INTEREST AND SELF-EFFICACY IN DISTANCE LEARNING – A COMPARISON OF SYNCHRONOUS DISTANCE AND ON-CAMPUS TUTORIALS

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Synchronous distance learning is still a very new and little researched learning environment. Using the example of a preparatory course, this paper investigates the effectiveness of synchronous distance learning tutorials and compares them with on-campus tutorials. We focus on the affective characteristics of interest in mathematics and mathematical self-efficacy, both of which are considered predictive of study success and retention. A study with 159 prospective teachers shows that synchronous distance learning and on-campus tutorials are comparable with respect to the development of interest and self-efficacy in general. However, interest in mathematics is less affected in distance courses than in on-campus courses. This paper discusses the implications for offering synchronous distance learning on affective characteristics in higher education.

Keywords: Preparatory course, Distance learning, Interest in mathematics, Mathematical self-efficacy

INTRODUCTION

The transition from school to university is particularly difficult for many students in disciplines with a high mathematics component (Hoyles et al., 2001). As a result, many students in STEM education drop out or change their major. In Germany, the dropout rate in mathematics and science bachelor's programs is correspondingly high at 43% (Heublein et al., 2020). Many universities therefore offer voluntary mathematics preparatory courses that are designed to facilitate the transition process by strengthening the content-related and affective prerequisites of prospective students. Accordingly, preparatory courses often have several goals: On the one hand, they refresh and improve the mathematical basics learned in school. On the other hand, affective characteristics such as interest in mathematics or mathematical self-efficacy are to be strengthened (Hochmuth et al., 2018).

Unlike traditional courses, individual universities have already been offering preparatory courses in different variants with e-learning elements for several years (Derr et al., 2018; Greefrath et al., 2017). These ranged from pure distance courses for self-study to pure on-campus courses with additional learning materials available online. Other universities have only recently gained experience with distance learning in the context of the COVID-19 pandemic (Büchele et al., 2021). The pandemic-induced shift to distance learning represents a completely new approach to teaching, as distance learning in this context is often offered synchronously via videoconferencing and is strongly oriented toward on-campus instruction in its design. We therefore refer to this type of learning as *synchronous* distance learning to capture the main differences to more traditional learning environment. However, the extent to which synchronous distance learning courses are suitable as complementary or alternative options for prospective students has hardly been investigated to date. This contribution therefore examines the effectiveness of synchronous distance learning courses and compares them with on-campus courses (Kirsten & Greefrath, in press). Doing this, we focus on the development of students' affective characteristics, namely their interest and

self-efficacy, as these characteristics are considered to be predictive of study success and retention (Geisler et al., 2023).

DISTANCE PREPARATORY COURSES

Since preparatory courses are voluntary and take place a few weeks before the start of studies, for many students participation depends on compatibility with other commitments. For this reason, some universities have been using distance and blended learning alongside on-campus courses for many years (Derr et al., 2018). While distance learning in this context is often implemented as an asynchronous online course with materials available on a learning platform, blended learning courses also include single face-to-face events on campus. Due to the high degree of self-study, such courses allow prospective students to work at their own pace and intensity without being tied to the university location. In particular, this allows students who live far away, study on a dual or part-time basis, or cannot attend on campus for other reasons to participate (Fischer, 2014).

Because independent learning requires a high degree of self-regulatory skills, the effectiveness of distance and blended learning courses is often questioned from an educational perspective. Therefore, comparative studies comparing distance or blended learning courses with on-campus courses have been conducted at a few universities. These studies focus largely on mathematics performance and measure the effectiveness of a course variant in terms of student learning gains. For example, Greefrath et al. (2017) reported that students who chose a distance learning preparatory course performed significantly better in the subsequent mathematics exam than students who attended the on-campus course. Similar findings were reported by Fischer (2014), who compared blended learning and on-campus preparatory courses. Again, students in blended learning courses performed better at the end of the preparatory course than their peers in on-campus courses, even when controlling for pre-test scores. However, it should be noted that students with stronger prerequisites, such as a better overall school performance or an advanced mathematics course at school, were more likely to choose a blended learning course in this study (Fischer, 2014). To our knowledge, the influence of course modality on the development of *affective* characteristics has hardly been studied so far. Initial indications are provided by Fischer (2014), who found no differences between the two preparatory course variants in terms of students' self-efficacy or attitudes toward mathematics.

To what extent the results described here are transferable to synchronous distance learning courses remains questionable. Since these courses, unlike those described above, typically involve fixed schedules and video-based face-to-face interactions, it is reasonable to assume that they place different demands on students in terms of self-directed learning and social interaction. This may affect their effectiveness. Although Büchele et al. (2021) report that overall performance in 2020 pandemic preparation courses was better than in previous years, other studies suggest that pandemic distance learning may have a negative impact, particularly on students' affective characteristics (Händel et al., 2022; Kempen & Liebendörfer, 2021; Reinhold et al., 2021).

INTEREST AND SELF-EFFICACY AT THE START OF STUDIES

Both, interest in mathematics and mathematical self-efficacy are considered as relevant predictors for academic learning and thus for study success. In person-object theory, *interest* is understood as a special relationship of a person to an object (Krapp, 2005). A positive relationship promotes engagement with the object and can implicitly aim at expanding one's knowledge and skills in this field. Therefore, interest in mathematics is considered to predict learning success since interested learners pay more attention to the object of study (Hidi & Renninger, 2006). However, the results of

Rach & Heinze (2017) suggest that the influence of interest on study success is lower than the influence of prior mathematical knowledge. Nevertheless, in terms of retention, dropouts often report a declining interest in mathematics (Geisler et al., 2023). Accordingly, the importance of interest for academic decisions and for self-directed learning can be emphasised (Köller et al., 2001).

Because mathematics in school and university is often very different, students' interest in mathematics often changes at the beginning of their studies. First-year university students experience a mismatch between what is expected and what is experienced, leading to a decline in interest (Kosiol et al., 2019; Rach & Heinze, 2017). The development described here can already be observed during preparatory courses when university content is taught in addition to school content (Hochmuth et al., 2018). The trend described here could be exacerbated by distance learning, as it has been shown in the context of the COVID19 pandemic that individuals with a higher interest in mathematics have a higher need for face-to-face instruction (Reinhold et al., 2021).

The term self-efficacy refers to the confidence in one's own abilities to perform certain actions successfully (Bandura, 1997). Thus, from a discipline-specific perspective, *mathematical* self-efficacy describes a person's confidence in his or her abilities to successfully perform *mathematical* actions (Pajares & Miller, 1994). This can include solving specific tasks, constructing proofs or, more generally, mastering a mathematics' major. Empirical findings show that students' self-efficacy initially declines during the transition from school to university (Schunk & Meece, 2006). This may be explained by a variety of challenges that accompany the start of studies: The rapid progression of lectures, a high amount of self-study, and failures in weekly exercises often result in high pressure and a low experience of competence. However, a decline in self-efficacy appears problematic as self-efficacy can have a direct or indirect influence on performance (Schunk & Pajares, 2002). Furthermore, self-efficacy also influences the decision for or against retention: Dropouts, especially if they leave their studies early, have a lower mathematical self-concept than other students (Geisler et al., 2023). In this context, self-concept is a more general construct than self-efficacy, because it is not task- or situation-specific and describes a more stable notion of one's own mathematical abilities (Bong & Skaalvik, 2003). However, it is often conceptualised similarly to self-efficacy and is equally used in studies of student self-assessment.

Empirical findings show that students' mathematical self-efficacy can be increased both in blended learning courses and in on-campus courses (Fischer, 2014; Hochmuth et al., 2018). To what extent this finding is transferable to synchronous distance learning remains an open question. However, a study by Kempen and Liebendörfer (2021) on the first pandemic semester suggests that distance learning may have a negative impact on self-efficacy, at least for certain student groups.

THE PRESENT STUDY

Synchronous distance learning is still a very new and under-researched learning environment. Using the example of a preparatory course, this contribution therefore examines the effectiveness of synchronous distance learning courses and compares them with on-campus courses. More precisely, the study is based on a preparatory course held at the University of Münster in September 2021. In terms of experimental variation, this course was offered in two variants: In both variants, lectures were video-recorded and provided asynchronously on the university's learning platform. The daily tutorials, on the other hand, were offered synchronously, either on campus or via synchronous distance learning. Since the development of affective characteristics can be particularly influenced by a change in modality, we focus on these aspects. In particular, we examine the development of students' interest in mathematics (Krapp, 2005) and their mathematical self-efficacy (Bandura,

1997). Both characteristics are related to academic success and retention (Geisler et al., 2023) but are possibly not addressed to any great extent in distance learning (Kempen & Liebendörfer, 2021). More specifically, research is guided by the following question:

How do interest in mathematics and mathematical self-efficacy develop during a synchronous distance learning preparatory course and how does this development differ in an on-campus course?

METHODS

Design and sample

The preparatory course examined is designed for prospective student teachers at primary and lower secondary level. Because both degree programs contain a comparable amount of mathematics there is a joint course for both programs. The course included eight lectures and seven tutorial sessions. For each tutorial session there is a worksheet with tasks that address the content of the lecture and encourage practice and application. The aim of the preparatory course is both to deepen mathematical knowledge from lower secondary school and introduce students to university mathematics. Therefore, the course teaches basic mathematical skills such as fractions, transformations, and linear equations, as well as strategies for mathematical reasoning and problem solving.

To compare synchronous distance learning with on-campus learning, both tutorial options were designed to be as similar as possible in terms of time slots, tutors, group size, and instruction. The tutors were guided by predefined course plans in which the teaching methods and expected learning outcomes were described over time. In particular, the teaching methods, such as working together or presenting results, were to be designed in a comparable way in both tutorial options. Therefore, elements of on-campus teaching, such as group work and writing on the blackboard, were transferred to the digital learning environment using breakout sessions, integrated whiteboards, and split screens.

The sample consists of N = 159 first-year students, of whom n = 133 were pursuing a teaching degree in primary education (127 female, 5 male, 1 not specified) and n = 26 a teaching degree in secondary education (16 female, 10 male). Students could independently sign up for a course option, resulting in n = 71 students in the on-campus course and n = 88 in the distance learning course. In both groups, data collection took place at the beginning of the first tutorial session (T1) and at the end of the last tutorial session (T2). The sample considered here only includes those students from whom data is available at both measuring points.

Instruments and procedure

Since interest in mathematics and self-efficacy have already received much attention in preparatory course research, we made use of existing instruments (see Table 1).

Construct	# Items	Sample item	α	Source
Interest in mathematics	5	I simply enjoy puzzling over a mathematical problem.	.77/.76	(Köller et al., 2000)
Mathematical self-efficacy	4	I am confident that I can perform well in homework and exams in mathematics.	.82/.76	(Hochmuth et al., 2018)

Table 1. Overview of the instruments

Following the original scales, a four-point response format was used for interest and self-efficacy, ranging from "strongly disagree" (1) to "strongly agree" (4) (Hochmuth et al., 2018). Due to possible discrepancies between school and university mathematics, we did not include institutional references in both scales. However, it can be assumed that students relate the questions to school mathematics, at least at the first measuring point. Since the reliabilities of both scales are good or satisfactory, group comparisons can be made. In addition to affective characteristics, we collected data on students' age and gender, well as their overall school performance grade (1.0 to 4.0) and their last mathematics grade at school (0 to 15 points).

RESULTS

Although students independently assign themselves to a tutorial option, an even distribution was achieved in terms of degree programmes (80.3% and 86.4% primary school teaching), gender (88.7% and 92.0% female), age ($M_{OC} = 19.53, SD = 2.16$ and $M_{LD} = 19.39, SD = 2.01$), overall school performance grade ($M_{OC} = 1.93, SD = 0.49$ and $M_{DL} = 1.94, SD = 0.45$) and last mathematics grade at school (M_{OC} = 10.63, SD = 2.56 und M_{DL} = 10.68, SD = 2.21).

	Total		**On-campus (OC)**		**Distance learning (DL)**	
	T1	T2	T1	T2	T1	T2
Interest	2,48 (0,59)	2,37 (0,53)	2,60 (0,58)	2,41 (0,52)	2,39 (0,59)	2,36 (0,53)
Self-efficacy	2,56 (0,52)	2,61 (0,43)	2,70 (0,49)	2,72 (0,39)	2,44 (0,52)	2,52 (0,45)

Table 2. Mean values (and standard deviations) of the affective characteristics separated according to tutorial variants and measuring points (T1/T2)

Table 2 provides an overview of the mean values achieved at the individual measuring points. At both measuring points, students in on-campus tutorials reported higher average interest and self-efficacy values than their peers in distance learning tutorials. While interest decreased over time, self-efficacy increased slightly in both tutorial variants across measuring points. To examine the development of affect in more detail, mixed ANOVAs were conducted with interest and self-efficacy as dependent variables. The factor *time* entered with two measuring points as the within-between factor, while *tutorial variation* entered as two-level subject-between factor. Levene's tests showed that the variances were homogeneous for both measures ($p > 0.05$). A normal distribution as well as sphericity could be assumed due to the sample size and the two-stage design.

	Interest				**Self-efficacy**			
	F	df	p	η^2	F	df	p	η^2
Time	16.54	1, 156	.001	.096	2.61	1, 156	.108	
Time*Tutorial	8.45	1, 156	.004	.052	0.97	1, 156	.326	
Tutorial	2.30	1, 156	.123		11.44	1, 156	.001	.068

Table 3. Results of the mixed ANOVA

The ANOVA showed that there was a statistically significant main effect of time only for interest (see Table 3), indicating that the students' interest decreased significantly from the pre-test to the post-test. Additionally, there was a significant interaction effect between time and tutorial variation. This effect suggests that interest in mathematics declines significantly stronger among students in on-campus courses than among their peers in distance learning courses. In the case of self-efficacy, however, only the subject-between factor of tutorial variation proved to be statistically significant, meaning that students' in distance learning tutorials did have significantly weaker confidence in their own mathematical abilities.

DISCUSSION

Although preparatory courses, unlike other university courses, have been offered as distance or blended learning courses for several years (Derr et al., 2018; Fischer, 2014), *synchronous* distance learning is still a fairly new learning environment that is only becoming established due to the COVID-19 pandemic. Therefore, the aim of this work was to compare synchronous distance tutorials with traditional on-campus tutorials with regard to the development of affective characteristics. Overall, the results indicated that on-campus and distance learning tutorials can address interest in mathematics and mathematical self-efficacy in a comparable way.

With regard to *interest in mathematics*, a decline in interest during the preliminary course was observed in this study for both tutorial variants. This finding is consistent with previous studies (Hochmuth et al., 2018) and can be explained by the fact that elements of university mathematics were already covered in the preparatory course (Kosiol et al., 2019; Rach & Heinze, 2017). However, the intensity of the development differs in the two tutorial variants: While in on-campus tutorials interest decreases more strongly, synchronous distance tutoring seems to affect interest less. If the declining interest is attributed to discrepancies between school and university mathematics, we can assume that cognitive dissonance is perceived more intensely on-campus. While students in distance learning can consciously or unconsciously retreat, take breaks, or do other work in parallel, such avoidance strategies are hardly possible in on-campus classes. In this case, the decline in interest for students in distance learning tutorials might merely be delayed. This should be taken into account when students of different tutorial options take the same freshman course. If synchronous distance learning courses are to be offered as an equivalent alternative in preparatory courses, more attention should be given to discontinuities that occur, for example, by explicitly discussing the differences between school and university mathematics. However, when interpreting the results, it should also be noted that students in face-to-face courses showed a greater interest in mathematics at the beginning of their studies. This could reinforce the experience of divergence, so that not only the tutorial variant but also the initial interest is relevant.

With regard to mathematical self-efficacy, a slight, non-significant increase can be observed in both tutorial variants in line with Fischer (2014) and Hochmuth et al. (2018). The development of students in the two tutorial variants did not differ from each other. However, the results suggested group differences, as students who chose a distance learning course generally had lower self-efficacy. This indicates selection or choice effects, consistent with previous findings that students with higher self-concept show a greater preference for on-campus learning (Reinhold et al., 2021). With this in mind, distance learning courses should also target students with low self-efficacy and enable and reward even small experiences of success.

Overall, the results indicate that variation in tutorials is not crucial for the development of selected predictors of retention. Thus, under certain conditions, synchronous distance learning tutorials may

address affective characteristics in a comparable manner to traditional on-campus tutorials. It should be noted, however, that students in this study were not randomly assigned to tutorial variants. On the contrary, slight selection and choice effects could be observed, which may affect participation in the preparatory course. Moreover, only those students who participated in both measuring points were included in the sample. Including students who dropped out of the preparatory course early could provide deeper insights into the development of affective characteristics.

CONCLUSION

The study presented in this paper provides initial evidence that distance preparatory courses, i.e., with an asynchronous lecture and a synchronous tutorial in the form of a videoconference, can offer an equivalent alternative to traditional on-campus courses with regard to the development of affective characteristics. With this in mind, it is likely that synchronous distance learning courses could be offered in addition to asynchronous distance and blended learning courses in the future. This may promote social interaction in addition to location flexibility. However, the results also suggest that students with weaker prerequisites – in particular lower interest and lower self-efficacy – are more likely to choose a distance learning course. This should be taken more into account when designing courses.

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