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The transition from school to university mathematics is a difficult step for students, which many of them do not succeed to manage immediately. In this contribution we use questionnaires, which measure mathematics-related affective variables as well as subject-unspecific affective variables and students' achievement during the semester to predict the outcome of the exam at the end of the first semester (as a first indicator for success in their studies) and the students' attendance in this exam (as an indicator for early dropout). We are interested in whether the mathematics-related or the "general" affective variables are more suitable to predict the students' exam attendance and the exam outcome. The students' achievements during the semester turned out to be the best predictor for the exam outcome, whereas the students' attendance was best predicted by their interest in mathematics.

Keywords: transition to and across university mathematics, teaching and learning of analysis and calculus, dropout, study success, affect

INTRODUCTION

Dropout is a big problem for German universities, especially in mathematics. Nearly 80% of all mathematics students drop out or change their subjects – most of them during their first year at university (Dieter & Törner, 2012). However, this is not a typical German phenomenon: Chen (2013) reports similar figures of dropout and subject change for the United States. In this paper, we do not distinguish between students who drop out and leave the university system without examination and those who "just" leave mathematics and change to another subject.

At Ruhr-University Bochum, where our study takes place, students begin their studies of mathematics with two lecture courses in the first semester – calculus I and linear algebra I. Two so called "mini-tests" are written during the semester to prepare the students for their first "real" exam at university. These "mini-tests", designed by the lecturer, cover conceptual and procedural knowledge about definitions and proof which have been discussed in the lecture before. 73% of the students at Ruhr-University (who attended the exams) failed their calculus exam in 2017. Furthermore, 25% of the students did not even attend the exam. Following the goal to improve the support of students who are at risk to fail their exam and/or drop out, we are interested in which way students at risk differ from those who succeed.

Due to data protection regulations, it was not possible for us to identify which students really dropped out from mathematics at Ruhr-University in 2017. Instead, we could match the results from our questionnaires with the results of the exam at the end of the first semester. We therefore could identify which students were successful in their exam, which failed and which did not attend the exam. Students who did not attend the exams might have dropped out before or may be at risk to drop out soon. Baars and Arnold (2014) found that students who do not attend their exams in the first semester have a high risk to drop out.

THEORETICAL BACKGROUND

Both, dropout and study success, are considered to be influenced by multiple factors, which are often called predictors, such as the socio-economic and school background, personal psychological prerequisites, learning behaviour and study conditions (Tinto, 1975; Heublein et al., 2009; Thiel et al., 2008).

The predictors, which are listed by the students for their decision to drop out, are called dropout reasons. In Germany, most dropped out mathematics students name the course requirements (e.g. failed exams, work-overload) (33%) and low motivation (25%) as their main reasons to quit their studies of mathematics. Other reasons such as study-conditions (13%) and reasons related to health- or financial problems (12%) and personal reasons like family problems (10%), were less important – specially for early dropout (Heublein et al., 2009).

Given the fact, that most dropped out mathematics students in Germany name the requirements at university and their lack of motivation as crucial for their decision to drop out, we want to shed light on the following affective variables, which are considered to influence the students' motivation and academic achievements: mathematical self-concept, interest in mathematics, beliefs concerning the nature of mathematics, basic needs and general self-efficacy. These variables are briefly discussed in the following.

Mathematical self-concept

The self-concept can be seen as the mental model of one's personal competences, abilities and properties, or "in very broad terms, self-concept is a person's perception of himself" (Shavelson, Hubner, and Stanton, 1976 as cited in Bong and Skaalvik, 2002). The self-concept is influenced by the students' former experiences and achievements and can itself influence students' motivation (Bong and Skaalvik, 2002). The self-concept is considered to be domain specific. Rach and Heinze (2016) found that the mathematical self-concept is a significant predictor for dropout but not for students' success in the first semester.

Interest in mathematics

The interest in mathematics is considered to have a positive impact on the learning of mathematics. Schiefele et al. (1993) define interest as a specific relation between a person and an object. The interest in the subject that one is studying is rather stable, since it has been developed over a longer time through different experiences.

Due to contradictory results in various studies the impact of interest in mathematics on students' performance and success in their studies of mathematics remains uncertain. Rach and Heinze (2016) found no significant influence of the interest in mathematics on students' success during the first semester or on their risk to drop out. However, Blömeke (2009) found significant correlations between the interest in mathematics and the students' intention to drop out.

Beliefs concerning the nature of mathematics

It has been widely discussed that the nature of mathematics changes with the transition from school to university (e.g. Rach and Heinze, 2016). Mathematics in German schools is often focused on applying mathematical techniques to solve real world problems (modelling, problem solving). New mathematical contents are regularly presented more intuitively with examples and illustrations and yield on an intuitive or practical understanding of the concepts. Mathematics at university is more theoretically and proof oriented. New concepts are presented in a rather formal and abstract way and therefore less illustrated than in school. The focus often lies on encouraging logical and abstract thinking. The students have to develop understanding for deductive argumentations and proof – applying the theory is less important than at school. This change from a practical to a theoretical approach is not easy for most students. Many of them feel a big gap between mathematics at school and university (Geisler, 2017). This feeling might be a result of unfulfilled expectations and incongruences between the mathematical "reality" at university and their established beliefs concerning the nature of mathematics, which are based on their school experiences. Daskalogianni and Simpson (2001) call this phenomenon "belief overhang". Andrà, Magnano and Morselli (2011) found hints that students' beliefs concerning the nature of mathematics can influence their decision to drop out or to stay. Traditionally we distinguish between a *static* view, where mathematics is viewed as a summary of (unconnected) rules, facts and techniques, and a *dynamic* view, where mathematics is considered as a process and a creative field of research (Grigutsch and Törner, 1998). However, it is yet unclear which beliefs are beneficial for a successful transition from school to university.

Basic Needs

Following the framework of self-determination theory (Ryan & Deci, 2000), there are three basic psychological needs that are important for the well-being of humans and to generate motivation: social relatedness, competence and autonomy. In the special situation of the transition from school to university mathematics, many students do not experience autonomy and competence (Liebendörfer and Hochmuth, 2013). This is problematic since Faye and Sharp (2008) found that especially the feeling of competence is strongly associated with motivation in university. In an explorative case-study, we found hints for the impact of social relatedness and competence on the decision to drop out (Geisler, 2017).

General self-efficacy

The general self-efficacy is the strength of a persons' belief to be able to reach certain goals and to solve problems by his or her own competences and abilities (Luszczynska et al., 2005). This general belief is not limited to a special domain like mathematics or special academic settings. In contrast to the self-concept, self-efficacy is more focused on the consequences of one's own competences and abilities than on the competences and abilities themselves. That's why self-concept is rather past oriented whereas the self-efficacy focuses on the future (Bong and Skaalvik, 2002). Besides, self-concept is considered to be the more stable variable. Self-efficacy can influence the students' motivation in the sense that students who believe that they are able to succeed in their studies of mathematics are more motivated to put effort in their learning than those who believe that they have no chance in the exams. Self-efficacy is therefore associated with academic achievement (Luszczynska et al., 2005; Bong and Skaalvik, 2002). Students with lower self-efficacy have a higher risk to drop out than those with higher self-efficacy (Krieger, 2011).

Achievement during the semester

The students' achievement is an important factor for success and dropout. In Tinto's (1975) framework, achievement, as a part of the academic integration, is important for the decision to drop out or to stay. In an explorative case-study, Geisler (2017) found hints that students who are not satisfied with their achievement during the first semester sometimes drop out, even if they are successful in their exams at the end of the semester. Though achievement is closely connected with the perceived feeling of competence.

RESEARCH QUESTIONS

In order to support students who are at risk to fail their exam or even to drop out we want to know in which way these students differ from those who succeed. Following the theoretical background described above, we decided to focus on the students' achievements during the first semester and on affective variables which are likely to influence students' motivation. Since the dropout rate in mathematics is high compared to other subjects, it seems plausible that mathematics related variables have an important impact on dropout and success. We therefore distinguish between mathematics-related affective variables (mathematical self-concept, interest in mathematics, beliefs concerning the nature of mathematics) and more "general" affective variables (basic needs, self-efficacy). We are interested in whether the mathematics-related or the "general" affective variables are more suitable to predict students' exam attendance and their exam outcome. This leads to the following research questions:

Differences between the three groups of students

1) Which differences in the affective variables and the achievements can be found between students who do not attend the exam, students who fail in the exam and those who succeed?

Prediction of the students' exam attendance

2.1) In which way can the mathematics-related affective variables predict the students' attendance for the exam at the end of the first semester?

2.2) In which way can the "general" affective variables and the students' achievements approve this prediction?

Prediction of the exam outcome

3.1) In which way can the mathematics-related affective variables predict the outcome of the exam at the end of the first semester?
3.2) In which way can the "general" affective variables and the students' achievements approve this prediction?

METHODOLOGY

209 students in the calculus lecture in wintersemester 2016/17 voluntarily participated in our study. Undergraduate mathematics students as well as pre-service teachers in mathematics usually attend this lecture during their first year at university. The questionnaires were filled out during the lecture in the mid of the first semester, taking into account that students cannot rate their satisfaction of the basic needs at the begin of the semester. Due to incomplete datasets, only N=193 cases could be included in our analysis. The instruments used in our questionnaire can be found in Table 1.

construct	**source**	**No. of items / Crobach's α**	**Item-example**
Interest	Schiefele et al. 2007	12 / 0.82	"It is personally important for me that I can study mathematics."
Self-Concept	Kauper et al. 2012	4 / 0.82	"I am very good in mathematics."
Beliefs: static	Laschke & Blömeke 2013	6 / 0.67	„Mathematics means learning, remembering and applying."
Beliefs: dynamic	Laschke & Blömeke 2013	6 / 0.73	"Mathematics involves creativity and new ideas."
Social Relatedness	Kauper et al. 2012	6 / 0.78	"I feel comfortable with the other students."
Competence	Kauper et al. 2012	3 / 0.66	"I get clear and detailed feedback on my achievements."
Autonomy	Kauper et al. 2012	3 / 0.58	"I can do tasks in my way."
Self-Efficacy	Beierlein et al. 2012	3 / 0.88	"I can solve most problems on my own"

Table 1: Instruments with numbers of items, reliability and item-example

All reliabilities (Cronbachs α) were at least sufficient – except for the reliability of the autonomy-subscale. All items were answered on a five-point Likert scale (1=totally disagree; 5=totally agree). To measure the students' achievement during the semester, we used their results in the first "mini-test" (1 to 12 points).

The results of the questionnaires were analysed using a MANOVA (to prevent the accumulation of the α-error compared with t-tests) to answer research question 1. To answer the other research questions, we used linear and binary logistic regressions.

RESULTS

Students who do not attend the exam at the end of the first semester differ significantly from those who fail the exam and those who succeed in almost all affective variables (research question 1), except for the static beliefs (Table 2). Focussing on the mathematics-related affective variables, the biggest difference between the three groups of students can be found in the interest in mathematics, which can explain 13% of the variance (η^2=0.13***). Regarding the "general" affective variables, the self-efficacy turned out to explain the most variance between the three groups of students (η^2=0.1***). Taking into account all measured variables, the biggest difference between the three groups of students can be found in their achievements in the "mini-test" (η^2=0.19***).

	No Attendance N = 54		Failed N = 101		Succeeded N = 38			
	M	*SD*	*M*	*SD*	*M*	*SD*	F	η^2
Interest	**2.99**	**0.66**	**3.43**	**0.7**	**3.7**	**0.56**	**13.89**	**0.13*****
Self-Concept	**2.64**	**0.83**	**2.93**	**0.67**	**3.11**	**0.58**	**5.45**	**0.05****
Beliefs: static	*3.77*	*0.66*	*3.79*	*0.58*	*3.68*	*0.5*	*0.46*	
Beliefs: dynamic	**3.07**	**0.68**	**3.46**	**0.65**	**3.56**	**0.62**	**8.22**	**0.08*****
Self-Efficacy	**2.46**	**0.96**	**2.78**	**0.78**	**3.25**	**0.69**	**10.18**	**0.1*****
Social Related.	**3.77**	**0.68**	**4.07**	**0.55**	**4.23**	**0.57**	**7.69**	**0.08****
Competence	**2.94**	**0.87**	**3.23**	**0.86**	**3.43**	**0.81**	**3.91**	**0.04***
Autonomy	**2.89**	**0.72**	**3.28**	**0.79**	**3.42**	**0.66**	**6.83**	**0.07****
Achievement	**6.19**	**3.9**	**7.81**	**3.16**	**10.89**	**2.75**	**22.74**	**0.19*****

Table 2: Means, standard deviations and results of the variance analysis
***p<0.05 **p<0.01 ***p<0.001**

To answer research questions 2.1 and 2.2, three different logistic regression models were tested (Table 3). Model 1 only contains the mathematics-related affective variables. The only significant predictor for the students' attendance in this model was interest in mathematics. Model 1 can explain 19% of the variance and is able to classify 71% of the students correctly as attending or not attending. Model 2 additionally contains the affective variables basic needs and self-efficacy. None of these variables has a significant influence on the students' attendance and they do not improve the students' classification. In contrast, the students' achievements are a (weak) significant predictor for the students' attendance (Model 3). The inclusion of the students' achievement can improve the classification of the students (75.1%

correct) and increases the explained variance (Nagelkerke's R^2=0.26). Note that the interest in mathematics is still the most significant predictor in Model 3.

	Model 1	Model 2	Model 3
Interest	**2.43****	**2.5****	**2.42****
Self-Concept	*1.22*	*0.89*	*0.8*
Beliefs: static	*1.14*	*1.3*	*1.29*
Beliefs: dynamic	*1.66*	*1.3*	*1.24*
Self-Efficacy		*1.33*	*1.18*
Social Relatedness		*1.3*	*1.14*
Competence		*0.93*	*1.04*
Autonomy		*1.4*	*1.39*
Achievement			**1.13***
Nagelkerke's R^2	**0.19**	**0.22**	**0.26**
Correct classification	**71 %**	**71 %**	**75.1 %**

Table 3: Results (coefficients Exp(B)) of the logistic regression to predict the exam attendance - *p<0.05 **p<0.01

We used three linear regression models to answer research questions 3.1 and 3.2 (Table 4). In Model 1 only the mathematics-related affective variables were included.

	Model 1	Model 2	Model 3
Interest	*0.08*	*0.06*	*0.01*
Self-Concept	*0.17*	*-0.03*	*0.04*
Beliefs: static	*-0.09*	*-0.01*	*0.02*
Beliefs: dynamic	*0.05*	*-0.02*	*-0.05*
Self-Efficacy		**0.41*****	**0.2***
Social Relatedness		*0.11*	*0.07*
Competence		*-0.08*	*0.02*
Autonomy		*-0.03*	*-0.07*
Achievement			**0.54*****
R^2	**0.05**	**0.13**	**0.37**

Table 4: Results (standardized beta coefficients) of the linear regression to predict the exam outcome - *p<0.05 ***p<0.001

None of them can predict the exam outcome significantly. All these variables together only explain 5% of the variance in the exam outcome. The "general" affective variables, specially the self-efficacy, seem to have a bigger impact on the exam outcome (Model 2). The inclusion of these variables improves the variance that can be explained (R^2=0.13). The self-efficacy is a highly significant predictor. The most important (highly significant) predictor for the exam outcome is the students' achievement in the "mini-test" (Model 3). The inclusion of the achievement increases the explained variance to 37%. Multicollinearity of the variables in our models is at least tolerable (tolerance>0.48, VIF<2) and should not have a big impact on results.

CONCLUSION

The interest in mathematics is the most important predictor for exam attendance in our study, whereas the mathematical self-concept has no significant influence. This is contradictory to Rach's and Heinze's (2016) findings, where only the mathematical self-concept was able to predict the attendance. However, both studies have in common that a mathematics-related affective variable is the most important predictor for the attendance, whereas the "general" affective variables have no influence.

The mathematics-related affective variables do not predict the exam outcome. The only affective variable that significantly predicts the exam outcome is the general self-efficacy. This is rather surprising, taking into account that self-efficacy and self-concept are (at least theoretically) closely connected variables and it seemed plausible that the mathematics-related variable provides more insights. However, in contrast to the mathematical self-concept, the general self-efficacy is not only focussed on one's competences and achievements in mathematics but also takes into account subject unspecific competences which could be beneficial at university, too.

All in all, it turned out that the students' achievements can predict both, exam outcome and exam attendance. Interest in mathematics is suitable to predict the exam attendance, whereas self-efficacy can predict the exam outcome. Firstly, this finding shows that, mathematics related as well as general affective variables play an important role in the transition from school to university. Secondly, it suggests that success and dropout should not necessarily be viewed as two sides of a coin.

Our study has some limitations. We conducted data from only one university, which could lead to cohort specialities. Furthermore, questionnaires were filled out in the mid of the semester during the lecture. Students who do not (regularly) attend lectures or have dropped out before have not been captured by our study. Some results might be different if we could capture those students, too.

Our on-going research will now focus on a more detailed characterisation of dropped out students, taking into account cognitive and metacognitive variables (e.g. students learning behaviour) as well. In addition, it seems to be useful to identify different types of dropped out students in mathematics. This might help to design and evaluate more individualized supporting programs for students in the transition.

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