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Designing for students' self- reflection in online learning settings: A mixed method study

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ABSTRACT

Shifting from traditional face-to-face education to online mode of education (or online learning) presents several challenges, such as increased difficulty for students to get immediate feedback and lack of social interaction. To tackle these challenges, supporting learners' self-reflection process is seen to be crucial to help students achieve academic success. Students in higher academic institutions are generally not exposed during their education to self-reflection, and it is a skill that teachers consider many students lack. However, there is a lack of studies that focus on self-reflection in online environments. In this paper we aim to investigate in what ways can online learning platforms support university students' self-reflection. In this study a self-reflection tool was developed for an online environment and evaluated through a set of iterations in a mixed method approach. A total of three iterations were conducted, with their respective evaluations. Results show that participants perceived a clear improvement of their learning process through self-reflection. Findings also show that there are a few requirements not present in traditional self-reflection tools, which suggest a clear need for self-reflective methods tailored to learners' needs.

ABSTRAKT

Skiftet från traditionell salsundervisning till nätbaserad kunskapsförmedling innebär många utmaningar, t.ex. det är svårare för elever att få omedelbar feedback och de saknar socialt utbyte. För att komma tillrätta med de här utmaningarna anses det viktigt att den som studerar får stöd genom självskattning, för att målen för studierna ska kunna uppnås. Den som studerar på högre nivå får sällan tillfälle till kunskapssjälvskattning under sin utbildning och lärare anser att det är kunskaper som många studenter inte besitter. Samtidigt saknas det studier som fokuserar på självskattning i en nätbaserad studiemiljö. I den här uppsatsen så undersöks hur utbildningsplattformar online kan främja universitetsstuderandes självskattning. För undersökningen har ett verktyg för självskattning inom nätbaserad undervisning utvecklats, ett verktyg som utvärderats genom en serie iterationer och tillämpning av mixad metod. Totalt har tre olika iterationer genomförts med respektive utvärdering. Resultaten visar att deltagarna upplevde att deras inlärningsprocess tydligt förbättrades med hjälp av självskattningen. Svaren visar också att vissa förutsättningar saknas i traditionella självskattningsverktyg och det i sin tur pekar tydligt på att det behövs metoder för självskattning som är anpassade efter elevernas behov.

Designing for students' self-reflection in online learning settings: A mixed method study

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ABSTRACT

Shifting from traditional face-to-face education to online mode of education (or online learning) presents several challenges, such as increased difficulty for students to get immediate feedback and lack of social interaction. To tackle these challenges, supporting learners' self-reflection process is seen to be crucial to help students achieve academic success. Students in higher academic institutions are generally not exposed during their education to self-reflection, and it is a skill that teachers consider many students lack. However, there is a lack of studies that focus on self-reflection in online environments. In this paper we aim to investigate in what ways can online learning platforms support university students' self-reflection. In this study a self-reflection tool was developed for an online environment and evaluated through a set of iterations in a mixed method approach. A total of three iterations were conducted, with their respective evaluations. Results show that participants perceived a clear improvement of their learning process through self-reflection. Findings also show that there are a few requirements not present in traditional self-reflection tools, which suggest a clear need for self-reflective methods tailored to learners' needs.

Author Keywords

Self-reflection; Self-regulated Learning; Online Learning; Design-based research; Higher Education; Mixed Method

INTRODUCTION

Online learning environments provide several benefits compared to traditional settings. Among them are easier distribution of material as well as the possibility to interact with peers and teachers' online participation and the possibility for students to regulate their own learning process [4]. Online environments allow for asynchronous learning with no restrictions of time and place [11]. However, shifting to an online mode of education presents several challenges, such as increased difficulty and lack of social interaction [27]. Students are less likely to get timely feedback in an online environment compared to their face-to-face peers [7]. In a recent study [1], around 50% of the students said that they are not able to effectively complete an online course, after switching to online learning. The surveyed students emphasized the importance of face-to-face contact with their teachers for effective learning. While these studies highlight challenges with online learning,

most of them were conducted in an environment where online learning was considered optional [15].

The covid-19 outbreak was declared a global pandemic by the WHO (World Health Organization) in March of 2020 [29]. Many academic institutions were forced to quickly shift their teaching to an online environment. This immediate change exposed students to challenges that may affect their learning process and created a strong need for academic institutions to improve their teaching methods [22]. Students lack time management skills when performing learning tasks, especially when accustomed to a real-time context [20]. Furthermore, students that feel a sense of isolation and lack of community, have difficulties when doing group projects [1]. Findings from a recent study [15] point out that teachers consider that students lacked skills and knowledge necessary for online learning before the pandemic.

To tackle the above mentioned challenges, students need support on several levels (social, academic, and medical services) [22]. One of the approaches to help students is supporting them with their self-regulation [30] by integrating skill teaching in the courses. Self-regulation is seen as a necessity to pursue academic goals in an online environment [25] which is deeply linked with academic success¹ [23,31,26] and a skill that many higher education students lack [26, 30]. Students' emotions play a big part in their motivation and learning process [13], positive emotions are assumed to facilitate self-regulatory behaviour, while negative emotions may influence their reliance on external guidance in their learning process. Improving students' emotions is done through self-observation and awareness tools but requires students to have a high self-reflective ability.

The Self-Regulated Learning (SRL) model by Zimmerman [32] is especially relevant for higher education environments, where the SRL skills are viewed as an important skill for students' academic success [25]. Zimmermann's SRL model [32], is a cyclical and systematic model, consisting of three phases (forethought, performance, and self-reflection), to help students improve

¹ Academic success can be defined as the attainment of a specific result on an assignment, usually denoted in a numerical grade or grade point average (GPA) [18].

their learning process. SRL strategies (SRLS) as defined by Zimmerman [33] are “actions and processes directed at acquiring information or skill that involve agency, purpose, and instrumentality perceptions by learners”. Previous studies show that students who used SRLS in online environments perform better than those who did not [19,10]. Yet, studies investigating the relationship between self-reflection and academic performance in an online environment, do not show promising results [5,14]. In Zimmerman's model, self-reflection is seen as a crucial activity since learners use information from the self-reflection phase to make accurate decisions for their study sessions in the forethought phase. However, only 9% of the studies which investigate aspects of Zimmerman's model focus on the reflection phase [24]. Hence, the importance for studies to examine how to support learners' self-reflection activities, especially in online environments.

This paper investigated how to design self-reflection tools to support students' needs in an online learning environment. This study built upon established self-reflection frameworks and design methodologies to develop a self-reflection prototype for an online environment. The following research question was investigated: “In what ways can online learning platforms support university students' self-reflection?”. The study used a design-based research approach consisting of three design iterations, each consisting of a design and evaluation phase.

This study was conducted in an online platform for university students to study and practice various tasks and assignments from previous exams. The platform aimed to improve students' study process by offering theory and exercises of specific Swedish university courses within engineering and math. Students can plan their study, track their progress, and help each other solve the different tasks. In this study a self-reflection feature was developed which allowed users to reflect on their experience on each exercise at the platform.

BACKGROUND

In this section, theory and studies about SRL and self-reflection are presented and explained, giving a better insight to why there is an increased need for self-reflection. Research gap of this study is further discussed outlining the importance of more studies of self-reflection. This section also contains information about the two selected self-reflection frameworks for the tool design. Lastly, the importance of design-based research in this study is discussed by providing relevant theory and similar studies.

Self-Regulated Learning

Zimmerman grounds his definition of SRL in early psychology [32], where researchers began researching students' awareness of their own thinking (Metacognition)

and the effect social influences had on students' self-regulation development (Social cognitive). Zimmermann's SRL model [32] is presented as a cyclical three phases (*forethought*, *performance*, and *self-reflection*). The three phases are interlinked with a significant interplay, in that a positive change in a phase would be reflected in the other phases.

The forethought consists of all the actions and processes preparing for a certain task. The forethought has two major processes: task analysis and self-motivation beliefs. Task analysis refers to the process where learners set specific goals and create strategic planning. Self-motivation derives from learners' idea of their own learning capabilities, such as self-efficacy, learning goals or intrinsic interest.

The performance phase includes the processes and actions done to achieve the goals set in the previous phase. The two main processes are: self-control and self-observation. Self-control refers to the use of the specific methods and strategies set during the forethought phase. Self-observation refers to the actions by the learner to self-record the events to find any cause. Self-reflection is the last phase of this model and is defined as the evaluation of past events and own thoughts, to gain understanding about oneself and the learning process.

The self-reflection phase encompasses two major processes: self-judgement and self-reaction. Self-judgement is the process of evaluating one's own performance against a standard or previous performance. Self-reaction refers to the feeling of self-satisfaction regarding one's performance.

According to Zimmerman's SRL model (figure 1), learners start in the forethought phase, setting goals and establishing learning objectives (LOs). Moreover, learners plan and schedule tasks to achieve those goals. After that, learners work on the tasks set to achieve the goals in the performance phase. Learners work according to their set schedule and record their progress and insights. When achieving a certain milestone, learners reflect on their own work in the self-reflection phase. With the help of recordings of the performance phase, learners evaluate their performance and outline any underlying issues or inconvenience found. After reflecting on their work, the cycle starts again in the forethought phase where learners use the insights gained from the self-reflection phase to plan their task and goals more effectively. Zimmerman's model relies on different qualities of the learners, such as: the ability to self-reflect, self-discipline, effective planning, and the learner's ability to adapt during the learning period. Relying on the learner's ability can be difficult for users that are not familiar or lack this type of skills. Making it important to assist learners in their self-regulated learning.

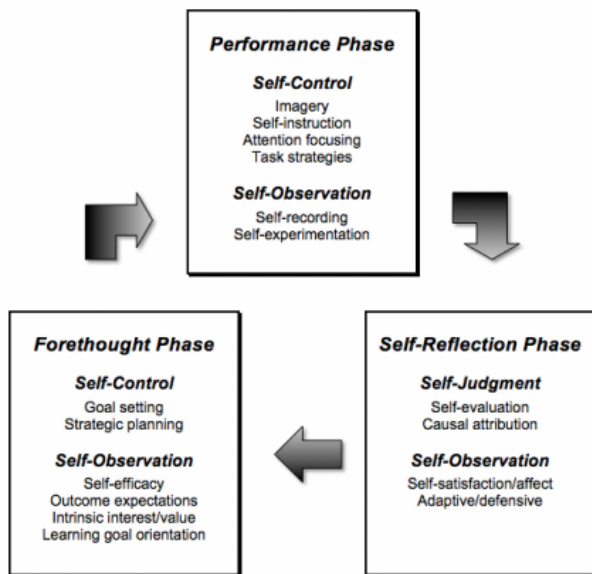


Figure 1. Visualization Zimmermann's SRL model containing the three different phases: forethought, performance, and self-reflection. Based on [30]

Online learning environments allow the inclusion of tools that can assist learners in their self-reflection. Providing self-reflection suited for online environments is important to improve their lack of self-reflection skills and there is a lack of studies regarding self-reflection [24]. The next sections will explain self-reflection more in detail and the self-reflection frameworks used to design the self-reflection tool.

Self-reflection

The task of self-reflection is an important aspect of learning in both academic and non-academic environments. It is defined as "the conscious examination of past experiences, thoughts and ways of doing things. Its goal is to surface learning about oneself and the situation, and to bring meaning to it to inform the present and the future. It challenges the status quo of practice, thoughts and assumptions and may therefore inform our decisions, actions, attitudes, beliefs and understanding about ourselves." [16]. Traditionally, self-reflection is practiced using daily diaries and portfolios [8]. Students who reflect on their learning process may promote the ability to self-regulate and to increase effectiveness of their learning process. A study found a significant correlation between students with high ability of self-regulatory behaviour (such as self-reflection) and engagement [21]. User engagement directly links students' satisfaction with the course and their academic performance [12]. Emotions are an important factor in students' learning process [13] since they can dictate students' motivation and self-regulatory behaviour. Emotions can use cognitive resources and interfere in the students' learning tasks, and to improve these conditions it is important to increase the awareness of their emotions. Awareness tools can make students aware of their emotions

which can enable them to self-regulate but require a high level of reflection. Self-reflection has shown to be very important in students' academic progress, but little research has been conducted.

Self-reflection Frameworks

There are few studies regarding self-reflection frameworks in an online environment. To design a tool to support students' self-reflection, this study explores and adapts two established self-reflection frameworks to an online environment. The two frameworks are the 5R framework and the CARL method.

The 5R framework was the first used self-reflective framework of the study and was developed by Bain et al. [2]. The 5R framework has five stages, each focusing on a different aspect of reflection. The framework allows for an in-depth reflection on the experience through the different stages. The first framework was selected with an explorative goal of evaluating and identifying important aspects of self-reflection in an online learning environment. The 5 stages of the 5R framework are:

- *Reporting* of the context of the experience - A brief description of the experience/problem or issue
- *Responding* to the experience (observations, feelings, thoughts, etc.) -Provide your personal response to the situation.
- *Relating* the experience to knowledge and skills you already have - Provide your understanding of how the situation relates to your own knowledge and past experiences.
- *Reasoning* about the significant factors/theory to explain the experience - Explore and explain the situation or experience.
- *Reconstructing* your practice by planning future actions for a similar experience - Reframe or reconstruct future practice by drawing conclusions from the four previous stages.

After evaluating the 5R framework, a second framework (The CARL model) was selected based on the findings of the evaluation. The CARL model is originally a framework from a job interview technique [16]. The framework allows to adapt answers according to the 4 aspects of the model. Due to the nature of the framework, it can be easily used in a more general reflective process. The 4 CARL stages are:

- *Context*: Briefly describe the context of you experience
- *Action*: Explain what actions you took
- *Results*: Explain what happened as a result of your actions
- *Learning*: Identify what you have learned

Design-based research

In this study design-based research [28,3] (DBR) approach is used to design and evaluate a self-reflection tool for

students in an online learning environment. Design-based research is a new methodology within qualitative research that consists of iterative cycles of analysis, design, implementation, and redesign [28]. The design is theory-driven and builds upon grounded research and theory, in a participatory design approach and is commonly used in the development of tools in the field of education [28]. Design-based research utilizes a range of different research methods (e.g., surveys, interviews, observations) to maximize credibility of ongoing research. DBR is well suited for fields such as interaction design, due to the lack of strong theories and models [17], making it a relevant method for this study due to the lack of grounded frameworks of self-reflection in an online academic environment.

METHOD

In this section the method used will be presented. The section will include a description of the iterative steps of the design-based research approach. The iterations are detailed below, with their design reasoning and respective evaluation. All students participating in this study were from different technical Swedish universities.

Design Framework

Choosing an optimal self-reflection framework for an online environment is not trivial, since there is no conclusive empirical evidence supporting the choice of frameworks. In this study, two frameworks were selected and tested based on their relevance to the current study and context. After evaluating the first framework, a second framework was selected based on the issues found in the evaluation of the first framework. Details on the evaluation and reasoning of a second framework will be detailed below.

Iteration 1

In the first iteration, the first prototype is presented. It consisted of exploration design, where the 5R framework was adapted to an online academic environment.

Design and Implementation

The prototype was developed in Figma, the main objective of the design was to help the user self-reflect when he/she completes an exercise on the online platform. The reflection tool in the prototype consisted of four multiple choice questions (MCQs) based on the different stages of the 5R framework. The *Reporting* stage was omitted since users

The image shows a screenshot of a user interface for a self-reflection tool. It consists of two main sections. The first section is titled 'How did it go with the exercise?' and features a row of five emoji options: a sad face, a neutral face, a slightly smiling face, a happy face, and a very happy face. A red circle with the number '1' is placed above the emoji options. The second section is titled 'What is the most important aspect of this situation?' and contains two text input fields. The first field contains the text 'I realise that I have a vague study plan' and the second field contains 'I have problems remembering the theory'. A red circle with the number '2' is placed above the input fields. Below the input fields, there are two more text input fields, one containing 'I notice that I don't know how to approach the exercise' and the other being empty.

Figure 2. First prototype using the 5R Framework on the online platform

were reflecting on a recently completed exercise, making it

redundant. For the *Responding* stage users rated their experiences by selecting an emoji that expressed their feeling towards the exercise (Fig 2 label 1). The included emoji were curated with Deepmoji [6], a deep learning model that finds relevant emoji's that matched the keywords which were selected for the context of the study (Good, Frustrated, Wonderful, Bad and Ok). The *Relating*, *Reasoning* and *Reconstructing* stages were MCQs that included three prompts and a blank input option (Fig 2 label 2). All the MCQs would be displayed consecutively after completing an exercise on the online platform.

Evaluation with designers

The aim of the first iteration is to establish the requirements that a self-reflection tool needs for an online learning environment.

Demographics and Evaluation Setup

Four designers and developers were interviewed in an unstructured manner. Prototype and design decisions were presented prior to the interview. The main goal of the interview was to analyse the viability of the methods adapted (5R Framework) and highlight important factors of a self-reflection feature in an online environment.

Evaluation Results

The purpose of the tool and MCQs were clear to the participants. The 5R framework was seen as a good alternative but it was perceived as very taxing for users of the online platform. The inclusion of the *Relating* as a MCQs seemed very open-ended and vague, making it hard to ask in this context. The emoji's (which represented different emotions) were not identified properly. Participants also underlined the integration and flow of the prototype on the online platform as not being optimal. To adapt the self-reflection tool to the platform, it was suggested the inclusion of a MCQs which focus on helping students reflect their progress on the main goal of the online platform (pass their exams).

Findings

Participants reported that the most important factor was the necessity of a simple way to self-reflect. The 5R framework was reported not relevant to the context of the platform and required elaborate answers for each of the MCQs. Utilizing emoji to convey the user's emotion was not optimal and was interpreted differently by the participants. The tool was visually redesigned to be better integrated on the platform since it was perceived as intrusive and not part of the flow of the platform.

Iteration 2

For the second iteration the CARL framework was adapted. The CARL framework shortens the self-reflection process and focuses on 4 stages: what users did, why they did it, how it went and lastly what can be learnt from the experience (*Context, Action, Results and Learning*).

Design and Implementation

The second iteration consisted of four MCQs each representing a stage of the CARL model. The *Context* stage was omitted since the context is given by the exercise itself. The *Action* stage (Figure 3 label 1) was included as a 5-point Likert scale. The *Results* and *Learning* stages (Figure 3 label 3 and 4) were included as MCQs. Each MCQs included three prompts and a blank input option. These MCQs helped to; identify issues and ponder on future solutions, respectively. Another MCQs included (Figure 3 label 2) in the tool was “Could you be able to complete this exercise in an exam?” and answered by a 5-point Likert scale. While this MCQs is not part of the CARL model, it was proposed by the designers since it helped users to reflect on their progress towards the end goal of the online platform (pass exams).

The screenshot shows a vertical list of four MCQs, each with a red circle containing a number (1, 2, 3, or 4) next to it.

1. "How did it go?" with a 5-point Likert scale: Very Poor, Poor, Fair, Good, Excellent.

2. "Could you be able to complete this exercise in an exam?" with a 5-point Likert scale: Definitely not, Probably not, Possibly, Probably, Definitely.

3. "Why did it go that way?" with four checkbox options: "I had problem remembering the theory", "I do not know how to start", "I do not understand the exercise", and "Other...".

4. "What can you learn from this?" with four checkbox options: "I need to stucture better the exercises I do", "I have to prepare more the theory", "I have to do the exercise more carefully", and "Other...".

Figure 3. Second Prototype using the CARL model on the online platform

Evaluation with users

To evaluate the second iteration, a survey and a series of semi-structured interviews were conducted with end users. The main purpose of the survey was to get an understanding of user needs and their perception of the self-reflection tool. The survey also helped shape the interview questions conducted after. The interview questions aimed to get a deeper insight on users' learning habits and the perception of self-reflection in their learning process.

Demographics and Evaluation Setup

The survey participants were contacted through email and a total of 14 answers were collected. After the collection of data from the survey, the interview was created. The interview consisted of eight questions with an average duration of 20 minutes. A total of 4 interviews were conducted, participants were recruited through social media and were awarded with 100 SEK (Swedish crowns) at the

online platform. Interviews were conducted over zoom in Swedish and recorded for later transcription.

Evaluation results

Results outlined the need for users to self-reflect, as some users reported to already include self-reflective practice in their learning process. The MCQs utilized in the prototype, as well as the answers were clear and relevant for the users. Participants highlighted how the visual design of the tool was overwhelming, due to all the MCQs and answers being presented at the same time. The prototype was not considered necessary for all situations. Users who completed a simple or short exercise did not find use of self-reflection.

Findings

From the results we can draw the conclusion that there is a clear need for users to reflect on their work, but it is highly situational. Users do not want to spend a lot of time reflecting on an exercise if it is very short or simple. Self-reflection was perceived as essential and something missing on the platform. The participants considered the self-reflection tool as a reactive tool which not only provides an easy way to reflect, but also includes other functionalities to help and guide the user in their learning process.

Final Iteration

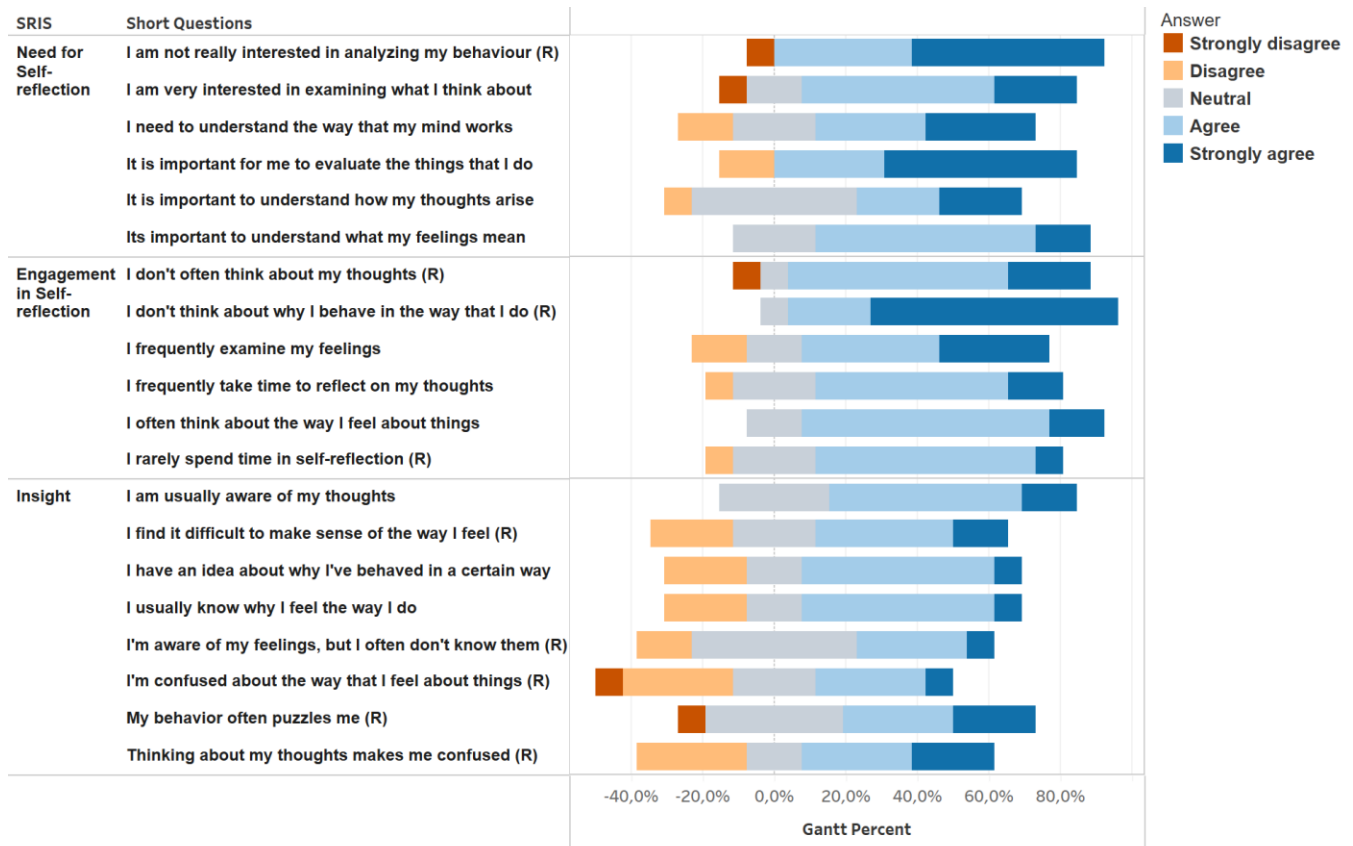
For the final iteration, the self-reflection tool was redesigned to fit in the online platform and released on the online platform. MCQs and their respective answers formulation were adjusted, as well as inclusion of a Swedish translated version.

The screenshot shows a single MCQ titled "How did it go?". Below the title are five radio button options: "Very bad", "Bad", "Neither good or bad", "Good", and "Very good". At the bottom right of the form, there are four small red dots in a horizontal row.

Figure 4. Final iteration using the CARL model on the online platform.

Design and Implementation

To get access to the tool users needed to mark an assignment as completed to be able to access the MCQs. After that, users were presented with one MCQs at the time consecutively. When completing all the self-reflective MCQs, users were able to see the answers of the MCQs next time they visited that same exercise.



Gantt Percent for each Short Questions broken down by SRIS . Colour shows details about Answer. Size shows Percent of Total Sizing.

Table 1. Gantt Chart Visualization of the results from the SRIS survey. For readability purposes the name of the items have been shortened. (R) represents reversed items

One week evaluation with users

To evaluate the final iteration, the self-reflection tool was released to all students using the online platform. A combination of qualitative data from interviews to evaluate the perceived value of the tool and quantitative data to identify user's ability to self-reflect, was used to draw final conclusions.

Demographics and Evaluation Setup

Participants of this study consisted of 13 users of the online platform studying in a higher education institution. Users were recruited via email and compensated with full access to the online platform for three months after completing the research. Neither gender nor age was included in the analysis since it is not considered relevant for the study.

Participants, after filing a consent form, are tasked with doing a Self-reflection and Insight Scale (SRIS) [9] survey in a 1-5 Likert scale, to evaluate their ability to self-reflect. After that, participants are tasked with using the self-reflection tool on the online platform during an entire week. After using the tool for a week, users were interviewed in a semi-structured approach. The semi-structured interview was conducted in Swedish and consisted of 8 questions based on the SRIS and the System Usability Scale (SUS).

Thematic analysis (TA) was used to evaluate the interview data.

Evaluation results

SRIS consists of twenty self-reported items to measure three factors: *engagement in self-reflection*, *the need for self-reflection* and *insight*. Higher scores denote a higher ability to self-reflect and use insight. The results show a high baseline ability for self-reflection amongst the participants (3.76 ± 0.99)². In Table 1 the results show relatively high scores in all the items of SRIS. The items regarding *engagement in self-reflection* (3.97 ± 0.87) and *need for self-reflection* (3.95 ± 1.01) have the highest scores, indicating a high tendency amongst the participants to self-reflect. Whereas participants showed lower scores in the items regarding *insight* (3.45 ± 1).

Regarding the factor *need for self-reflection*, the average score was 3.95 ± 1.01 . Participants reported that it is important for *them to evaluate the things that [they] do* (4.23 ± 1.09), *analysing [their] behaviour* (4.3 ± 1.11). While most participants reported that *analysing [their] behaviour* (4.3 ± 1.11) and *examining what [they] think about*

² Mean ± Standard Deviation

(3.85±1.07) to be very important, a small number of participants reported it not being important at all.

Participants' *engagement in self-reflection* was reported to be the most important factor, with an average score of 3.97±0.87. Regarding this factor, participants reported that *[they] think about why [they] behave in the way that [they] do* (4.61±0.65) and *often think about the way [they] feel about things* (4±0.58) to be the most important. Some participants only reported *[they] often think about [their] thoughts* (3.92±1.04) as not being important.

The factor *insight* was scored the lowest amongst the three main factors, with an average score of 3.45±1. Regarding *insight*, participants considered that being *aware of [their] thoughts* (3.85±0.69) the most important and it is the only item with no negative answers. The item indicating students were *confused about the way that [they] feel about things* received the lowest score by students indicating uncertainty about their own feelings.

The following section will present the result of the thematic analysis based on the interview data. The transcribed data was analysed and extracted into different sentences and sections based on several factors. The analysis factors included how often it was brought up, the novelty of the idea or the similarities with previous studies and theory. The different codes were categorized, and three main themes were identified (*monitoring and awareness*, *task analysis*, and *adaptation*), details and determining factors are presented below. All participant quotations have been translated from Swedish.

Monitoring and awareness

All the participants reported a positive perceived impact with the use of the self-reflection tool. Participants stated how clearly the self-reflection process could benefit their own learning process. One participant stated *"I become conscious of what I am doing. It's easy to do exercises without thinking, more mechanically"*. The increased awareness of their progress was shared by other participants which stated that *"It felt very useful when the exercise was very hard, to think about why it did not go that great"* and that *"the tool can help give a clear image of where one's weaknesses are"*. The self-reflection tool was also seen as a tool which can help introduce students to self-monitor, *"when we start in University there is a lot of working by oneself. One must assess themselves on what they are doing good or wrong. To know how to do this you need a tool that can help you assess"*. Some participants stated how the increased consciousness of one's progress can motivate students more. To have a clearer picture of one's progress, participants reported the necessity of overview visualization of their current progress. Participants stated that *"it is hard to get an overview of one's performance"* and that *"a week later it is hard to know what you need to work on in for the exam"*. Participants highlighted the importance of being able to observe one's progress, especially within smaller sections of a course they are studying for. Participants

considered the importance of the student to be able to self-identify their weaknesses regarding a course or an exam. To do so, it was stated the necessity of a better way to get an overview of previous answers on the individual exercises. It was also considered more relevant to go back to previous exercises since *"there is documentation on that exercise on how it previously went"*.

Task Analysis

Some participants outlined the potential benefits of having a self-reflection in an online learning platform, stating that *"the thought process of "do I need to do it again" is something that the system does for me, which would be great and very useful"* and that *"otherwise I must go through all material and try to find something (exercise)"*. The tool itself was perceived to provide a better structure during their learning process by *"isolating the different parts of the course I have difficulties with, before starting to study for an exam"*. Participants reported that the tool relevant was through all the stages of a university course. Continuous self-reflection would allow for easier structuring and planning to *"set up what I need to work more on in for the exam"*, but participants reported wanting more detailed answers in the self-reflection tool to better plan their learning.

Adaptation

A common issue highlighted by all the participants was the lack of flexibility. It was reported that the tool did not provide proper answers when things went well, *"the thing is that the tool itself was based on the fact that it did not go well on the exercise and then I was forced to answer what went wrong instead of stating what I knew or allowing me to skip the questions"*. Initially the self-reflection tool was not perceived as beneficial to them by some participants, one participant stated, *"I provide the platform with data, but it feels that it is not used to improve my learning process"*. Filling in a self-reflective form after an exercise created expectations within participants that the platform would react to the answers and adapt accordingly. Following this statement, participants highlighted the importance of such a feature (tailored to each student), since it would enhance the overall structure and make the self-reflective tool clearly seen to optimize their learning process, *"being redirected to what I need to study more on. Alternatively, "here are some similar exercises you can work on"*. The self-reflection tool was perceived to improve their reflective process, but participants stated the potential of the tool to improve their learning process by being reactive to the data they sent in each self-reflection.

DISCUSSION

This study aimed to identify requirements and important factors to support students' self-reflection in an online learning platform. A self-reflection tool for an online environment was designed and developed through different iterations in a design-based research approach. The different iterations included their design reasoning, based

on established self-reflection frameworks, and respective evaluation with mixed methods. The aim to design the self-reflection tool was to develop knowledge that can be used in practice by other designers and educators.

Choosing a self-reflection to base the design on was not trivial, and there is a lack of empirical evidence for self-reflection frameworks in online environments. The 5R framework was arbitrarily selected and tested first. In retrospect, with the feedback collected throughout the study, it's easier to evaluate the 5R framework as a framework not suited for the context of this study. This is mostly due to its long and elaborate answers required by the framework. Stages of the framework such as Relating are difficult to suit for the context of the study, since users are required to elaborate and relate to past similar experiences (if any issues were encountered) on exercises. This does not contribute to the student's main goal of passing their exams and would make the self-reflection process more taxing (take longer time and require more mental process to complete). It is possible to omit stages of the frameworks that are not suited for the context, but there is an established structure to the frameworks that should be followed. Many changes can disrupt the structure and connection of the different questions of the framework, making it hard to evaluate the outcomes based on the framework's goals. If many changes are required it is better to base the design on a better suited framework for that context, thus the second framework (CARL) was selected.

The initial evaluation of the CARL framework and its perceived potential were promising. The inclusion of simple Likert scales and MCQs to answer contributed greatly to a better self-reflective process. These items created some requirements which are not necessarily shared by more traditional self-reflection methods. The requirements were based on the context of the self-reflection tool being in an online environment. The whole platform was expected to be more reactive with the answers they provided in the self-reflection and guide users directly in their learning process. This notion was created with the understanding of the answers, by the participants, as data which the platform collected and processed. This was mostly due to the answers being predefined and easier to categorize by the platform. With the data, users expected different ways to observe and analyse their progress, something only possible in an online environment. This highlights the necessity for designers and teachers to design and adapt self-reflection frameworks to suit the desired online context to properly support students' self-reflective process. The different methods and items used in the tool (MCQs and Likert scales) to self-reflect are just one of many approaches taken to design and adapt the self-reflective tool. These methods and items were chosen based on their relevance to the context of this study, other studies should not be limited to the same choices.

The results of the study show that all the participants have a strong ability to self-reflect and insight. The students' high ability to self-reflect reflected a good understanding of the self-reflection tool and the perceived potential to improve their learning process. The SRIS scale also showed a high propensity by the participants to self-reflect, increasing the importance of a tool that supports students' self-reflective process. This resonates with a recent study which denoted the need to support students' self-regulatory skills [30]. The result of the study may have been influenced by the bias in the recruitment, since participants were already active users of the platform. Some participants also shared that they were already using a similar process to self-reflect in the online platform before the study and noticed an improvement in their process with the specialized tool. It's important to highlight the reported scores in insight on the SRIS scale, since participants showed high engagement and need for self-reflection, but many reported lower scores on the insight in their feelings and behaviours. This can be associated with some participants being engaged and familiar with self-reflection, but their methods of self-reflection might not be optimal. Participants reflected on past experiences but had difficulties interpreting and structuring that information for future improvement. This is comparable with the results of the study by Yen, Cherng-Jyh, et al. [30], showing a lack of SRL skills amongst students. Students can be engaged in self-regulated behaviour but require further support for a more effective self-reflection process to gain better insight of their learning process. To properly measure the effects of self-reflection in an online environment, participants need to be exposed to the self-reflection tool for a longer period.

The three main themes identified in the thematic analysis, give a clear picture of the importance of a self-reflective process in an online environment. The main themes also share similarities with the different *phases* and *subprocesses* of the SRL model proposed by Zimmerman [32]. *Self-observation* is a *subprocess*, in the *Performance Phase* of Zimmerman's SRL model, which "*refers to self-recording personal events or self-experimentation to find out the cause of these events.*". This *subprocess* has some similarities with the theme of *monitoring and awareness* identified in this study. Both relate to the learner's ability to get an overview of their current progress and react to it.

The *subprocess* of *Task Analysis* from the *Forethought Phase* of the Zimmerman's SRL model, was identified also as a theme in the analysis of the results. Participants reported how continuous self-reflection using the online tool can contribute to improve their structure when planning and performing their tasks. The perceived improvements consist of a more efficient and effective process by an automated and easier handling of their progress. This concept relates strongly with the increased awareness previously mentioned, since participants now have a clear picture of their learning process, goal setting and strategic

ITERATION	DEMOGRAPHIC	METHODOLOGY	DESIGN ADAPTATIONS	EVALUATION RESULTS	
				negative	positive
1	4 designers and developers	Interviews with think-aloud	Adapting 5R framework to an online tool. Utilization of prompting and emojis to answer self-reflection	-5R framework is not suitable for the context of the study -Emojis are not identified properly	-Purpose of the tool seemed clear -Prompting contributed positively to the simplicity of the tool
2	14 students (survey) and 4 students (interviews) using the online platform	Survey and Semi-structured interviews	Adapting CARL framework to an online tool. Utilization of 5-point Likert scales alongside prompting, with questions directed to end users' goal	-Overwhelming design of the tool -Not useful when doing simple exercises	-A desired tool for participants learning process
3	13 students using the online platform	SRIS and Semi-structured Interviews	Simpler design layout. View of previous answers and mark as complete button	-Lack of adaptation on the user data -No overview visualization	-Perceived as a tool that improves the learning process in various stages through a course -Improved awareness and engagement

Table 2. Overview of all the design iterations for the self-reflection tool and outcomes

planning. The discussed themes are an outcome of the increased awareness of the participants, which did not only improve their planning and structure but was also reported to better the engagement. Increasing the awareness through self-reflection follows the pattern in the study by Lavoué, Elise, et al. [13], where emotions are an important part of students' learning process, and it is only through a reflective process that students can improve their awareness of their emotions which are assumed to contribute to their self-regulated behaviour. Like the results of the same study, the results of this study suggest that it is vital for students to self-observe and monitor their progress to increase their awareness. Thus, visual tools of the students' progress are an important factor in the online learning context to facilitate students' awareness.

The themes identified are concepts perceived by participants as a complementary or necessary step in their learning process. The themes are not necessarily related directly to the self-reflection process but rather a connection and interplay like the phases and subprocesses of the SRL model. The findings further highlight the importance of self-reflection in an online environment and its connection with different parts of the learning process and might suggest difficulties when studying self-reflection in isolation from other SRL processes.

Participants stated that they experienced increased engagement with their learning process due to better

awareness of their progress. Participants also reported that they did the exercises more carefully to answer the self-reflection tool. This resonates with previous findings that suggested a high correlation between the student's ability to self-reflect and their engagement [21]. Which also correlates with the findings of the same study, suggesting that the use of tools in online learning is an important way to enhance students' engagement.

CONCLUSION AND FUTURE WORK

The self-reflection tool provided a simple and effective way for participants to self-reflect. Participants perceived a clear improvement of their learning process through self-reflection and found it useful through all the stages of a university course. Table 2 presents an overview of all the iterations and the main outcome of each iteration.

The study is in the interest of professors teaching in an online environment, and researchers in the field of education, and contributes to improving the conditions of online learning environments that affect many today.

This study was limited to small participants in the mixed method with a response rate of 7.2% of contacted users. The study also included a degree of bias in the recruiting process, since participants were already active users of the platform and were already motivated to help improve the platform. Most participants were all from different Swedish universities but only limited to technical careers. The scope

of the study also limited the amount of design iterations and evaluations, which could have better outlined the factors and requirements of a self-reflection tool in an online environment. While the self-reflection tool was designed specifically to suit the online platform, the results are generalizable for other contexts and frameworks if it contributes to the learner's self-reflective process.

Future designs and research may find a better suited self-reflection framework for their specific context. The results, however, may not differ if the design and goal of the self-reflection is based on the learners needs. To further support designers and teachers, more research needs to be conducted on the effects of different self-reflection frameworks in an online learning environment. Future work could include larger sample size and distinct groups based on their reflective ability to compare their perception on self-reflection in an online learning environment. It would be fruitful for future work to study the effects an online self-reflection tool has on students over a longer period.

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