

Research in PRIME: where statistics and educational science meet.

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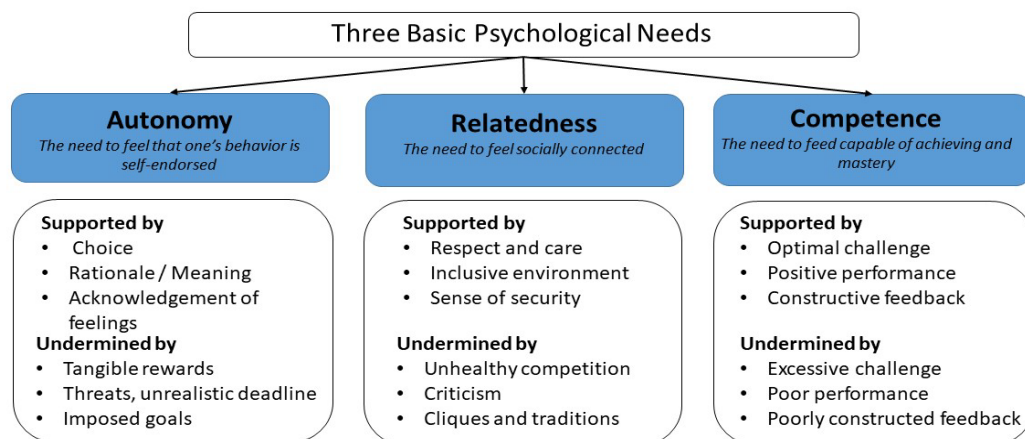
With every innovation in education, it is crucial to not only look at what works but also seek to understand what works for whom and how it works. A multidisciplinary team of researchers are working together to investigate interfaculty mathematics education within PRIME. The core team consists of Laura Menschaart (PhD candidate), Natalie van der Wal and Jacqueline Wong (Postdoctoral researchers), Annoesjka Cabo and Geurt Jongbloed (TUD), Renate Klaassen (TUD & 4TU.CEE), and Martine Baars (EUR). Together, they are conducting multiple studies to understand and enhance motivation for mathematics education as well as the transfer of knowledge from mathematics to engineering. The studies can be broadly categorized under two main lines of research. Since the research is embedded in the section Statistics of the Delft Institute of Applied Mathematics (DIAM), the statistical methods used in educational science will also be subject of research, thus providing a sound basis for the research conducted in the following two lines. Another goal is to find an answer to the question how to tackle the problem that conditions needed for statistical methods to be applied, are often not met in practice.

Two lines of research: Self-Determination Theory and Self-Regulated Learning

The first line of research builds on the Self-Determination Theory (SDT), a macro-theory of human motivation. The theory proposes that there are three basic human psychological needs: the need to feel competent, autonomous, and related to others (Deci & Ryan, 2008). Figure 1 illustrates the conditions that support or undermine the three basic psychological needs. The extent to which these needs are supported or undermined within the social contexts influences the extent of internalization of external regulation, and in turn, the quality of motivation. Accordingly, when students feel that their needs are being supported by the learning context, they are more likely to internalize external regulation of their behavior and become more autonomously engaged in their learning (Niemiec & Ryan, 2009). SDT makes a distinction between autonomous and controlled motivation that direct and energize behavior, as opposed to amotivation that refers to a lack of motivation to act. Enhancing motivation is key to the PRIME project. Therefore, we aim to use SDT as a starting point to examine student motivation and to develop interventions to enhance student motivation.

Figure 1

Three basic psychological needs from the framework of Ryan and Deci's self-determination theory adapted from Cook and Artino (2016)



Two studies are currently proposed in the first line of research. Figure 2 provides a summary of the research questions in the two proposed studies. In Study 1, a cross-sectional research design will be used to investigate the relationships between students' perceptions of teacher support, their satisfaction and frustration in their needs for relatedness, competence, and autonomy, and academic performance. It is hypothesized that higher perceptions of teacher support will be positively related to needs satisfaction and negatively related to needs frustration. We also hypothesize that autonomous motivation is positively related to academic achievement whereas controlled motivation is negatively linked to academic achievement. The aim of the Study 1 is twofold: to examine the relationship among the measured variables using statistical modelling and to examine whether there are gender differences in the measured variables. Results of the study will be used to inform the design of subsequent studies (e.g., Study 2) where interventions will be developed to promote sense of belonging and feelings of competence.

Figure 2
Summary of research questions in first line of research

First Line of Research: Enhance Motivation

Study 1. Using concepts in self-determination theory to examine student motivation in PRIME

Research Question 1a: What are the relationships between student perceptions of teacher cues in monitoring and scaffolding, satisfaction and frustration of needs for relatedness, autonomy and competence, motivation, and academic performance?

Research Question 1b: Are there gender differences in the relationship examined in 1a?

Study 2. Interventions to enhance sense of belonging and competence

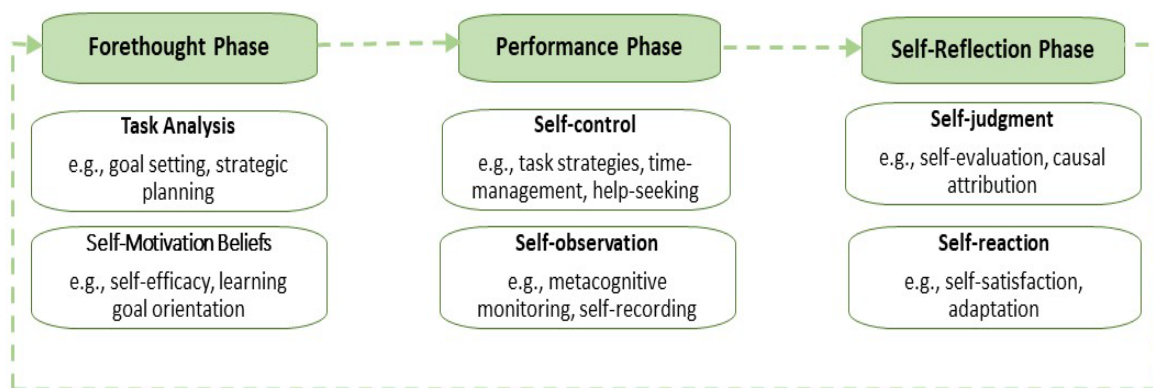
To design and implement interventions to promote sense of belonging and feelings of competence.

To take differences in student characteristics into account and examine whether the intervention(s) have differential effect on different groups of students.

The second line of research builds on the theories of self-regulated learning (SRL) and metacognition. Theories of self-regulated learning suggest that students are active agents who direct and steer their learning process in pursuit of personal learning goals. Figure 3 illustrates the three cyclical phases of Zimmerman’s SRL model adapted from Zimmerman and Moylan (2009) (for review of Zimmerman’s SRL model, see Panadero, & Alonso-Tapia, 2014). Students typically set goals and make plans before embarking on a task. When working on a task, students will deploy various learning strategies and self-monitor their learning. At the end of the task, students will self-reflect on their learning process before repeating or adjusting their cycle of SRL. Research suggests that SRL is positively related to academic achievement. Therefore, the second line of research will employ the theories of SRL and metacognition to better understand how students learn, and ultimately, enhance performance and transfer of knowledge from mathematics to engineering.

Figure 3

Three cyclical phases and processes of self-regulated learning adapted from Zimmerman and Moylan (2009)



The main focus of the second line of research is on students’ learning performance and transfer of knowledge from mathematics to engineering in PRIME. Currently, videos with contextual examples of mathematics in engineering are created. The intent of the videos is to support non-math students in their mathematics education by 1) making mathematical concepts more meaningful through the applied examples, 2) increasing engagement with mathematics education by relating to students’ own field of interest, and 3) promoting a sense of autonomy by giving students the choice to watch the videos and manage their study pace. As shown in the Figure 4, Study 3 will be an empirical study to investigate the effectiveness of adding in-video prompts on student performance and transfer. We will examine two types of in-video prompts: 1) prompts with math problems in context to support self-testing and 2) prompts to elicit self-explanation of the solution steps in the provided worked examples.

Another study in this line of research is to investigate the study strategies that are frequently used by students to learn math (Study 4). Prior studies suggest that students are prone to use less effective strategies, such as cramming instead of spacing out their study, which can have negative effects on their performance. Therefore, the aim of Study 4 is to understand whether students are using effective study strategies and to examine the role of the study strategies on students' academic performance. Results of Study 4 will provide a basis for further studies (e.g., Study 5) in which we will develop and examine interventions to support students' autonomy during study and to enhance academic success in PRIME.

Figure 4

Summary of research questions in second line of research

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| <p>Second Line of Research: Enhance Performance and Transfer</p> |
| <p>Study 3. Enhancing student performance and transfer using videos with contextual examples Research Question: What is the effect of adding in-video prompts (i.e., practice questions vs. worked examples with self-explanation prompts) to contextual example videos on students' performance and transfer?</p> |
| <p>Study 4. How do students learn? Research Question 1a : What are the study strategies that students most frequently use? Research Question 1b : Are there differences in the reported study strategies between different groups of students? Research Question 2 : What is the relationship between the reported study strategies and academic achievement?</p> |
| <p>Study 5. Interventions to enhance study strategies as a way to support autonomy To design interventions (e.g., training, serious games, or learner analytics visualization) to enhance students' study strategies and facilitate better decision making.</p> |

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