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Advice and guidance for students enrolled in teaching mathematics at primary level

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In the winter semester 2013/14, the department of Mathematics Education at the Justus Liebig University of Gießen launched a two-year-project offering assistance to students aspiring to become primary school teachers. The aim is to identify and rectify deficits pertaining to core mathematics. Moreover, the objective is to develop a positive attitude towards mathematics. This project applies to all but particularly to students, who have a weak mathematical foundation and require a boost in motivation. Data from the student's initial standard is used to develop practical modules such as tutorials, reflections, learning portfolios, consultations as well as systems that help manage individual learning.

Keywords: MKT, primary school preservice teacher education, reflection, learning opportunities, education support programme.

INTRODUCTION

Various studies have shown that a teacher's mathematical foundation plays a key role in good teaching (Döhrmann, Blömeke, & Kaiser 2010). As such, the German state of Hesse has made German and mathematics mandatory subjects for teacher-students, who are studying to become primary school teachers (Grade 1 to 6). Hence, passing these two subjects is a prerequisite to becoming a primary school teacher. Our investigation is about the skills, beliefs, self-concepts and motivations of teacher-students in the first year of their studies. In this paper, we focus solely on the students' skills and the various support-offers for students.

According to our surveys, only about half of the students, who enrolled into the course of becoming a primary teacher, would have opted to study mathematics by choice (see Table 1). The study groups have heterogeneous motivation and foundation levels. Among

students who pass mathematics with ease, there are also struggling students that attend math lectures. Therefore, weaker students need to overcome their deficits. Fears, which may have developed and accumulated over time, are also covered in this project. If the deficits in math are not eliminated, the path of becoming a primary teacher cannot continue despite the level of motivation or performance in German and their third subject of choice. Should this be the case, students would be forced to change to secondary teaching or transfer to a university located in another state of Germany.

PROJECT IDEA

Due to the pressing issue mentioned above, the department of Mathematics Education of the Justus Liebig University of Gießen has launched a two-year-long project since the winter semester 2013/14. The aim of this project is to identify potential deficits of students' with regard to their skills, problems, attitude as well as their self-concepts pertaining to mathematics. Thereupon, supportive arrangements should be developed and evaluated.

All students, including those with weak mathematical foundations and low motivational drive, are supported throughout their course of study. In an attempt to overcome learning difficulties, students learn to reflect and develop a positive attitude towards mathematics through consultation sessions and additional training programmes provided by the department. This is done based on retrieved data from the analyses of the students. The level of math expertise and motivation as well as self-concepts of one's own abilities are to be inquired. In addition, the attitude towards mathematics needs to be identified. The results from these steps are used to customise consultations and training programmes for students in need of assistance.

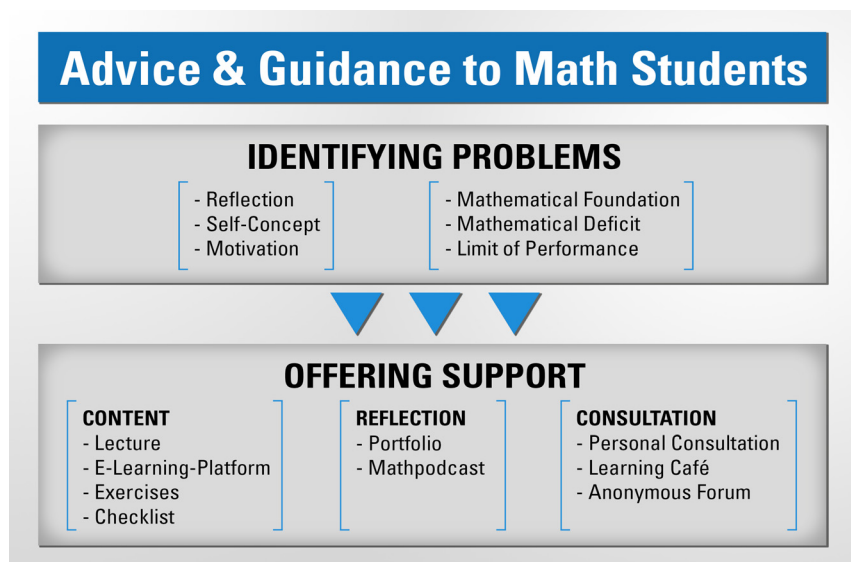


Figure 1: An overview of the project idea

INVESTIGATION

This investigation focuses on primary school teacher-students, who are in their first two semesters of academic study and may experience a drastic change: changing from school to university life. They are now confronted with having to be responsible for their own attendance of lectures and tutorials. Their whole academic study period is made of 7 semesters (3 ½ years) including a semester of examination. It has a total of 180 credit-points (ECTS). In the department of Mathematics Education they have to earn 26 or 38 credit-points, depending on whether they choose to do an internship for German or mathematics. The lecture, pertaining to this project, deals with ‘subject matter knowledge’ (Ball, Thames, & Phelps, 2008), together with the tutorials constitutes of about 330 hours of work, which are equivalent to 11 credit-points (ECTS). The module consists of two main lectures that run over two semesters and are accompanied by tutorials. A final exam will round up the second semester. The lecture’s content covers in particular the basics of arithmetic, stochastic and geometry. Around 190 students attend the first academic year. In the first year, the dropout rate, usually before the second semester’s final exam, is about 10%. We gathered data of all these students in order to get a good overview about their skills, their motivation and their beliefs. In future,

we hope to continue to evaluate individual students to investigate different cases in greater detail.

At the beginning of their first semester, students completed a mathematical proficiency test and filled out a questionnaire anonymously with regard to their personal attitude towards mathematics (Grigutsch, Raatz, & Törner, 1998), their self-concepts (Dickhäuser, Schöne, Spinath, & Stiensmeier-Pelster, 2000) and level of motivation (Brandstätter, Schüler, Puca, & Lozo, 2013) towards their tertiary studies. The mathematical problems that had to be solved in the test were mostly from junior high school. The math problems were selected according to their mathematical relevance at university level, so as to identify the student’s mathematical knowledge boundaries. These results are explicitly of a pilot-study and they are still preliminary in nature. Therefore, we will only describe observed trends and provide a few examples from the tests of October 2014 in the following (n=155):

Pertaining to individual personal assessment, we observed that a majority of students started their studies with overall low levels of motivation. Only about 32% of the students have indicated to be of the opinion that they are good enough to meet the demands of their mathematics course. However, 93% of them believe that they will become great math teachers.

Item	Strongly Agree (%)	Agree (%)	Agree Less (%)	Disagree (%)	No Declaration (%)
Having been given the freedom of choosing a subject, I chose mathematics.	18	31	15	33	3

Table 1: Choosing Mathematics freely

Item	Strongly Agree (%)	Agree (%)	Agree Less (%)	Disagree (%)	No Declaration (%)
I believe I can meet the demands of the subject mathematics.	32	38	23	7	0
I believe that I can be a good mathematics teachers.	18	75	6	0	1

Table 2: Excerpt of the questionnaire concerning students' self-concepts

We have to consider that these results are based on the students' self-assessments. 70% of the students feel, that they are able to study the math they need for becoming a primary school teacher. Interestingly, the percentage of students who believe they already have the required knowledge, does not match the results of the mathematical proficiency test.

The evaluation of the mathematical proficiency test shows that 80–95% of the students were able to solve questions of the German 'Abitur' (general qualification for university entrance) standard. In particular, applying Pythagoras theorem and mathematical equations. Moreover, commonly used units such as length or currency were converted correctly with ease.

The following results show that one third or even half of the math students cannot apply their knowledge learnt in school. This correlates with our assumption that there is a need to provide support options for the weaker students. Thus, these problem areas are indeed important and relevant to the educational path of studying to become a primary school teacher.

In the following year, we will try to achieve a greater participation of students for the questionnaire, so as to optimise the foundation of our support options. Furthermore, we will evaluate the initial approaches that started in the first year of the project in the following paragraphs.

After having gathered the data mentioned above, we have chosen a broad sample of students to be interviewed. The interviews adopted the problem-centred approach by Witzel (2000). Each student is interviewed 4–5 times. It should be noted, that the focus lies not on the interviews nor on the questionnaires, but rather on the upcoming project approaches.

PROJECT APPROACH

As the project launched in the winter semester 2013/14, only a few approaches to address the identified deficits could be outlined. We have conducted another inquiry, although still ongoing, dealing with the initial circumstances that the students begin their studies with. By the means of this data, measures are customised to fit the needs of the students. The measures, which have already been implemented and those that have yet to be, will be described in the following. We have to consider, that it is an alternating iterative process: There are existing measures and some that have yet to be implemented, but the problems are not yet sufficiently identified in detail. At the same time we have to support the student's learning, we have to identify problems, prevent them from occurring and evaluate measures.

Exercises

Besides lectures, exercises play the most important role in learning. Students may even feel that exercises

Item	Tested skills	Answered Correctly (%)	Answered Wrongly (%)	No Attempt (%)
Solve the following problem: 9475:25=	Basic Arithmetic Operations	65	27	8
In a square, draw all the axes of symmetry.	Concepts of Plane Figures, Symmetry	76	16	8
In a parallelogram, draw all the axes of symmetry.	Concepts of Plane Figures, Symmetry	48	44	8
How many results can be produced by rolling a dice four times consecutively.	Combinatorics, Concepts of Multiplication	47	36	17

Table 3: Examples of the mathematical part of the questionnaire

go before lectures. As the feeling is mutual, this paper will focus on the importance of exercises. As the project began upon the commencement of the winter semester lectures, the already prepared math exercises received only minor adjustments. Just like in previous semesters, students were assigned exercises to deepen their understanding of the lecture content. These exercises were discussed in weekly tutorials lead by students of higher semesters, supervised by a research associate. The exercises can be categorised into five types, namely arithmetic problems, application questions, problem solving and modelling tasks as well as justifying mathematical concepts.

In the following semester, the exercises will be restructured to take the form of “productive practicing” (Leuders, 2014). The exercises should help sustain knowledge and be retrievable at any given point in time. During these exercises, automated calculations should be prevented, as they tend to be forgotten easily. Nevertheless, it is important to strengthen and link mathematical understanding to arithmetic technique. In each series of exercises, the following competences should be covered: ‘Securing factual content’, ‘automation of skills’, ‘broadening and deepening of perception’, ‘reflection of concepts and their application’, ‘applying knowledge pertaining to problem-solving’ as well as ‘creating an appropriate impression of mathematics’ (Leuders, 2014, p. 253; translation by the authors). As such, the homework of the following semester will comprise of three parts:

- The first part deals with tasks in which students are taught to solve problems on a syntax level. This skill should be integrated into structure and problem-solving tasks. Either a structure is investigated to practice applying skills or simple forms of problem-solving tasks can be used. As each student approaches the task on his own terms, they develop a personal heuristic to solving problems using the given arithmetic rules. The tasks remain at a standard that allows students to check if they have understood their calculation method and the arithmetic rules used. Two days before the tutorial, students receive a suggestion sheet providing a solving method for the task. If necessary, the students can receive help using the online-forum or bring their query to the tutorials.
- The second part covers mathematical problems that are in line with the competences mentioned above. These tasks should meet the demands of the math lecture. The students are given one week to solve the problems. These problems aim to teach the students mathematical understanding, justification, problem-solving and derivational skills. After the given week, the suggested answers are only handed out if they have been compared and discussed within the tutorial. The tutorials actively incorporate the student’s input and provide a platform for communication to take place.
- The third part occurs during the tutorials, where math problems are done in class. These tasks can cover various types of the targeted competences. Due to the broad spectrum of lecture topics available, various types of questions can be chosen for discussion in the tutorial. Moreover, mathematical topics can be explored and nurture comprehension by using the resources provided by the Math Learning Lab to create practical situations.

Personal consultation

After the mathematical proficiency test had been evaluated in the first part of the project, students were given the opportunity to seek advice and support through consultation sessions. Consultations were visited on a voluntarily basis, in light of having to remove a student’s anonymity in order to discuss his test results.

First, the students were asked about their own expectations. The idea was to observe if the students were able to assess themselves and reflect on their performance. Thereafter, the students received feedback pertaining to the test. Having identified their strengths and weaknesses, they were given advice on what topics to focus and brush up on. These suggestions were supposed to help the students to cope with the expectations of the syllabus. If deemed necessary, a follow-up consultation could be arranged to discuss topics of the first session in greater depth.

As the project continues, we plan on implementing consultation sessions addressing topics beyond the proficiency test, so that students are able to receive advice and support anytime. In order to make these consultation sessions more sustainable in the long run, consultation sheets have been introduced to secure results and progress as well as to give students

a way to prepare for the sessions (Macke, Hanke, & Viehmann, 2012).

E-learning platform

The University provided an online learning platform called 'Ilias' for the students. Based on this platform we provide tasks, which enable students to practice additional math problems at their own time, while being able to instantly monitor their learning progress. The following types of math problems were incorporated into this system.

- Some problems merely recapped mathematics of secondary education. Algebra, geometry, arithmetic and stochastic theory make up the foundation and prerequisites of studying mathematics at tertiary level.
- The majority of problems were similar to the above-described homework. The tasks are derived from lecture content and serve as additional practice. These tasks are especially relevant for the examination at the end of the lecture-period.
- Some tasks go beyond basics and covered lecture content. This is done, so that students receive a broader spectrum of topics and greater understanding through exploring other topics on their own.

In future, more features will be added to this platform in order to break down complex lecture topics and to be able to tackle them with a variety of methods. For example, relevant Internet links and teaching videos can be useful for post-preparation of lecture content. In addition, the learning platform is undergoing developments to enable the upload of mock exams for additional exam preparation. As a result, students receive a first glance and what might face them during an exam.

Portfolio

Different forms of e-Portfolios used in teacher education are described by Vogel and Schneider (2012). Our paper exclusively refers to a 'reflection-portfolio' (Vogel & Schneider, 2012, p. 136, translation by the authors). Nearly every exercise worksheet has questions incorporated that trigger self-reflection. These are supposed to be worked on individually and filed, so that each student has a portfolio that documents their learning progress over the first year of their studies.

Up to now, the students were required to reflect on the following:

- Personal experiences of primary and secondary school
- Their opinion of certain lecture topics being relevant for teaching in primary school
- The importance of mathematics and certain lecture topics to society
- Their factors which motivate them to become a teacher

At the end of the summer semester 2014, the portfolios were collected, looked through and given feedback by the lecturers. On one hand, the portfolios shed light on personal attitudes and each learning progress. On the other hand, they revealed that several students did not take the reflections seriously as they were written rather superficially. Bräuer (2014) experienced the same scenario and demonstrates how students could be supported.

Hence, the next round of portfolios will be integrated into the platform's server. The lecturers can not only monitor entries and strategically upload additional exercises and revision material but also address problems and difficulties in the lecture itself once voiced out in the reflections. If necessary, the lecturer can also leave comments immediately and encourage the student to reflect deeper (Bräuer, 2014). The portfolios can also serve as personal learning diaries or be published on a blog to help others too.

Anonymous forum

From the winter semester 2014/15 onwards, students have the opportunity to post questions onto a second forum. Previously, students had the tendency of asking questions directly to their tutors via email. Thus, interactive discussions on the forum were non-existent and there was no need for other kinds of support. Furthermore, many questions were asked repeatedly. It was not clear if they were general problems or isolated incidents. We assumed that the reason students had refrained from using the non-anonymous forum was due to the fear of humiliating themselves when posting their question. Therefore, the anonymous forum aims to promote the asking of questions through the means of an open and safe platform. As the stu-

dents are generally familiar with the social-media platform 'Facebook', Kempen (2014) refers to it as an appropriate tool for exchanges between the students. We however, chose 'Ilias' (s. above), an e-learning platform that is more secure and ensures more privacy.

Learning Café

Students can come to the Learning Café located at the institute's Math Learning Lab. They will be given a room in which they can meet to discuss math problems. Additionally, a staff member of the lecture will be present to provide answers to questions students might have. Some math concepts can be visualized through the ready-available resources found in the Math Learning Lab. Over time, study groups may develop, as the Learning Café serves as a conducive meeting point. Students can create "learning communities" (Gunnarsdottir & Palsdottir, 2013, p. 3085) to acquire and develop a professional jargon as well as collaborative competences. This suits reserved students, who may now have the courage to clarify concepts with lecturers, tutors or even students directly. A similar project is described by Zimmermann (2012), in which though, these opportunities are offered on a daily basis and for students of different ages.

MathPodcast

Students can volunteer to participate in a podcast project that runs alongside the lectures. Audio podcasts are created within small groups. They are based on math lectures and trigger students to reflect on mathematical content and their standard of math skills. They need to explain a lecture topic verbally without the use of gestures or other materials. The podcast production starts with the recording of a spontaneous attempt of trying to explain the topic using basic knowledge. This recording will then be fine-tuned through collective research. Thereafter, a script will be designed which will be used to create a podcast ready to publish (Schreiber, 2013). This process is suitable to allow students to reflect on a particular math topic. Tutors will accompany the podcast productions throughout, while the students will receive feedback on their correct and wrong understanding of concepts (Klose, Tebaartz, Schreiber, & Lengnink, 2014).

FURTHER PROSPECTS

In the second part of the project it is important to get data of all the students, not only of 110 out of 160 like we did this semester. The E-Learning-Plattform will be

available once the lecture-period begins. As such, the students can benefit from its content throughout the semester and we receive access to evaluate the platform's success. Furthermore, the Learning Café and tutorials will be offered from the first week onwards throughout the lecture-period. Hence, we can evaluate the students' reception of both support options and optimize them further.

The project's running time is limited to two years. It serves to develop and implement measures that nurture and foster mathematical understanding. Once the project is over, the measures have to be continued without any additional financial support. Many points mentioned above are easily implemented and complemented in terms of materials. Specific assistance can only be given if the evaluation of a student's learning process requires minimal effort. Therefore, it is vital to carry out an online evaluation, so that lecturers receive an overview by the means of simple statistical data on the current learning standard of the students.

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