This is an author produced version of a paper presented at ESERA 2011, September 5th-9th 2011, Lyon.

Mikael Winberg
Motivation for Learning Science and Mathematics: Identifying Personal and Environmental Factors
ESERA 2011, September 5th-9th 2011, Lyon
Motivation for learning science and mathematics: identifying influential personal and environmental factors.

Abstract
Several theories in motivation research aim at explaining or predicting the emotional experiences and behavior of students in academic situations as well as the quality of learning outcomes. However, there are still ambiguities regarding the mechanisms of motivation, how motivation can be influenced, and what effects motivation has on learning. As a first step to examine the role of situational and personal variables involved in some of the most influential motivation theories, their relative ability to predict student behavior, emotional experiences and learning outcomes were investigated by PLS analysis of questionnaire data from 658 upper secondary school students. As to outcomes, results show that experiences of anxiety, on one hand, are orthogonal to perceived degree of learning, enjoyment, and motivated behavior, on the other. Major predictors of anxiety emotions were; Attributions, pertaining to the perceived degree of control over outcomes; the nature of relations to peers; and whether the students perceived that the goal of the lesson was understanding or ‘production’. The degree of learning, motivated behavior, and enjoyment were, in descending order, predicted by students’ achievement goals and motivation type, the teacher’s engagement, character of feedback, autonomy support and the level of teacher demands on students. To some extent, students’ epistemological beliefs regarding the complexity of knowledge also predicted these types of outcomes.

Background, framework and purpose
Motivation, defined as the process whereby goal-directed behavior is instigated and sustained (Pintrich & Schunk, 2002), can be considered as an absolute requirement for efficient learning. The higher the level of motivation, the higher is the probability that the student will engage in the learning and persist when encountering difficulties, an inherent component of learning. However, as well as there are different levels of motivation among students, they also differ in the reasons they have to engage in an activity, i.e., type of motivation. Some students engage in learning because it satisfies a need for understanding and/or elicits feelings of satisfaction, while others may be driven by a wish to outperform their peers in order to enhance or protect self worth. Research indicate that the type of motivation, together with, e.g., the student’s beliefs about knowledge and learning, attribution patterns, expectancies of success and value beliefs influence students’ persistence, concentration and emotional experiences of the learning process (Ryan & Deci, 2000). In a longer perspective, emotional experiences are also assumed to contribute significantly to the student’s attitudes toward the activity of learning a specific subject (Eagly & Chaiken, 1993). Thus, understanding what motivates our students is important, not only for the quality of learning but also for the student’s future career choices. However, there is little consensus among researchers on the nature of the motivational process, or, as Schunk et al. (2008, p. 3) puts it, “…what motivation is, what affects motivation, how motivational processes operate, what effects motivation has on learning and performance, and how motivation can be improved.”. Indeed, due to reciprocal relationships, e.g., in the case of emotions, it is often difficult to discern when a variable is the result of the motivational process and when it is an initiating factor. The present study aims at investigating the relative ability of different motivational constructs to predict behaviour, cognition and emotional experiences in different learning situations. This is part of a larger study, aiming at investigating interactions between a selection of personal and situational factors, and how this interaction influences their motivation to learn Science and Mathematics in school.

Method
Two questionnaires were distributed to 658 students in 55 upper secondary schools, which were selected by the national school inspectorate as a “reasonably representative” sample. The first questionnaire assessed students’ personal characteristics, e.g., beliefs about themselves and about learning mathematics as well as the general characteristics of the learning situations in mathematics. After a specific lesson, students completed the second questionnaire, measuring the characteristics of the specific learning situation and their responses to it, in terms of behaviour, emotions and cognition. 502 students completed both questionnaires.

Constructs measuring personal characteristics of students were: Achievement goals (Elliot & Thrash, 2001), epistemological beliefs (Hofer, 2001), expectancies of success, utility-, incentive- and attainment value of learning mathematics (pertinent to the expectancy-value theory by Wigfield & Eccles (2000)), motivation types (Ryan & Deci, 2000), and attributions (Weiner, 1985). Among the situational features were: perceived level of autonomy support, attitudes towards mathematics and supportive ability by peers and parents respectively, social relation to peers in class, opportunities for verbal interaction with peers and teacher, character of feedback from teacher, performance-related expectations and control/support from teacher, task difficulty (perceived), perceived novelty of task and information encountered during the activity and perceived goals of the activity (e.g. creativity and independent thinking or understanding vs quantitative performance (number of tasks solved per lesson)). Outcome variables were: emotional experiences (i.e., anxiety, enjoyment and “interest”), behaviour (concentration, effort) and cognition (perceived learning).

The validity of the questionnaires was examined by principal component analysis (PCA) of each construct, followed by interviews with respondents to check up on interpretations of items that did not show expected patterns of co-variation with other items within the respective construct. Problematic items were revised and the validation procedure was repeated. A total of, four validation rounds were performed. For some constructs, statistical validity, in terms of cross validity (Q²), was difficult to obtain, possibly due to the relatively few items that could be allowed due to restrictions in questionnaire length. In these cases, face validity judgements, i.e., if the constructs were intelligible with respect to dimensionality and correlation between items and alignment with underlying theory, and construct eigenvalues above 1 were criteria for inclusion in the next step of analysis in which relationship between constructs and the relative predictive ability of constructs were investigated by hierarchical PLS analysis (figure 1). For reasons of brevity, only an overview model is presented here. In-depth analysis of the variables that predict individual outcomes will be presented at the conference.

Results
The components of the resulting model were significant according to cross validation and the model as a whole was significant according to response permutation testing. $R_x^2 = .45$, $R_y^2 = .35$ and $Q^2 = .31$. Interest/enjoyment, Perceived learning and behavior were predicted to $38\%$, $36\%$ and $29\%$, while metacognition and anxiety were predicted to $23\%$ and $21\%$ respectively.

At this stage, the relative influences of the independent variables on the outcomes were in focus. A variable importance (VIP) analysis revealed that task curiosity, intrinsic or identified external motives for learning, non-demeaning and constructive feedback from the teacher, and mastery goals were the most influential variables in the model, simultaneously predicting all outcome variables. Most of the ‘independent’ variables had predictive importance, but for different aspects of motivation. For example, in addition to the above mentioned factors, the performance-related expectations and control/support from teacher (‘teacher demands’) together with autonomy support and the teachers own interest for teaching the subject were especially important for predicting students’ perceived learning, behavior and interest/enjoyment while students’ attributions, on the other hand, only predicted the level of anxiety the student experienced in the learning situation. A detailed analysis showed that attributions to uncontrollable factors predicted the degree of anxiety (pos. correlation), while attributions to effort were positively associated with metacognition. Task curiosity is an especially important variable for predicting metacognitive activities and, somewhat surprisingly, anxiety (together with high task difficulty). A perception that understanding was the goal of the lesson (as opposite to solving many problems) reduced anxiety as well as perceived task difficulty.

Conclusions.
To understand what motivates our students to learn mathematics, we need to simultaneously consider several aspects of the situation as well as their personal thoughts and beliefs. Some variables are more important than others but it is by simultaneously “optimizing” several factors that we get the most pronounced effects on student motivation. Teachers need to consider how to communicate and support the development of mastery goals and stimulate
intrinsic or identified types of motivation. This would include design of learning situations where competition between students is minimized but still with clear goals and were students are expected and encouraged to do their best, as well as development of tasks that are perceived as relevant and challenging and stimulate students curiosity. The character of teacher feedback as well as his/her own interest and enthusiasm about teaching the subject in the particular class were found to influence behavior and perceived learning. These variables also have potential to influence students’ perceived need to protect self worth and thus their motivation type. To be able to properly inform the design of learning situations, more research is however needed on how the studied variables interact, e.g., how epistemological beliefs mediates the effects of a high degree of autonomy on motivation and learning, as well as more in-depth studies of the causal relationships between constructs.

References


