SELF-CONCEPT AND INTEREST AT THE TRANSITION TO UNIVERSITY MATHEMATICS: A REPLICATION STUDY

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The transition from school to a university mathematics program poses substantial challenges for many students and is associated with high dropout rates. Previous research has shown that students' interest and self-concept are relevant for study satisfaction, although evidence has often been based on single lectures. The present study aims to replicate these findings using a larger sample comprising multiple university mathematics lecture courses and examines whether satisfaction differs between courses. To account for the hierarchical data structure, multilevel regression analyses were conducted. The results indicate that interest and self-concept related to university mathematics are positively associated with study satisfaction across courses, whereas school-related interest and self-concept show no clear associations.

INTRODUCTION

The transition from school to a university mathematics program poses substantial challenges for many students. This is reflected in particularly high dropout rates in mathematics-related degree programs, which are among the highest across academic disciplines, reaching approximately 50% (Heublein et al., 2022). Research suggests that the decision to discontinue a mathematics degree is often made during the early phase of study (Dieter & Törner, 2012).

According to theories of person-environment-fit, successful studying depends on the fit between students' personal characteristics and the learning environment at university (Lubinski & Benbow, 2000). Within this framework, study satisfaction plays a central role, reflecting the perceived correspondence between individual needs and environmental demands. Empirical research has shown that low levels of study satisfaction are predictive of dropout in mathematics programs (Geisler et al., 2023).

From the perspective of the person-environment-fit, students' interest and self-concept are considered key determinants of study satisfaction (Lubinski & Benbow, 2000). Corresponding associations between interest, self-concept, and satisfaction have been reported in several empirical studies focusing on mathematics students. (e.g., Geisler & Rach, 2019; Kirsten et al., 2025; Kosiol et al., 2019; Rach et al., 2021).

However, many of these studies were based on relatively small samples, often drawn from student surveys conducted within a single lecture course. From a person–environment fit perspective, study satisfaction depends on the fit between students' characteristics and the specific learning environment (Lubinski & Benbow, 2000),

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raising questions about the generalizability of findings derived from single lectures. The present study addresses this limitation by aiming to replicate previous findings using a substantially larger sample comprising 18 university mathematics lecture courses. Given the hierarchical structure of the data, and in contrast to previous studies, a multilevel modeling approach was adopted to examine potential differences in average satisfaction levels between lectures. In doing so, the study aims to both verify existing results and provide a more differentiated understanding of study satisfaction in mathematics higher education.

THEORETICAL BACKGROUND

School mathematics differs substantially from the way mathematics is taught at universities (Engelbrecht, 2010). In school, mathematics is often closely connected to everyday contexts, and mathematical concepts are frequently introduced and developed through concrete applications (Engelbrecht, 2010). In contrast, university mathematics focuses on abstract structures that are developed through formal definitions and logical reasoning (Gueudet, 2008).

Due to these fundamental differences, research commonly distinguishes between interest and self-concept related to school mathematics and those related to university mathematics (e.g., Kosiol et al., 2019; Rach et al., 2021).

Interest

Krapp (2007) describes interest as a specific relation between a person and an object, such as mathematics. This relation comprises both emotional and value-related components and reflects the personal significance attributed to the object. Empirical research has shown that interest differs between school and university contexts (Ufer et al., 2017).

Previous studies have shown that interest in school mathematics and interest in university mathematics are differently related to study satisfaction. At the beginning of mathematics studies, interest in school mathematics has been found to be unrelated to study satisfaction, whereas interest in university mathematics shows a strong positive association (Geisler & Rach, 2019; Kirsten et al., 2025). Similar positive associations between interest in university mathematics and study satisfaction have been reported at mid-semester (Geisler & Rach, 2019; Kosiol et al., 2019). In contrast, higher levels of interest in school mathematics at this time point have been associated with lower levels of study satisfaction (Geisler & Rach, 2019; Kosiol et al., 2019).

Given the differences between school and university mathematics, these findings appear plausible. Interest in school mathematics may be less relevant for study satisfaction at university, whereas unmet expectations regarding university mathematics may contribute to lower satisfaction.

Self-Concept

Shavelson et al. (1976) define self-concept as a dynamic system that emerges from the interaction between self-perceptions and one's own behaviour. It is shaped through comparisons with other individuals, social norms, and performance criteria, as well as through experiences of competence and competence development (Bong & Skaalvik, 2003). In the context of mathematics education, self-concept refers to students' perceptions of their own mathematical abilities (Bong & Skaalvik, 2003). Empirical findings indicate that self-concept related to school mathematics and self-concept related to university mathematics differ substantially (Kirsten et al., 2025).

Previous studies suggest that self-concept related to school mathematics at the beginning of the semester is not associated with study satisfaction (Rach et al., 2021; Kirsten et al., 2025). In contrast, a small positive association between self-concept related to university mathematics and study satisfaction has been reported (Kirsten et al., 2025). Results by Rach et al. (2021) indicate that this association emerges primarily at mid-semester, while no meaningful relationship between school-related self-concept and study satisfaction was found at this time point.

These findings also appear plausible given the differences between school and university mathematics. Self-concept related to university mathematics may be particularly relevant for dealing with university-level demands and may therefore be associated with higher study satisfaction, whereas self-concept related to school mathematics does not appear to play a role.

RESEARCH QUESTIONS

The aim of the present study is to examine the relationships between students' interest, academic self-concept, and study satisfaction. From a person–environment fit perspective, study satisfaction is influenced not only by individual student characteristics but also by features of the educational environment. It is therefore necessary to examine the extent to which study satisfaction varies within and between lectures. Accordingly, the following research questions were addressed:

1. What proportion of the variance in students' satisfaction is attributable to differences within lectures and what proportion is attributable to differences between lectures?
2. How are students' interest and academic self-concept at the beginning and at mid-semester related to student satisfaction, when differences in average satisfaction levels between lectures are taken into account?

As outlined in person–environment fit theories, interest and self-concept are closely related constructs that jointly influence study satisfaction (Lubinski & Benbow, 2000). These relationships can be examined in a more differentiated way by distinguishing between school-related and university-related interest and self-concept.

Based on previous findings reported by Geisler and Rach (2019) and Kosiol et al. (2019), it is hypothesized that interest in university mathematics is positively associated with student satisfaction. In contrast, no association is expected between interest in school mathematics at the beginning of the semester and student satisfaction. Furthermore, students who report a persistent interest in school mathematics at mid-semester are expected to show slightly lower levels of student satisfaction.

In addition, drawing on the results reported by Rach et al. (2021), a small positive association between self-concept related to university mathematics and student satisfaction at mid-semester is expected.

METHODS

The present data comprise first-semester students enrolled in 18 different Real Analysis lectures at 15 public German universities. These courses were proof-based introductory mathematics lectures offered to prospective upper secondary school teachers as well as to students majoring in mathematics.

The analyses were based on data from N = 1215 students. Missing data were handled using multiple imputation (N = 50 imputed datasets), taking the clustered structure of the data into account. Students were surveyed in the second week of the semester (T1) and again in the ninth week of the semester (T2).

Table 1: Instruments, reliability and example items

Variable	Source	# Items	Cronbach's α (T1/T2)	Example Item
Interest in school mathematics	Rach et al. (2021)	5	.76/.78	In school, mathematics was very important for me
Interest in university mathematics	Rach et al. (2021)	5	.87/.90	The kind of mathematics that is done in university is fun for me
Self-concept in school	Ufer et al. (2017)	3	.75/.76	I am very good at the mathematics I learned at school
Self-concept in university	Ufer et al. (2017)	3	.88/.88	I am very good at the mathematics I learned at university
Study satisfaction	Schiefele and Jacob-Ebbinghaus (2006)	4	-/.85	All in all, I am satisfied with my studies of mathematics

Students' interest and self-concept regarding school and university mathematics were measured using established questionnaire items from Ufer et al. (2017) and Rach et al. (2021) in both questionnaires. Study satisfaction was measured using items developed by Schiefele and Jacob-Ebbinghaus (2006) in the second questionnaire, as study satisfaction can be assessed more representatively at a more advanced stage of the semester than at the beginning (Schiefele & Jacob-Ebbinghaus, 2006). These are the same items that were used in previous studies (e.g., Kosiol et al., 2019; Rach et al., 2021). All constructs were assessed using five-point Likert scales. As shown in Table 1, the scales demonstrated good to very good internal consistencies in the present sample, with Cronbach's α values ranging from .75 to .90.

Because students were nested within 18 different lectures, the hierarchical structure of the data was taken into account in the analyses. Accordingly, multilevel models in Mplus 8 were estimated. First, an intercept-only model was specified to determine the proportion of variance in student satisfaction attributable to the student and lecture levels. Building on this, random-intercept models with student-level predictors were estimated to answer research question 2.

RESULTS

To examine how variance in students' satisfaction is distributed within and between lectures, an intercept-only multilevel model was estimated. Results indicated a pooled within-lecture variance of .776 and a between-lecture variance of .094. This corresponds to an intraclass correlation coefficient (ICC) of approximately .10, suggesting that about 10% of the total variance in student satisfaction is attributable to differences between lectures. According to common guidelines, this represents a meaningful proportion of variance and indicates that the clustered data structure should be taken into account in multilevel analyses (González-Romá & Hernández, 2017).

When predictors assessed at the beginning (T1) and middle (T2) of the semester were included simultaneously in a single regression model, several strong correlations between predictors were observed ($r \geq .70$). These high correlations resulted in unstable regression coefficients, consistent with multicollinearity effects. Given that the primary aim of the study was to examine how students' interest and self-concept at different points in the semester relate to student satisfaction, predictors from the two measurement occasions were therefore analysed in separate models.

In Model 1, interest and self-concept measured at the beginning of the semester (T1) were included as predictors of student satisfaction. In Model 2, the same constructs assessed at mid-semester (T2) were used as predictors. Table 2 presents the regression coefficients and the proportion of explained within-lecture variance (R^2) for both models.

Model 1**,** which included interest and self-concept assessed at the beginning of the semester (T1), showed that among the four predictors, only interest in university mathematics was significantly associated with student satisfaction at T2 ($\beta = .48$, $p <$

.001). All other predictors were not statistically significant. The predictors included in Model 1 explained 32% of the variance in student satisfaction within lectures.

Model 2, which included the same constructs assessed at mid-semester (T2), indicated a strong positive association between interest in university mathematics and student satisfaction at T2 ($\beta = .62$, $p < .001$). In addition, self-concept related to university mathematics showed a smaller but significant positive association with satisfaction ($\beta = .18$, $p < .05$). No other predictors reached statistical significance. The predictors included in Model 2 explained 53% of the within-lecture variance in study satisfaction.

Tabel 2: Standardized regression coefficients from the random-intercept multilevel models predicting student satisfaction at T2.; *p<.05 ***p<.001

Predictor	Model 1	Model 2
Interest school T1	-.03	
Interest university T1	.48***	
Self-concept school T1	.06	
Self-concept university T1	.12	
Interest school T2		-.05
Interest university T2		.62***
Self-concept school T2		.07
Self-concept university T2		.18*
Between-lecture variance	.05	.03*
R^2	.32	.53

After accounting for the predictors in the random-intercept models, the between-lecture variance in study satisfaction was substantially reduced and accounted for only a small proportion of the total variance (ICC(T1) < .04; ICC(T2) < .07). This suggests that the observed associations are largely consistent across different lectures. However, the remaining between-lecture variance was still significantly different from zero.

DISCUSSION

The reported findings largely support the hypotheses derived from theories of person-environment-fit (e.g., Lubinski & Benbow, 2000) and the results of previous research. The results show that most differences in study satisfaction occur within lectures, while a smaller but still meaningful proportion of variance exists between lecture courses. When these differences were taken into account using random-intercept models, the remaining between-lecture variance was further reduced. This suggests that differences in students' interest and self-concept (compositional effects) explain a part of the initial variation in satisfaction between lectures.

With respect to predictors assessed at the beginning of the semester (T1), interest in university mathematics emerged as the strongest predictor of study satisfaction at mid-semester. This finding closely mirrors the results reported by Kirsten et al. (2025) and is further supported by the cross-disciplinary study of Schiefele and Jacob-Ebbinghaus (2006). In the present sample, interest in university mathematics was the only significant predictor at T1. Neither school-related interest nor self-concept showed a meaningful association with student satisfaction, which is in line with previous findings reported by Geisler and Rach (2019) as well as Rach et al. (2021).

A similar pattern emerged for predictors assessed at mid-semester (T2). The strong positive association between interest in university mathematics and study satisfaction reported by Geisler and Rach (2019) and Kosiol et al. (2019) was replicated in the present study. In fact, the observed association was slightly stronger than that reported in these earlier studies. In addition, a positive relationship between university-related self-concept and student satisfaction was found, in line with the results of Rach et al. (2021), although the strength of this association was somewhat weaker in the present sample. In contrast, the small negative association between school-related interest at T2 and study satisfaction reported in previous studies could not be clearly replicated. Although the estimated coefficients were comparable in magnitude to those reported by Geisler and Rach (2019) and Kosiol et al. (2019), they did not reach statistical significance in the present analyses. Overall, most of the reported effects could be replicated, indicating stable associations between interest, self-concept and satisfaction across different lecture courses.

Although deviations from previous findings in effect sizes were generally small, some limitations should be considered when interpreting the results. In particular, the study relied on a convenience sample. In addition, data were primarily collected during lecture sessions. Although students also had the option to complete the questionnaire online, response statistics indicate that students who did not attend lectures or who dropped out early were less likely to participate in the survey. This may limit the generalizability of the findings. Nevertheless, the present study draws on a comparatively large sample comprising 18 different lectures when compared to previous studies (e.g., Kosiol et al., 2019; Rach et al., 2021).

Outlook

As shown by the results, students' interest and self-concept explained a substantial proportion of the variance in study satisfaction within lectures. Nevertheless, the inclusion of additional individual-level predictors may be a promising direction for future research in order to further clarify the determinants of study satisfaction. At the same time, some variation in satisfaction between lectures remained after controlling for individual student characteristics. This indicates that lectures still differ to a certain degree in their average satisfaction levels. Future research may therefore benefit from examining lecture-level predictors, such as instructional characteristics, and from

investigating whether these factors moderate individual-level associations using more advanced multilevel approaches (e.g., random-slope models).

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