Preparatory Mathematics Course for Non-Traditional Engineering Students

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***Abstract*— This paper reports the concept of a preparatory mathematics course for non-traditional students in electrical engineering, and its evaluation. The blended-learning course is part of the initial study phase smoothing the transition to learning at university level. The instructional design of the preparatory course is aligned with that of the Bachelor's study program. However, it takes place prior to the beginning of the first semester. The initial phase additionally encompasses the whole first semester with different courses meant to help students getting ready for studying. Prospective students indicated that they needed to refresh their knowledge in mathematics. Thus, a preparatory mathematics course was given priority. This course serves several purposes: Students get an impression of the requirements in mathematics necessary for the study program; they refresh their basic knowledge; they make themselves familiar with self-organized learning and the blended-learning concept of the program. Design and implementation were evaluated with a questionnaire at the end of the course. The results show that the course is an appropriate instrument prior to engineering studies in order to prepare and support non-traditional students. In the conclusions potential for improvement is identified.**

***Index Terms*—Bachelor's degree, blended learning, engineering, evaluation, initial phase, mathematics, non-traditional students, Preparatory course.**

I. OPENNESS REQUIRES PREPARATORY COURSES

Within the program "Upward mobility through academic training"[1] put forward by the German Federal Ministry of Education and Research, the Universities of Applied Sciences at Darmstadt (Hesse) and Aschaffenburg (Bavaria) develop a joint Bachelor study program in electrical engineering for non-traditional students. The student target group is employed in industry and plans to study in parallel to maintaining their jobs. Either, they have never acquired a formal high school degree, or this was long ago. As a consequence, their prior knowledge of mathematics differs substantially. In a survey, prospective students announced the highest demand for a preparatory course in mathematics, followed by a request for a programming course [2]. The self-assessment of the target group shows that they are conscious about their perhaps insufficient mathematical skills and that further support is needed in order to start a study program. The lack of mathematical skills is a common problem throughout study beginners of several technology-based study programs and is not only restricted to this special target group of non-traditional students. Universities are responding to this challenge with various arrangements and new concepts [3]. One of these ideas are bridging courses, which are quite common in engineering programs. Literature shows various forms and concepts (e.g. blended learning, online learning, self-study, classroom teaching) how bridging courses in mathematics can be carried out and organized [4,5,6]. The concept of the initial phase presented here, takes these findings into account; however, the concept of this course is tailored to the needs of the target group, and part of a starting program during the initial phase. Sixty prospective students enrolled in the 2013 preparatory mathematics course, their ages ranging from the mid-twenties to the mid-fifties. About one third of the participants lived more than a two-hour drive away from the campus Aschaffenburg. We report the design and the resulting evaluation of the preparatory course. In the end, the course helped the participants in their decision whether to enroll or not. The first students have begun testing the study program in the fall semester 2013.

II. INITIAL STUDY PHASE

A. Starting point and objectives

Prospective students possess rather different prior knowledge and competencies due to their scholastic, professional, and subject-specific experience [2]. In order to support them in getting started successfully with their studies, a concept for the initial study phase is developed. Currently, there is considerable interest in the design of the initial phase in the German scientific community, because higher retention rates are expected from a smoother transition to university [7, 8]. Drop-out can be definitely reduced by preparation and adequate support during the first semesters [9, 10, 11]. The following objectives are on our agenda: Filling gaps in mathematics, introducing students to the learning platform, strengthening their study techniques, fostering learning groups, and cutting fears and worries. Figure 1 summarizes the course elements to accomplish these objectives. The initial study phase consists of three well-matched, consecutive courses. Five months before the start of the first semester the preparatory math course starts. The first semester of the regular study program begins with a summer-school block.

The four-day summer school program helps students to get to know the study program, each other, the teaching staff, and serves team building. Furthermore, study techniques are actively taught; a session working with LabVIEW is included. There is enough room for teamwork and questions of the students. Towards the end of the first semester a preparatory programming course will start. It helps students who have never done any programming before and paves the way for "Programming in C", a module scheduled for the second semester.

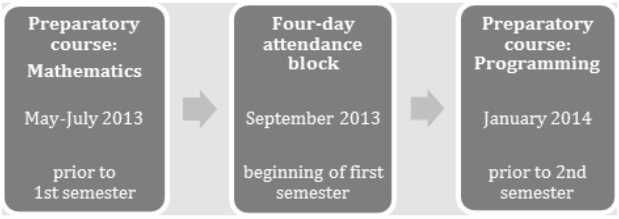

Figure 1. Courses during the initial phase

B. Preparatory Mathematics Course

The following section is on the conception of the preparatory math course, the first element of the initial study phase. Emphasis is placed on the specifics of the target group, the description of the concept, implementation and sequencing of the study phases characterized by blended-learning, the topics covered in the course, and its evaluation.

1) Specifics of the Target Group

As a measure to prepare the students for their Bachelor's in engineering studies, the preparatory mathematics course is pivotal. Some students lack knowledge of elementary functions and pre-calculus since their formal training has never covered these topics. Understanding differentiation and integration is much more difficult, if possible at all, without sufficient basic knowledge, e.g. handling fractions. According to our observations, it is the mathematics curriculum from grade 8 to 9 that is often missing the prospective students and inhibits further understanding. Main idea of the preparatory course is to improve students' basic mathematical skills. The syllabus comprises topics from grades 8 to 10. The contents of the preparatory math course are given in table I. The course script starts with basics, followed by equations and inequalities, the exponential function and logarithm, trigonometric functions, and vector algebra.

2) Concept and Implementation

The special situation of the target group requires a course design which allows students both working and studying. Various aspects, e.g. the participants' available time slots, remote residences and travelling times to the university, had to be considered. Therefore, a blended-learning concept similar to the one of the study program is proposed. On top, there is an advantage for the students to be able to try out how to get along with the proposed rhythm of learning. Fig. 2 shows the time structure of the concept. The course consists of two alternating phases – self-study phases at home and in-class trainings on campus – which are intertwined. On the whole the course lasts over a period of three months, from the beginning of May until the end of July. The three in-class trainings took place at the Aschaffenburg University of Applied Sciences and were planned for 3.5 to 4.5 hours on Friday afternoons each. Self-study phases were organized on the learning platform Moodle supported by electronic material. A script was supplied by the lecturer who will teach mathematics in the Bachelor's study program. We estimate an overall workload of two ECTS credit points for the whole course.

a) In-class training

In May, the course started with an in-class training on campus. A total of 61 potential students had registered for the preparatory course, of which 49 came to Aschaffenburg for the first class. Participants came from all over Germany, not just from Aschaffenburg and its surroundings. Groups were built according to residency in order to help students to get to know each other and to set up learning groups with others who live in geographical proximity. Students with residence close to Aschaffenburg belonged to one group, students with a residence within a 200-kilometer radius to another group. Finally, the third group consisted of students who lived farthest from Aschaffenburg. Each group was supervised by a tutor who acted as a contact person for questions and problems. The tutors themselves were students in their second year of the regular study program in electrical engineering and information technology and experienced in teaching. Students - instead of lecturers - were chosen as tutors because this helps to reduce the inhibition threshold to ask questions at this pre-university level.

TABLE I.
TOPICS AND CONTENTS OF THE PREPARATORY MATH COURSE

Topics	Content
Basics	Elementary mathematics, fractions, binomial formulas, powers and roots, percentage calculation, sums and the sigma sign
Equations and inequalities	Transforming equations, quadratic equations, high order equations and polynomial division, equations with roots, inequalities
Exponential functions and logarithm	Exponential functions with different bases, logarithm
Trigonometry	Triangles, trigonometric calculations and functions, radian, inverse trigonometric functions, use of a calculator
Functions	Differential calculus and integral calculus of simple functions
Vectors	Vectors, calculating, coordinate representation, scalar product, line equation, circle equation

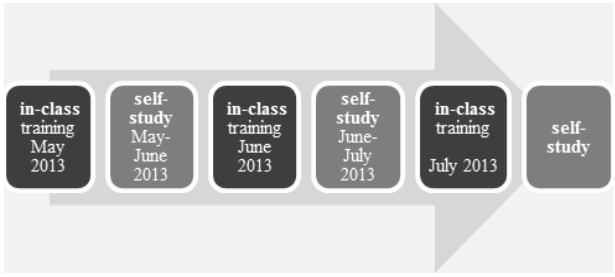

Figure 2. Alternating phases in the blended-learning concept of the preparatory mathematics course

The first in-class training started with a welcoming address and a test which gave feedback to the students on their current abilities in math. The test consists of 10 test questions and is based on Knorrenschild [12]. The test took some 15 to 20 minutes, without using a calculator. The results were immediately evaluated during the lesson and shown to the students. As expected, a wide spectrum of adeptness occurs. Some students did quite well, for others the test indicated shortcomings. The same test is used in the regular engineering programs. Although the participants of the preparatory mathematics course have been out of school for much longer than the regular students the overall results were very similar.

During the in-class trainings the students got a short theoretical introduction into the basics of a certain mathe-

matical topic first. This input took place in a plenary session with all participants and was delivered by a lecturer, similar to a short lecture in style. The idea of this introduction was to activate students' memories and to present basic methods concerning the topics dealt with. Afterwards tutor sessions with smaller groups of about 10 to 16 persons each were offered. The three groups were organized in different rooms. Problem sheets were handed out to the students. Students worked in teams on the exercises, while their tutor supported them. Furthermore, the tutor explained calculation methods on the fly. Later on, the tutor developed the solution stepwise on the blackboard for comparison. It was always possible to ask questions.

b) Self-study phases

Each class was followed by a phase of self study. These phases were enriched by e-learning material on the learning platform Moodle. Within the self-study phases students were expected to work through the content and prepare the next in-class training. For assistance a special Moodle preparatory math course is offered on the platform, with various learning materials provided. Main component is an electronic HTML- based math script, which explains the basic topics of the preparatory course. Table I shows the topics and the content of the script in more detail. The script gives a structured introduction to the topic and explains associated mathematical rules. This is complemented by exercises, and supplemented by sample solutions. For each chapter further exercises and solutions are offered for download in portable data format.

In addition to the online script and the exercise files for download several online-learning possibilities are being offered: Online cloze tests, interactive applets, and exercises within the MathCoach program [13]. The online cloze tests are developed for special topics like the antiderivative, or finding the first or second derivative. With these cloze-tests students can train and internalize the corresponding rules and methods. Figure 3 shows an example of a cloze test.

In order to visualize key mathematical concepts, several applets which offer interaction are designed for the platform. The integration principle is shown in figure 4 as one example for such an applet.

The math learning program MathCoach is another possibility offered for online learning [13]. The program is developed by Grabowski, htw Saarbrücken, and provides students with interactive online exercises. Special features of the program are the individual feedback and the valuation system. Depending on the input of the student, the program returns a hint, which helps to find the solution. The evaluation is adjusted to the actual working step. The program offers different types of problems and answers, like multiple choice, fill in the blank, matching tasks, experiments and exercises [13].

A discussion forum is open for students' questions concerning the above-mentioned online-learning options. Also, questions concerning download exercises or the math script were gathered in a discussion forum. The three tutors of the in-class trainings commented and answered questions in these discussion forums, in cooperation with the lecturer. A consultation hour was arranged for each tutor on the platform. This helped students to straighten out misconceptions and stay in contact with their assigned tutor.

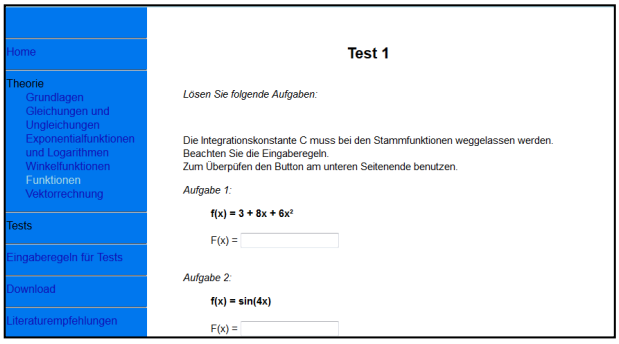

Figure 3. Online-cloze test on the learning platform

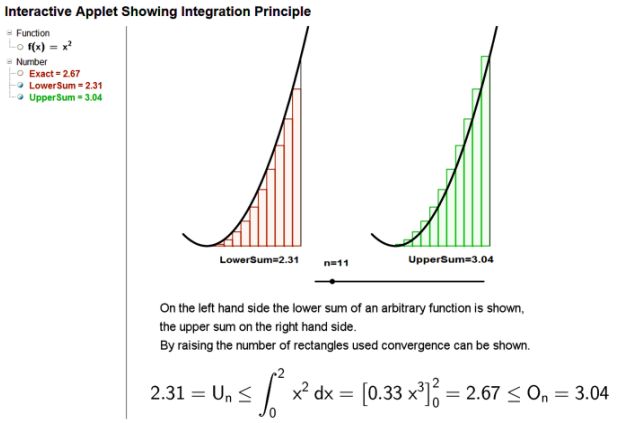

Figure 4. Interactive applet showing the integration principle

III. EVALUATION

Upon the end of the preparatory mathematics course a questionnaire with a five-point Likert scale – ranging from "fully applies" to "does not apply at all" – was used for evaluation. A total of 24 students took part in the final evaluation: 22 persons filled the questionnaire out in class, two persons completed it online. The questionnaire concentrated on the following categories: benefit, difficulty level, in-class training, learning platform, working method and knowledge concerning the mathematical topics. At the end of the questionnaire the students could fill in free text what should be improved and what they liked about the course. For the graphical presentation in the following section the answering categories were grouped such that three categories result: "Fully applies/applies", "partially applies", the third one being "does not apply/does not apply at all". Percentage values were calculated from the data.

A. Benefit of the preparatory course

The benefit of the preparatory course for the students was checked (Fig. 5). Students answered that the preparatory course was well suited to prepare them for studying: 79.2 % percent agreed with the statement that they are now better prepared for the study program. Nearly all students (95.8%) were able to find out where they needed to fill gaps by means of the course. The course allowed them self assessment: The course helped all students (100 %) to obtain a picture of their current status concerning their math knowledge.

The course gave 37.5% of the people a good impression what to expect from a blended-learning course in distance education. However, 50% specified that this was only

partially fulfilled. Furthermore, most of the people (70.9%) do *not* agree with the statement that the preparatory course raises doubts whether studying electrical engineering is the right thing to do. One third of the people agree with the statement that the preparatory course helped to make a general decision whether to start a study program at all. 45.8% see this partially fulfilled, whereas 20.5% do not agree with this statement.

The number of participants taking part in the first, second and third in-class training decreases as can be seen in table II. The preparatory course selected the highly motivated people and definitely contributed to the decision-making process whether to start the study program or not.

TABLE II.
COURSE PARTICIPANTS PRESENT AT IN-CLASS TRAININGS

	First in-class training	Second in-class training	Third in-class training
Participants	49	26 / 9 excused	23 / 9 excused

Starting with 61 registrations for the preparatory course, 35 persons took part regularly as proven by activity on the learning platform and participation in class (on campus). Their high commitment can be drawn from the fact that 33 out of these 35 prospective students in fact enrolled and became students of the Bachelor program in October 2013.

B. Difficulty level

The difficulty level of the preparatory course was also evaluated (Fig. 6). This was important because of the heterogeneous group with varied prior knowledge and different school-leaving qualifications. The potential students were asked whether the difficulty level was appropriate or should be adjusted. 58.4% answer that the difficulty level is appropriate. The content is not too easy (87.5%). Only 8.3% agree with the statement that the course is too difficult, 37.5% partially agree, and 54.1% do not think so.

C. Design of the in-class training

The in-class training is part of the blended-learning concept. Results (see figure 7) show that the vast majority of students (91.6%) consider in-class trainings to be a necessary component; they do not prefer pure online-learning. In addition the results reveal that in-class training helps most participants (87.5%) to get a better understanding. For 54.1% of the students further travelling to the university will be o.k., if they can get individual assistance. Concerning the preparatory course 50% of the students answer that one in-class training per month is enough. 33.3 % wish to have more offerings for individual in-class training support, 37.5% do not need it.

For the in-class trainings a learning arrangement with short introductory lectures, tutors and group work is chosen. Therefore we were interested how the students got along with the lectures and what experiences they made. As reported, upon the first in-class training a math test was provided to allow for individual feedback on basic knowledge. Results show that the preliminary test is very helpful for students. 75% mention that the test showed them existing gaps. Furthermore the engagement and presence of the tutors is evaluated well. The number of tutors who support the in-class group work suffices

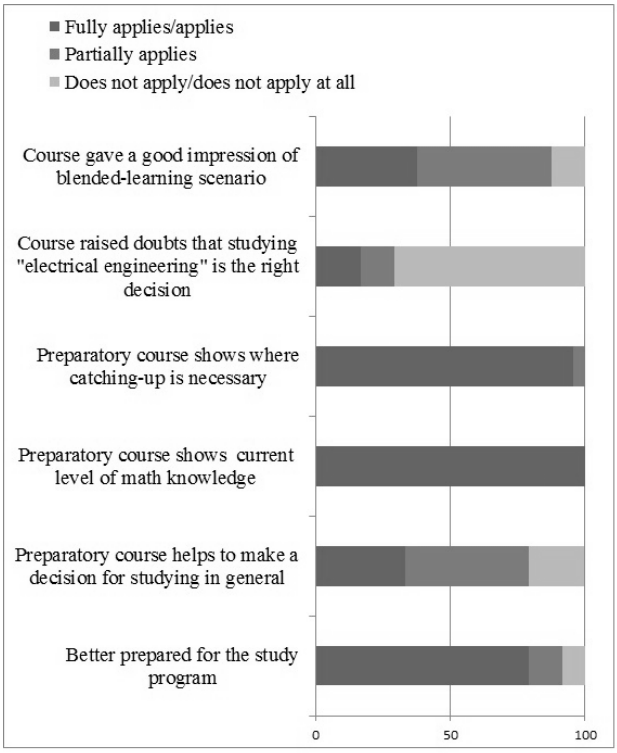

Figure 5. Category: benefit of the preparatory course

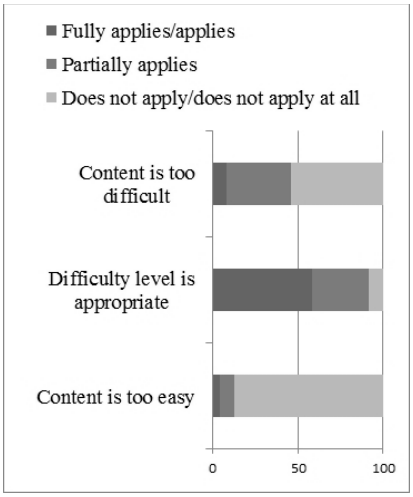

Figure 6. Cateogory: difficulty of the preparatory course

(91.7%). More than half of the questioned people (62.5%) answer that tutors showing and calculating examples are helpful and foster understanding. Only 8.3% do not agree, while 29.2 % agree partially. The detailed analysis of the tutors' presentation of exercises (in the dimensions rapidity and comprehensibility) shows a somewhat different picture: 25 % articulate that it was too fast and incomprehensible, while 29.1% do *not* think so. Almost half of the participants (45.8%) do not commit themselves. Of course, it is an interesting question how to organize in-class trainings in mathematics for the special target group. Considering the different levels of competency and formal qualifications, some people need more theory or input of the mathematical basics as a start, whereas others already know the basics quite well and want to spend time on applying the mathematical methods. Two questions of the evaluation picked up this problem. The results show that

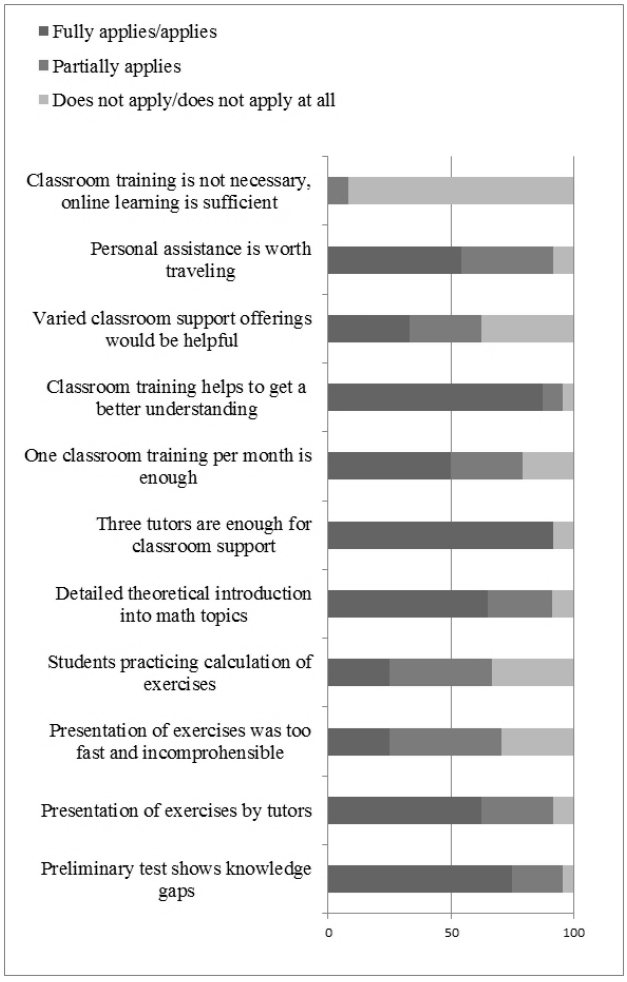

Figure 7. Category: classroom training at the university

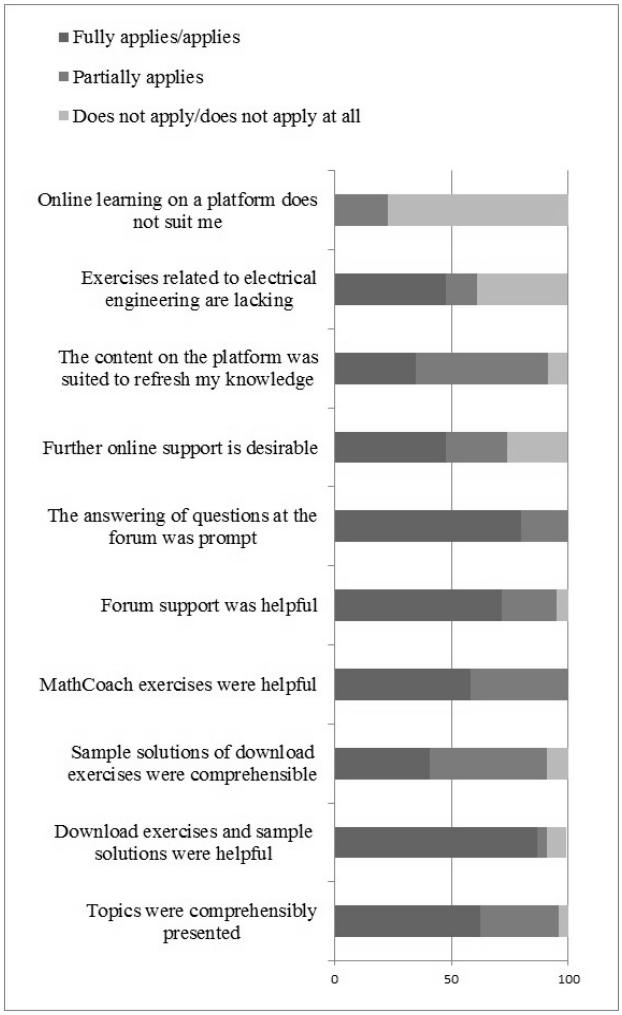

Figure 8. Category: learning platform

students favor a detailed theoretical introduction of mathematical topics (65.2%) rather than practicing during contact time (25%).

D. Learning platform

The Moodle learning platform is a main component of the blended-learning concept and supports the self-study phases of the students. As reported above, the platform offers different online-learning materials and communication tools. The questionnaire contains ten questions concerning the learning platform and the online content (download exercises, script, MathCoach exercises). Figure 8 shows the results: students did *not* dislike online learning, and were rather open towards this learning format. Students felt especially confident with the download exercises and sample solutions. 86.9% of the questioned persons answered that these exercises and solutions were helpful. More than half of the students (58.4%) also rated the MathCoach online exercises as helpful, 41.7% found this to be partially true; nobody regarded them to be unhelpful.

Besides the exercises the forum support convinced the students. 71.4% answer that it is a helpful feature. This could be associated with the way requests were answered in the forum. 80% mention that questions were answered promptly. The comprehensibility of the content, especially the presentation of the topics and the download exercises are also evaluated. 61% of the students feel that the topics are, in general, comprehensibly presented. Some results indicate potential for improvement. Concerning the download exercises 40% find them comprehensible, and 50% agree partially. Furthermore, nearly half of the students (47.8%) like to have further online support. Regarding the provided content, only 34.7% agree with the statement that it is sufficient to reactivate their math knowledge; the major part of the students (56.5%) is undetermined. Finally, 47.8% of the students wish to have special exercises related to electrical engineering.

E. Working approach of the students

We were also interested how students got along with the design of the preparatory course and especially with the exercises. The decreasing number of participants during the preparatory course shows that possibly not everyone took it totally seriously and planned on finishing the course. Maybe some people were only interested in the topics and wished to get an overview. Therefore we asked the participants how seriously they had taken part in the course and worked through the exercises (see Fig. 9). 50% answer that they seriously solved the problems, 41% mention that this applies partially. 20.8% wanted to have an overview over the topics without putting more effort into solving the given problems, whereas 54.2% do not agree with this statement. Results reveal that 29.2% had enough time besides work for working through the exercises, 33.3% partially agree. However, 37.5% indicate that they did *not* have enough time to solve math problems.

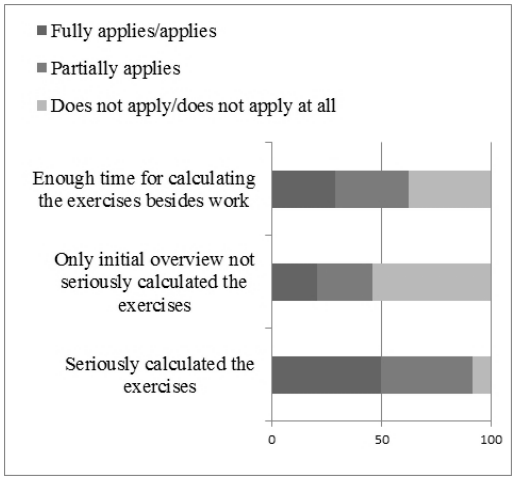

Figure 9. Category: working approach

F. Competencies of basic topics in mathematics

On the last page of the questionnaire students are asked to assess their competencies of different mathematical topics. This is helpful in order to get an idea on which topics the next preparatory course should focus. The assessment of abilities was measured on a scale from 1 - very poor to 5 - very good (see Fig. 10). The results show that students are more confident in handling the mathematical basics like percentage calculation, fractions, binomial formulas and trigonometric functions. Students are less familiar with exponential functions and logarithm as well as differential and integral calculus. This may be due to the profile of the target group, the secondary school-leaving certificate often being their level in mathematics.

G. Potential for improvement and reassuring responses

Free-text answers offer students the possibility to give detailed feedback – potential for improvement as well as reassuring responses – on the preparatory course. The various answers were categorized, and the most frequently mentioned answers are reported here. In general, students make suggestions for improvement related to the learning material used and the implementation of the course. Students wish to have more learning material and exercises (three replies), and also a more detailed design of the learning material and the script (three replies). Especially the sample solutions should be presented in more detail and at a slower pace (three replies). Furthermore, they request an extended theory part, more explanation of the theory, and focus on teaching the basics (two replies). The positive feedback emphasized the dedication and support of the organizational team and lecturers (three replies). Some students praised the comprehensible explanations, the presentation of content, and the way of teaching (three replies). The use of the media on the e-learning platform was upraised positively (two replies). Likewise, they were satisfied with the short reaction times to answer their questions (two replies).

IV. CONCLUSIONS

The evaluation allows a detailed assessment of the entire preparatory mathematics course. The most important finding is: The course helps students to get a sound first impression of a distance-learning program. The evolution of the number of course participants shows that the preparatory course selects the really interested people. In that sense it can be regarded as an effective self-assessment. This will contribute to lowering the drop-out rate in the Bachelor's degree program for which the preparatory course is offered. With a comparatively small investment, prospective students get hands-on experience and find out whether studying towards an engineering degree alongside working will suit them. Taking part in the preparatory course makes students feel better prepared to study electrical engineering and information technology. Doubt could be dissipated; confidence into their own ability to master challenges in mathematics was built up by the students. Another benefit of the course is that students are able gain first experiences how to organize study times and become familiar with the organizational requirements. During the course, most of the participants recognized knowledge gaps in basic mathematics. Within the three months between the end of the preparatory course and the beginning of the Bachelor's program there should be enough time for them to catch up. The vast majority of the participants found the preparatory course overall encouraging. More than half of the participants of the preparatory course enrolled for the fall semester 2013, several others plan to do so in 2014.

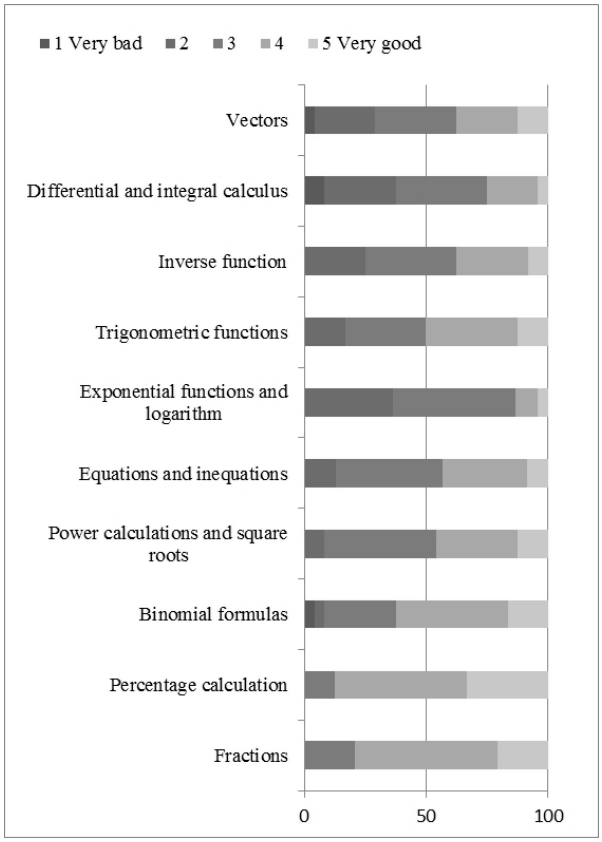

Figure 10. Command of mathematical topics at the end of the course

The difficulty level of the preparatory mathematics course can clearly be described as adequate: slightly more than half of the answers support this statement. This does not apply for all students, however. Therefore it is important to provide further self-study learning material with varying degrees of difficulty. Varied learning material could be offered through e-learning, e.g. videos with explanations or videos showing sample solutions. In this respect there is potential for ongoing improvement of the

course in order to meet the needs of the heterogeneous target group and support individual learning.

In-class training is a characteristic component of the concept, even if the number of participants decreased with time. Those who came to class and took part in the survey argue for traveling and attending the in-class trainings. They are convinced it helps to gain a better understanding of the topics. Furthermore, it is interesting how students evaluate the applied methods of teaching. It turns out that most of the students prefer a detailed introduction of the topics, and to a lesser extent practicing actual problem solving. This finding could be associated with the specifics of the target group: Some participants had not attended a math lecture in years. As a consequence, it seems appropriate to structure lectures into a first part that gives a short introduction to the topic, where the most important rules and calculation methods are explained, whereas the second part should give room to problem solving.

The learning platform was overall well received by the students. They were very open to this learning format. The exercises and sample solutions were regarded to be helpful. Altogether students ask for more problems that they can solve. This was also pointed out in participants' free-text responses. A need for enhancement can be deduced. Not every student feels confident with the comprehensibility of the explanations. Several students request an even slower pace and more detailed explanations. While the time on campus is limited in such a blended-learning format, this request could be resolved by producing short explanatory videos that are viewed on demand.

Another positive aspect of the preparatory course, and in particular, of the in-class trainings, is the possibility for the participants to meet other prospective students. Working in groups fosters early team building. This emphasizes the important social aspect of learning, which would otherwise fall short in a pure distance-learning format. This way, about half of the students got to know each other before the start of the first semester, and established contact beforehand.

In sum, the idea of a preparatory course and its instructional design are well suited for non-traditional students who plan to start with a technical Bachelor's program. The objectives of the course are met: Students were able to fill individual gaps in basic mathematics. They were introduced to academic training in a blended-learning arrangement and could make their own experiences with it. Learning groups emerged. Fears and worries could be reduced by exposure to a realistic scenario what learning at university level will look like. Some improvement should be considered by adding further problems and explanatory material.

V. PREPARATORY COURSE AND MATHEMATICS FOR ENGINEERS 1 IN RETROSPECT

This section reports about the experiences with the first year students who passed the mathematics preparatory course and subsequently the module "mathematics for engineers 1". As reported we are of the opinion that the preparatory course selects the really interested people before the start of the study program and helps to reduce the dropout rate. Actually 28 out of 33 persons who took part in the preparatory course and started the study program in September 2013 are meanwhile students in their second semester. However, we note that a considerable fraction of these students did not pass the mathematics for engineers 1 exam at the first attempt even though they visited the preparatory course. So far we cannot estimate the final success rate because students are only in their second semester. Still, this made us reconsider the structure of the mathematics preparatory course. Suggestions for improvements are deduced from the evaluation of the module mathematics for engineers 1: students were asked about the usefulness of the preparatory course in retrospective. Contrary to the students' assessment after finishing the preparatory course where the vast majority of the students answered that they feel better prepared to study electrical engineering the more recent results show modified answers.

In retrospective students feel that they still have knowledge gaps in mathematics. While 83% of the respondents were able to cope with the requirements of the preparatory course, only 23% felt the same for the mathematics for engineers 1 course. A mere 13% answered that their mathematical knowledge prior to the first semester was enough to pass the module mathematics for engineers 1; for 26% it was partially enough, whereas 61% rate their previous knowledge insufficient. This indicates that there is a gap between the requirements in the study program and the students competencies after passing the preparatory course. Therefore the students were asked to rate the adequacy of the preparatory course in retrospect. Still, 45% rate the preparatory course as adequate, for 36% it was just partially adequate and 18% say that it was not an adequate preparation. Altogether, the feeling of being prepared for the study program only slightly decreased in the evaluation after the first semester.

Further evaluation indicates that students are not only challenged regarding their mathematical competencies, but also when it comes to other aspects of learning: time issues and work-study-balance. Through the preparatory course students became familiar with the organizational requirements of studying. For this purpose the preparatory course was helpful and gave a first impression what it means to be a student. On the other hand, students reported that the organization of the whole first semester study program was a much bigger challenge than expected. The preparation for the courses took much longer than assumed, and students underestimated the workload. Therefore some students had problems to reconcile both working and studying. The bottom line of the students' responses was that they needed more time to process the learning material. Furthermore the students suggested a more intensive preparation in mathematics before the start of the mathematics engineering 1 module. This includes for example extended in-class trainings and more and flexible exercises for the weaker students.

The evaluation also considered students' learning habits in the mathematics 1 module. This module was organized in a blended-learning concept, similar to the preparatory course. In addition to self-study phases at home with e-learning content and a textbook, two phases of attendance (of one day each) took place. The evaluation showed that within self-study phases students used the offered learning material on the learning platform. Especially the videos showing examples of calculations, and recordings of the in-class trainings were rated helpful or very helpful during the self-study phases (77% and 78%). Furthermore, the

exercise sheets with solutions were thought to be helpful (78%).

Students also consulted further learning material like youtube videos or special mathematics textbooks, a reasonable behavior in line with studying. Compared with other module evaluations of the first semester, the use of additional learning material to such an extent is special for the mathematics 1 module.

Furthermore the evaluation shows that the two days of attendance at the university with in-class lectures were crucial for the students' learning. This seems to be in particular associated with the subject of mathematics. Students asked for more in-class trainings and further support. Therefore online-tutorials and extra tutorials were offered at the university. Face-to-face communication was regarded to be important by the students, which can be read from the fact that many even took the burden of a long journey. During the in-class lectures the lecturer still experienced a heterogeneous student group concerning previous mathematical knowledge. Taking into account the results from the retrospective evaluation, further improvement of the mathematics preparatory course needs to be made to contain the heterogeneity of the student group, and to nurture their learning behavior.

VI. PREPARATORY MATHEMATICS COURSE MODIFIED CONCEPT

The evaluation results as well as the teachers' experiences during the preparatory course and mathematics module in 2013 lead us to modify the preparatory mathematics course in 2014. The following modifications were made in order to achieve a better involvement of students concerning their mathematics preparation and knowledge update before the first semester starts.

- Students wish to get a more detailed theoretical introduction into a mathematical topic. This was realized by the lecturer of the preparatory course. Each class began with an explanation of the theory of the topics in great detail before showing examples and doing calculations.
- Classes play an important role for mathematics education. They are essential and helpful for students. Therefore four instead of three afternoons were offered in 2014.
- For some students basic techniques (like fractions, equations, binomial formulae) were an obstacle to manage the module "mathematics for engineers 1" in 2013. The modified preparatory course starts with a lower level and emphasizes the mathematical basics.
- The tutor concept was changed. A tutor is responsible to answer questions on the learning platform, holds an e-tutorial once a week, and offers an additional class at the university from time to time.
- The lecturer practices the calculation of exercises with the students and shows the calculation path. Students work on problems while having the possibility to ask the teacher in class.
- Homework is handled differently: Problems are being discussed first; students are asked to work on the exercises and invited to submit their solutions for feedback. Beforehand, exercise sheets were available on the platform, but less guidance was given to the students.
- More basic exercise sheets were given to the students.
- In addition to a test at the beginning of the preparatory course a test at the end is introduced. This test is intended for self-assessment to give students hints where they are lacking knowledge.

The modified course concept will be evaluated in 2014.

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