentors/tutors. The degree of freedom increases over time and is included in the curriculum.

The same tenor can be asked on educational level; is the CreaTe bachelor program sufficient focused on this core-aspect of TOM? It was found that CreaTe responded on this part to the educational policy of the UT, as a *professional development* course was set up which forms a part of the curriculum. Also, some resources that are provided to learn students to become a self-driven student were found. Every student receives the booklet *“Get Smarter”* (a booklet with many useful study tips) at the begin of the academic year and is mandatoried to visit one interview with the study advisor to discuss the study progress. A critical analysis has been conducted to investigate on which points any quality strokes could be made. It was found that the curriculum is in line with the earlier mentioned SDL core-aspect of TOM, as one of the learning objectives of the entire CreaTe curriculum is to “become a self-directed student” (Reidsma, 2017). This also became clear as the curriculum dedicates a complete course to this topic. However, according to interviews that have been conducted with the experts in the educational field, the execution of this policy is not in line with SDL, as the quality of this course is not guaranteed, nor is it regulated. Teachers do not follow an unambiguous line and thus does the quality depend on the interpretation of the teacher (EduCie S.A. Proto, personal communication, 2017). Although it was noticed that planning is actually explicitly appointed within the module manual of module 1, no description is provided how proper study planning can be executed which thus leads to this earlier mentioned free interpretation of the professional development course teachers. Moreover, in the module manual of module 2, terms as study planning, self-monitoring or other SRL skills are not mentioned at all.

As mentioned earlier, it is also the responsibility of the student to act proactively to gain these SRL skills. To make sure the problem analysis is comprehensive, it was also analysed who has actually the self-discipline to learn these skills by themselves and why other students do not. It was found that students who are ambitious from the start, as well as students who are demanding on these SRL skills, do acquire them by themselves or dropout during the study year. If they dropout, the experience teaches that most of the students retry the study the year after and still force themselves to learn so, or they switch to another study. Because it was found that most students complete the first two modules while experience the third module as hard, the level of difficulty was examined as well. CreaTe offers a broad spectrum of the engineering, as well as from the design world. As no further admission requirements besides a VWO or HBO-P certificate are needed, the curriculum is constructive from a respectively low starting level. As a result, other students than the earlier mentioned do not necessarily endorse SRL skills to be useful to learn during the first two modules. Although it is their own responsibility, without any (metacognitive) guidance from the study and without this necessary pressure, it is hard to let them learn these skills on their own.

The third logical question that could be asked is why this topic is not earlier addressed by the policy makers of the university and why suddenly now. An appropriate answer can be found in a political change in financial supporting students. Since 2015 has the Dutch government implemented a new system to support students financially, as the scholarship was exchanged for a loan system. Although this lending system has currently an extreme low rate of interest, in the end do students have to pay back their study costs, which explains the increase of the study pressure in order to avoid additional costs. On its turn, this increased study pressure leads to an increase of psychological problems among students (Huygen, 2016). It is simply no longer an option to take six years to achieve a bachelor’s degree; the students of today have to finish their study on time if they do not want to deal with the corresponding financial consequences.

The fourth and last question to answer is what the benefits are of educating SRL skills (earlier) in the bachelor program, apart from the fact that it is a requirement from the “TOM” policy. The answer was found by analysing the entire problem analysis strictly and was evaluated with professionals. On study level, educating students in study planning behaviour could possibly close the gap between (among others) the earlier mentioned difficulties between quartile 1, 2 and 3. On academic level, it would lead to a surplus of time that can be invested in more qualitative study activities, honour programmes or extra-curricular activities. In conclusion, students will be able to spend more quality time on enriching themselves.

All in all, it can be concluded that there is still a quality stroke possible to be made, making it possible to respond on the needs of a starting academic student. Skills to increase SRL can be educated earlier to benefit from the advantages. Sufficient evidence was found to emphasize the positive effect of providing these tools to learn how to self-regulate a learning process. This effect is also endorsed by the UT education policy called TOM, as one of the core aspects is to educate students to actually become self-driven students.

1.2 Goal setting

As concluded in the problem analysis, a quality stroke can be made within the achievement of the self-driven learning objectives that are also in line with the educational policy TOM. This is set as ultimate goal of this graduation project. As this is quite abstract, a more detailed goal will be worked out within this section.

1.2.1 Final goal

The final goal, which incorporates the preliminary conditions, is to design, create and evaluate a prototype of a digital platform/application that facilitates principles of SRL for first-year students who follow the bachelor program Creative Technology at the University of Twente. This can both be based on general study skills such as planning, as on course specific topics.

1.3 Research questions

To systematically conduct a background research to obtain data that is required to provide an elaborated project idea based on experiences and (scientific) theories of various experts and users, several research questions have been formed as follows:

> How can the principles of SRL be used in an online study support system to improve study efficiency among Creative Technology bachelor students?

1. What are the possible relevant theories and technologies on which the online support system can be based on?
2. Who is the actual potential user group of this project?
3. Which factors should be taken into account to maximise the effect of this online study system

The ultimate goal of a CreaTe graduate project in general is to achieve the greatest possible impact (Bults, 2018), which is interpreted as improving the student efficiency through an online support system as much as possible in terms of this project. The main research question is set as *how can the principles of SRL be used in an online study support system to improve study efficiency among Creative Technology bachelor students?*

As the answer of this question will be too broad to have grip on, several sub questions have been designed. The first sub question, *what are the possible relevant theories and technologies that can be used on which the online support system can be based*, is devised to give a more detailed insight in the scientific theories about personalized learning strategies and to get an elaborated view on state-of-the-art technologies.

To investigate and specify the actual user group that is aimed to benefit from the result of this project, the second sub question is *who is the actual potential user group of this project?*

The last sub question is based on maximizing the impact by the online support system. To get more insights on the corresponding factors to do so, the final sub question is formulated as; *which factors should be taken into account to maximise the effect of this online study system?*

1.4 Outline of this thesis

This thesis consists of seven chapters, divided over three parts. The first part focuses on introductory topics and incorporates two chapters about the relevance, goal and corresponding research questions and the state-of-the-art research on both literature as well as on similar technologies. Within the second part, the entire design process, realisation and evaluation is described. This incorporates the methodology and techniques that were used. The last part entails the conclusions and future recommendations.

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For all the personal communication, see Appendix A.

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2. State of the art background research

Involve me and I will understand

Within this section, the status quo of the (scientific) literature about SRL was analysed and evaluated, aiming to provide an answer on the first sub question "what are the possible relevant theories and technologies on which the online support system can be based on?".

This was done by conducting a theoretical background research. Subsequently, a state of the art research was conducted to learn more about similar technologies. Both researches will further be used as inspiration to form the final idea of this graduation project.

2.1 Theoretical background

2.1.1 Theoretical framework, definitions and concepts

In a broad sense, the definition of self-regulated learning (SRL), also known as self-driven or self-directed learning (both abbreviated as SDL), can be reduced to a learning process whereby the student regulates his or her own learning process. To accomplish this, one must possess metacognitive skills in order to make it possible to plan, monitor and reflect on his or her own cognition and/or learning abilities (Zimmerman, 2001). As this planning, monitoring and reflection is considered as the main condition to be able to autonomously guide a learning process, it can be stated that SRL is not possible without the possession of metacognitive skills (Winne, 2001). Thus, metacognitive skills are considered as a resource to conduct SRL. Because SRL and metacognition are of this importance, a more detailed definition of these concepts will be given first before the in-depth literature research will be described.

2.1.2 Definition of self-regulated learning and metacognitive guidance

Pintrich (2000) described SRL as "an active, constructive process whereby learners set goals for their learning and attempt to monitor, regulate and control their cognition, motivation and behaviour, guided and constrained by their goals and the contextual features in the environment" (p. 453). This definition consists of multiple elements. First of all, it conveys an active part which can directly be linked to the goal-setting part (De Boer et al., 2013). According to Pintrich, an active process refers to the principle that students should actively be involved and have clear intentions to be engaged in learning. Secondly, students should attempt to monitor, regulate and control their learning process on their own. Their goals and constraints about their cognition, motivation and behaviour form an integrated whole. This includes their motivation and affectivity of a certain learning goal and associated learning process (Flavell, 1987; Zimmerman, 2001). The environmental factors will be elaborated on later in this chapter.

Metacognition is described as the learner's views and beliefs on learning and the active regulation of his or her learning processes (Flavell, 1977). Much literature can be found when searching on the concept metacognition and many different interpretations can be found, although there consist a consensus within the taxonomy of metacognition. Two widely acknowledged taxonomies are described by Flavell (1987) and Brown (1987). These taxonomies describe different factors that have a hierarchical relationship and/or how they interrelate to each other, which are necessary to understand to make metacognitive guidance and thus SRL practical executable. These taxonomies will be further discussed later on in this chapter.

2.1.3 Literature research

To learn more about the relevant theories that can be used in the ideation and specification of this graduation project, a literature research was conducted. First, the concept of metacognition will be further discussed by using the taxonomies of Flavel and Brown. Complete understanding of metacognition is necessary as it is considered as the basis for the model that will be given. This model classifies the different steps that should be taken during the learning process to make it self-regulable. Subsequently, the elements of this model will be further discussed. To emphasize the relevance of SRL, the results of a study about the effects of SRL will be discussed next. The literature research will end with a conclusion which is the answer on first and second sub question of this thesis.

Metacognition knowledge and regulation

As mentioned earlier, the metacognitive taxonomies of Flavell (1987, p. 22 - 25) and Brown (1987, p. 67-68) will be used to provide a more in depth description of metacognition. Roughly does Flavell focus more on metacognitive knowledge, whereas Brown focuses more on metacognitive regulation. As this study mainly focus on the application and regulation of SRL strategies rather than the knowledge, the taxonomy of Brown will be further explained.

Brown goes in depth about the metacognitive experiences by describing them in terms of a regulation taxonomy with different phases. Within this taxonomy, he distinguishes four phases based on the (learning) task to be performed, which are also displayed in Table 1. These phases are; (1) estimation, (2) planning, (3) monitoring and (4) evaluation.

1. The first phase is meant to estimate the task to be performed by analyzing it. This should be done in preparation of the next phase.
2. The second phase is not only about the planning of the tasks. Instead, it is also about planning the learning strategy that will be used. Questions that could be asked, for example, are "which learning strategies will be used" and "which steps should be taken to succeed".
3. The third phase, which is monitoring, is about mapping the knowledge that is already available and what is not. This information can be compared to the intended learning goal.
4. The last phase is about evaluation, which can be formative as well as summative. Formative evaluation questions are questions like; "is my mind-map sufficient enough to clearly give an overview of the concerned text". Summative evaluation questions could be; "in which extend did I manage to understand the core of the text".

Metacognitive regulation (Brown)	
1. Estimation	Analyzing the task to be performed
2. Planning	Planning the task to be performed, taking into consideration the strategy and methodology.
3. Monitoring	Mapping the knowledge transfer during the learning process.
4. Evaluation	Reflection about the learning goal

Table 1: Table of metacognitive regulation as described by Brown (1987, pp. 67 – 68). Adapted from "Onderwijskunde als Ontwerpwetenschap" by Valcke, 2010. Ghent, Belgium: University of Ghent.

General conceptual framework of the self-regulated learning theories

In order to have an overview in the many different studies that can be found when searching for SRL theories, Desmedt (2004) created a coherent model which acts as a framework of a

SRL process. This model is displayed in Figure 1. Principles from metacognitive knowledge and regulation as earlier described can be found in the structure of this model. Desmedt (2004) states that social cognitive theory found by Schunk (2001) and Zimmerman (1989, 1995, 2000), embeds these self-regulatory processes in a larger system, including personal, behavioural and environmental factors. Furthermore, this social cognitive theory does include important factors of metacognition, learning and motivational theories.

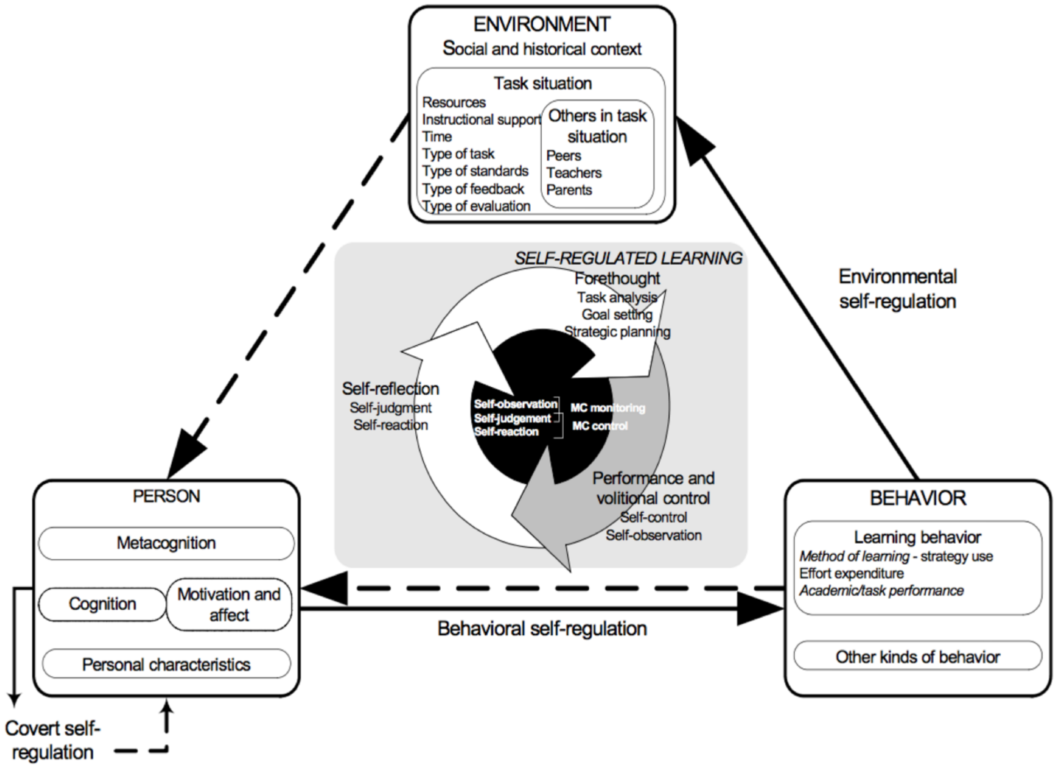

Figure 1. General framework of a self-regulated learning process. Reprinted from *Research into the Theoretical Base of Learning Styles in View of Educational Applications in a University Setting* (p. 66), by E. Desmedt, 2004, Ghent: University of Ghent.

The model as described by earlier mentioned authors will be further discussed within this section. The learning process and corresponding phases will first be described as displayed in the center of Figure 1. This will be followed by the contextual factors of a learning process clustered over an environmental, behavioural and personal cluster. These are the environmental, behavioural and personal factors.

SRL is based on three self-regulated feedback loops which interrelate to each other, as displayed by the arrows in the central cycle of Figure 1. These loops concern the cyclic process whereby students self-monitor the effectiveness of their learning methods and strategies (Zimmerman, 1989). The feedback loops are behavioural, environmental and covert (cognitive) self-regulation and are distinguished by Schunk (2001) and Zimmerman (1989, 1995, 2000).

According to Desmedt, the application of this self-regulation is described in terms of three cyclical phases. These phases are:

1. Forethought: This refers to the processes that are required prior to the actual learning task is executed. The aim of this process is to set clear goals, beliefs, expectations of the end result. This include processes like task analysis, strategic planning and goal setting. This goal setting is also emphasized by Taylor (1984), who introduced the concept of a *personal study contract* that a student makes with him- or herself. An important condition is that the student knows about his/her own abilities of the situational context (Taylor, 1984). Zimmerman (2013) also states that these goals have to be set proactively.
2. Performance and volitional control: This is about self-observation and monitoring; it is about processes that occur during learning activities.
3. Self-reflection: Contains of all the self-judgement processes which will be executed after the actual learning activity is completed. This involves self-evaluation of the goals and expectations that were set in the first phase and affective feelings (feelings about how a certain task is performed) and it concludes how one needs to alter his or her self-regulatory approach in the following learning situations to keep learning (efficient).

Environmental factors

The environmental factors are based on the environment of the student, which does also have an influence on, or could be influenced by, SRL. Such factors are instruction support, time allocation, type of task, type of feedback and evaluation (Schunk, 2001; Winne, 2001). Surrounding people in the task situation, like peers, teachers and parents, are also a key factor in SRL as they could have influence on the earlier described thermostat of self-efficacy. Environmental factors are crucial as they determine the extend to the student is able to self-regulate his or her learning process (Desmedt, 2004).

Behavioural factors

The behavioural factors are about the perceptible behaviour of the student. This includes the method of learning, the effort and the academic/task performance of the student. Other behaviour that should be taken into account is behaviour that could influence self-regulated learning, like sleeping and eating behaviour.

Personal factors

Within this section, the personal factors as displayed as the personal cluster in Figure 1 will be discussed. A detailed version of this cluster is displayed in Figure 2. The selected topics that are expected to be relevant and will therefore be further discussed, are (1) metacognition, (2) cognition, (3) motivation and affectivity and (4) personal characteristics.

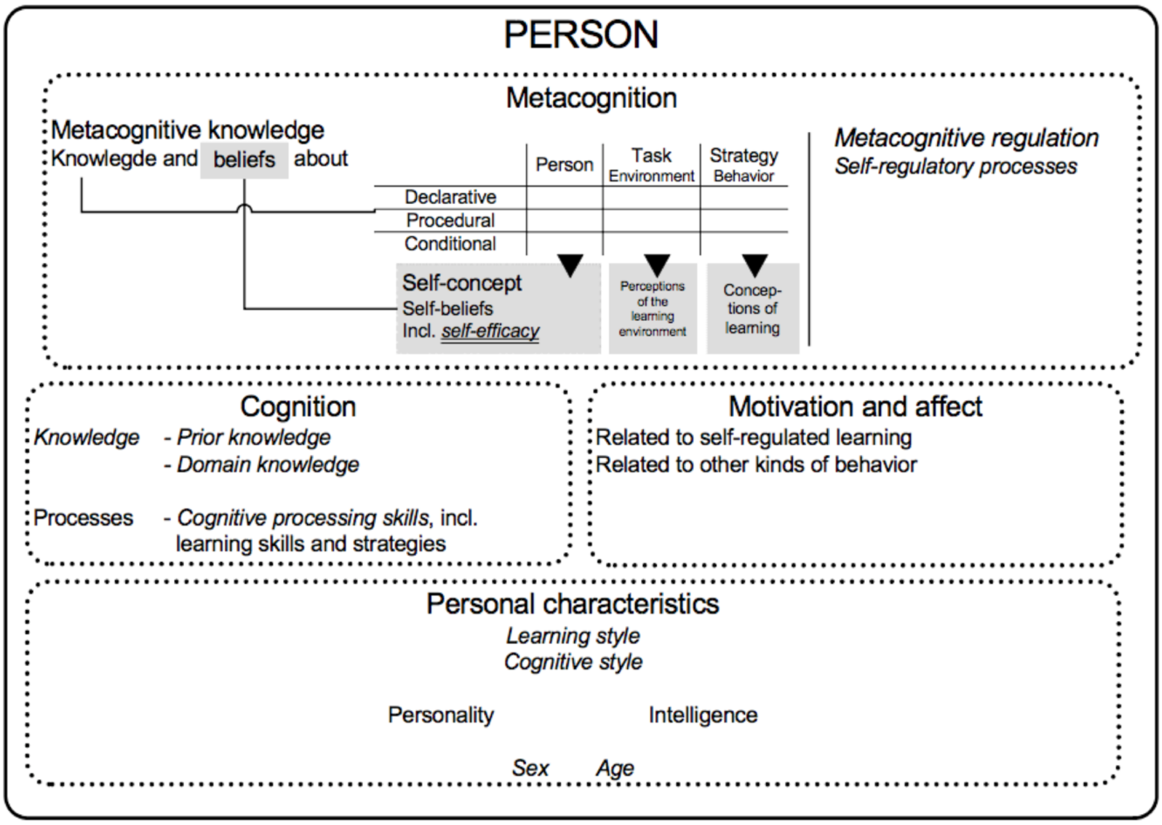

Figure 2. Zoomed in on the general framework, personal factors. Reprinted from *Research into the Theoretical Base of Learning Styles in View of Educational Applications in a University Setting* (p. 68), by E. Desmedt, 2004, Ghent: University of Ghent.

1. **Metacognition:** This module is an elaborated version of the basic principles of metacognition as described by the theories of Flavel and Brown in the previous paragraph. The principles of metacognition regulation as mainly described by Brown can be found in Figure 1, whereas the principles of metacognition knowledge as described by Flavell can be found in Figure 2. Besides the personal, tasks and strategy variables, Desmedt added a second dimension to this principle as displayed in the table in Figure 2. The second dimension as displayed on the y-axis of the table, is based on three different types of knowledge as distinguished by Schraw and Moshman (1995) and Schraw (2001). These types are (a) declarative, (b) procedural and (c) conditional knowledge.
    a. Declarative knowledge is knowledge that is mainly based on definitions and laws;
    b. Procedural knowledge is knowledge about the regulation of declarative knowledge. More concrete, it the knowledge of how to tackle certain problems.

c. Conditional knowledge is knowledge about when and why to use declarative and procedural knowledge.

According to Bandura (1997), people's - and therefore students'- motivation, affective states and actions are rather based on what people believe than what is objectively true. The key-concept of Bandura's theory is self-efficacy, which refers to the level of believe students have in their own abilities to accomplish a certain learning task, based on their actions. Zimmerman (2000) states that a high level of self-efficacy is associated with better learning strategies, more self-monitoring and a higher academic achievement. self-efficacy can be obtained by the feedback that students experience during a certain learning process. Desmedt creates a metaphor by comparing self-efficacy as a thermostat that "regulates strategic efforts to acquire knowledge and skills" (p. 69). It is clear that the believe-aspect of metacognitive knowledge by the student is highly important for this regulation.

2. **Cognition:** The knowledge part is divided into two aspects; prior knowledge and domain knowledge. This in complement with the cognitive processing skills, which includes learning skills and strategies that the student masters (Winne, 2001).

3. **Motivation and affectivity:** As described by Desmedt, "motivation refers to the will to self-regulate and to learn". Affect refers to all kinds of feelings that come up as a result of executing the cycle and therefore influence the self-regulated learning. As Bandura (1997) describes, motivation and affect are strongly determined by the metacognitive beliefs a student holds.

   Although it is not mentioned within Desmedt's model description, different motives (called approaches by the authors) are found that also influence the student's study behaviour. Tait, Entwistle and McCune (1998) distinguishes three dominant study approaches. The distinguished study approaches are; a deep learning, strategic and surface approach. Biggs (1998, p. 129) also distinguishes those approaches, although he calls strategical learning achievement learning instead. With a surface learning approach, students are motivated to learn exactly what the teacher has to offer so they can recall the study material, while when a deep-learning approach is used, students are intrinsic motivated to learn more about a certain topic; he/she wants to understand the knowledge deeply and want to elaborate this. The last approach is achieving learning; students want to obtain a certain grade, wherefore they are motivated to do whether it takes to achieve this. This approach is very economic; it desires a high efficiency in combination with a low task load.

4. **Personal characteristics.** As age and the level of intelligence are roughly the same for the participants of the bachelor curriculum, these are left out of the paper. Sex and personality do have some differences, but are left out of the scope of this thesis as it is simply too much to take into consideration. What is left are the learning and cognitive styles, which will be further discussed.

In most cases, learning styles could intuitively be explained which has led to many possible interpretations of this concept. Curry (1983, 1987) uses three terms to approach the concept of learning styles. Curry's approaches are represented by a layer-model which refers to the layers of an onion, as displayed in Figure 3. The outer-layer is about the instructional preferences, the middle one about the information processing style and the core about the cognitive personality style. The last one is called cognitive style in terms of the model of Desmedt. First, the information processing style will be further discussed as this is the one to which Desmedt refers to when talking about learning styles. Secondly, the cognitive processing styles – described as cognitive style by Desmedt – will be described. Lastly the learning style as instructional preferences will be described which forms a bridge to the environmental cluster of the framework.

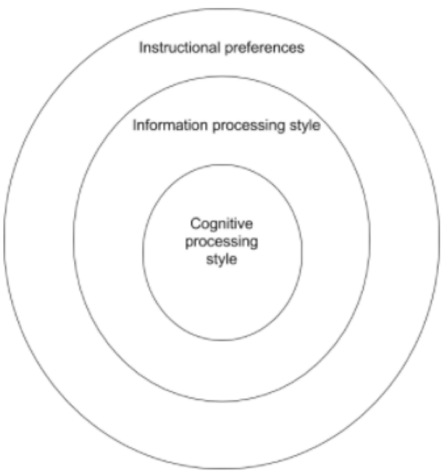

Figure 3: The layer-model as described by Curry (1983, 1987).

I. *Learning style as information processing style*

The information processing style is based on how a student processes information; how it is received, processed, saved and retrieved (Valcke, 2010). The answer on this "how" question has obviously interfaces with metacognition i.e. when students use this to improve their learning abilities. The most respected learning style in this domain is Kolb's (1984) theory. According to Kolb, four different learning styles exist within a learning process as displayed in Figure 4. This learning process could be mentally displayed as a learning cycle, which has two conditions. The first condition is that every person has his/her own preferable learning style to start with. The second condition is that, according to Kolb, all learning styles should be passed during the learning process. The four learning styles are as following; a (1) pragmatic, (2) theoretical, (3) reflective and (4) active learning style (Kolb, 1984) and are in the same order based on a(n) (1) concrete experience, (2) abstract conceptualization, (3) reflective observation and (4) active experimentation. Kolb also states that these preferable learning styles depend on the characteristics of the domain of knowledge, by which is meant that the learning style in, for example, mathematics can differ from that one in social sciences.

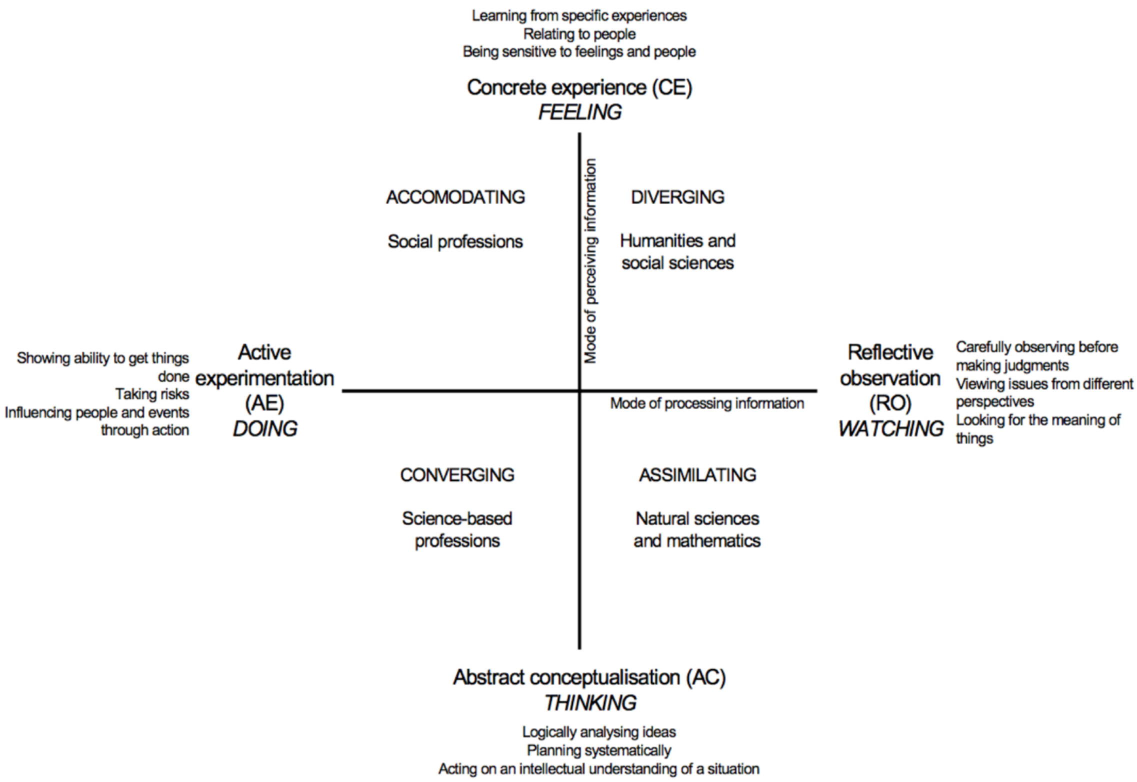

Figure 4. Kolb's experiential-learning theory displayed. Reprinted from *Research into the Theoretical Base of Learning Styles in View of Educational Applications in a University Setting* (p. 50), by E. Desmedt, 2004, Ghent: University of Ghent

II. Learning style as cognitive preferences

The last style Curry (1987) distinguishes is the cognitive personality style. The ASSIST *(approaches and study skills inventory for students)* was created to understand and describe the way wherein students approach their learning process (Tait, Entwistle & McCune, 1998).

III. *Learning style as instructional preferences*
The instructional preferences mainly focus on the Dunn (1984) learning model. The styles are based on the preferences students have for a certain learning environment such as temperature, design-aspects and sounds, emotional preferences such as motivation and structure in learning processes, social preferences such as rather working in a team or alone, physical preferences such as time of day and psychological preferences based on analysis and action (Dunn, 1984). Although this can be considered as personal characteristics, they also have a great overlap with the environment factors in the model as earlier described in the environmental section.

Taking it all together, the factors that are clustered around and the cyclical phases of SRL can be used as aspects to form personalized learning strategies. The cyclical phases do have overlap with the described metacognitive regulation of Brown (1987, p. 67-68) and can be used as a framework for metacognitive regulation. Metacognitive knowledge is required for this regulation, which can be distinguished in two dimensions. The dimension as earlier described within the previous section about metacognition by the work of Flavell (1987, p. 22-25) and the dimension as described by Schraw and Moshman (1995) and Schraw (2001). The list (of examples) that was formed in the previous section of stable and unstable variables of metacognitive regulation can be extended with the literature that has been found. A clear overview of these aspects is summarized in Table 2, which makes a difference between these relatively stable and varying variables.

Variables dependent on the task to be performed	
Task variables (Flavell, 1987, p. 22 – 25)	Knowledge about the characteristics of a learning task
Prior and domain knowledge (Desmedt, 2004)	Knowledge about similar task performed in the past Knowledge about this task domain
Motivation and affectivity (Biggs, 1998; Desmedt, 2004; Tait, Entwistle & McCune, 1998)	Achievement approach Surface approach Deep learning approach Feelings about the learning materials
Learning styles (Kolb, 1984)	Learning styles that are dependent on the task to be performed, although everyone has his/her own dominant learning style
Self-efficacy (Bandura, 1997)	The belief that someone has to perform a certain task
Some environmental factors (Desmedt, 2004; Dunn & Dunn, 1984)	Working in a group or alone Instructional support

Variables which are relatively stable and independent on the task to be performed	
Personal variables (Flavell, 1987, p. 22 – 25)	Intra-individual Inter-individual Universal
Cognitive personality styles (Curry, 1987)	Based on the ASSIST
Some environmental factors (Desmedt, 2004; Dunn & Dunn, 1984)	Ideal time of the day to study Ideal study temperature

Table 2: Overview of the aspects that can be used to form a personalized learning strategy based on different theories.

Instruments to use to determine the learning styles as described by Curry (1983, 1987)
While the definition of personalized learning strategies and the aspects that are involved with are clear, it still has to be investigated how these aspects can be determined, which is also the last sub question. Whereas some of these aspects can be determined by simply asking a question, e.g. to learn more about what someone's ideal study temperature is, others are more complicated. Literature research reveals different instruments that were used in the past to learn more about such complicated aspects, such as a preferred dominant learning style of a student.

Three instruments were found to determine learning strategies as described by Kolb (1988), instructional preferences as described by Dunn, Dunn & Price (1998) and cognitive styles as described by Tait, Entwistle and McCune (1998).

1. Dunn, Dunn and Price (1998) and Kolb (1998) both use a *Learning Style Inventory* (LSI) to diagnose the most dominant learning styles of the student, with of course a different meaning of learning styles as described before. The LSI of Dunn et al. has 104 items to determine individual preferences on 22 domains, such as light incidence and level of sound (Valcke, 2010).
2. The LSI of Kolb exist of twelve theses which have to be rated on the 1 to 4 Likert-scale according to someone's own behaviour to determine which learning style dominates. As, according to Kolb (1984), this learning styles are dependent on the task to be executed, this proof should be done after a new task is going to be executed.
3. The ASSIST (*approaches and study skills inventory for students)* is used to learn more about someone's learning motives. It is based on 52 items on 13 scales, which should be answered based on an 1-5 Likert-scale. In the end, it can be determined whether someone is deep, strategic or surface learning. Biggs (1985) invented the study progress questionnaire (SPQ), also to determine the approach of learning. Although this test is less valid as it has less items, it consist of only 20 thesis and is therefore much faster to fill in.

The effect of metacognition and SRL
The positive effect of metacognition is widely acknowledged among scientists and practitioners. Research has clearly demonstrated that students achieve more and more satisfaction with their work when using SRL strategies during their learning activities (Desmedt, 2004). Several studies (Roll et al., 2007; Schraw & Denisson, 1994; Sperling et al., 2004; Swanson, 1990) reveal that students with a stronger developed metacognitive knowledge

are better capable of solving problems as their strategic approach is better, which results in an higher learning efficiency. Metacognitive regulation leads to more thorough and more efficient learning (Bannert & Mengelkamp, 2008; Gheorgiades, 2004; Zimmerman, 2013). Furthermore, Zimmerman states that this regulation leads to a quicker process to mastery.

Hattie (2009), who has been conducting a meta-analysis, also endorses the positive effect of metacognitive skills in teaching approaches. He found an effect size of *(Cohen's) d* = 0.69, which is considered as medium large (*d* = 0.5 is considered as medium and *d* = 0.8 as large (Cohen, 1988; Hattie, 2009)). With this effect size, the conduct of metacognitive skills is ranked on the thirteenth spot, out of the more than 200 aspects that could influence learning outcomes. This rank endorses the importance of the possession and mastering of these skills.

Biggs (1988) emphasizes that awareness of a student his or her own metacognition is essential, as this results automatically into acting metacognitive. He also states that the acquirement of metacognitive skills should rather be seen as a process instead of a product. Therefore, Biggs advocates to not just give trainings explicit about those skills, but to adjust these skills in (self-made) exercises during a learning process.

Besides these positive effects, there exist also some negative ones. As stated by Brehm, Kassin, Fein and Mervielde (2000), there exist a contractionary effect of self-regulation of behaviour. They state that every conscious attempt to control it, attends some fear to fail. This can be explained by the fact that people who attempt, become aware of the complexity of a certain behaviour can be and become uncertain whether they are doing it right. Taken this potential negative effect into consideration it can nevertheless be concluded that there is an overall positive effect found on students who possess metacognitive skills.

2.1.4 Conclusion and discussion

The aim of this literature research was to find an answer on the sub research question 1, which was formulated as "what are the possible relevant theories and technologies on which the online support system can be based on?" It was found that metacognitive skills were required to act metacognitively and thus apply SRL strategies.

In other words, it was found that metacognitive guidance is necessary to self-regulate a learning process. The concept of metacognition was split into two concepts as defined by Flavell and Brown; metacognitive knowledge and - regulation. These two concepts were considered as basis of the model as described by Desmedt, which also elaborates on the work of Schunk and Zimmerman.

The actual model is a cycle that a self-regulated learner should take during a learning process. The model exists of three self-regulatory processes (phases) which are (1) the forethought, (2) the performance and volitional control and (3) the self-reflection phase. Phase one is completed before the actual learning activities take place, phase two will happen during the learning activity and phase three happens after a learning process was ended. To facilitate progression, the evaluation can be used within the forethought phase of the next learning cycle.

The self-regulatory processes are embedded in a larger system. The factors that influence this system were clustered in personal, behaviour and environmental factors, which can all be self-regulated and are interrelated to each other. The personal cluster is the most important one for SRL. Next after comes the environment and thereafter the behavioural one. The personal cluster (detailed displayed in Figure 2) consists of (meta)cognition, motivation and affect and more specified personal characteristics, including individual learning and cognitive styles. The environmental cluster has some overlap with these learning styles of Kolb as it is also focused on the task to be performed. However, it focuses more on another interpretation of the concept learning style, namely the learning style considered as instructional preferences that is based on the work of Dunn. These styles are based on the preferences students have during the performance of a learning task. The last cluster, the behaviour one, is about the perceptible behaviour of the student, which is a result of the factors that play a role within the other clusters. Within this cluster, factors as sleeping habits and hobbies are also taken into account.

It can be concluded that students can be supported to learn in a more efficient way by giving them the right tools that provides metacognitive direction to do so. This starts with creating awareness of metacognition, as it was found that a student who is aware of metacognition automatically starts to act metacognitive. From this on, a SRL strategy can be developed to perform a learning task, which consists of different aspects. The main aspects of this strategy are the cyclical phases of Desmedt. In order to create a right strategic planning, many described factors should be taken into account. Some of these aspects are quite solid and can be determined once in a time, while others should be determined every time another learning task will be performed as they are dependent on it. These aspects are for every student different as they all do have their own mixture of knowledge, motivation, beliefs, dominant learning style and (environmental) preferences. This makes that the learning strategy that is used by the student has to be personalized to obtain the highest return and thus becomes efficient.

Limitations
Although it was found that metacognitive guidance can lead to deeper motivated students and accelerate mastery of certain knowledge, it should also be taken into account that being aware of the complexity of learning could have a negative effect as it was found that every attempt to control behaviour is attended by the fear to fail, which is called the negative effect of self-awareness. Measures should be taken to minimize this negative effect, such as focusing on the success of SRL and reward practitioners when they did something well because of a well-applied SRL strategy. Besides, it should be noted that there exist some doubts about the used methods and there exist some limitations to the methods that were used. First, there exist a lot of contradictory literature about Kolb's work and his learning styles are never empirically proven. Second, it should be noted that the personality and sex factor of the personal cluster of the model are left out of the scope of this research.

It is clear that metacognitive knowledge and regulation has scientifically proven effects. However, it is never proven that students do get higher grades. Moreover, this metacognitive regulation does depend on that many factors, that there are most likely always some factors that are not taken into account to explain a certain (learning) behaviour. Although it is tried to cover the key-aspects as much as possible, it should be taken into consideration that never all aspects are. This has influence on the validity of the described methodology to find out and improve study behaviour.

Future work
To make the found literature applicable, it will further be used as basis of the system and thus will return as basis in the design process of the system. This means that the findings will be tested on feasibility, applicability and relevance. How this will be done will further be described in Chapter 3, whereas the implementation of these theories in the system will be described in Chapter 4 and 5.

2.2 Research to similar and relevant technologies

To explore which current similar technologies exist in SRL, a state-of-the-art investigation was conducted. Although different applications such as Trello[1] could contribute to support students to self-regulate their learning processes, no systems were found that explicitly possesses this goal. A recent study among 711 students concluded that “even when they (students of various Spanish universities, red.) are frequent users of digital technology, they tend not to use these technologies to regulate their own learning process” (Yot-Dominguez & Marcelo, 2017). To learn more from current systems that approach this goal, a systematic research was conducted to find these and classify them on relevance according to this project. Besides, a small research was conducted to learn more about possible programming languages that could be used.

2.2.1 State-of-the-art research

2.2.1.1 Systematic research

To conduct this research systematic, different key-words were identified by an individual brainstorm session and subsequently been used to find related work. The key-words that have been used, were as following;

- Self-regulated learning technologies
- Self-directed learning technologies
- Self-driven learning technologies
- Online study coach
- Online study video
- Online learning
- Online planning
- Online goal setting
- Online task analysis
- Learning technologiesResults

The results were selected on relevance, meaning that the found technology should contribute to a (part of the) solution of the problem statement as described in Chapter 1.

[1] Trello is a free online platform that enables to organize in a structured way by creating online cards like post-its. Visit www.trello.com for more information.

2.2.1.2 Results

- Open Universiteit

It was found that the Open Universiteit has many supporting videos online to help students plan their study behaviour. These videos are actually small lectures in which an expert tells more about subjects as planning, study behaviour and learning strategies as mind mapping and summarizing (Open Universiteit, 2018).

- Wakker bij Bakker

Wakker bij Bakker is a website where students can sign in for study coaching. Although online information is available about the same subjects as the Open Universiteit, they insist that a physical face-to-face appointment is made with one of their study coaches.

- Learning Management Systems

Several Learning Management Systems (LMS) have been found. These systems aim to support educational courses or training programs. Although the UT currently uses Blackboard, from the start of the next academic year they will switch to Canvas (University of Twente, 2018). This LMS facilitates course information such as lecture slides, notes, assignments and a calendar with deadlines and study activities.

- Leiden University

Leiden University facilitates a web-based platform that provides study tips and instructional videos about how students can study in an efficient way (Leiden University, 2018). Although this is quite general and not very user-friendly, a broad variation of study tips is provided about several topics such as "how-to" information about exams, time management, speaking, writing and personal issues.

2.2.2 Relevant programming languages

The programming languages that can potentially be usefully to realise the system have been investigated and are listed below. They are considered as useful as they are standard programming languages and are therefore widely applicable, as well as much documentation was found to support the (web-)developer.

- HTML
- CSS
- PhP
- SQL
- JavaScript
- Java
- C
- C++

2.2.3 Conclusion of the state-of-the-art research

Several systems were found that are partly based on the principles of SRL, although they are very general. While these systems consist of study tips that can be applied in general, none of these systems was completely integrated in and adjusted to a curriculum of a bachelor study. Besides the found study support systems, a small research was conducted on the potential programming languages that can be used. These can be used to make decisions in the future during the design process.

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Part II

The design, realisation and evaluation of the system

3. Methodology and techniques

Prior proper planning prevents a piss poor performance

- British Army

Within this chapter the methods and techniques that will be used are explained and motivated. First of all, a model will be presented that will be used as framework of the design process. Secondly, the techniques that will be used to create ideas and obtain information will be described. Thirdly, the analysis that will be conducted to learn more about the aspects that have their influence on the project are elaborated. The last section will focus on the evaluation process.

3.1 Method

The final system should be customized to the (potential) user, which requires a human-centered design (HCD) approach (Benyon, 2010). The Creative Technology Design Process as described by Mader & Eggink (2014) will be used as framework of the entire design process. This model is organized into 4 phases which are based on diverging and converging ideas to explore the field of possible creative solutions to a certain problem and to distillate a final idea from it.

3.1.1 Creative design process: The creative design process as displayed in Figure 3.1 consists of 4 phases; a (1) ideation, (2) specification, (3) realisation, (4) evaluation phase. The first two phases are intended to explore the possible solution and converge it to one solution, taking into account the users their preferences and opinions. During the subsequent realisation phase, the final product is realized which is evaluated within the evaluation phase. A more detailed explanation is found underneath.

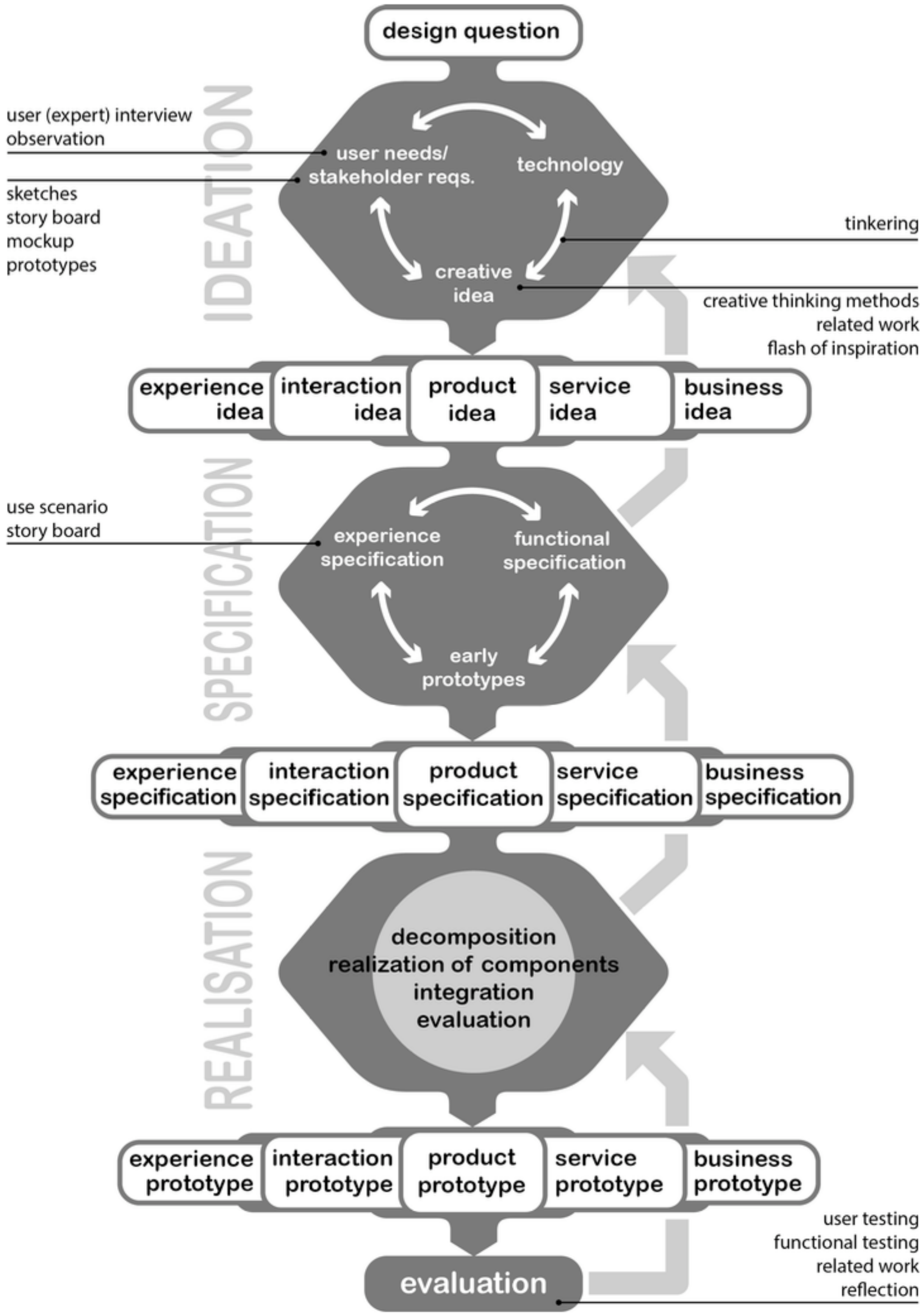

Figure 3.1: The Creative Design Process as described by Mader, A. and Eggink, W. (2014).

Ideation phase: The ideation phase is intended to create the initial idea and explore the possible solutions. Sources from which the project idea can be derived are current technology, user need or creative inspiration. In this project, the initial idea was formed by a creative idea that was formed through expected user needs. To check whether this user needs are right and - perhaps more important - to learn more about the potential user-group, surveys as well as brainstorm sessions will be organized. Also, experts who have expertise within the field of educational sciences and/or teaching will be consulted. The final aim of this phase is to create an elaborated project idea together with preliminary requirements.

Specification phase: The specification phase is aimed to specify the project idea created in the previous phase and eventually select one idea that will be worked out. In order to do so, a requirement and functional analysis will be conducted. Also, the schematic system architecture will be created.

Realisation phase: During the realisation phase, the project as defined in the specification phase will be worked out and realized. Furthermore, the functional test will be conducted at the end of this phase to test whether the requirements are met.

Evaluation phase: The evaluation phase is the last phase as defined by Mader et al. (2014). During this phase, the usability tests will be conducted. From the test results, conclusions and future recommendations will be given.

The model is dynamic, meaning that even though a subsequent phase is started, adjustments can still be made on the previous phase. This enables the designer to keep implementing feedback. These feedback loops are displayed in Figure 3.1 by the arrows in between the phases.

3.2 Techniques to obtain ideas and information

Different techniques will be used to create ideas and obtain information. The different techniques that will be used are (1) brainstorming and (2) interviewing.

3.2.1 Brainstorming: Brainstorm sessions will be conducted both individually and in groups. The latter has the advantage that a diversity of perspectives can be taken into account while the ideas are formed. Through a mind-map, ideas can clearly be mapped out, enabling the participants to elaborate on former ideas.

3.2.2 Interviewing: In order to acquire both quantitative and qualitative data, stakeholders will be interviewed during the ideation, specification and evaluation phases. Crabtree and Miller (1999) describes three different ways of interviewing that will be used:

1. *Unstructured:* Although a small structure/agenda can be found in every interview, the unstructured way of interviewing can be compared to a daily conversation with a certain specified goal. According to Crabtree et al., this form is usually executed in combination with a participant observation.
2. *Semi-structured:* Open-ended questions will be asked during this kind of interviewing, which also entails that during the interview, new questions will be generated and asked. This means that the interview is dynamically and can be as depth as wanted. As is also the case with unstructured interviews, this can be organized in groups, although the participants may bias each other which could influence the outcome.
3. *Structured (surveys):* A questionnaire will be used when a large group of participants should be asked. The advantage of this kind of data that it can relatively quickly be analysed. The questions should be well prepared beforehand, which can eventually be reviewed by experts, conducting an expert review. This kind of data gathering will be used during the ideation and evaluation phase among the potential users.

3.3 Analyses

3.3.1 Stakeholder Analysis

To learn more about the stakeholders that are involved, it is important to map them. Subsequently, each stakeholder will be estimated on the value to the system, based on their power and interest. Lastly, the motivation of each stakeholder will be analysed to determine his or her role within the project. The entire analysis is called the stakeholder analysis as described below.

Phase I, mapping the stakeholders: To create an overview of the stakeholders, a brainstorm session will be conducted. The stakeholders that are thought of will be divided over the different stakeholder categories. Sharp, Finkelstein and Galal (1999) distinguished four different stakeholders, which can be found in Table 3.1.

Kind of stakeholder	Definition
User	Those who interact with the system
Developer	Those responsible for creating the system
Legislator	Those who provide guidelines about the system that might affect the development and/or operation of the system
Decision-maker	Those in decision making structures that relate to the system under development

Table 3.1: Stakeholder categories as defined by Sharp, Finkelstein and Galal, 1999.

Phase II, the power-interest matrix: To map the position of each stakeholder, a power-interest matrix will be used to provide a clear overview of the power and interest a certain stakeholder has in the final product. The matrix is displayed in Figure 3.2.

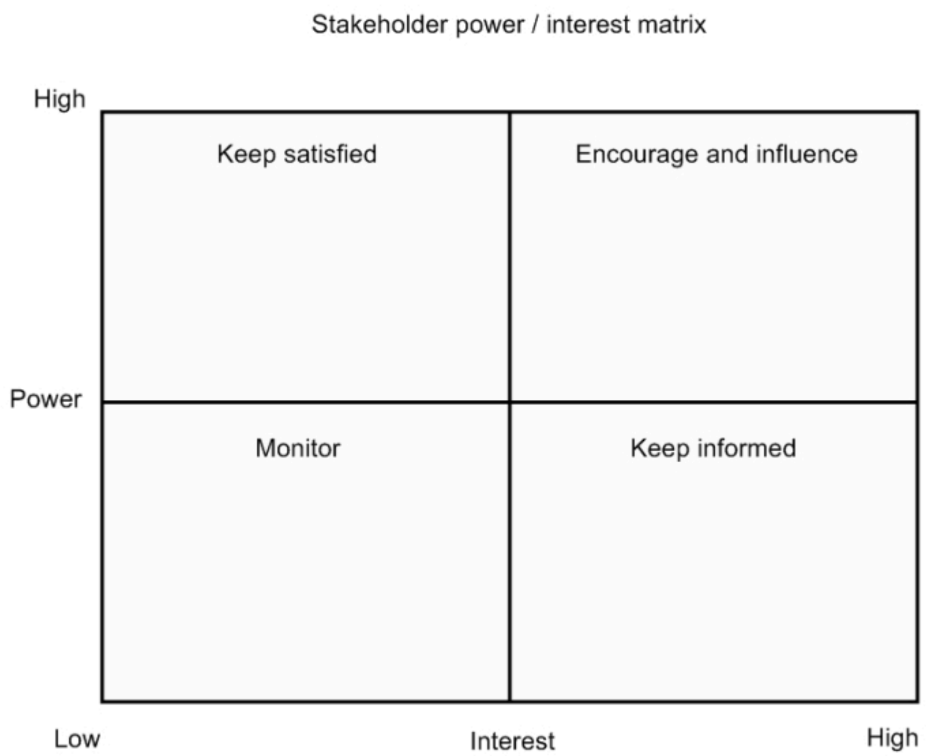

Figure 3.2: The power-interest matrix of Eden and Ackermann (1998, p. 122).

Phase III, motivation of stakeholders: The last phase is to find out more about the motivation of each stakeholder; whether he/she is an advocate or opponent of the project and whether he/she is willing to put effort and time in it. In the end, this can be used to determine whether someone should be involved or not.

3.3.2 IPACT analysis

The iPACT analysis forms a framework which aims to create understanding of the user group among designers, which is considered as an essential part of HCD (Benyon, 2010). The acronym iPACT stands for **i**ntention, **p**eople, **a**ctivities, **c**ontext and **t**echnologies and attempts to get an elaborated view on the user needs, linked to the possibilities to design a system. The ***i**ntention* describes the aim of the system, ***p**eople* which people are involved, ***a**ctivities* the series of tasks that has to be done to operate the system, ***c**ontext* the location and/or context wherein the product will be used and ***t**echnology* the possible technologies that will be used by the system.

3.3.3 Requirement analysis

At the end of the ideation, the initial requirements of the system must be clear. During the specification phase, these requirements will be evaluated and adjusted to form the final requirements that specify the requirements of the product. The requirements will be categorized in two ways; (1) the priority of the requirement and (2) whether it is non -or functional.

Priority of the requirement: To make a division in the different priorities of the requirements, the MoSCoW-method is used as described by Ross and Schoman (1977). MoSCoW priorities requirements in a **M**ust, **S**hould, **C**ould and **W**on't have category. Must have requirements should be met in order to let not fail the project. Should have are requirements that would be nice to have for the system and should be considered as a pré to have, whereas "could have" would just be nice to have. Won't haves are requirements that will not be implemented within the current project and can be considered as recommendations for a further project.

Functional versus non-functional requirements: The requirements can be divided into functional and non-functional requirements. Whereas the functional requirements describe what the system should do, the non-functional requirements describe what the system should lead to.

3.3.4 FICS analysis

The FICS analysis is quite similar to the iPACT analysis. Whereas the iPACT analysis mainly focus on the human-centered perspective, the FICS framework is used to get a designers perspective on the system (Widya et al., 2009). According to Vogelzang (2017), FICS stand for **F**unctions and events, **I**nteraction and usability issues, **C**ontent and structures and **S**tyle and aesthetics. The functions and events focus on what the system should do and how it reacts to certain events and interaction and usability issues describes how the user should use the system. Content and structures will describe how the data is stored and style and aesthetic will describe how the graphical user interface should look.

3.4 Evaluations

The evaluation has three main goals to be conducted; (1) to test whether or to which extend the requirements are met, (2) whether the system is considered as useful to solve (a part of) the problem statement and (3) to obtain data for the future recommendations and eventually final conclusions of the graduation project.

3.4.1 Types of tests

Two types of tests have been distinguished that can be used to evaluate a certain system. These types are (1) the functional and (2) the usability test:

1. *Functional test*

This test will test whether various aspects of the application work as intended to be and will be executed by the developer. This will be done by checking whether the must-have requirements are met. To make sure no errors will be made during the user test evaluation that could have been avoided, this functional test will be executed before the usability test take place.

2. *Usability tests*

Both an expert-based as a user-based usability tests will be conducted to test the current version of the system. According to Lazar et al. (2010), usability testing has one basic main goal which is “to improve the quality of the interface by finding flaws in it” (p. 283). In addition to this basic main goal, the test will be used to meet the three evaluation goals; testing whether the requirements are met and the usefulness is sufficient enough, and obtaining data for future requirements.

One note should be made about the testing procedure of usability tests to emphasize the difference between usability research and traditional research. Although there are similarities with a traditional method (e.g. using surveys to measure user satisfaction) the methodology of usability test differs a lot as the end goal is quite different (Lazar et al., 2010). According to Wixon (2003), the development process is rather driven by schedules and resource issues than by theoretical discussions of methodology. Furthermore, as the design process is dynamical (Mader et al., 2014), changes will be made during the testing process to improve for example the interface of the system resulting in that the subsequent user will test another (upgraded) system. This is contradictory to traditional research methods (Lazar et al. 2010).

3.4.2 Test procedures

This section provides insights on when test procedures take place during the design process. Two different types of evaluations will be conducted at different times; (I) a formative and (II) a summative one. In general, formative (usability) tests focus more on qualitative feedback, user observation and problem discovery, whereas summative (usability) tests tend to focus on task-level measurements and quantitative measurements (Lewis, 2006). A more detailed description as well as a test procedure on these tests is found underneath:

I. Formative evaluation

This will be a formative evaluation which will be executed multiple times during the development process. During the design process, the developer will continuously check whether the system meets the functional requirements. The functional requirements on its turn are normally developed during the ideation/specification of the design process as described by Mader et al. (2014). The formative usability evaluations will start during the ideation phase of the project, as the choices that are made have to be tested and evaluated by experts and potential users of the system. These evaluations will also take place during the specification phase to create and evaluate low-fidelity prototypes. This will be done by using semi-structured interviews and focus groups of potential users to obtain their opinions.

II. Summative evaluation

The final system, also known as the high-fidelity prototype (Dumas & Fox, 2007), will eventually be evaluated by the so called summative evaluation (Lazar et al., 2010). This will also be done by a functional and usability test. The testing procedure for the summative functional test will not differ from the formative variant; the developer will execute a series of task and check whether the system meets the requirements as set in the specification phase. The summative usability test has some additional features.

Experts are first asked to give a summative evaluation to filter out flaws and to give their opinion on the system. In terms of this project, it was chosen to use the cognitive walkthrough that is developed by Lewis et al. (1990), as this is often used and considered as a decent expert review method (Lazar et al., 2010). According this method as described by Lazar et al., the experts will be asked to simulate the user and cognitively walkthrough a series of tasks. Aimed is to get some insight of how users will interact with the system the first time they attempt to use it (Hollingsed & Novick, 2007). Through a semi-structured interview the experts will be questioned on what their thoughts are about the system and how this can possibly be improved.

After the summative expert reviews, a summative user test will be executed to test whether the non-functional requirements are met. The test procedure is based on the work of Lazar (2006), who described seven steps to take as researcher:

1. Selecting representative users;
2. Select the setting;
3. Decide which series of tasks do have to be executed by the user;
4. Decide what type of data to collect;
5. Before the test session (meet the participants);
6. The test session itself;
7. Debriefing.

The users will execute a series of tasks to get used to the system and execute all the functionalities that are included. Subsequently, quantitative data will be obtained by conducting a survey, using the 1 - 5 Likert scale, whereby 1 stands for strongly disagree and 5 strongly agree (Likert, 1932). The questions of this survey were based on the Computer System Usability Questionnaire (CSQU) as described by Lewis (1995), as this was considered as an established method (Lazar et al., 2010).

If the setting still permits independent individual answers by thinking out loud, this will be asked to the user when conducting the tasks.

To acquire qualitative data as well, participants will be able to fill in additional comments on a question if they think that is appropriate when conducting the survey. Furthermore, a focus group of available respondents will be created to conduct a semi-structured interview to get more in-depth inside on their opinions.

3.5.3 Number of participants

Although there is still no real hard rule that states how many users should approximately be tested to conduct a reliable test, the 7 ± 2 is used as rule of thumb (Lazar et al., 2010). Lewis (2006) distinguished three main variables to decide how many participants are minimum required, which are their wanted accuracy, their problem discovery goals and how many participants are actually available. As approximately 80% of the flaws is detected when a test is conducted with 5 participants (Virzi, 1992) it is aimed for get at least 5 participants to conduct the user tests on.

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4. Ideation

"If I had asked people what they wanted, they would have said faster horses"

- Henry Ford

In this chapter, the ideation phase of the design process as notified in the previous chapter will be described. First of all, the description of Creative Technology (CreaTe) will be given and be used as starting point. Subsequently, the initial project idea will be described and elaborated until the final requirements are defined. This chapter also incorporates the results of the stakeholder analysis.

4.1 Description of Creative Technology

The urgency to understand what the description of CreaTe is, is twofold; (1) the entire bachelor programme is defined as the client to which the project will be dedicated to and (2) this graduation project is the final part of this study, meaning that the final idea should contain several elements and be in line with the goal setting of this study.

4.1.1 Description of CreaTe: Creative Technology is a study which uses technology to solve social issues, by keeping an eye on the changing needs of the society and think of corresponding solutions. It has interfaces with electrical engineering and industrial design, but instead of creating new technology it uses existing technologies in novel combinations (University of Twente, 2018). During the study, one learns to ideate creative solutions into prototypes. To learn to do so, hardware, software and design courses are a major part of this study.

4.1.2 Unique features and challenges of Creative Technology: As mentioned in Chapter 1, no further admission requirements are needed besides VWO or a HBO propedeuse. As a result, the population of CreaTe students do have many different backgrounds, interests and motives (University of Twente, 2018). This can be considered as a unique characteristic, but it does bring along a challenge. The education programme responds to this by starting relatively easy.

4.2 First ideation

From the author his own perspective it became clear that formal lessons aiming to acquire new methods to improve learning skills were never provided by the CreaTe curriculum. To discover whether this was a major issue by multiple studies, a small explorative survey was conducted among students who follow a study at the University of Twente and University of Utrecht *(n=8)*. It turned out that 5 of them never received formal education about learning strategies, while 7 of them did expect that these lessons would be an added value to their curriculum.

The author also got inspired by a lecture given by an educational scientist, who stated that nobody ever had lessons in formal education in which learning strategy is scientifically proven to work/fail (Gijselaers, 2017). This while there are many videos out there about learning and performing.

4.2.1 Initial requirements: From these insights, the initial requirements were formulated:

1. The product should be in line with the needs of the society and has similarities with CreaTe and educational sciences, as both disciplines are of the author his interest;
2. The students (users) should be supported in their study performance;
3. The students (users) should learn more about SRL strategies caused by the system;
4. The user threshold the platform should be low.

4.2.2 Initial goal: The initial goal of the project was formulated as "to create a digital platform that facilitates personal advice of scientifically proven learning strategies for students at the university."

4.3 Stakeholder analysis

A stakeholder analysis has been conducted as described in Chapter 3 to learn more about the user group and other stakeholders that are involved and identify their role. The results are listed below.

4.3.1 Users:

- The first-year CreaTe student[2]. This student is intended as main user of the system. This should be the one who benefits from SRL strategies to perform in a structured and result-oriented way.
- Instructors (of the professional development course as mentioned in Chapter 1). They are responsible for the execution of the SDL strategies as defined by TOM and are called tutors and/or mentors.

[2] An elaborated description who will actually use the system will later be given as answer on the second subquestion: *Who is the actual potential user group of this project?*

- Lecturers, in particular programming and mathematic lecturers[3].

4.3.2 Developer(s): There will be only one developer during this process, who has a high rate of interest and power. He will be the owner and is final responsible for the entire graduation project.

4.3.3 Legislators:

- The program director of Creative Technology has also a role as she can decide whether the application will be implemented as standard part of the tutoring courses.
- The policy makers of the TOM. As the CreaTe curriculum should be in line with the policy of the UT and the product aims to be implemented in the professional development course, they do indirectly have an influence on the product.
- The Dutch government. In the end, the product should be in line with the Dutch legislation. Possible legislation that could influence the usability of the system is the General Data Protection Regulation.

4.3.4 Decision makers: The final decision makers is the same person as the developer. However, the supervisor of the developer has a major part in it as well, as he will be used as sparring partner and some decisions will be made together. Besides, the supervisor will control the time schedule of the graduate candidate.

The stakeholders are classified according to their power/motivation ratio compared to the initial idea and data received from the problem analysis (see Chapter 1). This was done by estimating this ratio which was based on the stakeholders expected level of interest. The result can be found in Table 4.1.

[3] The rason that mathematic and programming lecturers were chosen in particular will be explained in section XXX.

	Stakeholder	Type	Power	Interest
A	The first-year CreaTe student	User	7	8
B	Mentors / tutors	User	3	7
C	Programming teachers	User	5	7
D	Math teachers	User	5	7
E	Developer	Developer and Decision-maker	10	10
F	Program director of CreaTe / TELT team[4]	Legislator	8	8
G	Policy makers of TOM	Legislator	8	5
H	Dutch government	Legislator	9	1
I	Supervisor	Decision-maker	8	8

Table 4.1: Estimated power/interest ratio of the stakeholders, based on their expected level of interest.

[4] TELT team stands for the Technology Enhanced Learning & Teaching team. This prior task of this team is to use and explore new applicable technologies that can be used by the university.

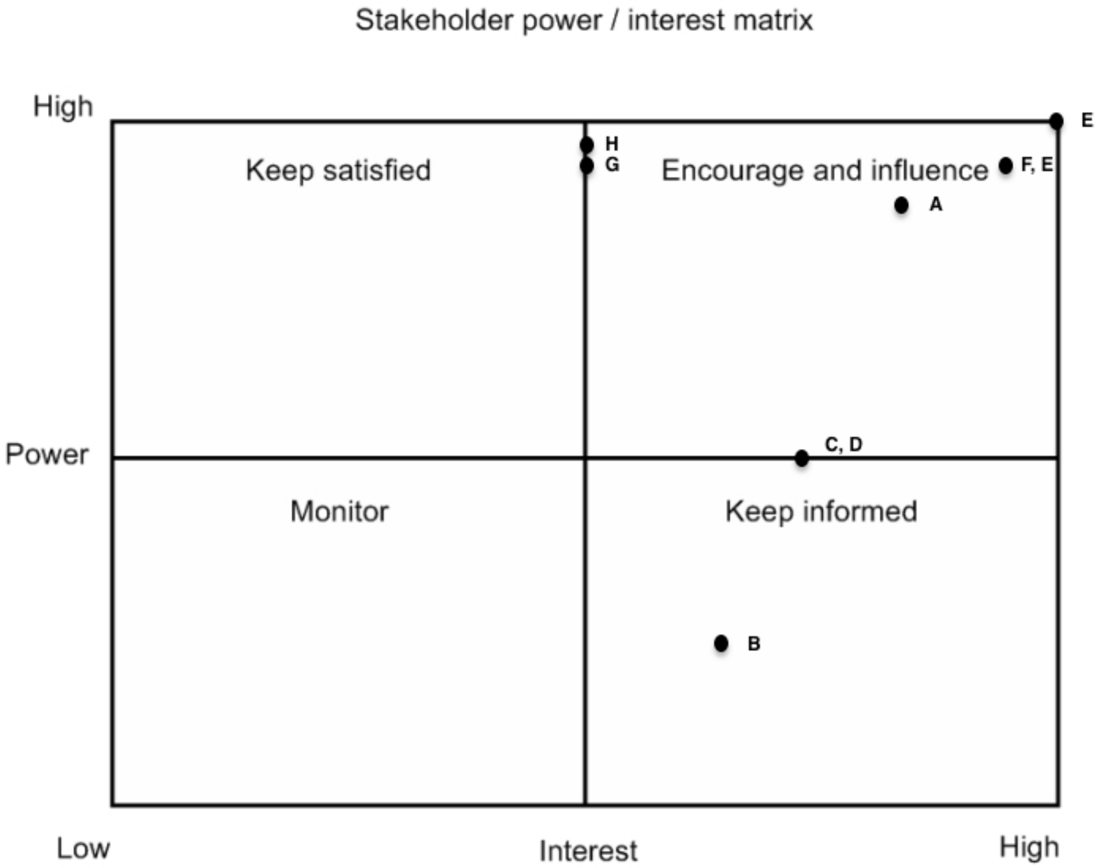

Figure 4.1: Stakeholder power / interest matrix. A) The student, B) Mentors/tutors, C) Math - and D) programming lecturers/professors, E) Graduate candidate, F) Program director of CreaTe / TELT team, G) Policy makers of TOM, H) Dutch government and I) Supervisor. The figure is reprinted from NCVO (2018).

4.2 The ideation process

To form the preliminary requirements, the stakeholders that have been identified were interviewed using different interview structures as mentioned in Chapter 3. The steps that were completed during the design process to ideate the initial idea, were making an observation, conducting a brainstorm session, an interview, a brainstorm session, …, an interview etc. This process continued until an idea was formed. The same process will be used to form the final idea.

In total, 43 respondents were interviewed, whom 40 CreaTe students and 3 experts within the educational field. Of the 40 CreaTe students, 37 participated on a survey and 3 were attending a focus group. The 3 experts were 2 members of the TELT team and one study advisor.

4.2.1 Results of the ideation process

A summation of the most important findings will be given within this section. The elaborated log of results that were gathered can be found in Appendix B.

It was found that on this moment, awareness about the benefits of using SRL strategies is missing and if there is awareness, it is not acted on. Although some students are satisfied with a 6 out of 10, no proper planning is created to achieve which leaves room for failure. Furthermore, generally speaking students do not acknowledge their responsibility on their learning process. Academic teachers that were interviewed noted that it feels like many students make exercises to keep the teacher satisfied instead of gathering knowledge.

To make a major change on this, the pattern that was used on high school must be broken. This is also in line with the identified main challenge of the system, which is to convince students to change their way of studying. This can possibly be done by ensuring that students experience the success of planning and reflection. Initially this can be done by forcing the students to use the system, aiming to eventually motivate them intrinsically to use the application. This can be done by implementing SRL strategies as a standard part of the bachelor curriculum.

37 first-year CreaTe students were asked what the most difficult courses are of the current curriculum in the first module. 17 respondents appointed programming and 11 respondents appointed mathematics as most difficult courses. Furthermore, out of these 37 respondents, 25 would like to learn more about SRL strategies. Through several brainstorm sessions, study tips on these courses were considered as an added value to the system. It became also clear that a peer-to-peer control mechanism would be. Besides, first-year CreaTe students also mentioned that the current schedules they made are barely based on the corresponding European Credit (EC) that is set by the study.

4.2.2 Conclusion of the ideation process: the final idea

The aim is to support first-year CreaTe students who are in their first two modules of the bachelor curriculum. This support will attempt to improve student's their study behaviour by providing several insights on their learning process. In addition, study tips of the most difficult courses will be provided, as well as general study tips which also attempt to provide several insights on certain learning behaviour.

To do so, usage of the system must become a fixed part of the professional development course taught in the first two modules. In order to achieve this goal, the final idea is to create a prototype of a system that is based on two main pillars;

1. A subsystem that supports strategic planning by facilitating a task analysis and goal setting, based on the European Credit Transfer and Accumulation System (ECTS) and corresponding mean study investment time;
2. A subsystem that provides study tips about mathematics and programming.

4.3 iPACT analysis

Intension: To create an application that facilitates (personal advice of) scientifically proven learning strategies for students at the university.

People: Sam is a 18-years old student Creative Technology. He likes rowing, which takes around 8 hours a week. Besides, Sam lives on the Campus where he is often to be found hanging out with friends. Sam is an ambitious, self-disciplined student who easily learns. One could also notice this when taking a look at his grades.

Tim is a first year Creative Technology student at the University of Twente. He is eager to learn, but does often not keep up with his own created planning. This is caused through a bad task-analysis and a lack of self-discipline and concentration. He requires some social control to keep up with the study materials. Generally, Tim has an achievement-based learning approach, meaning that he wants to achieve a certain grade. What this exact grade is, depends on whether the subject is within his spectrum of interest. During high-school, Tim did not have to put a lot of effort in it to finish it.

Since the start of this year, Ben is the tutor of Creative Technology students. His aim is to help students through their first year by proactively monitor them and coach them through the study process. Still, he needs a tool that gives him an overview and prioritizes the level of help students need.

Activity: The student will use the application during his first two modules of CreaTe in order to acquire SRL skills and to bridge the determined gap between high-school and university. An overview of the courses and the corresponding ECTS will be provided, as well as the number of hours that should be invested within that specific course during a specific week. Ideally, when the students plan in their time investment, the remaining hours that should be planned in on average are also displayed through a feedback loop.

Context: The application will be designed to use during the first two modules of CreaTe.

Technology: An web-based application, as it would be an advantage if the system is online accessible as this increases the reach, and thus increases the possible impact.

4.4 Preliminary requirements

From the results and iPACT analysis of the ideation phase, the preliminary requirements were developed as described in Chapter 3 and displayed in Table 4.2. The requirements that were not applicable (based on the earlier described MoSCoW principle) are left out of the table.

(Sub)subsystem	MoSCoW	(Non-)functional	Requirement
Online support system	Must haves	Functional	The system must be online accessible
		Non-functional	The system must be experienced as an added value to an overall increase of the learning efficiency of the users
			The system its interface must be experienced as easy to understand by the user
			The number of clicks to execute certain functions of the system must be experienced as acceptable
Subsystem I: strategic planning support	Must haves	Functional	The subsystem must support the user to schedule (study) activities
			The subsystem must compare the currently planned study time investment to the norm which is defined by the CreaTe bachelor program
		Non-functional	The subsystem must be experienced as useful, meaning that the user must feel that he or she is supported by the subsystem to create a study planning according to a specific norm
	Should haves	Functional	The subsystem should be able to let users self-evaluate their planning behaviour
		Non-functional	The self-evaluation function should be experienced as an added value to constructively improve planning behaviour
	Could haves	Functional	The subsystem could have an option to give peer-to-peer feedback to keep track of each other's study contract and progress
Subsystem II: study-related support	Must haves	Functional	The subsystem must provide general study tips which are mainly based on SRL principles and educational experts
			The subsystem must provide a subject-specific tool for the mathematics and programming courses offered in the first two modules of the Creative Technology bachelor program.
		Non-functional	The subsystem must be experienced as useful, meaning that the user must feel that he or she is supported to successfully finish the mathematics and programming courses by the system
	Should haves	Non-functional	The subsystem should contribute to the acknowledgement of the relevance of using SRL strategies by the user
	Could haves	Functional	The subsystem could have an ability to document pre-set goals and a self-reflection on it

Table 5.2: Preliminary requirements based on the MoSCoW principle. The not applicable requirements are left out of the table.

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5. Specification

Acting metacognitive starts with metacognitive awareness

The specification phase is the second phase as described by the Creative Design Process of Mader and Eggink (2014) which aims to obtain the best possible functional specification of the envisioned product prototype through the use of user scenarios (Bults, 2018). The user requirements and needs were tested in practise by evaluating early prototypes on the potential user group. Furthermore, several stakeholders that have been identified through the stakeholder analysis in Chapter 4 participated in interviews and brainstorm sessions. In total, 9 respondents were interviewed divided over 7 interviews.

Firstly, the user-test and in-depth interviews that were conducted with experts will be described. Subsequently, the FICS analysis and the corresponding designer's perspective will be described, which leads to the envisioned system architecture. Lastly, the conclusion of the specification will be provided in terms of the final system requirements.

5.1 Specification of the ideation

5.1.1 Low-fidelity prototyping and user testing

To test whether the envisioned system is also considered as useful in practice, a low fidelity (lo-fi) prototype was created, tested and evaluated with the Education committee of S.A. Proto. This committee consisted of 6 members who represent the entire population of CreaTe students. As mentioned in Chapter 4, the final idea exists of two main pillars. A system that supports strategic planning was tested via a spreadsheet created Microsoft Excel. Through a cognitive walkthrough and a semi-structured interview, the participants were asked what their first thoughts were on the system and what their major points of improvements would be. The same was asked about the subject-matter support system that provides study tips, although this was discussed orally only as no lo-fi prototype was developed. The whole session was audio recorded.

The lo-fi prototype is displayed in Figure 5.1. The most important findings will be described briefly within this section.

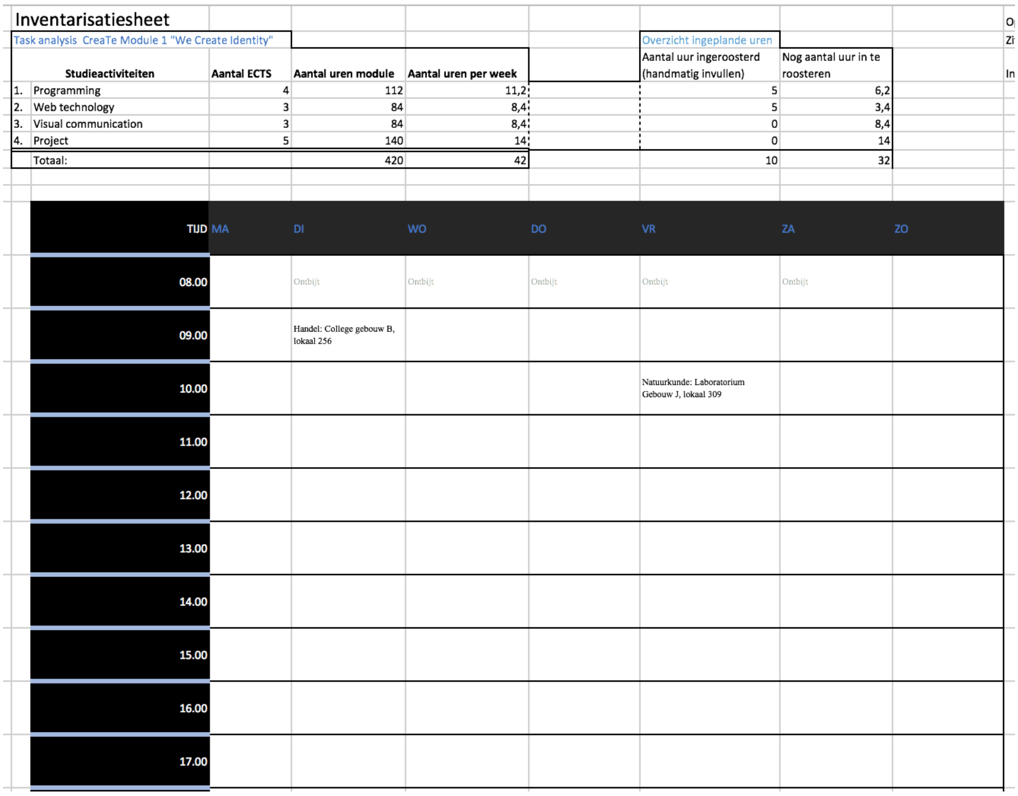

Figure 5.1: Lo-fi prototype of a potential planning tool that could support students to plan in their time properly.

Results of the user test and evaluation

The assumption that no framework of reference about time-management is currently provided by the study was proven right. Students do indeed have to find how much time is required for a certain course or other activities such as the average time of relaxation by themselves. Several improvements have been suggested by the interviewees, which will be further discussed.

The functional recommendations are as following. First of all, it would be an added value to provide both the average amount on time of studying and of relaxation as indicator in order to create a realistic time planning. Furthermore, the prototype is currently developed in such a way that the user should manually fill in the current amount of time that is planned in for a specific study task. As this table will be an essential part of the system, it was recommended to let this happen automatically. Finally, two non-functional recommendations were given; (1) it would be a plus if the system uses a login system that is currently used by the university to lower the usage threshold and (2) the idea to implement the system as standard part of the professional development course was endorsed by the interviewees.

5.1.2 In-depth interviews

5.1.2.1 Interviews with subject-matter experts

To get an in-depth view on the subject-matter system, interviews have been conducted with two lecturers in Computer Science and Programming at the UT and one lecturer mathematics. The elaborated results can be found in Appendix A. The main findings of these interviews are listed below:

1. No responsibility for their own learning process and/or future planning from the start of the module; a long-term task analysis is not executed. Instead, it looks like students make exercises for the teachers. Besides, many students starts too late with their assignments.
2. Knowledge is not transferred from earlier learning moments; students do not activate their prior knowledge.
3. Error analysis of exercises; students do not analyse where it went wrong during their learning process/steps. Instead they ask for help immediately.
4. Studying can be considered as a new phase in life which brings a lot of other things to worry about. Students should take this into account when creating a study planning.
5. During colstruction, students start working on other courses to meet a deadline. This indicates planning problems;
6. Lectures are not prepared; students do not know what it is about on beforehand.
7. If a planning is made and executed, it is not used as measuring instrument to learn from it afterwards.

Canvas: Besides the subject-matter information, one respondent came up with the idea to use the new learning management system (LMS) Canvas, which will be implemented UT-wide to replace the current LMS Blackboard. The advantage of Canvas is that plug-ins can easily be added and the UT-wide coverage, which makes it easy to implement such a plug-in easily in other study programs in the future.

5.1.2.2 Interview with a system developer

To investigate the option to integrate the system within the Canvas LMS, an interview with a system developer at the UT and member of the TELT team has been conducted. The results and conclusions of this interview can be found in Appendix A.

It became clear that adding new functionalities to Canvas could be an IT (graduation) project in itself. As the project objectives are defined otherwise, it was concluded that is out of the scope of this project to do so. However, it seems possible to use the data model of Canvas that is currently available. By doing so, it is possible to access Google Drive applications within the Canvas interface and obtain data from Google Drive without creating an entire new LTI web-application, which would presumably also be too time-consuming to execute within this graduation project.

5.1.3 Final idea

The data that was obtained through the interviews was used to form the final idea through an individual brainstorm session.

Subsystem I: It was decided to use study, personal and work-related activities as planned in Canvas LMS, Google Calendar and the UT Timetables[5] as input data. This can subsequently be compared to the time investment norm per activity e.g. time investment course as defined by the UT CreaTe bachelor programme and the average time investment of relaxation a student should take. The result of this comparison will be displayed by either Google Calendar or Canvas LMS, as it was required that an already used system would be used.

Subsystem II: As an addition, study tips will be provided. These tips will be classified by three categories; mathematics, programming and general study tips. This data is obtained from the experts that have been interviewed. Furthermore, the last category also obtained the data from the experiences of the author, fellow students, and the SRL that were described in Chapter 2. Furthermore, a task analyser will be added to enable students to analyse a task before it is actually performed.

Scripting language: As the system will use many Google applications, it was logically investigated whether there exists a programming language that can be ran on these engines.

[5] MyTimetable is the application in use at the UT for the creation of personal timetables, which is accessible via http://www.rooster.utwente.nl.

Google Apps Script was found, which is “a JavaScript based scripting language that provides easy ways to automate tasks across Google products and third-party services and build web applications” (Google, 2018a). Because it seems that this scripting language makes this two subsystems programmable and feasible to do within the time that is available to execute the project, no further research was conducted.

5.2 FICS

From the data that was obtained and described, scenarios have been described which uses the FICS framework as described in Chapter 3.

5.2.1 Functions and events: There will be two main functions, called subsystems, which are embedded in a larger system that will act as the main system of this graduation project. The two subsystems are a strategic planning support system and subject-matter supporting one.

1. *The strategic planning supporting system:* This subsystem will support by facilitating a task analysis and goal setting, based on the ECTS and corresponding study investment time per subject. Furthermore, an overview amount of time invested in non-study related activities will be provided as well as a guideline for minimum weekly time investment on relaxation or other non-study related activities.
2. *The study-related supporting system:* This subsystem will provide several study tips which aim to support students with mathematics, programming as well as general study tips based on the principles of SRL. To bridge the difficulties of these subjects that have been identified, several study tips will be provided to the student. As this concept is based on the “by students, for students” principle, a larger support is expected from the user group to accept and use those.

5.2.2 Interaction and usability issues: The interaction between the user and the system is quite different on each subsystem. To use the first subsystem, students will have to act (pro)actively. The input data will be the events as planned in Google Calendar and the output data will be an overview of remaining hours that should still be planned in according to the corresponding ECs. The second subsystem will also have digital interaction with the user. The task analyser will ask several questions to the user to provide customized output data. The user will be asked whether study tips are needed when a high discrepancy is calculated. The study tips can be evaluated and updated by the system admin manually.

5.2.3 Content and structure: The student feed their timetable to Google Calendar, as well as their planned in study activities, classified by a course that is followed. Subsequently, this data is taken together and logic is applied to this data to compare the current time of investment of a specific course to its norm. The result of this calculation is send back through a Google Form to the user, who obtains a clear overview of the remaining hours that should still be planned in. Within this Google Form, the subject-matter study tips will also be provided.

5.2.4 Style and aesthetics: To meet the user requirement that no additional system should be added and thus guarantee a low threshold value, the system should be accessible via Canvas LMS or via Google Calendar. As Canvas LMS offers a data object to implement Google Drive (and thus Google Form) files in its user interface, the systems results can be integrated in Canvas LMS. As it makes use of the Google Drive and Canvas LMS GUI, no additional GUI will be developed.

5.3 System architectures

To visualize how the various components of the system will interact with each other, several diagrams which display the system architecture were created. The FICS applies as basis for the structure. The system architecture consists of different levels, whereby the level of abstraction decreases over the diagrams until a full architecture of the envisioned system is provided.

5.3.1 Level 0 architecture

The level 0 architecture provides an overview of the entire system on a respectively high level of abstraction. The result is displayed in Figure 5.2.

Four input variables are necessary to make the system operable; (1) the activities which the user has planned in, (2) the normative average time of a specific activity, (3) the study tips about programming, mathematics and study tips in general and (4) the answered questions of the task analyser. This requires some interaction between the user and the system, as displayed in Figure 5.2 by the dashed lines.

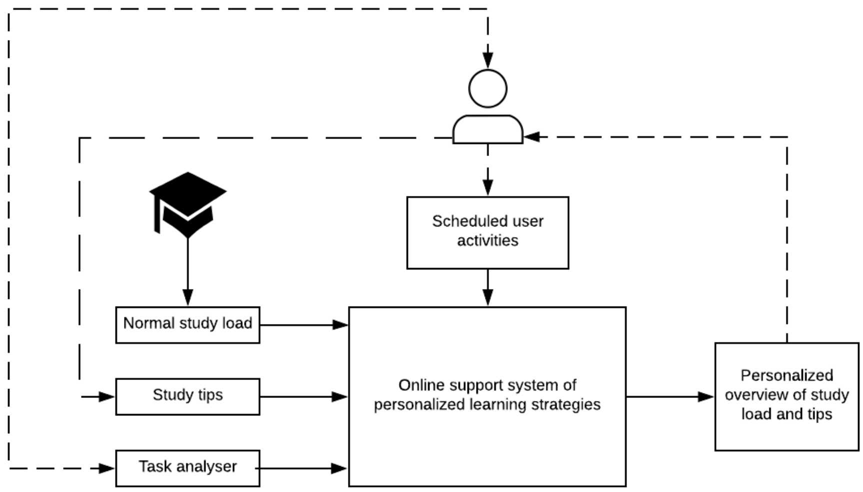

Figure 5.2: Abstract system architecture of the graduation project.[6]

5.3.2 Level 1 architecture

The level 1 architecture provides an overview of the entire system on a respectively higher level of abstraction. The three basic variables are more worked out which resulted in the diagram as displayed in Figure 5.3.

The activities that have been scheduled are merged into the Google Calendar. Data that feeds this calendar consists of the timetable (provided by the study), the study related activities from Canvas (provided by the lecturers as well as the individual students) and the own personal activities of the student. The table of the average time investment per activity is fed manually. The data can be obtained from the module manuals of M1 and M2 as well as data from sources

[6] Symbols are reprinted from *https://www.flaticon.com/free-icon/user-symbol-of-thin-outline_51256* and *https://icon-icons.com/icon/university/49967*.

on the scientific field addressing this topic. The Google Database of study tips is fed by data from the interviews that have been conducted with the subject-matter experts, supplemented by data from the author his own study experiences.

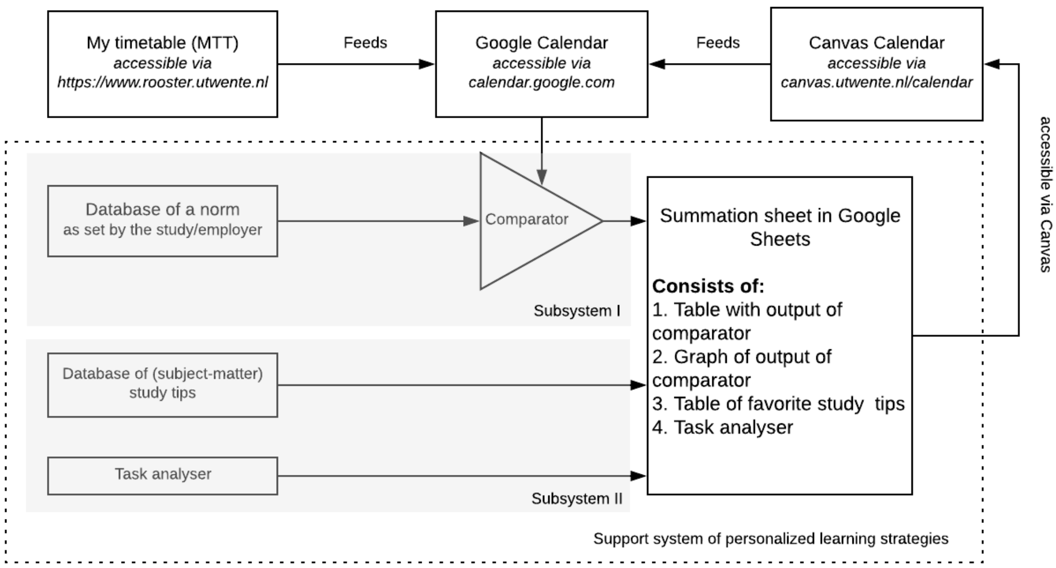

Figure 5.3. Concrete overview of system architecture. The top shaded part contains the functionalities of subsystem I, whereas the bottom shaded part contains the functionalities of subsystem II.

5.3.3 Level 2 architecture

On this level, the system architecture of the online support system itself will be elaborated and visualized, as displayed in Figure 5.4.

The data from the Google Calendar will be retrieved through an add-on and be sent to a Google Spreadsheet. The data will subsequently be clustered into activities from (1) course 1, course 2, …, course n, (2) time investment on extra-curricular activities and (3) time investment of non-study related activities as relaxation. The clustered data will be compared to the databases of normative time investment, which is fed by the input data as described in the previous section. This will be done automatically. The result of this comparison will be dropped into an overview database, which will also automatically create a bar graph out of this data to provide a clear overview.

The elaborated architectures of the task analyser will be described in Appendix C.

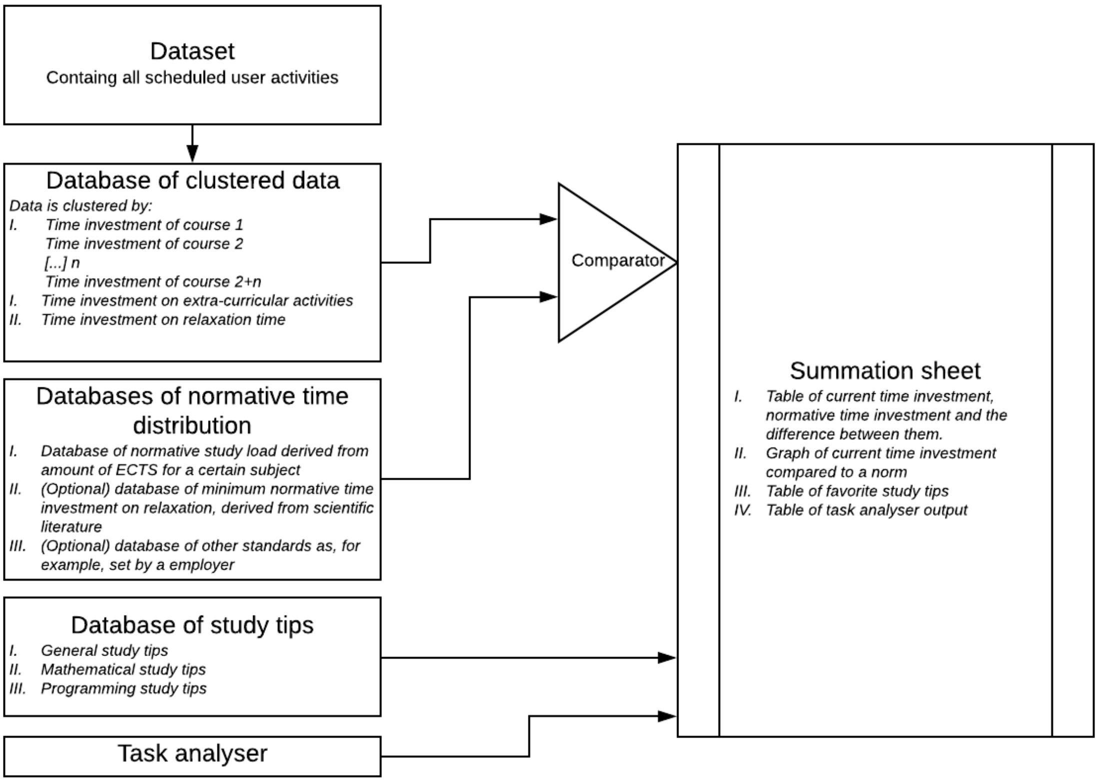

Figure 5.4: The system architecture of the support system itself.

5.4 Conclusions and final system requirements

Taking all the data together this was used to define the final system requirements. The same (MoSCoW) principle is used to define the final requirements. The results can be found in Table 5.1. The changes of requirements that were made based on the specification are listed.

5.4.1 Changes in comparison to the preliminary requirements

1. The system should be accessible via Canvas LMS (which is on its turn accessible via Google Drive).
2. There should be interaction between subsystem I and II to make it a comprehensive whole, which should be experienced as useful by the user.
3. No additional functionalities will be added to Canvas LMS itself.
4. The subsystem must compare currently scheduled study-related as well as non-study related activities to a certain norm, distracted from scientific literature and/or experts
5. The subsystem should have an integrated calculating subsystem that automatically reduces the amount of time to invest in a certain activity when it gets scheduled
6. The subsystem could have an option to give peer-to-peer feedback to keep track of each other's study contract and progress
7. The subsystem will not have an explicit planning functionality such as an agenda
8. The subsystem could have the ability to analyse a task based on SRL principles and variables
9. The subsystem could have the ability to facilitate an online community with first-year students and older students who can act as mentor
10. Although it is considered as a benefit to have to strengthen the second subsystem functionalities, the system will not necessarily include the ability to document self-reflection about pre-set learning objectives, as the scope of the project is narrowed to a time tracking system, task analyser and study tip platform.

(Sub)subsystem	MoSCoW	(Non-)functional	Requirement
Online support system	Must haves	Functional	The system must be online accessible for CreaTe students of the UT via Canvas LMS
		Non-functional	The system must be experienced as an added value to an overal increase of the learning efficiency of the users
			The system its interface must be experienced as easy to understand by the user
			The number of clicks to execute certain functions of the system must be experienced as acceptable
	Should haves	Functional	There should be interaction between subsystem I and II
		Non-functional	This interaction should be experienced as useful by the user
	Won't haves		The system will not add new functionalities to the Canvas LMS GUI itself
Subsystem I: strategic planning support	Must haves	Functional	The subsystem must support the user to schedule (study) activities
			The subsystem must compare the currently planned study time investment to the norm which is defined by the CreaTe bachelor program
			The subsystem must compare currently planned non-study related activities to a certain norm, distracted from scientific literature and/or experts
		Non-functional	The subsystem must be experienced as useful, meaning that the user must feel that he or she is supported by the subsystem to create a study planning according to a specific norm
	Should haves	Functional	The subsystem should have an integrated calculating subsystem that automatically reduces the amount of time to invest in a certain activity when it gets scheduled
			The subsystem should be able to let users self-evaluate their planning behavior
		Non-functional	The self-evaluation function should be experienced as an added value to constructively improve planning behavior
	Could haves	Functional	The subsystem could have a rewarding subsystem for achieving certain goals/tasks
			The subsystem could have an option to give peer-to-peer feedback to keep track of each other's study contract and progress

		Non-functional	N/A
	Won't haves	Functional	The subsystem will not have an explicit planning functionality such as an agenda
		Non-functional	N/A
Subsystem II: study-related support	Must haves	Functional	The subsystem must provide general study tips which are mainly based on SRL principles and educational experts
			The subsystem must provide a subject-specific tool for the mathematics and programming courses offered in the first two modules of the Creative Technology bachelor program.
		Non-functional	The subsystem must be experienced as useful, meaning that the user must feel that he or she is supported to successfully finish the mathematics and programming courses by the system
	Should haves	Functional	The subsystem should display a pop-up to offer study tips when few less hours are planned in by the user
		Non-functional	The subsystem should contribute to the acknowledgement of the relevance of using SRL strategies by the user
	Could haves	Functional	The subsystem could have the ability to analyse a task based on SRL principles and variables
			The subsystem could have the ability to facilitate an online community with first-year students and older students who can act as mentor
			The subsystem could have an ability to document pre-set goals and a self-reflection on it
		Non-functional	N/A
	Won't haves	Functional	N/A
		Non-functional	N/A

Table 5.1: Final requirements of the entire system as defined by the MoSCoW principle.

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6. Realisation

One needs data to create a strategy

The realisation phase of the design model of Mader & Eggink (2014) was conducted to develop the system as designed in the previous phases, especially the specification phase. As mentioned in Chapter 5, the programming language JavaScript was used to do so. To facilitate inheritance – which is required as it is considered as one of fundamental aspects of such a programming language (Halbert & O'Brien, 1987; Stefik & Bobrow, 1985) – Google App Script uses several 'classes' and methods (Google LCC, 2018a). Although Google App Script is based on JavaScript, the objects that are called 'classes' by Google are actually called "objects" by the co-developers of JavaScript (Mozilla, 2018). According to Mozilla, one of the co-developers of JavaScript, each object has its own privacy property which links to another property, called its prototype. Several objects and their corresponding prototypes were used to create the functional system. The objects and prototypes that were used were retrieved from the Google App Script reference library and are clearly displayed in Figure 6.1.

6.1 Realisation process

The development process of the system was done by conducting several steps, which will be listed in chronological order. The actual coding was done by a trial-and-error approach and can therefore be considered as a dynamical learning process. The entire syntax can be found in Appendix D and the final user interface in Figure 6.2.

Two different important terms are used which ask for a small explanation as they are often confused. A *spreadsheet* consists of one or more *sheet(s)*. With *spreadsheet*, the entire document in (for example) Google Sheets is meant whereas the term *sheet* refers to only a single sheet. If a spreadsheet consists of multiple sheets, one can navigate through the sheets by using the tabs underneath the GUI. This is also displayed at the bottom of Figure 6.2.

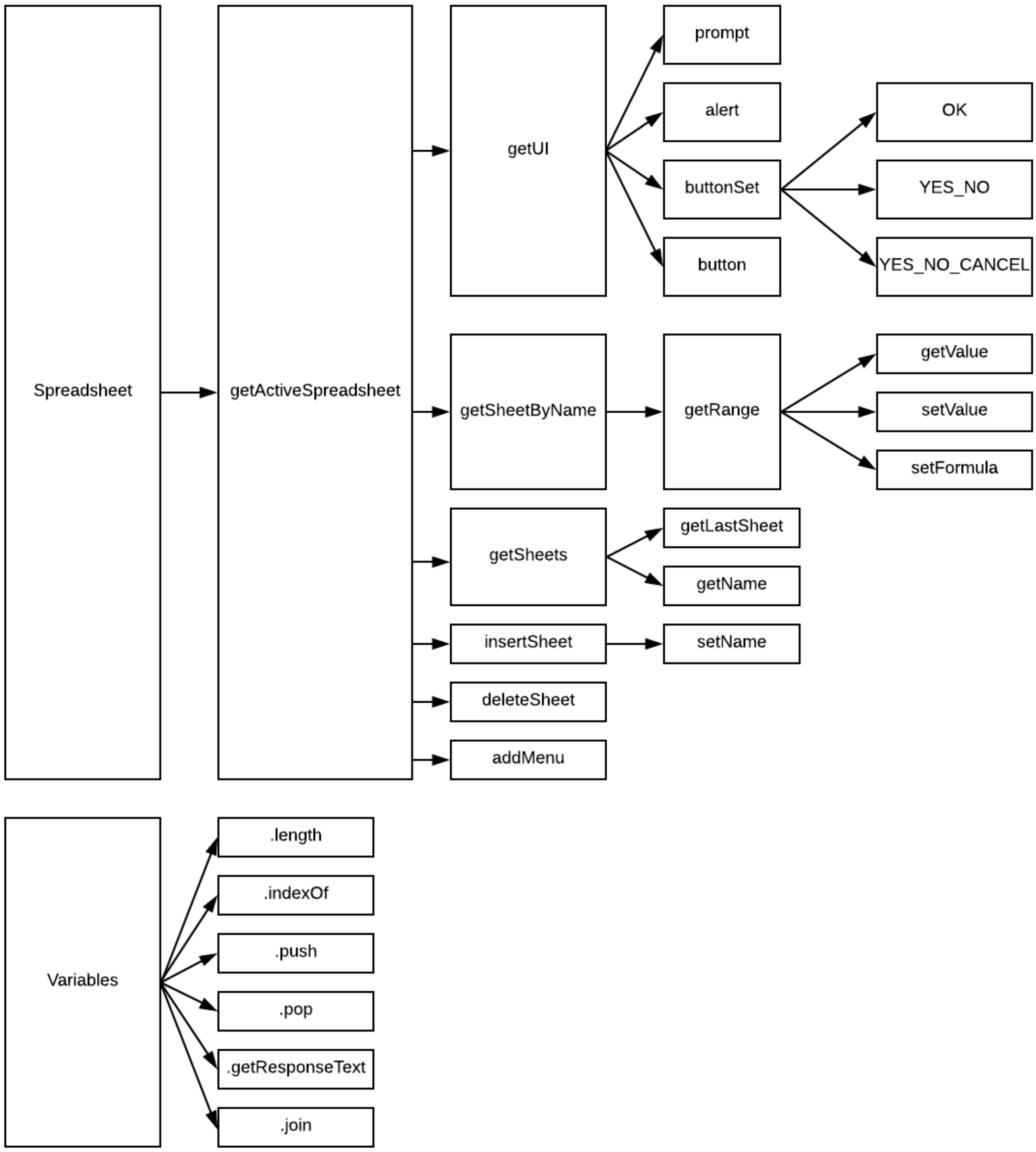

Figure 6.1: ‘Classes’ and methods that were used to realise the programmed functions which together forms the system.

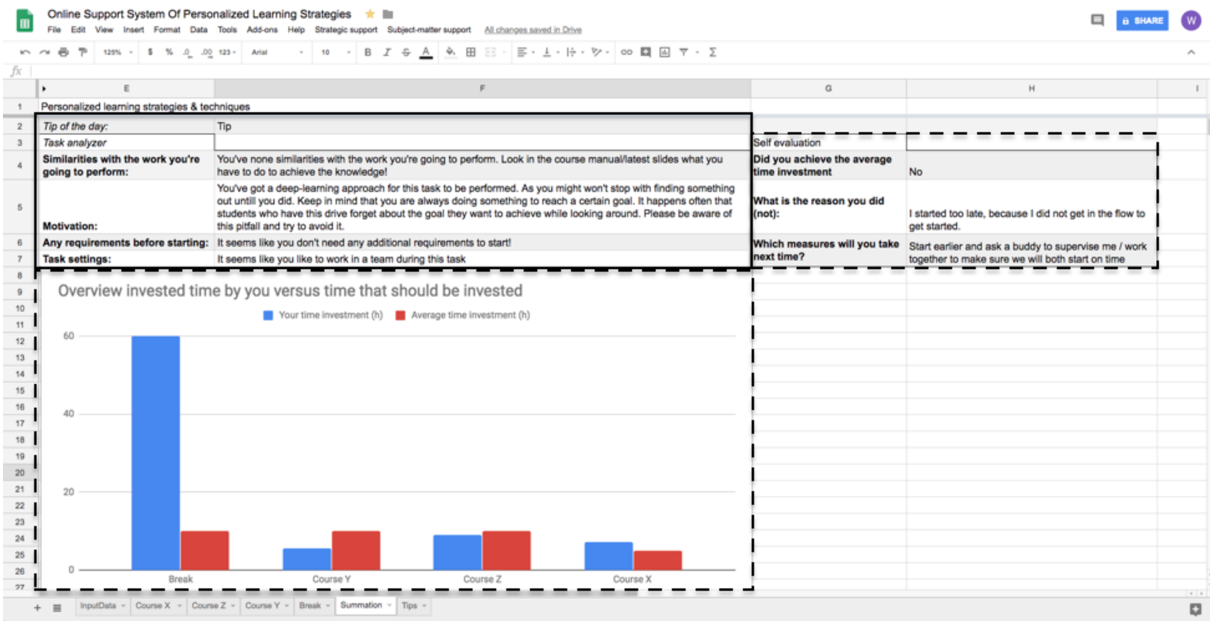

Figure 6.2: Overview of the output sheet of the entire system. The continuous line frames the output of subsystem II, whereas the dashed line frames the output of subsystem I. Note that this is all displayed in the summation tab as displayed at the bottom of the figure.

Figure 6.3: Drop-down menus to activate functions from the two subsystems.

6.1.1. Executed steps

The functions as displayed in the menus in Figure 6.3[7] were programmed step-by-step. The realisation process and results will be described in chronological order and are based to the architecture diagrams as displayed in Chapter 5. The steps that were taken are as follows:

1. Getting familiar with Google App Script
2. Getting familiar with JavaScript
3. Import data from the Google Calendar
4. Creating subsystem I: the strategic support system
5. Automate the sum of invested hours

[7] The self-reflection function was added later during the design process; during the evaluation as described in Chapter 7, this function was considered as an added value.

6. Implementing the delete generated sheets function
7. Creating the database of general study, programming and mathematics tips
8. Implementing the tip-function
9. Implementing the task analyser
10. Implementing the self-reflection function

1. Getting familiar with Google App Script

Knowledge of Google App Script was needed by the developer as this was used as platform on which the entire system was built. Google LLC (2018b) launched a quick starting guide for developers to learn how functionalities can be added to the existing Google Drive applications. This guide was followed by the developer to learn more about (1) how functions can be added and (2) to explore what knowledge was required to create the system as described in Chapter 5.

2. Getting familiar with JavaScript

Several resources were needed to reactivate prior knowledge about Java(Script) to use this subsequently to transfer this knowledge to create a usable application. First of all, the *introduction to JavaScript* course as facilitated by Codecademy was used by the developer to reactivate and elaborate on prior knowledge (Codecademy, 2018). Secondly, basic functions were attempted to be coded by using the earlier mentioned trial-and-error approach.

Subsystem I: the strategic (approach) support system

3. Import data from the Google Calendar

As the data had to be imported from the Google Calendar (as displayed in Figure 6.4) into Google Sheets, it was searched for an existing function that could make this happen. An add-on function called "Calendar event importer" as developed by *Apps Script Advisor* (2015) was found and implemented within the system. This lead to the output data which is displayed in the InputData sheet as shown in Figure 6.5.

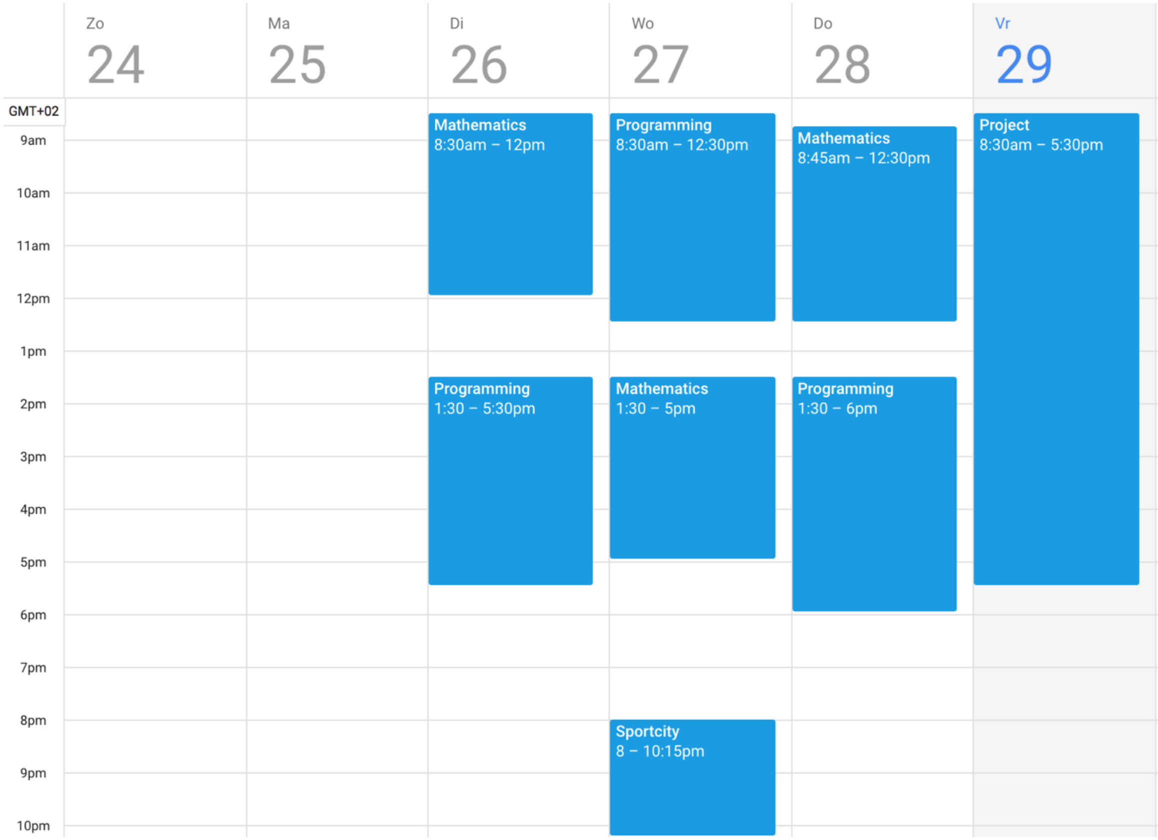

Figure 6.4: Example of planned in activities that will be displayed in the Google Calendar.

	A	B	C	D	E	F	G
2	**Title**	**Date**	**Creator**	**Description**	**Start Time**	**Duration**	**Duration Units**
3	Mathematics	6/26/2018	W.R.B. Drion	Lecture	2:30	3.5	hours
4	Programming	6/26/2018	W.R.B. Drion	Lecture	7:30	4	hours
5	Programming	6/27/2018	W.R.B. Drion	Self-study	2:30	4	hours
6	Mathematics	6/27/2018	W.R.B. Drion	Lecture	7:30	3.5	hours
7	Sportcity	6/27/2018	W.R.B. Drion		14:0	2.25	hours
8	Mathematics	6/28/2018	W.R.B. Drion	Self-study	2:45	3.75	hours
9	Programming	6/28/2018	W.R.B. Drion	Colstruction	7:30	4.5	hours
10	Project	6/29/2018	W.R.B. Drion	Self-study	2:30	9	hours

Figure 6.5: Example of the possible output data from the calendar, displayed in the sheet called InputData.

4. Creating subsystem I: the strategic support system

To realise subsystem I, the system must compare the currently scheduled activities to a certain norm which will be derived from the module manuals. This could easily be done by applying logic by using subtract- and if-functions and return the remaining hours. To clearly provide this output, it was chosen to use a bar-graph which is an already built-in option of Google Sheets (Google LCC, 2018c). An example of the result is displayed in Figure 6.6.

	Your time investment (h)	Average time investment (h)	*Remaining (h)*
Break	4	10	6
Course Y	5.5	10	4.5
Course Z	14	10	-4
Course X	7.25	5	-2.25

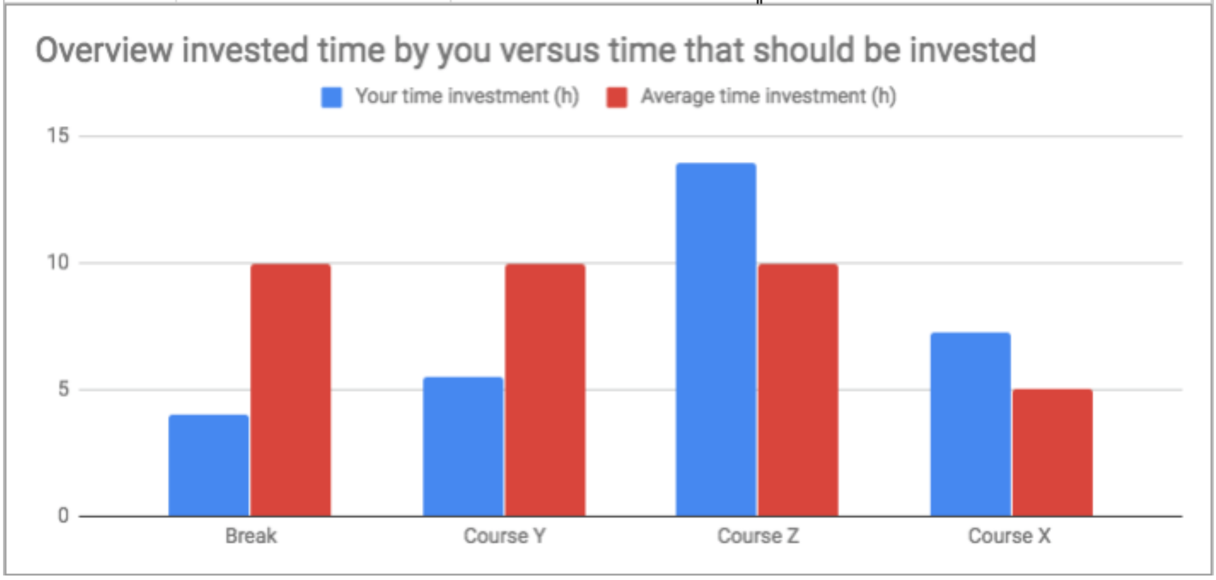

Figure 6.6: Example of the output data of the comparator of scheduled time investment compared to a certain norm. The top displays the table which is used as input data for the graph as displayed on the bottom.

5. *Automate the sum of invested hours*

As an automatic function of summing the amount of hours per activity was considered as a huge added value to the system and would significantly decrease the usage threshold, this function was implemented in the system as well. This was done by making use of already programmed classes by using the Google App Script documentation library which is accessible online (Google LCC, 2018a). The steps that this function walks through are (1) creating an array of unique activity names and create new sheets per activity out of these, (2) pushing all the corresponding hours per activity to the corresponding sheet, (3) summing the amount of hours per course and (4) feeding this data to the 'summation' sheet, resulting in the table on top of Figure 6.6.

6. *Implementing the delete generated sheets function*

To keep the overview on the interface, an additional function was added which enables the user to delete the created sheets which were necessary to sum the time investment per activity on the previous step. This was done by using the deleteSheets method derived from the Spreadsheet class.

7. *Creating the database of general study, programming and mathematics tips*

To provide a clear overview of these tips, the tips were derived from the SRL principles as described in Chapter 2, results from expert interviews as described in Chapter 4 and 5. These tips can be found in Appendix E.

Subsystem II: the study-oriented support system

8. *Implementing the tip-function*

A function was created to make sure the tips pop-up when the user requires them. The user has to select which tips are needed, resulting in a pop-up that will appear containing the corresponding tips. These tips are derived from one of the sheets which contains the database of all the tips that can be provided by putting them in an array and pop them in a dialog box, facilitated by the class UI (user interface), which is on its turn a subclass of Spreadsheetapp as seen in Figure 6.1. This database can manually be extended by the user. Besides this function, another one was added to create a dialog box automatically when the user has scheduled too few hours by using the first subsystem. This dialog box will appear to ask the user whether he or she desires to get some general study tips as seen in Figure 6.7. If this is the case, the same dialog box with general study tips will be displayed as seen in Figure 6.8.

In addition, it is possible to select one tip of the general study tips as tip of the day. This will subsequently be displayed in the 'summation' sheet which is aimed to act as reminder to act on this tip.

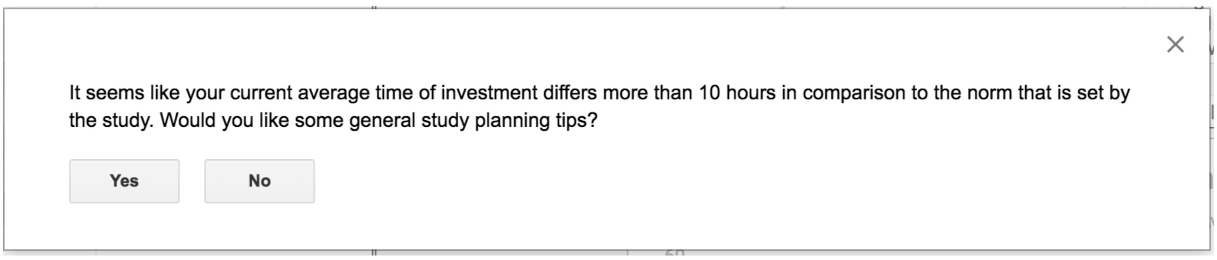

Figure 6.7: Dialog box that appears when too yew time is invested compared to a norm as calculated by the first subsystem.

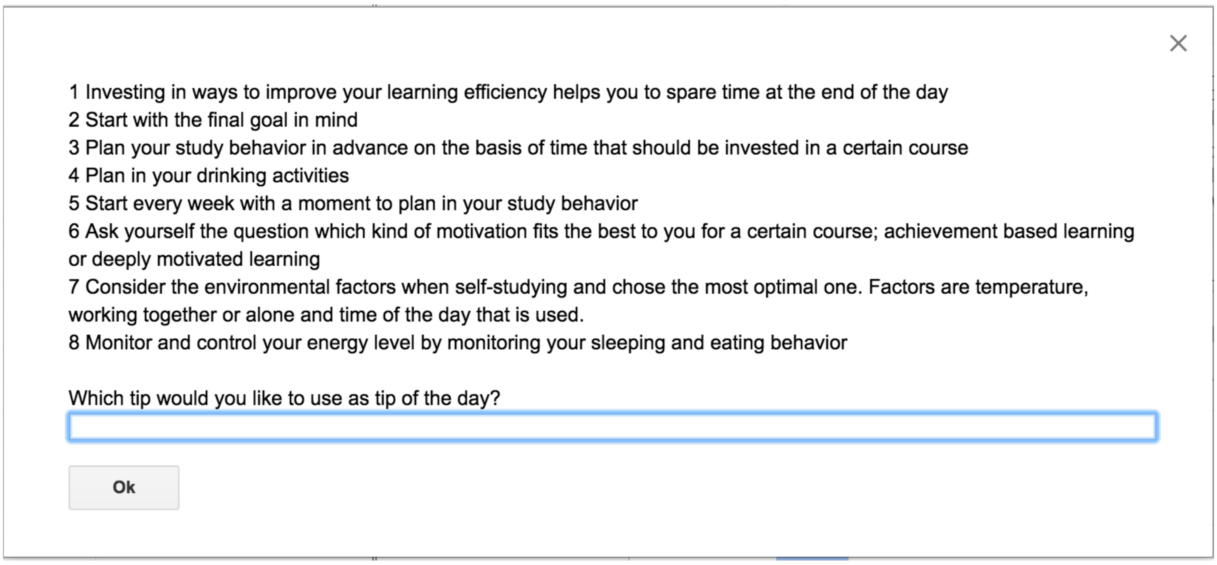

Figure 6.8: Dialog box of general study tips with the additional functionality to select a tip of the day.

9. Implementing the task analyser

The task analyser was based on the principles from the task analysis as described in Chapter 2. Four questions will be asked which aims to let the user act metacognitively. The four questions will appear through a dialog box. The output from this task analyser will be given in the 'summation' sheet (as displayed on top of Figure 6.2), as well as in the final dialog box that will show up as displayed in Figure 6.9.

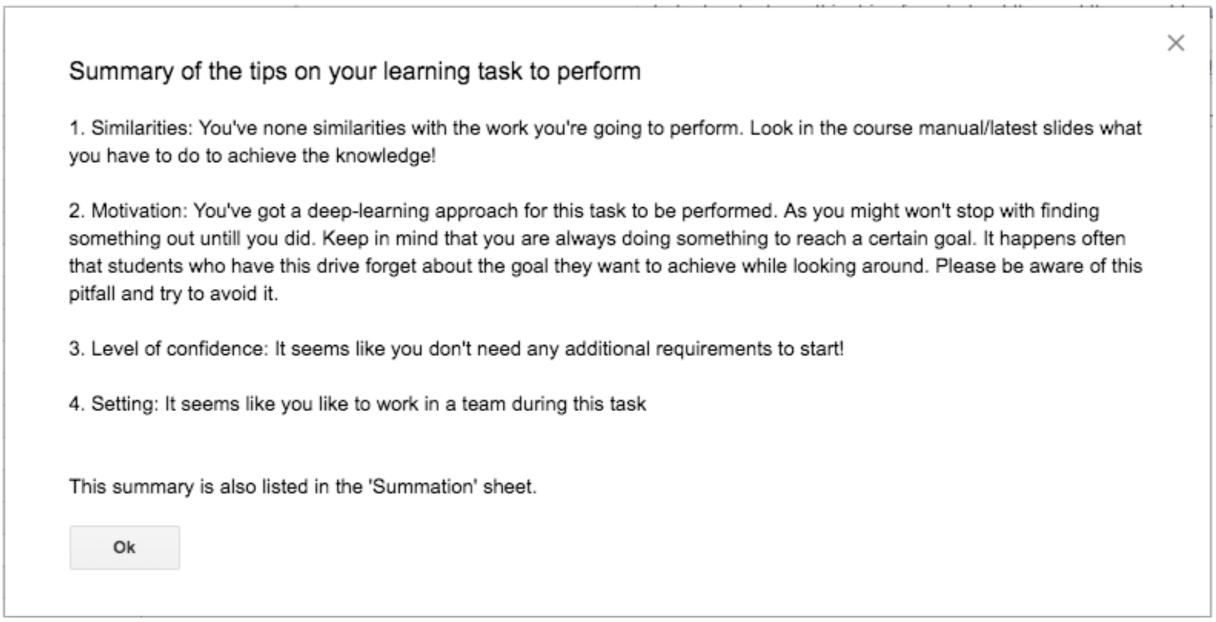

Figure 6.9: Example of the output data of the task analyser.

10. Implementing the self-reflection function

Self-reflection is considered as one of the main aspects to facilitate an increase in planning behaviour, which is also emphasized by Zimmerman as described in Chapter 2. To get a basic insight in a certain planning behaviour, three simple questions were created and will be asked through a dialog box to the user when the self-reflection function is called. The output data was displayed in the summation sheet, as displayed in Figure 6.10.

Self evaluation	
Did you achieve the average time investment	No
What is the reason you did (not):	I started too late, because I did not get in the flow to get started.
Which measures will you take next time?	Start earlier and ask a buddy to supervise me / work together to make sure we will both start on time

Figure 6.10: Example of the output data of the self-reflection function as displayed in the summation sheet.

The high-fidelity prototype of the system is now fully operational and is ready to be tested, which will be done in the next chapter.

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7. Evaluation

The need of reflection

The entire system has one main goal, which is to promote SRL among first year CreaTe students. To achieve this goal, two different subsystems were designed and realised, each with their own subgoal. Briefly said, subsystem I aims to support SRL by providing a clear overview of the currently scheduled time investment compared to a certain norm. Subsystem II provides study tips and a task-analyser to enable the student to analyse a certain task before actually getting started. According to the found literature as described in Chapter 2, these applications should support SRL.

Whereas the development of the system was continuously monitored by conducting formative evaluations, the summative evaluation evaluated with experts and (potential) users will be described in this chapter. The aim of this summative evaluation is to test whether the assumptions on the usability that were made about the system also holds true in practice, in particular by using the system. As described in Chapter 3, this evaluation was executed by conducting an expert-based review and a usability test. Firstly, the results of the summative functional evaluation that was conducted by the developer himself will be described.

7.1 Functional testing

As this concerns a formative evaluation, functional testing was continuously done during the realisation process, meaning that actual status quo of the system was continuously monitored and compared to the final system requirements as described in Chapter 5. When the realisation phase came to an end, a summative functional test was conducted. Bults (2018) stated that at least all the must haves must be accomplished. This was tested by walking through the system after the realisation phase. As displayed in Table 7.1, the system did meet all the 'must-haves' functional requirements.

7.2 Usability testing

Usability testing is meant to summative evaluate the hi-fi prototype and has three main goals as described in Chapter 3. These goals are (1) detecting whether there are any flaws in the interface of a system, (2) test whether the other system requirements are met and (3) obtain data for future recommendations. The usability tests were executed on two different types of stakeholders; the (educational) experts and the (potential) user group.

(Sub)system	MoSCoW	(Non-)functional	Requirement	**Fulfilled** (Y/N)
Online support system	Must haves	Functional	The system must be online accessible for CreaTe students of the UT via Canvas LMS	Y
	Should haves	Functional	There should be interaction between subsystem I and II	Y
Subsystem I: strategic planning support	Must haves	Functional	The subsystem must support the user to schedule (study) activities	Y
			The subsystem must compare the currently planned study time investment to the norm which is defined by the CreaTe bachelor program	Y
			The subsystem must compare currently planned non-study related activities to a certain norm, distracted from scientific literature and/or experts	Y
	Should haves	Functional	The subsystem should have an integrated calculating subsystem that automatically reduces the amount of time to invest in a certain activity when it gets scheduled	Y
			The subsystem should be able to let users self-evaluate their planning behaviour	Y
	Could haves	Functional	The subsystem could have a rewarding subsystem for achieving certain goals/tasks	N
			The subsystem could have an option to give peer-to-peer feedback to keep track of each other's study contract and progress	N
Subsystem II: study-related support	Must haves	Functional	The subsystem must provide general study tips which are mainly based on SRL principles and educational experts	Y
			The subsystem must provide a subject-specific tool for the mathematics and programming courses offered in the first two modules of the Creative Technology bachelor program.	Y
	Should haves	Functional	The subsystem should display a pop-up to offer study tips when too less hours are planned in by the user	Y
	Could haves	Functional	The subsystem could have the ability to analyse a task based on SRL principles and variables	Y
			The subsystem could have the ability to facilitate an online community with first-year students and older students who can act as mentor	N
			The subsystem could have an ability to document pre-set goals and a self-reflection on it	N

Table 7.1: Results of the functional requirement tests.

7.2.1 Expert based review

The expert-based review was conducted, following the procedure as described in Chapter 3; via a cognitive walkthrough the experts were asked to review and comment on a series of tasks, executed by the developer. They had to think-out loud while these tasks were conducted and a semi-structured interview was conducted afterwards. Two experts have been interviewed, which were the educational scientist of the CreaTe bachelor programming and a mathematics teacher. These were selected as they both do have a broad interest in education and didactics and were therefore considered as experts.

7.2.1.1 Results of expert review (educational scientist): It became clear that the system as how it was designed was not conclusive enough to learn and thus to take constructive measures to improve a certain learn behaviour. To ensure this learning curve, a small brainstorm session was conducted during the expert review. The result of this session was that an extra function was added to subsystem I which enables the user to conduct a self-reflection on the created planning. This function must be based on three questions; (1) is the norm of time investment met, (2) what is reason that it is (not) and (3) would you do something different the next time you are creating a planning. While the original system was only focussed on the forethought phase of the model as described by Zimmerman (1989), the answers on these questions (which can be considered as part of the self-reflection phase of this model) were assumed to be an essential requirement to promote SRL. As it was of this importance, this evaluation was immediately added on the system as described in step 10 of the previous chapter.

Besides the functionality of the system, the user test was also discussed via a cognitive walkthrough. It became clear that some initial instructions and awareness what the ultimate purpose of the entire system were missing. These were added to the final user test.

7.2.1.2 Results of expert review (mathematics teacher): Overall, the system was considered as a potential added value for students to support to create some insights to plan in a more efficient way and to stimulate to act premeditatedly. Still, some nuances should be made. First of all, there are situations imaginable wherein the tool becomes a goal whereby the output data is misinterpreted by the user. To prevent this, false precision has to be avoided, by which is meant that the user must be aware that the norm to which the time investment of the user is compared with is just a guideline instead of a fixed rule. Subsequently, the system leaves room for social desirable answers. To avoid these, the user has to be assured that the system is a support tool and he/she will never be dealt on the given data. In conclusion, a tool is as good and suitable as the person who uses it. The degree of honesty of the user is decisive for the rate of success of the system.

Besides a general consideration, more detailed questions were asked about the subsystems and their functions. The task analyser was reviewed as useful, although it was also considered as very basic. It can provide some initial insights whereon a teacher/student can build on. The latter is a necessary requirement to maximize the effect of the system and once again, the user should always be aware that is a tool and not a goal in itself.

As there were only two mathematical study tips implemented, asked was for more study tips in the form of a step-by-step plan. The elaborated tips can be found in Appendix G. Furthermore, some additional tips were provided what should not be done in case of time shortage in preparation to a mathematical exam. Due to time constraints, these tips were implemented in the system but not before the user tests took place.

7.2.2 User tests

As described in Chapter 3, the summative user evaluation will ideally be executed right after the expert reviews. However, due to time constraints, the expert review with the mathematics teacher did take place after the user tests.

The user evaluation was conducted by selecting five CreaTe students, whereof three of them were first-year and two of them were third-year students. The setting was located at the university for practical reasons and because students are familiar with this place. The series of tasks were carefully formulated and evaluated with the educational scientist as described in the expert based review section and adjusted according this evaluation. The detailed form can be found in Appendix F.

The user test consisted of a quantitative survey that the participants had to fill in after they completed the series of tasks. This survey contained 6 items about both subsystem I and subsystem II. This survey was extended with additional questions to ensure that the participants could give comments on certain functionalities to obtain qualitative data as well when they considered this as appropriate to substantiate their opinion. As using a focus group has the potential to lead to new insights through discussion among the participants, this method was also used to get a as comprehensive as possible representation of the user experience. Three out of five participants took part of this group.

7.2.2.1 Results from quantitative survey: The results from the quantitative survey are displayed in Table 7.2 and Table 7.4. The user satisfaction was based on the 6 items surveys and calculated by taking the mean of these item means as displayed in Table 7.3 and Table 7.5. To determine and eliminate possible outliers, the 1.5 * interquartile range rule (Upton & Cook, 1996, p. 55) was used on both tests. No outliers were found when doing so. Overall, the participants were positive about the system (average item mean > 2.5).

Item	Question or statement	Item mean
1	I felt supported by the system to create and execute a realistic study planning	3.6
2	I experienced the self-evaluation function as an added value to gain insights on my planning behavior	3
3	The subsystem will contribute to increase my planning skills	3
4	The system will contribute to the sense that creating task analyses and schedules will possibly lead to a surplus of time	3.8
5	I managed to use the system without additional instructions	3.8
6	The number of clicks I had to made to operate the system are logic and acceptable	3.2

Table 7.2: User experience about subsystem I. Item means (based on a 1-5 Likert scale; 1 = strongly disagree, 5 = strongly agree) per question/statement.

			Statistic	Std. Error
User satisfaction	Mean		3,400	,1549
	95% Confidence Interval for Mean	Lower Bound	3,002	
		Upper Bound	3,798	
	5% Trimmed Mean		3,400	
	Median		3,400	
	Variance		,144	
	Std. Deviation		,3795	
	Minimum		3,0	
	Maximum		3,8	

Table 7.3: Level of user satisfaction of subsystem I based on the 6 items survey that was conducted ($M = 3.4$, $SD = .3795$).

Item	Question or statement	Item mean
1	The general study tips were useful and definitely an added value to my study behavior	3
2	The mathematical study tips were useful and definitely an added value to my study behavior	2.8
3	The programming study tips were useful and definitely an added value to my study behavior	3.4
4	The task analyzer will be an added value to think through a certain task before it is performed	3.4
5	I managed to use the system without additional instructions	4.6
6	The number of clicks I had to made to operate the system are logic and acceptable	3.6

Table 7.3: User experience about subsystem II. Item means (based on a 1-5 Likert scale; 1 = strongly disagree, 5 = strongly agree) per question/statement.

			Statistic	Std. Error
User satisfaction	Mean		3,467	,2565
	95% Confidence Interval for Mean	Lower Bound	2,807	
		Upper Bound	4,126	
	5% Trimmed Mean		3,441	
	Median		3,400	
	Variance		,395	
	Std. Deviation		,6282	
	Minimum		2,8	
	Maximum		4,6	

Table 7.5: Level of user satisfaction of subsystem II based on the 6 items survey that was conducted (M = 3.5, SD = .6282).

7.2.2.2 Results from qualitative data analysis: Although the UI was considered as slightly chaotic, the participants generally agreed the system as useful meaning that it will probably contribute to increase study efficiency of students. The participants all agreed on the statement that the system I contributes to create insights that proper planning could lead to a surplus of time. Still, it was also stated that this system leaves room for social desirable answers and that the system requires time to use. Time that does most likely not immediately lead to the intended effects. As a result, the success is sensitive to the patience of the users. The opinions about number of clicks required to operate subsystem I were divided. Participant 1 stated that “the number of clicks could be reduced to a few less”, whereas participant 3 stated that “Once you know what menu-items is which it’s easy enough to navigate around the system”. 2 out of 3 participants stated that they would like to use subsystem I.

The second subsystem was also evaluated. Overall, the tips were considered as too general to use and most of them were “like kicking open doors that are already open, so not everyone would consider them as much.” No additional instructions were required once a participant knew where they can be found and the number of clicks to execute the functions works fine, although one participant stated that “the number of clicks can be reduced. It's a lot of pop-ups right now.” The programming tips were more liked as they all would think this would contribute to get started with programming, whereas none would think that the mathematical study tips would help them to get started with mathematics.

References

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Zimmerman, B.J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*, 329-339.

Part III

Conclusions

8. Conclusion and discussion

Involve them, and they will understand

This chapter consists of three parts. First of all, the conclusion based on the research questions will be provided. Secondly, the limitations that go along on this project will be discussed. The chapter will end with recommendations that are divided over two subclasses. The first subclass will describe the recommendations for the client (the CreaTe bachelor program) whereas the second subclass will describe recommendations for future work like a follow-up project.

8.1 Conclusions on sub questions

The final goal of this thesis was to design, create and evaluate a prototype of an online application that facilitates principles of SRL on first-year students who follow the bachelor program Creative Technology at the University of Twente. To conduct the analyses that were needed to find out the different aspects that goes along with this goal systematically, three sub research questions were and one main research question was formulated. Within this section, the conclusion of each sub research question will be discussed which will eventually lead to the conclusion of the main research question: *How can the principles of SRL be used in an online study support system to improve study efficiency among Creative Technology bachelor students?*

8.1.1 First sub question: The first sub research question was formulated as *what are the possible relevant theories and technologies on which the online support system can be based on.* An elaborated literature and state-of-the-art research was conducted which is described in Chapter 2, where the conclusion on this topic can also be found. The most important findings that were used were the forethought and eventually also the self-reflection phase of the learning process as described by Zimmerman and Desmedt. Several factors such as environmental factors, motivation, affectivity and self-efficacy were included in the system as well.

Based on the state-of-the-art research, it was concluded that such a system did not exist yet, or rather said, was not publicly accessible and therefore not found.

8.1.2 The second sub question: The second sub research question was formulated as: *Who is the actual potential user group of this project?* The system will mainly focus on first-year (CreaTe) students, as adopting SRL strategies in an early stage in the curriculum will most likely lead to the biggest impact. Furthermore, first-year CreaTe students who have difficulties with the programming and/or mathematic courses are set as main target group of the (sub)system (II).

Yet, according to expert interviews, every (CreaTe) student can actually benefit from the system, although the one will be better supported than the other. Especially students who are eager to plan well while not having that much of education on this topic are expected to benefit from the system. Furthermore, this output data of the system can be used to track a student for a while which can be used as input data for the development of a certain study strategy. At last, students who have issues to get started with the mathematical and programming courses can use the system to get more insight on this.

8.1.3 The third sub question: The last sub research question was formulated as: *Which factors should be taken into account to maximise the effect of this online study system?* First of all, subsystem I will only work when the input data is valid, meaning no social desirable answers are given by the users. This means that users must experience that the system is in their favor and will not be used to deal with students who do not properly plan their study time. Secondly, the users can firstly be forced to create a proper study planning by using the system (e.g. by implementing the system in a course), in the end they have to acknowledge the relevance of such a system as the aim is that they become self-driven learners.

8.2 Final conclusion

Taking it all together, it can be concluded that the principles of SRL can be used by the designed system which is programmed in a Google Sheets document. This system has four functionalities divided over two subsystems. The first subsystem is based on strategic planning support, which contains the planning tool and a self-reflection analyser. The second subsystem is based on subject-matter support. This entails a function to analyse a (learning) task that has to be performed before getting started, general study tips, programming tips and math tips.

It is most likely that if the system gets facilitated by as part of for example the professional development courses that are offered in the first two modules, it will entail a quality stroke on the self-driven learning core aspect of the Twents Education Model. With an overall user satisfaction score of M = 3.4/5 on the first subsystem and a score of M = 3.5/5 on the second, the system is considered as an added value by the test group. This is what also became clear from the results of the qualitative research on both experts as students. Given that all the participants agreed on this fact, it is supposed that is it valid to conclude that the system will definitely have an added value in the sense of supporting first-year CreaTe students with their planning behaviour, mathematics and programming courses and studying in general. This implicates that the system will improve the study efficiency of CreaTe students.

8.2 Limitations of this thesis

8.2.1 Limitation of a tool in itself: When developing and using a tool, one must realise that the usability of the tool is strongly dependent on the intentions of a user. In other words, a tool is as strong as the user who uses it. This can both be positive (thus being an advantage) or negative (thus being a limitation). This dependency is of that importance that the use and success rate of the system on long-term does entirely lies on this aspect.

The level of customization: Although subsystem I mainly focuses on facilitating conditions that aim to provide insights which can be used to create a realistic planning, the system is limited on the customization of the in-depth study tips that are provided. Even though the user will get tips about how to get started and how to take decent preparations on a certain learning task, no further in-depth customized study tips are currently provided by the system. To really implement such a function in the system is hard to do, as there are many factors that are defined by the study that has to be taken into account.

8.2.2 Target group: The project is currently focused on (first-year) CreaTe students, who also participated as final user testing group. Although there are indications that reveal that the system would be applicable on other study disciplines as well, it was left out of the scope of this project as this is not directly of interest for the client.

8.2.3 Selection of SRL theories: As many theories were found when looking for SRL strategies, a selection was made among them. This implicates that some theories are left out of the scope of this project. Although the theories that were actually described were selected carefully and it was attempted to oversee the most important findings in the field of SRL regarding the goal of the project, some theories could have been slipped through. Besides, a selection over this selection also took place to select the theories that were applicable in the time that was given to execute the project. This leaves out some principles which can be considered as a limitation of the project.

8.2.3 Graphical user interface: As it was thought to create a system within the UI of Google Sheets and Google Calendar, it was decided to focus more on the functionality than on the UI of the system. As also became clear from the usability tests, more attention could be invested on this aspect which will most likely increase the user satisfaction of the system(s).

8.2.4 Testing procedure: As also mentioned in Chapter 3, the testing procedure was mainly focused on user testing which is slightly different in comparison to the traditional research method as it is more based on the practical feasibility. This resulted in a small sample of users on which the system was tested (N=5) which decreases the reliability of the study when compared to a larger sample and could lead to generalization issues.

8.3 Recommendations for the client

Although CreaTe facilitates a mentor and a study advisor to which students can go when they seem to get in trouble, the experience (based on expert evaluations) reveals that students are often too late to ask for help. Even though there is evidence that a trial-and-error approach does work to become a self-driven student, it is very time-consuming and not efficient at all. It was found that SRL was already integrated in the CreaTe bachelor curriculum, as it is, for example, part of the professional development courses, taught in modules 1 through 8. However, the results also reveal that it is not taught consistently, nor is the know-how recorded as the description how these SDL should be taught is missing. From the data that was obtained to get an elaborated view on the applicable possibilities, recommendations can be distilled to increase the study efficiency among CreaTe students. Furthermore, it is assumed that the system will have a higher added value to the students if it will be implemented simultaneously with the recommendations which will also contribute to this goal.

8.3.1 Study contracting: The study contract approach as described by Taylor (see Chapter 2) could work to let students priorly set learning goals, aiming to implicitly motivate students to think through the learning process of an entire module before it will actually start. The study contract is actually an agreement which the student makes with him- or herself. It contains of personal learning goals that a student wants to achieve during a module and where the biggest threads lie to fail the module. These learning goals must be in line with the learning objectives of the module.

To integrate this study contract theory successfully, it is advised to reorganize the mentor system as how it works now. To avoid social desirable answers, the contact on the first line should not be someone from the university staff. To make this concept work, a division of tasks was created as displayed in Table 7.1. The first-year student will get coached by a second-year student. To add value to the second-year student to coach a first year, he/she will also be coached how to coach by a mentor who is actually an academic staff member. This mentor will additional act as stick behind the door to guarantee the quality. The third-year student will eventually be coached by the GP supervisor.

Coachee	**Coach**
First-year student	Second-year student
Second-year student	Mentor *(academic staff member)*
Third-year student	Supervisor GP *(academic staff member)*

Table 7.1: Recommended distribution of the coaches and coachees.

8.3.2 Learning styles: Within Chapter 3, several approaches to learning styles have been reviewed. A lot of controversial literature was found on this topic, which makes it difficult to make use of it. Eventually, it was not implemented on the system as the most plausible theory revealed that a learning style is rather task-dependent than personal, which was too complex to implement in the given time. However, as this theory can still be useful to increase the study efficiency, it is recommended to implement this in teacher trainings.

8.4 Recommendations on future work

Within this section, several recommendations will be described on future work. Most of them are based on the current limitations of the project and are aimed to decrease or eliminate them.

8.4.1 LTI[8] based web-application: The system was initially only created for first-year CreaTe students. As the concept is also usable in a much broader field as the entire European Union is based on the ECTS, the first subsystem and task analyser of the second can easily be extended to other studies as well. Before that is actually done, it is recommended that the UI will first be improved. What is currently left out of the scope purposely due to restricted project time, is the development of an entire LTI web-application that incorporates the functionalities of the current system. By doing so, the system can add an extra functionality to Canvas LMS, ensuring a low(er) threshold value and a more user-friendly UI. According to one expert that was interviewed, this could be an entire IT bachelor project in its own.

8.4.2 Extending the research reliability: To test the effect-size of the system in a more valid way that is considered as such by traditional scientists, an empirical experiment would be an added value. Furthermore, this increase of participants will make it implicitly easier to generalise the findings to the entire student population. Furthermore, a qualitative questionnaire can be attached to a possible quantitative survey, which leads to more in-depth insights and could lead to major improvements of the system.

8.4.3 Incorporating state-of-the-art MOOCs: On this moment, there exist many massive online open courses (MOOCs) such as Codecademy and other learning channels such as Khan Academy that are specialized on online teaching. As practicing and customized feedback is an integrated part of these courses and because these systems rely on feedback that is provided from an immense (user) group, these systems do have a major advantage and are probably far more extended in comparison to a system that is focused on local users ever could be. Therefore, it would be a huge added value to add the MOOCs that are currently available, selected on common ground with subjects that are part of the CreaTe curriculum.

8.4.4 Extending the reflection tool: As one of the limitations was the selection of SRL theories, these can be extended. Van Pinxteren (2018) created a reflection support system that can be

[8] LTI: Learning tools interoperability

used to reflect on the system in a more in-depth way. This system could be use in addition to this system which could lead to a more comprehensive whole.

References

Van Pinxteren, V.A. (2018). A Supporting Instrument for Reflection Based Activities in Higher Education. Enschede, The Netherlands: University of Twente.

Appendices

Appendix A: Audio records and reports of the interviews

In total, about 11 interviews were conducted and more than 30 brainstorm sessions to design and evaluate the system. The main findings are already described within the thesis itself. To make it possible to trace the data, a folder was made wherein all the data can be found. An overview of the different interviews can be found in Table A.1. Please request for access if you would like to enter the folder.

Participant(s)	File name	Type
Fellow students	Exploratory research	Survey
	Survey on first-year students	Survey
	Survey user test	Survey
Educational consultant/scientist	Interview educational expert	Semi-structured interview
Study advisor	Inleidend gesprek Thea	Open interview
Math teacher	Interview lecturers	Semi-structured interview
	Math expert evaluation	Semi-structured interview
Programming teacher	Interview lecturers	Semi-structured interview
Education committee S.A. Proto	Interview voorzitter EduCie	Semi-structured interview
	Interview EducaCie	Semi-structured interview
TELT	Interview software developer	Semi-structured interview
	Interview Linlin	Semi-structured interview

Table A.1: Interviews that has been conducted wherefrom the data can be found in the folder on Drive.

Appendix B: Log of the results during the ideation

The log of brainstorm sessions, interviews are provided within this section.

4.2.3 Brainstorm session no. 1, 25 June 2017

On June 25th, the intake took place, accompanied by B**** and F****. During this intake, the initial idea was discussed and two research questions were formulated;

1. How is it possible to increase and eventually optimise the student performance of a student through the usage of technology?
2. How it possible to create insight for the student within his/her own learning process?

To gain more insights on these topic, the following interventions were set up and took place:

1. A meeting with K**** S*****, educational scientist at the University of Twente;
2. A short need analysis to obtain a prior insight in whether this problem is also endorsed by students
3. The start with state of the art analysis, which is fully elaborated and described in chapter 2.

4.2.4 Interview no. 1: K***** S***** - educational consultant at the University of Twente - July, 2017

The first interview was conducted with the educational consultant at the UT. She was quite excited about the initial idea. Though it was admitted that a way should be found how students can be motivated to use the system. A peer-to-peer system could be the outcome, whereby students have to check their fellow student.

4.2.5 Survey no. 1 - July 2017

In order to investigate whether there is a potential support from the potential user group, a qualitative survey was conducted among people who all follow a study at the University of Twente and all visited the normal Dutch school-track; from elementary school to high-school to university (n = 8). The entire survey can be found at Appendix A. Although this survey is not representative for the entire population of academic students, it gives an indication. The following three conclusions were found;

1. Most students never had lessons in learning how to learn effectively. This is partly line with the statement of Gijselaers.
2. Every participant agrees on the positive influence the availability of such lessons would have.
3. Seven out of eight participants would actually use the platform where was thought of to become a better student, given that it is on voluntary base and can therefore be consulted anytime that it’s needed.

4.2.6 An interim conclusion, September 2017

Taking all the data together it can be concluded that sufficient evidence is found to continue with the project. The project idea is supported by professionals in the field, as well as by a majority of the students that were interviewed. In order to make it more personally and to respond to the needs from the students and university, further research have to be conducted among students, educational experts. Furthermore, a literature research has to be conducted to find out more about the underlying theories. As the project has to be completed within 17 ECTS, it was decided to only focus on first-year CreaTe students who are currently in their first two modules of the bachelor program.

4.2.7 Interview no. 2: T**** ** K*******, study advisor at the University of Twente - September 2017

An interview was conducted with T*** ** K******, study advisor at the UT. In general, her profession is to support students who have encountered difficulties during their study, which can be of every nature. According to the study advisor, there is missing some explicit awareness among students about learning strategies and how to use them.

4.2.8 Interview no. 3: K***** S******, educational consultant at the University of Twente - October 2017

An interview was conducted again with the educational scientist, aiming to learn from her expertise in learning strategies and what the possibly constraints are of this graduation project. The entire interview can be found at Appendix XX. The key points are listed:

1. The statement of the study advisor that there exist less awareness among students about learning strategies is confirmed.
2. The small awareness of learning strategies that is present, is not acted on. For example, students know they should not delay their work but still wait till the last moment to start learning
3. In general, planning and reflection on a learning process are missing. From convenience, it is easier to continue with using (subconscious) a certain strategy than to change it. Furthermore, breaking the pattern is not necessarily encouraged by the study and even if a pattern is broken and a new learning strategy is used, it is not translated into the new module.

4. Taking it all together, the biggest challenge is to convince students to change their way of studying, which can possibly be done by let those students experience the success of planning and reflection.

4.2.9 Brainstorm session no. 2. December, 1, 2017.

Out of the data that was collected from earlier interviews and literature research, an elaborated project idea was formed; creating a web-based application that provides personalized study advice. The input data was divided over three variable categories; (1) personal variables, (2) environmental variables and (3) task variables. The output variables were defined as (1) personal learning goal of the module/course and (2) learning strategies based on the preferable environment variables and the task to be performed. The idea was that the output variables together forms a "study contract".

To evaluate the results with CreaTe students, a focus group has been set up. This focus group consisted of three other CreaTe students who were in their final modules of this study and had therefore a clear overview to critically analyse the idea. Before the former project idea was revealed, it was first asked what they knew about SRL skills, how they achieved them and what their main motivation was. It became clear that a lot about learning strategies was figured out by self-conducted research/experimenting. They all admitted that learning these skills in a more structured way at the begin of the module would probably helped them to get through the study easier. They also admitted that their motivation was mainly achievement-based.

The idea of forming commitments at the begin of the module in the form of a "study contract", was well received. Though, a feedback loop c.q. evaluation of this study contract was important. One of the participants indicated that integrating general study tips in the platform would be appreciated. The entire focus group agreed that such a platform would be of greatest value at the begin of a student's study carrier. Therefore, they stated, the platform should be used in the first two modules.

4.2.10 Brainstorm session no. 3: E**** F****, lecturer at the CreaTe bachelor program - March 2018

A selection of relevant data was been made and discussed during this meeting with F****. The conclusions that were derived, were as following:

1. As general study tips were considered as valuable, this idea was further discussed. To concretize this more, it was thought of to provide study tips at the moments that students would need them at most; during the courses that were devoted as difficult. From Drion's and Faber's their own perspective, this were mathematics and programming.
2. To ensure an anchoring of the entire idea in the curriculum, it was thought of to make the idea a standard part of the course professional development. This course was already offered for first-year CreaTe students and the learning objectives are in line with the idea of this project.

4.2.11 Elaborated project idea no. 1, March 2018

In short, the elaborated project idea is divisible in two main "tools", which aims to transfer and facilitates the applicability of SRL strategies. The first one is the tvtool, based on mathematics and programming.

To learn more about these subjects and to learn more about their difficulties, teachers of these subjects were interviewed.

4.2.12 Interviews with F*****,. M***** and D* W****, all lecturers of first-year CreaTe courses - April

The solutions that are formed through a brainstorm session with the interviewees are listed that could be provided to tackle the main problems. These solutions are ought to be implemented in the system and are therefore classified by three categories which are based on the two main pillars as described in the final idea section of Chapter 4. The three categories have also been identified by the numbers 1 to 3:

1. The solution can be used by the system that will supports strategic planning;
2. The solution can be used by the system that provides study tips;
3. The solution can neither be used by the first system, nor can it be used by the second one. Therefore, the solution is further left out of the scope of this project.

Programming

The data is obtained from expert interviews F***** (on April, 4th) and M***** (on April, 6th), both lecturers programming at the UT.

Main problems:

1. Students do not start on time;
2. No responsibility for their own learning process and/or future planning from the start of the module; a long-term task analysis is not executed. Instead, students make exercises for the teachers;
3. Knowledge is not transferred from earlier learning moments; students do not activate their prior knowledge;
4. Students start with programming instead of conceptualizing an assignment; they miss an overview how the final product should look like;
5. Students are too early satisfied; no structure is added to the syntax;
6. Instead of local variables, global variables are often used.

Solutions:

A. Work with a partner system to create a social control mechanism
B. Task analysis/goal setting; let students for themselves decide what they want to achieve during the module and set the path to get there
C. Start with an activation of the prior knowledge
D. Visualize the final product by creating a sketch to get a clear overview what should be done and being able to divide it into several parts
E. Make sure a cleaning up session is done from time to time to structurize the entire code.
F. Use local variables when that is possible to keep the code logical and structured .

Mathematics

To learn more about the difficulties of mathematics, D* W**** the mathematics course coordinator of module 1 and 2, was interviewed.

Main problems:

1. Error analysis of exercises; students do not analyse where it went wrong during their learning process/steps, instead they ask for help immediately;
2. No responsibility for their own learning process and/or future planning from the start of the module; a long-term task analysis is not executed;
    a. Studying can be considered as a new phase in life which brings a lot of other things to worry about. Students should take this into account when creating a study planning.
3. Prior knowledge is not activated; students do not take time to think about what they already know about maths and just start;
4. During colstruction, students start working on other courses that do have many deadlines. This indicates planning problems;

5. Lectures are not prepared; students do not know what it is about.
6. If a planning is made and executed, it is not used as measuring instrument to learn from it

Tools:

A. Creating a location where students can document their study steps (1)
B. Task analysis/goal setting; let students for themselves decide what they want to achieve during the module and set the path to get there (1, 2)
C. Make sure students take into account that there will be more than their study as a new phase of their life starts and ask them which modules they want at least to finish successful.
D. Let students also plan in their extra-curricular activities (1);
E. Set up a standard to make sure students prepare their lectures well (e.g. two questions that students have to ask themselves before going to the lectures) (2);
F. Execute a midweek and endweek evaluation to evaluate the prior planning and write down adjustments that has to be done in the next week planning (1).

4.2.13 Interview no. 4: Sarah Hoekstra, officer educational affairs study association Proto, April 13

To learn more about the prevailing thought and attitude of the first-year CreaTe student, the officer educational affairs of the study association (of CreaTe) Proto, Sarah Hoekstra, was interviewed. According to this interview:

- Although it is common that students are satisfied with achieving 6 out of 10, no planning is created to do so

A. The corresponding problem is that many students do not know what a proper planning entails
B. The urgency of proper goal setting is not recognized. This can be explained as the first two modules are achievable without doing so. This is also the reason why significantly amount of students fails to achieve this “wanted” 6 in the third module.
C. Furthermore, students do not always recognize their responsibility to their own learning process
D. Professional development would be a nice possibility to include the platform

4.2.14 Brainstorm session no. 4 - L** D******, BSc. Biomedical Engineering, April 25th

As many input was collected, it was important to connect the dots in order to set up the preliminary requirements of the application. Three conditions were set up to find someone who could help me to specify the elaborated idea. First of all, the person should be independent and therefore should not have been involved in the project yet to reduce potential bias to a minimum. Secondly, the person should have the same level of thinking as he/she should be able to analyse and help me to make conclusions, considering the pro’s and con’s. Lastly, the person should be easy to approach as the brainstorm session as soon has to take place as possible.

Dirksen was found to conduct the brainstorm session with. He was not earlier involved within the project, have the same level of thinking as he just finished his bachelor biomedical engineering and was easy approachable.

The structure of the conversation was first to share the collection of data, ultimate goal of the assignment. Next comes the brainstorm session, goal setting and subsequently the selection of different data to be used.

The outcome of the brainstorm session was as following:

1. It is too hard to focus on all the phases of the model of Zimmerman. Therefore, a selection was made. It was concluded that we will only focus on the forethought and evaluation phases.
2. As there exist many planning tools already, it has been chosen to mainly focus on the task analysis and goal setting during the forethought phase, and leave the strategic planning for what it is.
3. It was decided to use ECTS and thus study hours as tool and measuring instrument to create a strategic planning. These study hours were determined per course and the corresponding type of education. For example, the 5 ECTS course programming was divided into 2 ECTS lectures, 1 ECTS tutorials and 2 ECTS self-study moments. This was subsequently divided over the 10 weeks that represent a module.

Appendix C: System architecture of the self-evaluation and task-analyser

The diagrams of the system architecture of the task analyser (Diagram E.1) and the self-evaluation (Diagram E.2) are displayed.

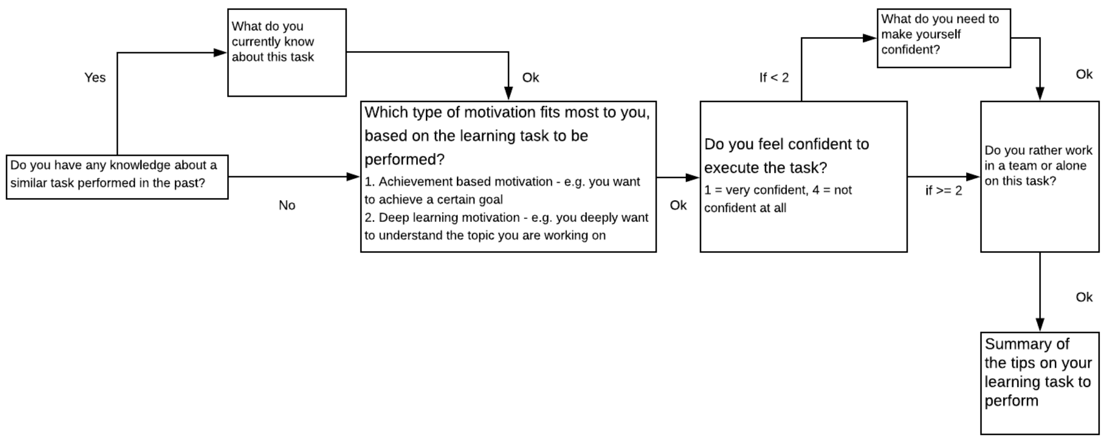

Diagram E.1: The system architecture of the task analyser function of subsystem II.

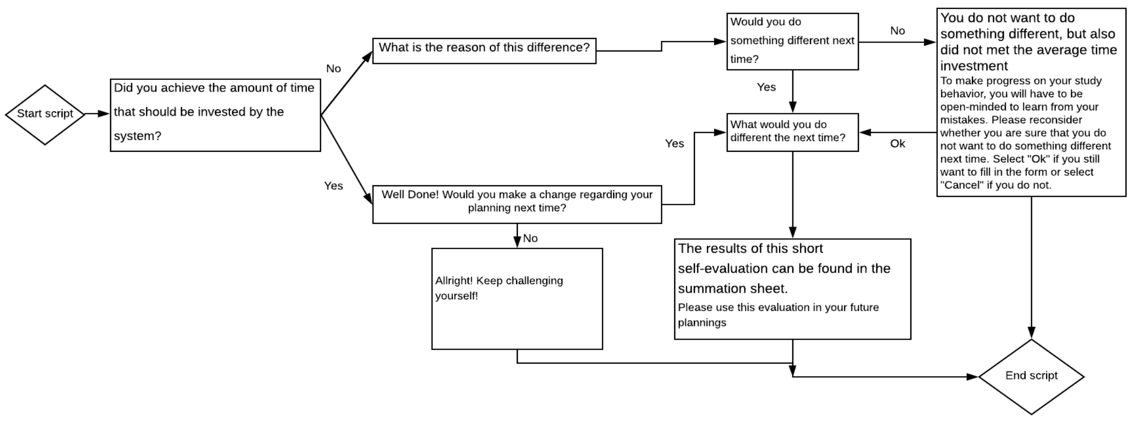

Diagram E.2: The system architecture of the self-evaluation function of subsystem I.

Appendix D: The syntax of the system

The syntax that was coded is as following:

```
function onOpen() {
ss.addMenu("Strategic support",menuEntries1);
ss.addMenu("Subject-matter support" ,menuEntries2);
};

 /* initalizing and declaring the variable(s) to be used and empty arrays*/
var ss = SpreadsheetApp.getActiveSpreadsheet();
var ui = SpreadsheetApp.getUi();
var dropSheet = ss.getSheetByName('Summation');
var lastRow = ss.getSheets()[0].getLastRow();
var pValue = SpreadsheetApp.getActive().getSheets().length;
var iValue = ss.getSheets().length;
var sheetValues = [];
var arrayOfRowNames = [];
var arrayOfSheets = [];
var arrayOfUniqueRowNames = [];
var arrayOfNewSheets = [];
var newSheetsToBeMade = [];
var menuEntries1 = [{name: "1. Use Supportystem", functionName: "countCourses" }, {name: "2. Count hours per course", functionName:
"countCourses" }, {name: "3. Self reflection", functionName: "selfEvaluation" },  {name: "4. (Optional) Delete generated sheets", functionName:
"deleteSheets"}];
var menuEntries2 = [{name: "General study tips", functionName: "generalTips"},{name: "Task analyzer", functionName: "learningTasks"} , {name:
"Program study tips", functionName: "programmingTips"}, {name: "Mathematical study tips", functionName: "mathTips"}];
var arrayOfCourses = [];
var sheetNames = [];

function countCourses() {

/* Creating an array of rownames */
for(p = 0; p < lastRow - 2; p++) {
  arrayOfRowNames[p]  = ss.getSheetByName('InputData').getRange(3 + p, 1).getValue();
}

/* Creating an array of sheetnames */
 for (p = 0; p < pValue -3;  p++) {
   arrayOfSheets[p] = ss.getSheets()[1 + p].getName();
 }

/* Comparing the array of rownames to the array of sheetnames */
arrayOfUniqueRowNames = removeDuplicates(arrayOfRowNames);
  var amount = arrayOfUniqueRowNames.length;
   for(i=0; i< amount; i++){
    if(!elementIsInArray(arrayOfSheets,arrayOfUniqueRowNames[i])){
      newSheetsToBeMade.push(arrayOfUniqueRowNames[i]);
    }
}

/* Sets content for new tabs, created per course */
  for(i = 0; i < newSheetsToBeMade.length; i++) {
    if(newSheetsToBeMade[i] != [null]) {
    ss.insertSheet(i + 1).setName(newSheetsToBeMade[i]);
    ss.getSheets()[i+1].getRange("'"  +  newSheetsToBeMade[i]+"'"  +  "!A1").setFormula("=filter(InputData!A:G,InputData!A:A"+  "="  +  "'"  +
newSheetsToBeMade[i] + "'" + ")");
      ss.getSheets()[i+1].getRange("'" + newSheetsToBeMade[i]+"'" + "!H1").setFormula("=SUM(F1:F)");
    }
  }
  declareTimeinvestment();
  countDifferences();


function removeDuplicates(arr){ // SOURCE: https://codehandbook.org/how-to-remove-duplicates-from-javascript-array/
    var unique_array = [];
    for(i = 0; i < arr.length; i++){
        if(unique_array.indexOf(arr[i]) == -1){
            unique_array.push(arr[i]);
        }
    } return unique_array;
};


function elementIsInArray(arr,element){
    if(arr.length > 0 && arr != null){
     for(i = 0; i < arr.length; i++){
       if(arr[i] == element)
```

```
      return true;
      }
    } else {
    return false;
      }
  };

function countDifferences() {
  var arrayOfDifferences = [];
  var summingDifferences;
  var warningValue;
  for (i=0; i < arrayOfSheets.length; i++) {
     arrayOfDifferences[i] = ss.getSheetByName('Summation').getRange(2 + i, 4).getValue();
      if (i == 0) {
      summingDifferences = arrayOfDifferences[0];
      } else {
      summingDifferences = summingDifferences + arrayOfDifferences[i];
    }
  }
  warningValue = 10;

  if (summingDifferences/arrayOfSheets.length < warningValue) {
    var responseOnWarning = ui.alert('It seems like your current average time of investment differs more than ' + warningValue + ' hours in comparison to the norm that is set by the study. Would you like some general study planning tips?', ui.ButtonSet.YES_NO);
    if (responseOnWarning == ui.Button.YES) {
      generalTips();
    }
  }
 };

function declareTimeinvestment() {
  arrayOfSheets.reverse();
  for (i = 0; i < ss.getSheets().length - 3; i++) {
   sheetValues[i] = ss.getSheets()[1+i].getRange(1,8).getValue();
  } sheetValues.reverse();
  for (i = 0; i < ss.getSheets().length - 3; i++) {
   dropSheet.getRange(2 + i,1).setValue(arrayOfSheets[i]);
   dropSheet.getRange(2 + i,2).setValue(sheetValues[i]);
  } ss.setActiveSheet(ss.getSheetByName('Summation'));
 };

};

function deleteSheets() {
 var responseDelete = ui.alert('Are you sure that you want to delete the created sheets?', 'The InputData, Summation and Tips sheets will not be deleted and the output data within the summation sheet will stay unchanged.', ui.ButtonSet.YES_NO_CANCEL);
  if (responseDelete == ui.Button.YES) {
  for (i = 0; i < ss.getSheets().length; i++) {
   sheetNames[i] = ss.getSheets()[i].getName();
  }
  sheetNames.forEach(function(sheetName){
    if (sheetName != 'InputData' && sheetName != 'Summation' && sheetName != 'Tips') {
      sheet = ss.getSheetByName(sheetName);
      ss.deleteSheet(sheet);
    }
  })
  }
};

function generalTips() {
  // Zie https://developers.google.com/apps-script/reference/base/ui#showModalDialog(Object,String)
  var arrayofGeneralTips = [];
  var tipsSheet = ss.getSheetByName("Tips");
  for(i = 0; i < 8; i++) {
    arrayofGeneralTips[i] = tipsSheet.getRange(3 + i, 1).getValue() +" " +  tipsSheet.getRange(3 + i, 2).getValue() + "\n";
  }
  var tipOfTheDayQ = ui.prompt(arrayofGeneralTips.join("") + "\n" + 'Which tip would you like to use as tip of the day?');
  var tipOfTheDay = 2 + 1*tipOfTheDayQ.getResponseText();
  ss.getRange("Summation!F2").setValue(ss.getSheetByName("Tips").getRange(1*tipOfTheDay, 2).getValue());
};

function learningTasks() {
  var arrayOfAnswers = [];

  /* Testing and summing similarities to the learning task to be performed*/
  var responseSimilarities = ui.alert('Do you have any knowledge about a similar task performed in the past?', ui.ButtonSet.YES_NO_CANCEL);
  var responseSimilaritiesTwo;
  if (responseSimilarities == ui.Button.YES) {
    responseSimilaritiesTwo = ui.prompt('What do you currently know about this task');
    ss.getRange("Summation!F4").setValue(responseSimilaritiesTwo.getResponseText());
    arrayOfAnswers.push("1. Similarities to your task: " +responseSimilaritiesTwo.getResponseText());
```

```
  } if (responseSimilarities == ui.Button.NO) {
    var answerIfNo = "You\'ve none similarities with the work you\'re going to perform. Look in the course manual/latest slides what you have to do to achieve the knowledge!";
    ss.getRange("Summation!F4").setValue(answerIfNo);
    arrayOfAnswers.push("1. Similarities: " + answerIfNo);
  }
  /* Testing the motivation of the user to perform a certain learning task*/
  var answerOneMotivation = "You've got an achievement base approach for this task to be performed. Set a certain goal (e.g. a desired grade) in mind and create your planning in such a way that you will get it. Check out reference books (e.g. module manuals) to learn what you have to do to achieve the desired goal. ";
  var answerTwoMotivation = "You've got a deep-learning approach for this task to be performed. As you might won't stop with finding something out untill you did. Keep in mind that you are always doing something to reach a certain goal. It happens often that students who have this drive forget about the goal they want to achieve while looking around. Please be aware of this pitfall and try to avoid it. ";

  var responseMotivationOne = ui.prompt('Which type of motivation fits most to you, based on the learning task to be performed?', '1. Achievement based motivation - e.g. you want to achieve a certain goal \n 2. Deep learning motivation - e.g. you deeply want to understand the topic you are working on \n \n Type in the number of the motivation type', ui.ButtonSet.OK);
  if (responseMotivationOne.getResponseText() == '1') {
    ss.getRange("Summation!F5").setValue(answerOneMotivation);
    arrayOfAnswers.push("2. Motivation: " + answerOneMotivation);
  } else if (responseMotivationOne.getResponseText() == '2') {
    ss.getRange("Summation!F5").setValue(answerTwoMotivation);
    arrayOfAnswers.push("2. Motivation: " + answerTwoMotivation);
  }

  /*Testing the self-efficiency of a certain learning task*/
  var responseSelfEfficiency = ui.prompt('Do you feel confident to execute the task?', '1 = very confident, 4 = not confident at all', ui.ButtonSet.OK);
  if(responseSelfEfficiency.getResponseText() > 2) {
    var responseLowSelfEfficiency = ui.prompt('What do you need to make yourself confident?', ui.ButtonSet.OK);
    ss.getRange("Summation!F6").setValue(responseLowSelfEfficiency.getResponseText());
    arrayOfAnswers.push("3. Level of confidence/additional requirements: " + responseLowSelfEfficiency.getResponseText());
  } else {
    var confident = "It seems like that you are confident about the task to perform and don't need any additional requirements to start!";
     ss.getRange("Summation!F6").setValue(confident);
    arrayOfAnswers.push("3. Level of confidence: " + confident);
  }

  /* Settings of a certain task to be performed*/
  var responseSettings = ui.prompt('Do you rather work in a team or alone on this task?', ui.ButtonSet.OK);
  if (responseSettings.getResponseText() == 'team') {
    var answerIsTeam = "It seems like you like to work in a team during this task";
    ss.getRange("Summation!F7").setValue(answerIsTeam);
    arrayOfAnswers.push("4. Setting: " + answerIsTeam);
  }
  if (responseSettings.getResponseText() == 'alone') {
    var answerIsAlone = "It seems like you like to work in alone during this task" ;
    ss.getRange("Summation!F7").setValue(answerIsAlone);
    arrayOfAnswers.push("4. Setting: " + answerIsAlone);
  }
    /* Summary of all the above */
  for (i = 0; i< arrayOfAnswers.length; i++) {
    arrayOfAnswers[i] = arrayOfAnswers[i] + '\n' + '\n';
  } ui.alert("Summary of the tips on your learning task to perform",arrayOfAnswers.join("") + "\n This summary is also listed in the 'Summation' sheet."
, ui.ButtonSet.OK);
};

function programmingTips() {
  var arrayofProgrammingTips = [];
  var tipsSheet = ss.getSheetByName("Tips");
  for(i = 0; i < 5; i++) {
    arrayofProgrammingTips[i] = tipsSheet.getRange(22 + i, 1).getValue() +" " +  tipsSheet.getRange(22 + i, 2).getValue() + "\n";
  }
  ui.alert(arrayofProgrammingTips.join("") + "\n");
  //var tipOfTheDay = 2 + 1*tipOfTheDayQ.getResponseText();
  //ss.getRange("Summation!F2").setValue(ss.getSheetByName("Tips").getRange(1*tipOfTheDay, 2).getValue());

};

function mathTips() {
  var arrayOfMathTips = [];
  var tipsSheet = ss.getSheetByName("Tips");
  for(i = 0; i < 5; i++) {
    arrayOfMathTips[i] = tipsSheet.getRange(29 + i, 1).getValue() +" "+  tipsSheet.getRange(29 + i, 2).getValue() + "\n";
  }
  ui.alert(arrayOfMathTips.join("") + "\n");
};

function selfEvaluation() {
  var responseHours = ui.alert('Did you achieve the amount of time that should be invested by the system?', 'Please consider the graph in your decision', ui.ButtonSet.YES_NO);
```

```
 if (responseHours == ui.Button.NO) {
  var responseProblemAnalysis = ui.prompt('What is the reason of this difference?', 'e.g. did you complete your task to be performed faster or it it not finished yet', ui.ButtonSet.OK);
  ss.getRange("Summation!H5").setValue(responseProblemAnalysis.getResponseText());
  var inventariseDoingThingsDifferent = ui.alert('Would you do something different next time?', ui.ButtonSet.YES_NO);
  if (inventariseDoingThingsDifferent == ui.Button.YES) {
  var responseNextTime = ui.prompt('What would you do different the next time?', ui.ButtonSet.OK);
  ss.getRange("Summation!H6").setValue(responseNextTime.getResponseText());
  } else if (inventariseDoingThingsDifferent == ui.Button.NO) {
    var intervension = ui.alert('You do not want to do something different, but also did not met the average time investment', 'To make progress on your study behavior, you will have to be open-minded to learn from your mistakes. Please reconsider whether you are sure that you do not want to do something different next time. Select "Ok" if you still want to fill in the form or select "Cancel" if you do not.', ui.ButtonSet.OK_CANCEL );
  } if (intervension == ui.Button.OK) {
    var responseNextTime = ui.prompt('What would you do different the next time?', ui.ButtonSet.OK);
    ss.getRange("Summation!H6").setValue(responseNextTime.getResponseText());
    var alertSummary = ui.alert('The results of this short self-evaluation can be found in the summation sheet.', 'Please use this evaluation in your future plannings', ui.ButtonSet.OK);
   }
 }
  if (responseHours == ui.Button.YES) {
    ui.alert('Well done!');
    inventariseDoingThingsDifferent = ui.alert('Would you make a change regarding your planning next time?', ui.ButtonSet.YES_NO);
    if (inventariseDoingThingsDifferent == ui.Button.YES) {
  var responseNextTime = ui.prompt('What would you do different the next time?', ui.ButtonSet.OK);
  ss.getRange("Summation!H6").setValue(responseNextTime.getResponseText());
  alertSummary = ui.alert('The results of this short self-evaluation can be found in the summation sheet.', 'Please use this evaluation in your future plannings', ui.ButtonSet.OK);
  } else if (inventariseDoingThingsDifferent == ui.Button.NO) {
    ui.alert('Allright! Keep challenging yourself!');
  }
 }
};
```

Appendix E: The tips provided by subsystem II

The study tips database that was created:

General study tips	
Nr.	Tip
1	Investing in ways to improve your learning efficiency helps you to spare time at the end of the day
2	Start with the final goal in mind
3	Plan your study behavior in advance on the basis of time that should be invested in a certain course
4	Plan in your drinking activities
5	Start every week with a moment to plan in your study behavior
6	Ask yourself the question which kind of motivation fits the best to you for a certain course; achievement based learning or deeply motivated learning
7	Consider the environmental factors when self-studying and chose the most optimal one. Factors are temperature, working together or alone and time of the day that is used.
8	Monitor and control your energy level by monitoring your sleeping and eating behavior
9	Conduct a midweek and endweek evalation to evaluate the prior planning. Write this down in a reflection form and use this as starting point in the subsequent module.
10	To keep your study planning realistic, you have also to plan in other activities such as relaxation time and other extra-curricular activities
11	Keep in mind that you not only starting a new study here, but also have to invest in a new life phase. This simply cost alot of time, which can also be planned in
12	Prepare your lectures by asking yourself what is about to aim for a higher learning efficiency.

	General tips on learning tasks
1	Try to learn more about the characteristics of the task to be performed
2	Ask yourself whether you have done similar tasks in the past that could might help you to remember how to translate that knowledge to this domain
3	What kind of motivation do you have to perform this task?
4	Are you self-confident to conduct the task without that many problems. If not, try to find out what you need to do so.
5	Do you prefer working in a group or alone on this task? Take this into consideration when doing so
	Programming tips
1	Start with an activation of prior knowledge about the topic
2	Analyse what the exact task is you have to perform. Most often, students just start instead of analysing what to do first.
3	Create a plan to achieve this task first before getting started
4	Visualize the final product by creating a sketch to get a clear overview what should be done and being able to divide it into several parts
5	Make sure a cleaning up session is done from time to time to structurize the entire code
6	Use local variables when that is possible to keep the code logical and structured
	Mathematics tips
1	Do not ask for help immediately when something went wrong. Try to backtrack your steps and find out where it went wrong and why
2	Ask yourself what you have learned when completing exercises. By doing so, you are backtracking and registering your steps which can be applied in a slightly new situation/exercise. It could help to keep up a diary(log) about this progress.

Appendix F: The series of task on the testing procedure

The series of tasks that had to be done by the participants that participated on the user test:

User test of the system

Introduction

One of the three core pillars of the Twents Onderwijs Model (TOM) entails student-driven learning; students must take control over their own learning process. A small study was designed to test whether this requirement is integrated in the Creative Technology (CreaTe) bachelor program. It was found that this integration was limited.

To stimulate this integration, two subsystems were designed in Google Spreadsheets which could be used during the professional development course offered two first-year CreaTe students.

1. *A strategic (approach) support system*

The goal of this subsystem is to give you an overview of hours that are you have currently planned in in a certain course, compared to the norm that is given by the study.

2. *A subject-matter support system*
The goal of this subsystem is to provide general study tips, and tips about maths and programming as these were pointed out as difficult. The aim is to provide some easy applicable tips.

Testing procedure
You will have to conduct a series of tasks by using the entire system. Afterwards, a quantitative survey will take place, which will be followed by a qualitative discussion within this focus group of three people.

To insurance the ethical aspect, please note that you are always allowed to walk away when you want to. The responses will become anonymous in the final report, although it will be stated that the education committee of S.A. Proto was interviewed. One can easily do the math to learn who were in the committee. Please let Wouter know if you do have any problems with it, as you do agree on this if you do not.

Questions
If you have any questions, please ask the moderator (Wouter).

Tasks
Situation: You've fed your schedule via utwente.mytimetables.nl to the Google Calendar, as well as all the study activities that you've planned. Imagine it is sunday, and you have to plan in several study activities.

1. Go to Google Calendar (https://calendar.google.com/calendar/r?tab=mc&pli=1) and plan in one study activity named "Mathematics" on Tuesday the and one course named "Programming" in the afternoon of Tuesday the 26 of June if that is not already done.
2. Go to your Google Spreadsheet
3. As the data (hours per study activity) from Google Calendar has to be compared with the norm as set by the study, the Google Calendar should be imported into the data sheet first. Please use the add-on "Calendar event importer" from the add-on menu and select "import events from calendars"
4. Select the usertestcreate@gmail.com agenda
5. Select as starting date 26-06-2018 and as end date 01 - 07 - 2018
6. Click on import
7. If the name of the new sheet (tab) is not "InputData" but instead usertestcreate@gmail.com , please remove the original InputData sheet and change the name of the new sheet tab to InputData.

8. Use the strategic support subsystem by selecting "strategic support" from the menu and click on use support-system.
9. Use the same menu to select the "count hours per course" functionality.
10. Click "no" on the pop-up that appears.

11. Please consider the graph that appears. Questions will be asked later on this functionality.

12. You noticed that you would like some additional study tips. Try to get them by using the subject-matter support system. Once you completed, select a tip as tip of the day.

13. Imagine you are working on a project during your study and you have to conduct a usertest with a potential user group of your project. You've never done this task before and are therefore seeking for support to do so. Please use the task analyzer of the subject-matter support system.
14. Consider the output of the task analysis. Questions will be asked later on.
15. Now imagine that you made a mistake on one of the questions of the task analyser as you filled in a "1" on confident level instead of a "4". Try to fix this mistake by using the system.

16. Imagine you're working on maths, but you got stuck. Try to get some mathematical tips by using the system.
17. Imagine the same situation as described by task 10, but now during the programming course. Try to get some programming tips.

18. Imagine you are at the end of the week and want to reflect on your planning. Use the self-reflection function of the system to conduct a self-reflection
19. Consider the output data of the self-reflection functionality. Questions will be asked later on.

Survey
Link to survey: https://goo.gl/forms/Nh2DiOtldF1Xagu43

Appendix G: Tips on mathematics

Blok 1: Basis-elementen in de wiskunde

1. Bekijk globaal de theorie en check jezelf of je dit kan d.m.v. opgaven maken (dit activeert impliciet de voorkennis). Kijk ook of je dit met een redelijk tempo kan doen om te testen hoe handig je hiermee bent.

Blok 2: Differentiëren. De meeste studenten hebben hier ervaring mee van de middelbare school.

1. Ga aan de hand van de theorie eenvoudige voorbeelden nalopen. Probeer eerst jezelf uit te leggen of dat wat gezegd is kan uitleggen aan een medestudent. Geen probleem om hier een hulpmiddel als een boek bij te pakken of bijvoorbeeld Khan Academy. Maak

de opgaven en kijk of dat klopt. Maak een opgave die al in een voorbeeld uitgewerkt is en vergelijk daarna je eigen uitwerking met die van het voorbeeld.

2. Probeer goed te begrijpen wat je aan het doen bent en welke stappen je doorloopt. Kijk achteraf terug naar de opgaven om hierachter te komen.

Blok 3: Integreren. Voor een deel van de studenten is dit totaal nieuwe stof.

1. Probeer eerst de link te leggen tussen differentiëren en integreren.
2. Ga naar de lijst met de standaard integralen; beginnen met machtfuncties omdat die makkelijk te primitiveren zijn.
3. Probeer erachter te komen wat integralen zijn met behulp van Riemanssomen