DEVELOPMENT OF ATTITUDES DURING THE TRANSITION TO UNIVERSITY MATHEMATICS – DIFFERENT FOR STUDENTS WHO DROP OUT?

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Students' attitudes are assumed to play a big role for successful learning processes and to differ substantially between students. To gain a better insight in which way attitudes at the start of a mathematics study program and their development influence study dropout, we asked 219 students to state their interest in university mathematics and their mathematical self-concept at the start of their studies and six weeks later. Applying a cluster analysis, we identified four development profiles which differ in both attitudes at the start of their studies and in the development of both attitudes. The dropout rate among students with different profiles ranged from 7 % to 44 %, highlighting that the development of attitudes in the first semester is of major importance for a successful start.

INTRODUCTION

High study dropout rates in mathematics study programs are a serious problem for individuals and for society. Noticeable is that many students drop out in the first year of study, in particular (Chen, 2013). Research assumes that beneath cognitive variables, such as prior knowledge (Rach & Heinze, 2017), motivational variables, such as attitudes, can explain why some students successfully complete their program whereas other students drop out (CHEPS, 2015; Di Martino & Gregorio, 2019).

In this contribution, we focus on the attitudes "interest" and "self-concept", which we define as follows: Interest in mathematics is a person-object-relationship (cf. Krapp, 2007) which includes a feeling-related component ("I enjoy mathematics") and a value-related component ("I value mathematics"); mathematical self-concept is the personal view of its own abilities in the domain mathematics ("I am fit in mathematics") (cf. Bong & Skaalvik, 2003). Research has shown that both attitudes at the beginning of a mathematics study program were related to study satisfaction (Bernholt et al., 2018; Kosiol et al., 2019) and to the attendance in final exams (Geisler & Rolka, 2018) which are (negative) indicators of study dropout. In addition, previous studies have documented that students' attitudes can develop during the study entry phase (e.g., Bressoud et al., 2013) and there are empirical studies which have assumed that the development of attitudes in the first semester influenced dropout (Di Martino & Gregorio, 2019) respectively have reported a relation between attitudes at the time point of dropout and actual dropout (Schiefele et al., 2007). Thus, beneath the level of attitudes at the start of one's studies also the development of attitudes in the first study

2022. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 283-290). PME.

year seems to play a big role for a successful transition in a mathematics study program.

This phenomenon could be explained by the ideas of Haak (2017). According to Haak, students are monitoring the fit between their own characteristics, such as attitudes or prior knowledge, and the characteristics of the learning environment of their study program. In case of a misfit, students can either adapt their own characteristics, for example by adjusting their attitudes, or they can leave the learning environment by dropping out or changing their study program. The latter is more likely, if they fail to adjust their own characteristics.

An initial fit between students' attitudes and the chosen mathematics study program is not self-evident, due to fundamental differences between mathematics at school and at university. Therefore, during the study entry phase students get to know a new kind of mathematics: whereas in school, new mathematical concepts are usually learned via experiences with real world objects or (counter)examples, in university formal concept definitions and rigorous proofs are used. Likewise, tasks at school often aim at applying mathematics to real world contexts and can be mostly solved via schematic calculations. In contrast, typical tasks at university involve deductive proving (Gueudet, 2008; Halverscheid & Pustelnik, 2013; Thomas & Klymschuk, 2012). With regard to these differences, researchers have argued that distinguishing interest in mathematics in school and in university mathematics helps to understand the role of interest for learning processes in the study entry phase (Liebendörfer & Hochmuth, 2013; Ufer et al., 2017). Indeed, in contrast to interest in school mathematics, interest in university mathematics strongly predicts study satisfaction (Kosiol et al., 2019). As academic self-concept is hierarchically organized (Bong & Skaalvik, 2003), it seems not necessary to split up mathematical self-concept in different facets.

To sum up, interest in university mathematics and mathematical self-concept at the beginning and its development during the study entry phase are probably important predictors for study dropout. However, it is questionable if a high level of these attitudes and a positive development are both important for being successful in a study program and if the development of interest *and* self-concept has to be positive. Instead, the positive development of one of the two variables could probably compensate the negative development of the other variable. Answering such questions calls for a person-oriented analysis, which is a well-known approach from analyses regarding learning strategies (Vanthournout et al., 2013).

RESEARCH QUESTIONS

The focus of this study is to describe students' attitudes at the beginning of the first semester, its development during the first six weeks, and the relation of students' attitudes to dropout. Precisely, we want to answer the following (exploratory) questions:

- In which way is it possible to identify different profiles of mathematical attitudes in the study entry phase?
- To what extend do students with different attitude profiles differ in their decision to drop out?

METHODS

The sample consists of 219 students in a pure mathematics bachelor program (n = 56) and a teacher education program (n = 163) at a large public German university. All students attended the same mathematics courses in the study entry phase and voluntarily participated on an informed consent in this study. Study dropout was measured at the beginning of the second year. 54 students, who were not enrolled in the program anymore, were called dropout students, the remaining 165 students were non-dropout students.

To measure interest in university mathematics and mathematical self-concept, the students rated statements on a five-point likert-scale from totally disagree (1) to totally agree (5) during the second week of the term (T1) and six weeks later (T2). The used items were taken from Kauper et al. (2009) and Ufer et al. (2017):

- Interest in university mathematics: scale of 5 items, "The kind of mathematics that is done at university is fun for me." (sample item), Cronbachs' α (T1) = .89, Cronbachs' α (T2) = .92.
- Mathematical self-concept: scale of 4 items, "I am very good in my study subject mathematics" (sample item), Cronbachs' α (T1) = .82, Cronbachs' α (T2) = .84.

The correlations between interest and self-concept and its development were weak to middle. Thus, it is adequate to apply a cluster-analysis to identify clusters which show similar attitudes or development patterns of attitudes. We included the following variables in the analysis: interest (T1), self-concept (T1), the development of interest (interest (T2) – interest (T1)), and the development of self-concept (self-concept (T2) – self-concept (T1)). All variables have been z-standardized. Applying the single-linkage procedure, we identified one outliner and deleted it from the data. The Ward-dendrogram indicated that a four cluster-solution is most appropriate to describe the data. A MANOVA revealed that the four clusters (profiles) differed significantly concerning their interest in university mathematics and their mathematical self-concept at the start of the program and concerning the development patterns of both attitudes ($F(12, 639) = 46.71$, $p < .001$, $\eta^2 = .47$).

RESULTS

Students' Profiles

We could identify four profiles which split the sample in rather similar big groups (see Figure 1).

- Profile 1 ($n = 64$, "average start but negative development"): Students belonging to this profile began their study program with an average interest and average self-concept which both decreased significantly in the first semester. In the middle of the semester, students with this profile reported the lowest interest and self-concept.
- Profile 2 ($n = 53$, "bad start but positive development"): Students with this profile began their study program with the lowest interest and self-concept but their attitudes developed positively during the first weeks.
- Profile 3 ($n = 46$, "average start and low development"): Students with this profile started with the second highest interest and self-concept and developed only little. Whereas their interest slightly decreased, their self-concept increased.
- Profile 4 ($n = 55$, "best start and low development"): Students belonging to this profile started with the highest interest and self-concept. Although their self-concept slightly decreased during the first weeks, it remained on the highest level of all profiles. Their interest even slightly increased.

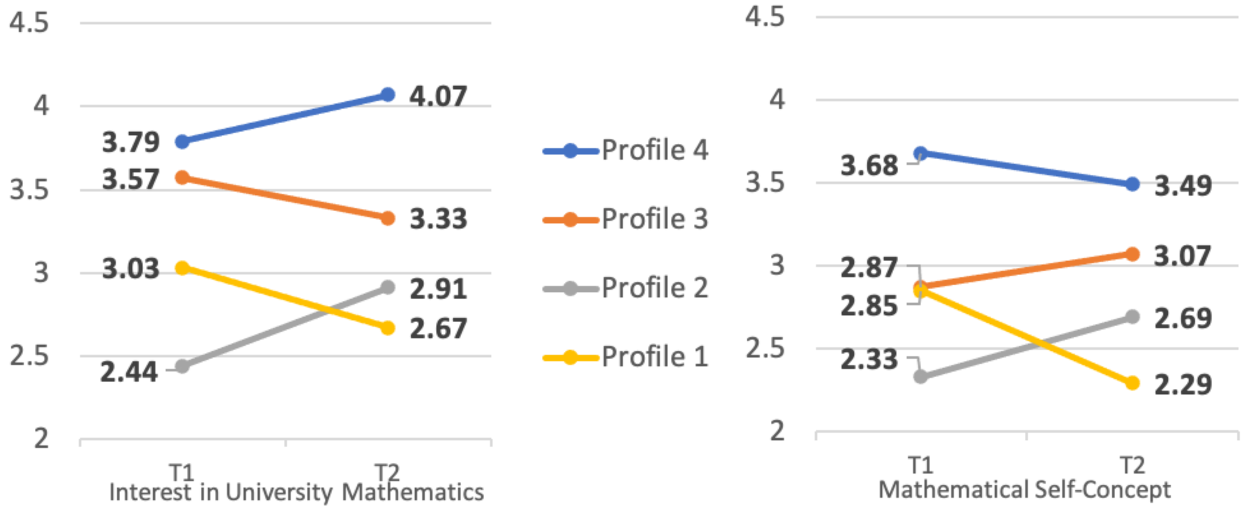

Figure 1: Interest and self-concept of the identified profiles. Statements rated on a five-point-likert scale from totally disagree (1) to totally agree (5) during the second week of the term (T1) and six weeks later (T2).

Female and male students were distributed nearly equally with regard to the identified profiles ($\chi^2(3) = 3.46$, $p > .10$). However, it is noteworthy that students from the pure mathematics bachelor and the teacher education program were not distributed equally with regard to the profiles ($\chi^2(3) = 9.93$, $p < .05$). Students of the teacher education programs were overrepresented in profiles 1 and 2, whereas students of the pure mathematics program were overrepresented in profiles 3 and 4.

Relation between students' profiles and study dropout

Significant differences in the dropout rate can be observed between the identified profiles (Table 1). Whereas profile 1 ("average start but negative development") has the highest dropout rate with 44%, profile 4 ("best start and low development") has the lowest rate with 7%. We expected such differences between profiles, which differed in their attitudes at the beginning of study. Noticeable is the big difference in the dropout rates between profile 1 and profile 2. These two profiles developed inversely in the first semester concerning their attitudes. Although profile 2 started their study with the lowest attitudes, it seems that the fit between students of this profile and the environment is better than the fit between students of profile 1 and the environment because students of profile 2 developed more interest in university mathematics and more mathematical self-concept. Profile 3 is an in-between profile because it shows average attitudes and developed only marginally in the first weeks of study.

	Profile 1 (n = 64)	Profile 2 (n = 53)	Profile 3 (n = 46)	Profile 4 (n = 55)	
Dropout rate in %	44%	17%	28%	7%	$\chi^2(3) = 8.65$, $p < .05$
N dropout students	28	9	13	4	

Table 1: Dropout rates of profiles.

DISCUSSION

At the transition to university mathematics programs, research has indicated that mathematical interest and self-concept predict study success respectively dropout (Di Martino & Gregorio, 2019). However, the interplay between these attitudes as well as its development and students' decision to dropout has not yet been clear. By applying a person-oriented analysis approach, we identified four profiles, which differ in both attitudes at the beginning of study and its development in the first semester. Whereas profile 4 ("best start and low development") showed the lowest dropout rates, profile 1 ("average start but negative development") showed the highest rates. It seems that both aspects – the level of attitudes at the beginning and the development during the first semester – played a big role for students' decision (not) to drop out. Noticeable is that neither interest nor self-concept stand out to predict students' dropout and there are no clear indications that the positive development of one attitude variable can strongly compensate the negative development of the other variable.

As this study is an exploratory one, we had no clear hypotheses that we could test with our study. Our results should be confirmed in follow-up studies. In addition, the study took place at one university and only students, who had participated in the lecture of the second week as well as in the lecture in the middle of semester, are included in the analysis. Thus, the results are restricted to students who did not drop out in the first semester weeks and who regularly attended the lectures.

Besides these limitations, the results of our study support the assumption of Haak (2017) that students monitor the fit between their attitudes and the environment and then decide to adapt their attitudes, for example to develop interest in university mathematics (see profile 2), or to leave the environment, by dropping out, as nearly half of the students with profile 1 did. Thus, a cluster-analysis enables a more differential perspective on the study entry phase: We identified a group of students (profile 2) with growing interest in university mathematics and mathematical self-concept in the first week of study (see Kosiol et al., 2019). Even if students with this profile started their studies with the lowest interest and self-concept, the dropout rate in this profile is rather low. Growing interest and self-concept can be understood as a first adaption to the learning environment in the sense of Haak (2017). Students with profile 1 ("average start but negative development") started with average interest and self-concept but underwent an unfavourable development. Likewise, the dropout rate was highest amongst students with this profile, since the pattern of development can be interpreted in the sense that students of this profile did not adapt their attitudes to the learning environment.

In practice, it seems to be not sensible to sort out students according to their attitudes at the beginning of the first semester. Instead, students need a chance to get used to the university mathematics. As many students get to know mathematics as a formal and deductive discipline for the first time at university (Halverscheid & Pustelnik, 2013), it can take some time to develop joy and value and a positive image of its own abilities concerning this form of mathematics. Lecturers can support this development by highlighting the advantages of this form of mathematics and by building bridges to school mathematics (Weber et al., 2020) which could be helpful for students in teacher education programs, in particular.

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