# ACTIVE LEARNING – HOW TO PROMOTE IT?

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## ABSTRACT

Nowadays, learning occurs increasingly in online or blended learning environments. This can cause challenges for learners. Digital learning possibilities require i.e. self-regulatory skills such as time management and monitoring and controlling learning behaviour. According to literature, students with self-regulatory skills are typically the active ones and they are able to control their learning behaviour in different ways. Designing learning activities that are meaningful for the students can stimulate self-regulated learning and engagement to the studies. Hence, developing instruments that promote students' self-regulated learning, is considered important.

This study contributes to the discussion of promoting active learning of engineering students in online and blended learning setups. Active learning is discussed from the perspective of engineering mathematics and physics courses. The study applies Zimmerman's [1] social cognitive model of self-regulation and presents a vast variety of instruments for promoting active and self-regulated learning. This study is a part of development process that adopted design-based research approach. The aim of this study is to provide principles for changing instructional design to promote active learning.

## 1 INTRODUCTION

Design-based research approach has become an important approach utilized in educational research contexts during 21st century. The approach enables building a stronger link between theoretical research and an authentic learning context by designing and testing interventions that aims to improve local educational practices [2]. In the context of this study, principles of design-based research were utilized when linking theory of self-regulated learning and active learning methods in authentic learning context. This study is a part of a larger development process reported in [19].

Putting emphasis on such instructional methods that promote students' own activity has become important in engineering studies. Mathematics and physics are subjects in which learning requires students' engagement and own activity. Self-regulated learning is one of the most important areas of educational research and it is also often connected with students' learning engagement and activity [3]. This study discusses promoting active learning and self-regulated learning in engineering mathematics and physics courses. In this section, concepts of active learning and self-regulated learning are presented. Self-regulated learning is discussed from the perspective of Zimmerman's [1] social cognitive model of self-regulation.

### 1.1 Active learning

Broadly speaking, active learning covers a variety of instructional methods which engage students as active participants. Hence, active learning is anything but passive listening of a lecture. Prince [4, p. 223] defined active learning as "any instructional method that engages students in the learning process". Thus, engaging and activating students during their learning process are the core principles of active learning [4].

In science, technology, engineering and mathematics (abbreviation STEM), examples of active learning methods are i.e.: simulation, demonstration, laboratory work calculating, learning from educational videos, group discussion, taking online exercises, self-assessment and peer instruction. Such instructional methods promote students' own activity and taking responsibility of their own learning process. Instead of passively listening to a lecturing, students actively do learning activities and process information in various ways. In mathematics and physics much of studying includes understanding of mathematics/physics concepts and procedures, which require active learning from students.

Different studies have highlighted benefits of active learning methods. Freeman et al. [5] carried out a meta-analysis of 225 studies that had reported course scores and passing rates in STEM courses and they compared results of studies between traditional lecturing method and active learning methods. Their analysis indicated that using active learning methods can increase passing rates and course scores. Especially, they found that active learning methods have great benefits with small groups, but it is effective for all group sizes. Similar positive effects have been found also in other studies [4, 6, 7].

### 1.2 Self-regulated learning

Active learning can be promoted in both traditional classroom setting and online learning environments. When learning activities occur in online learning environments, it requires from learners i.e. time management, attention focusing, capability to select, use and apply effective learning strategies and ability to control and monitor their own learning process. In other words, it requires self-regulatory skills. Such self-regulatory skills are often connected with active learning. Research has shown that when mastering own learning process, learning outcomes are typically better [8, 9].

Different theoretical models for self-regulated learning have been developed such as Borkowski [10], Efklides [11], Pintrich [12], Winne and Hadwin [13] and Zimmerman [1], for example. Social cognitive perspective is the most widely used theoretical perspective for self-regulated learning [14]. This study uses Zimmerman's model [1], which relies on the social cognitive perspective of self-regulation.

### 1.3 Zimmerman's model of self-regulation

From a social cognitive perspective, self-regulated learning is a context-related cyclical process [1, 15]. Based on Zimmerman's perspective, a self-regulated learner uses the feedback from prior learning efforts to monitor and adapt his/her learning behaviour, while occurring learning tasks [16].

Zimmerman's self-regulated learning model (see *Fig. 1*) has three phases: forethought, performance/volitional control and self-reflection, each divided into two sub-processes.

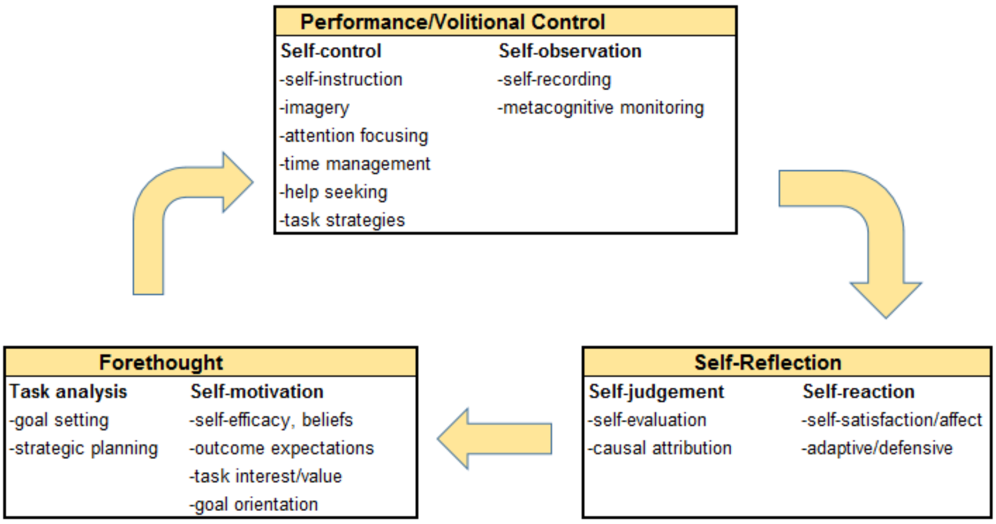


*Fig. 1.* Zimmerman's model of self-regulated learning [1, 15]

During the forethought phase, a student sets goals for a learning task and selects proper learning strategies. Self-motivation components such as e.g. self-efficacy beliefs, outcome expectations and task interest usher the process and selection of strategies. During the performance/volitional control phase, a student executes the learning task at hand. A self-regulated student monitors, observes and controls his/her learning behaviour, uses proper time management and seeks help while completing the learning task, for example. In the third phase, self-reflection phase, a self-regulated student self-evaluates his/her performance. Attributions are student's beliefs about the reasons of success or failure. Self-reactions that are caused by success/failure can be positive or negative and the reactions can influence student's future motivation and performance [1, 17].

## 2 PROMOTING ACTIVE LEARNING

Self-regulatory skills are not mental abilities but rather they are task related skills. Students can learn to become a self-regulated learner [1, 18] and an instructor can promote students' self-regulatory processes. As active learning and self-regulated learning are often connected with academic achievements, promoting self-regulated learning is one perspective for enhancing students learning in engineering mathematics and physics [19]. The following chapters introduces methods and instruments for promoting active learning in engineering mathematics and physics courses especially from the perspective of self-regulated learning.

### 2.1 Different lecture structures

Research has shown, that students can maintain their attention only about 15-20 minutes during lectures [20, 21]. Hence, putting emphasis on instructional design that promotes students' own activity is important.

One way to support maintaining students' attention during in-class sessions is to vary lecture structures in a meaningful way. Active learning can be promoted with different lecture structures, for example by varying the activation tasks and lecturing. *Fig. 2* demonstrates examples of different types of face-to-face lecture structures that promote active learning.

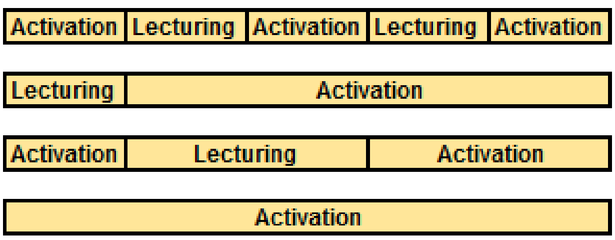


*Fig. 2.* Examples of different types of lecture structures

A lecture that promotes students' active learning can for example start with activation task and continue with lecturing and activation tasks. A lecture can also be fully activating. Following presents examples of more specific instruments for promoting students active learning in engineering mathematics and physics before, during and after lectures.

### 2.2 Instruments for promoting active learning

In engineering mathematics and physics courses, students' own activity is important to be able to learn abstract concepts, procedures and problem-solving skills, for example. *Fig. 3* presents different instruments for promoting students' active learning from the perspective of self-regulated learning [applied from 19]. Different instruments are connected with Zimmerman's self-regulated learning cycle.

In the forethought phase, a student sets learning goals and selects learning strategies. Self-motivation typically controls these actions. Students' strategic planning and goal setting can be promoted by i.e. providing clear assessment criteria for course or learning task, setting detailed weekly learning goals and giving specific learning goals for the course. For example, competence-based assessment criteria for different grades help students to recognize, what are the learning outcome expectations of the course, which naturally influence on students' learning goals [17].

Motivation consists of different components. Students' outcome expectations, self-efficacy beliefs and task interest are examples of such components that influence learning motivation [22]. From this point of view, for example a survey at the beginning of a course that helps students to recognize, how they are learning and studying, can promote students' motivation and support self-regulated learning.

Self-efficacy beliefs are one of the components that influence student's learning motivation [22] and are strongly task related. When a student experience learning task as useful or valuable, it typically promotes student's learning motivation towards the learning task at hand [23]. In physics, demonstrations, measuring exercises supporting theory, practical laboratory exercises and different types of exercises from easy to demand, are elements of instructional design that students typically experience as useful. Hence, these kinds of elements can contribute student's learning motivation that are connected to successful learning outcomes.

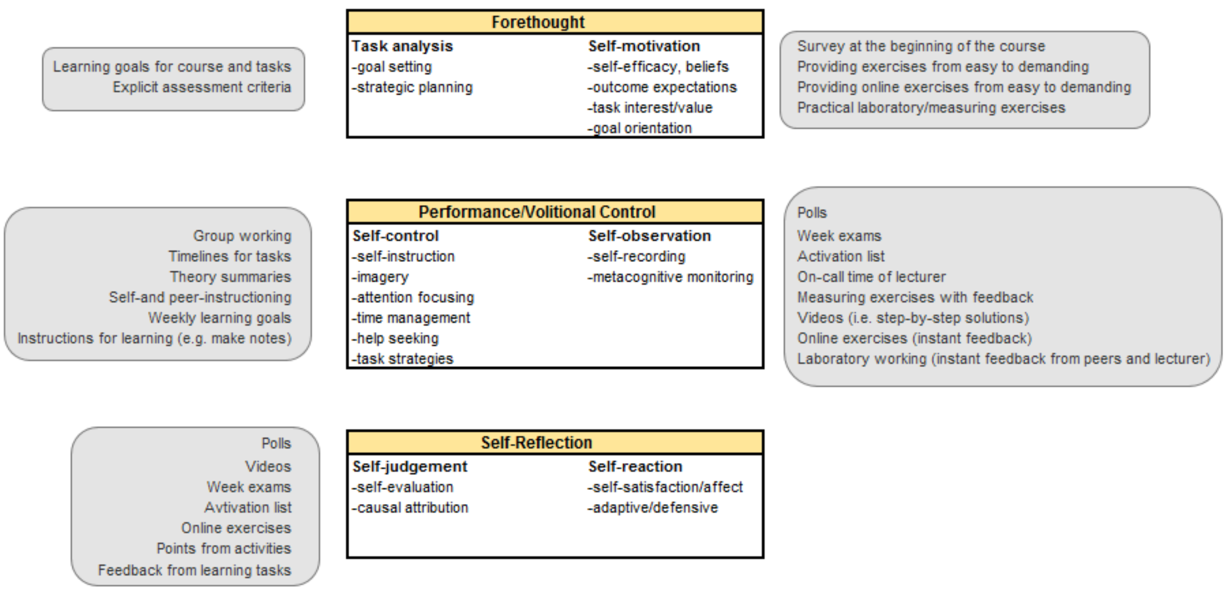


*Fig. 3.* Examples of elements for promoting active learning

The next phase in Zimmerman's cyclical process is performance phase, when a student executes the learning task and uses the strategies that he/she selected in the forethought phase. Performance phase includes self-control and self-observation classes.

Group working and self/peer-instructions are elements that can contribute students' self-control. If an instructor provides specific timelines for different learning tasks and gives learning goals at weekly level, these can help students to focus their attention, promote help-seeking and enhance time management, all elements of self-control. Also, instructions for learning, such as make notes about the video lectures or keep learning diary about laboratory working, are instruments that promote students own activity and self-control.

A part of the performance phase in Zimmerman's model is self-observation, when a student tracks and monitors his/her learning behaviour systematically [16]. E.g. different types of polls and week exams activate students and can provide valuable feedback to students about their personal performance and help their self-observations. Such instruments are online exercises and short learning videos, as well. These all can contribute students' learning by giving instant feedback about individual student's current performance. In subjects such as mathematics and physics, where a lot of learning is calculating exercises, instant feedback is of great importance in the development of students' conceptual understanding and procedural fluency.

Third phase in Zimmerman's model that occurs after learning effort, is self-reflection. This phase includes self-judgement and self-reaction classes. Student's performance related self-reflections typically influence the forthcoming forethoughts (i.e. outcome expectations and self-efficacy beliefs in the future) completing the cyclical nature of Zimmerman's self-regulated learning model [16]. In this phase, a student evaluates usefulness of selected strategies and reasons for good performance or possible failure [24]. In this phase, a student typically evaluates, whether the success was due to effort or whether the lack of effort or lack of ability cased the performance failure [16]. The attribution style a student has, influence on which emotions, positive or negative, a student experiences regarding to performance. This naturally can affect student's motivation in the future [17].

Figure 4 shows an example of student self-evaluation tool used in physics learning. Each week the students filled in a detailed online self-evaluation form of their mastery of the week's topics. The form is adopted from the work of Peura [25]. The table was visible to all students. Therefore, only nicknames were used on the table. In *Fig 4* the first weeks of the table are shown. Students typed a letter to the cells according to their perception of the mastery of the topics and the cells were then coloured automatically accordingly:

a) I have learnt this so well that I could teach it to my peers.
b) I feel I understand this topic.
c) I think I have understood this partially, but partially it is unclear.

d) I need more practice to understand this.

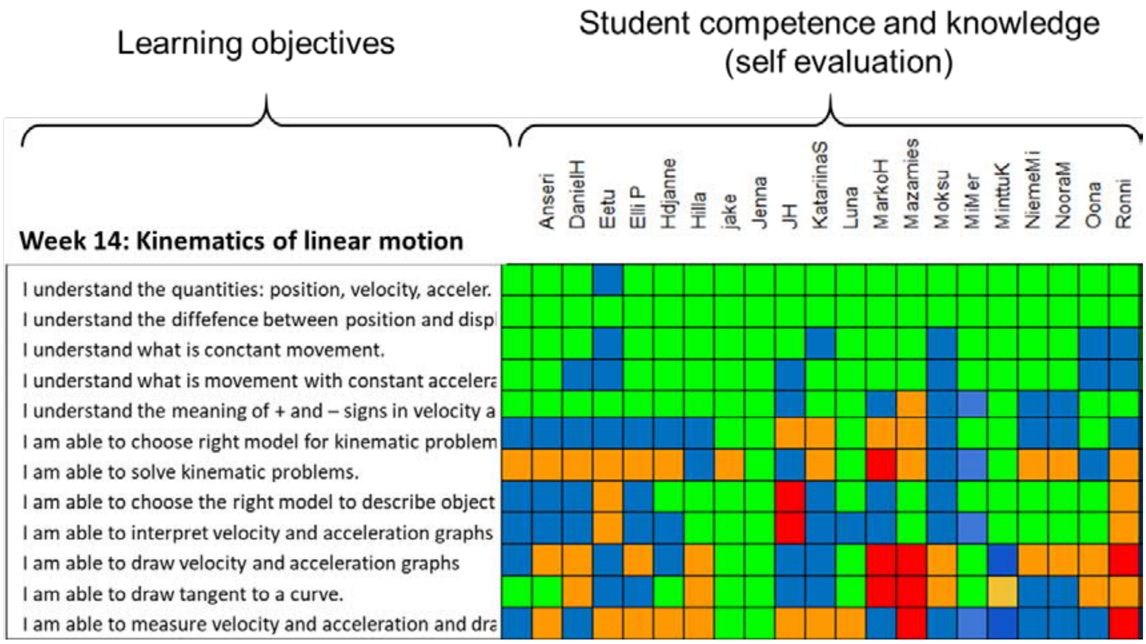


*Fig. 4.* An example of an online student self-evaluation form adapted from [25].

Different types of instruments that provide feedback about student's progress and performance give to a student an important information for self-evaluation. Such instruments are e.g. polls, videos, week exams and online exercises that help students to evaluate and reflect their understanding and learning. Also, assessment instruments such as points from week exams and activation list (list of exercises) give students resources for self-evaluation. Different form of feedback also serves adaptive students that learn from their mistakes and modify their learning strategy in the future.

## 3 SUMMARY

This study discusses promoting active learning of engineering students in engineering mathematics and physics courses. The study gives examples of methods and instruments for activating students from the perspective of self-regulated learning. Students that have self-regulatory skills are typically active and engaged to their studies. These students are also able to control their learning behaviour in different ways. With proper instructional design, it is possible to develop learning activities that are useful and meaningful for the students, which can stimulate self-regulated learning and engagement to the studies. This study is a part of a larger development process that adopted design-based research approach [19].

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