INTEREST IN MATHEMATICS AND THE FIRST STEPS AT THE UNIVERSITY

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Abstract: *First, we discuss interest in mathematics from a theoretical perspective. For this, we outline theory on interest and supplement it by the specific context of the secondary-tertiary transition, constructing a specific perspective. We then use some interview data to demonstrate, how this perspective may help structuring practice reports and sketch an example for the interplay of the theoretical facets.*

Keywords: Interest, secondary-tertiary transition, self-determination theory

INTRODUCTION

Interest is an important "element" in the experience and behaviour of students entering university for some different reasons. First, we should see interest itself as a goal of the university education. Especially when we think of pre-service teachers or academic careers, we believe interest in the subject to be a necessary competence facet. Second, numerous empirical studies have shown that interest (notwithstanding the way it was operationalized) is an influential factor in learning, being closely connected e.g. to the student's use of deep learning strategies, their effort and learning outcomes (Krapp, Schiefele, & Winteler, 1992). Such findings have not been replicated for the university, but can presumably be transferred from school. One might even speculate upon increasing influence at university, since students have more personal responsibility there (e.g. uninterested students might even not attend lectures). Third, interest is closely linked to a positive experience, and it goes without saying that we as teachers want our students to experience university positively. Therefore we believe it to be useful to learn more about interest, its structure and development, and present an approach how to tackle this topic.

The study and thus our theoretical considerations refer to courses at the German mid-size university of Kassel where the mathematics is based on definition and proof from the beginning. The dropout rate is around 40-50 %.

THEORETICAL FOUNDATIONS

The context of the **secondary-tertiary gap** has many facets (see e.g. Gueudet, 2008). Personally, it often coincides with a new social situation and many more liberties and responsibilities. Much more than before, one may set goals for oneself. This is an opportunity to gain more autonomy, but may also lead to uncertainties. Then, the formal requirements of the study regulations are often taken as benchmarks, which unfortunately disregard important factors like learning goals, professional qualifications, the own vision of education and their contribution to science. These

rather general issues are supplemented by some points which are specific to mathematics. Transition problems may be caused by a high degree of formalization, in which the focus is no longer given by calculations, but by proof (Tall, 2008). University mathematics requires skills (like language) which rarely correspond to the expectations of the students, which then again play an important role in the experience and behaviour within this new system.

Our conception of **interest** is based on the theoretical framework provided by Krapp (Krapp, 1992). Here, interest is conceptualised as a person-object relation which is characterised by value commitment and positive emotional valences. Individual interest is perceived to be a disposition that associates the object of interest with positive emotions (experienced and expected in future) and a personal value. Interest differs from motivation in the specific object. This can be a real object, but also something imagined, as long as it is known to the subject and perceived as one object. It can be located at different levels, e.g. school mathematics and university mathematics may be considered, but also specific aspects like proof or issues like calculus. According to Krapp, we distinguish personal interest from a behaviour-based level used for the analysis of specific activities with the object of interest. Here, the object is much more specific, since the subject acts in a concrete situation. Such interest actions can be based on individual interest and are then called actualised interest. They can also be given by external stimuli, which is then called situational interest. In both cases, an interest action requires the locus of causality to be perceived in the person itself (cf. autonomy, below). Interest development can be characterised by three stages: introjection, when interest actions are conducted for reasons which have nothing to do with the object, identification when the object has a value besides the aims of the interest action, and integration, when interest is integrated in the concept of self and doesn't conflict with it.

As an important background for the analysis of origins and influences on interest the **Self-Determination Theory** (SDT) is to be mentioned (Deci & Ryan, 2000). It posits the three basic needs for (perceived) autonomy, competence and social relatedness. All three factors are important, maybe necessary, for the development of interest (Krapp, 2005). This leads us to the following questions: When is competence experienced? How is autonomy experienced and secured? In which contexts do students feel relatedness? The very personal view is stressed in (Hannula, 2001), where the author revealed a strong interplay of needs and their satisfaction, goals and beliefs in school context, emphasising, that "what students want, has a strong influence on their experiences". Concerning university students, (Ward-Penny, Johnston-Wilder, & Lee, 2011) emphasised the importance of "students' view of what constitutes success and achievement" for the developing identities, which can be different on seemingly similar trajectories.

Our emphasis is on individual interest, which also requires situational interest to be considered, as both are closely linked. In the last decades, individual interest in

mathematics had not often been tackled deeper, apart from (Bikner-Ahsbahs, 1999) who e.g. investigated different facets of individual mathematics interest (like its history or cognitive problem solving). Recently, interest as outcome has received more attention, e.g. see (Frenzel, Goetz, Pekrun, & Watt, 2010). In our work, we want to investigate interest in higher mathematics (HM), but also in school mathematics (SM), since it is assumed that the initial interest in HM and the attitude towards the subject are based on experiences and interest in school mathematics. The third major theme is the studies in general. From the theoretical perspective, we would not believe, that interest in the HM is present from the first day, since it would require HM to be known to the beginners. Even interest in SM doesn't need to be present, since there is a whole bunch of additional motives for going to university. An important aspect of our work is the question how the new objects are perceived in the light of the facets of interest emphasised by the SDT, and of which opportunities of action, belonging to these objects, are realised in which context. In this way we hope to obtain evidence, how and why interest developments are hampered or supported by some aspects of the context or typically appearing partially habitualised behaviour and patterns of argument. Thus, we have to capture the context and the way the subject deals with the context to understand the interest. Here, it makes sense to use a theoretical approach that reflects the role of the basic needs and includes pragmatic and habitual aspects, as offered in (Grotlüschen, 2010).

We could not find much literature on interest development during the transition. Yet, in (Daskalogianni & Simpson, 2002), it is described that entering university is a critical point for interest in mathematics. The observed students showed a substantial loss of interest in the first six weeks, based on a mismatch of their beliefs and the mathematics they encountered. Some could recover as they managed to rearrange their belief system, whereas others not. Here, we offer an alternative interpretation based on the presented framework: If we distinguish SM from HM, then we might see the early interest as referring to SM, as the first interviews were held in school and the authors mention school mathematics in this context. However, a possibly later interest might refer to HM, which the interviewers had asked for ("Why do you think, that Further Maths is more difficult?"). It seems that the students differentiate the two objects, as Kenneth states: "it's really quite a lot different to A-Level Maths". The "loss" would then be caused by changing the considered object of interest and the individual insight that the two kinds of mathematics differ (even from expectations). Inappropriate student expectations are well known to university teachers and e.g. documented by (Hirst, Meacock, & Ralha, 2004) concerning the importance of proof or technology use. The "recovery" would then simply be a new genesis of interest, which apparently requires the right kind of beliefs and some time for development. The importance of the student's beliefs system and its adjustment had already been stressed by both authors in (Daskalogianni & Simpson, 2001). From the SDT-perspective on interest

genesis, this again raises the question of the above mentioned interaction of beliefs and need satisfaction.

THE EMPIRICAL PART

We report findings from a focus group discussion and a subsequent interview at the University of Kassel, Germany. There, the typical course includes 2x2 hours of lectures a week with some 100 students, and a tutorial in smaller classes (10-20 students). Each week, the students get a sheet with about four tasks as homework and have to hand-in their solutions. Successful participation (i.e. receiving at least 50% of the maximum score) is precondition for admittance to the exam.

We take the data from a project where we investigate interest and its development in the first semester at university. In the study, we aim at reconstructing the subjective experience and behaviour, and want to relate it to interest. First, we conducted a focus group since we believe that the more natural atmosphere of a group can help revealing their orientations and typical behaviour without reflection. The participants were all taken from a lecture on linear algebra which normally is attended in the first semester (which was the case for two of the five students only). For about two hours we talked about transition problems and interest. The group discussion was audio-taped and transcribed. We first coded in an inductive way and then recoded using theoretical categories emerging from SDT. All students agreed in anonymous scientific use of the data and were given the possibility to delete audio sequences. They reported very intense emotions concerning the homework assignment, like stress, anxiety and frustration. In their view, HM was quite different from SM. They also reported coping strategies like copying. We found that the students mostly didn't experience autonomy and competence. When asked for interest, they described themselves e.g. as "not uninterested" in HM, but couldn't specify this interest. It might be the case, that they had no interest in HM in the sense of Krapp, but didn't want to admit. As a disadvantage of the method, we couldn't easily ask for more details since the method requires the discussion to go on. Thus, we asked some students to come again for an interview (under the same ethical conditions), and it was a student we call Anna who decided to do so. The interview was based on her statements from the focus group and took about 60 minutes. It was again digitally recorded but not entirely transcribed. The analysis by the two authors was mainly done by discussion of the critical passages based on the theory sketched above. Anna is an untypical case regarding the fact that her major subject is physics and also regarding her education biography. Anna dropped out of school before doing the Abitur (compares to A-Levels) and went to schooling as chemical-technical assistant. She then decided to do her Abitur in evening classes. As a physics student, Anna attended the lectures on analysis in her first year, and those on linear algebra in the second year. (Mathematics majors usually attend them at once.) The focus group was conducted at the end of her 3rd semester; the interview was in her 4th semester. For us, her case was interesting since she reported

mainly negative experiences, yet thought about switching major to mathematics, a seemingly contradicting behaviour. Additionally, she spoke openly and reflected, although a self-report can only partly reveal her experience. We hope to have a broader image since we first taped her talking in the more natural group and then went into detail in the interview. But still, we have methodological limitations some of which are inherent to any retrospective research method.

The transition experience

At school, Anna has always had good maths teachers and felt interested in this subject, at which for her, doing mathematics was mostly doing calculations. When Anna came to university with a friend of her, they both had decided to study together. After presentations of different courses, they agreed to study physics, although it wasn't Anna's first choice. It was more important for her, to not start studying on her own. When they couldn't solve tasks no. 3 & 4 of their homework assignments in the first (!) week, they looked for a guy she calls "private tutor" who solved the tasks for them. In the focus group she described herself as "desperate" since she "completely failed". One might wonder why she didn't see the two solved tasks as a success or give herself another try, especially since we know that neither the teachers expect the students to solve all tasks, nor many students do so. We hypothesize that her definition of success is adopted from school, where she usually solved a higher percentage, she always knew what to do, and copying homework is quite common. The tutor offered them additionally to explain the solutions, but in most times, they refused it. The following interview passage illustrates her expectancies and her experience with the homework:

Anna:	Well, we didn't understand the sheets at all. Well, yes, I think it was the first two tasks of the first sheet and there it stopped. And then I couldn't do it. Well I couldn't, I couldn't somehow handle the writing in mathematics, they have their own writing, e.g. that is sets, this and that, and I – I couldn't do this. I have never somehow worked on sets in school and thus it was difficult to read, what you want from the students. And therefore we were desperate and looked for a private tutor.
Interviewer:	Was it new, this feeling that there is something you can't do in mathematics, that it is so unfamiliar?
Anna:	Well yes, but I have – that is strange, but I have not really [related the sheets] to mathematics somehow – well I didn't really see them as mathematics. Well for me, that was something completely different. For me, mathematics had always meant calculating something, setting up something, and actually that's it. But not any strange proof. Maybe you have heard before a bit, that higher mathematics is something slightly different. But you have never really perceived what is really there.
Interviewer:	That's exciting, what kind of mathematics would you have expected, can you describe this?

Anna: This is difficult now, because now I know what is to come. But if I – I do not know what I would have said if someone asked me when I was in school. (..) If someone had asked me, I don't know. Maybe – I think I would not have expected so many proofs. Well, calculations yes, also without using numbers, but simply just this general; but more calculations are what I have thought. But what do calculations mean? Not silly replacement of variables, just setting up [equations], too. So, where does all this come from, e.g. we had proven in calculation methods [a course for physics students] why the volume of a sphere equals pi times r^2 – of a circle – and we have deduced it. And this is what I have thought, that we would do more things like this. But not, don't ask me, what we have done. But I have passed it!

Obviously, HM is very different from SM for her. Today, she still struggles with formalism and couldn't manage to adjust her beliefs on the nature of mathematics. ("How do they know 4-dimensional spaces exist?") She still describes mathematics as "understanding, seeing, calculating". Although she failed at the two analysis exams and her exam on linear algebra (as well as some exams in physics) she still thinks she will manage her studies, albeit it will take her more time than usual. Anna's aims are dominated by achievement goals. In the interview, she often refers to exams, to the homework assignments and even to her CV. In contrast, she never talks about learning goals, but at one point about applications of mathematics (playing poker), she would like to master.

Basic needs

Anna experienced her first year as very stressful, and university didn't match her expectancies. She couldn't solve the homework on her own and didn't pass the exam. Anyway, she managed to feel competent. Copying from her private tutor, she got the admittance for the exam (which is also valid the next years), what she calls a success. In addition, she learned some calculus techniques like integration by parts and feels competence in doing calculations (like she did in school). Concerning proof, she often didn't even understand the tasks, and showed no need to clarify this. Instead, she tries to fade-out or to dismiss such tasks (disvaluation of unaccessible tasks was also described in (Hannula, 2001)). She additionally excuses her problems by her education biography, often referring to her inferior prerequisites. Another explanation is the 'fact' that only gifted students can fully meet the requirements. Asked for feelings of success she reports that once she found a solution for a task in a book. This matches her goal orientation since it helps her receiving credits for her homework (but not achieving learning goals). When in the second semester she had success doing the homework with a colleague, she started solving the tasks without her private tutor. She reports she had learned how to deal with the symbols and now the tasks were more based on calculations. So, situational interest sometimes appeared when calculations were involved, at one point she even reported flow. Concerning autonomy, Anna felt forced to do the homework, but managed this by copying. Here, unwanted behaviour

turns out to implicate an advantage since others reported much more problems with autonomy. Her own need is strongly stressed:

Anna: "I don't surrender quickly, but if I don't understand it, then I won't do it. I won't sit down and do this for hours until I understand it. I won't do this for sure. I'm not proud of it, but yes…"

Unlike the other aspects, social relatedness is not a problem for her. She often mentions others (common decisions, work and experiences) and at no point reports feelings of unrelatedness. Anyway, the situation is unlikely to foster interest in HM.

Interest in studying

An astonishing point is that (rather than thinking about dropping out), in the focus group Anna had thought about changing her major subject to mathematics, although her motives were unclear. In the interview, she said that she first wanted to see how physics is going, and since she has passed her last exam there, she sticks to physics, focussing on the more mathematical topics. We believe that her interest in studying mathematics has been preserved from the end of school. However, stressing this interest can also be an expression of an exit option from studying physics. Then it would be seen typical for a developing interest in studying physics (cf. (Grotlüschen, 2010)) and is an emphasis of autonomy. Concerning both study subjects, she reports that they are untypical for a woman but respected and important. From the SDT perspective, relatedness and perceived autonomy may be given. The obvious lack of competence in mathematics needs not be necessarily an obstacle for Anna. First, she didn't experience it so much after she started copying and also when she repeated the 1st semester course. Second, she has the expectancy that once she would start engaging more, she eventually would succeed: "I don't think that after years, when you do this, that you still don't understand it. I don't believe this."

The special case of proof

We picked out proof because although proof is the basic paradigm of university mathematics, Anna managed it to study two years without acquiring a taste for proof. She starts with a special obstacle, since she sometimes struggles with language. Her parents presumably emigrated from Eastern Europe, which (besides her accent) sometimes causes phrasing problems. Again we take a passage from the transcript:

Anna: […] and I liked calculating everything nicely, writing down everything nicely, yes. – And still, well I still like calculating, and when we have the calculation tasks, but proof, maybe, you don't really see how to do these proofs yet. Maybe that's why it still is. But if I talk about it with someone or so, everybody says it: 'Oh I hope there is no proof [in the exam]' or so.

Interviewer Yes ok. Is it the same with you?

Anna: Yes. Proof is more difficult. Because, maybe you don't hm – have this learning effect for proof, because you have never had proven anything

	this in school. Well, we only have, the only thing we maybe proved is for example hm, oh how do you call it, hm this derivatives, well
Interviewer:	The derivation rules?
Anna:	Exactly, we have proven these derivation rules. However, that is also nearly calculating. You have to put in [variables].

Anna had never proven anything in school and she shows no meta-knowledge on doing mathematics. The instrumentality of "getting credits" undermines autonomy, hampering interest actions concerning proof. Thus, it is not easy for her to feel success or to act autonomously. At no point, she reveals a need for proof, which fits her belief system: If mathematics is about having the right formulae and doing the right calculations, proving doesn't help. Proof is also problematic regarding her goal orientation. Her performance goals are not compatible with understanding proof, since proof seems to be different every time. She doesn't notice a learning effect, except for simple calculation-based proofs. So she is missing e.g. knowledge on what can be learnt by exercising proof and typical heuristics. One might even speculate about the question, if the repeated refusal of proof might habitualise.

On this basis, the requirements of the SDT can hardly be fulfilled. Anna feels incompetent in two ways: She doesn't know how to solve a given proof problem, and very often she even doesn't understand the problem itself (also strongly restricting autonomy)! This becomes clear e.g. when she joyfully tells, that in the exam she could understand all tasks. Meanwhile, she has learned to do proofs built on calculations, like checking subspace axioms, but not more. Even typical induction proofs seem unfamiliar to her. Concerning the need for autonomy, she doesn't mention any positive aspect, but some negative ones relating to the homework assignments. Social relatedness appears in avoiding proof only ("everyone says it: I hope there is no proof [in the exam]"). Sharing the same problems with proof, the students can exchange experiences. In summary, proof is a case where the lack of autonomy and competence is big and Anna neither has a good coping strategy, nor cannot construct a different view for herself. Consequently, she avoids proof whenever possible and has no interest in proving.

CONCLUSION

In this paper, we present an approach to investigate interest in Higher Mathematics (HM) using the interest theory by Krapp and Self Determination Theory (SDT). Therefore we distinguish different objects of interest, namely School Mathematics (SM), HM and studying mathematics. Relating this approach to the work of (Daskalogianni & Simpson, 2002) revealed a new perspective of interest genesis at university. We then used empirical data to check plausibility of this new perspective. In a group discussion we could see that the participating students had different views on SM and HM and a problematic competence and autonomy experience. For an application of SDT we picked out one student (Anna) for an interview to explore her subjective experience, beliefs and goals, and relate it to her articulated interests. Anna

couldn't manage to feel competence or autonomy concerning proof within HM and didn't develop any interest in it. However, she could manage to keep her interest in studying alive by different strategies. Lack of perceived success on her homework assignments was compensated by a private tutor, which also restored autonomy. Lack of success in the exams was explained and excused by external factors. Besides situational interest, we see her individual interest in higher mathematics at the introjection stage, apart from identification with calculating, which form the only point in which she had success and thus feelings of competence. The theoretical framework helped structuring the reports and identifying aspects which are presumably strongly connected to interest of different kinds. Her expectations and beliefs played a role in how she dealt with the new mathematics and her goal structure can help explaining her behaviour, both forming the basis for competence and autonomy experience. We could then observe that competence and autonomy were generated in different ways, sometimes leaving the promising ways behind.

The conclusions are drawn from very few data, including problems of reliability of self-reports. Anyway, we believe our theoretical approach to be helpful to structure relevant aspects of research in interest.

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