

Effects of a Mathematical Bridging Course

Stephanie Reich¹, Markus Ebner¹[0000-0002-5445-1590], and Martin
Ebner¹[0000-0001-5789-5296]

Department Educational Technology, Graz University of Technology, Graz, Austria
martin.ebner@tugraz.at

Abstract. The secondary to tertiary transition is generally considered as problematic. Thereby, especially mathematics is a significant barrier for students of universities. The reasons are diverse and occur not least because of the changes in the school curriculum caused by the centralised school leaving examination. Subsequently, many universities and academies in the European area provide various approaches to work against the widely spread issue. In 2018, a free accessible online bridging courses for mathematics was designed by Graz University of Technology. The course is provided on the iMooX platform¹ and represents a form of technology-enhanced learning. The aim is to optimise the design of the course considering the needs of freshmen and freshwomen. Following the active course period, course participants take part in evaluations. The outcomes are investigated, which represents the empirical part of the paper. The online course receives positive feedback. As a consequence, it is recommended to continue the course offer within the next few years.

Keywords: bridging course · MOOC · technology-enhanced learning · MINT

1 Introduction

In recent years not only Graz University of Technology (TU Graz) has observed major problems with the mathematical content of first-year students at the beginning of their technical studies [9]. Mathematics plays an important role in almost all studies and is therefore taught in introductory courses at university level. Students obviously find it difficult to follow this level [2]. It has been observed that beginners in studies are more and more often lacking in mathematical basic knowledge from the secondary school material [1]. A lack of basic knowledge must be compensated by one's own willingness to learn. Introductory courses usually have no specific prerequisites concerning the previous knowledge of the students [9]. As an alternative to previous knowledge, university mathematics itself can also be regarded as a problem area. Many of the students do not know how to learn mathematics properly after their first year of study [8]. Accordingly, the correct learning, structural understanding, thinking and working methods for university mathematics must be practised with the students in

¹ iMooX, <https://imoox.at/> (last accessed 17 December 2018).

Reich et al.

the introductory phase [7]. These are the reasons why in 2017 TU Graz commissioned the Department Educational Technology to create an online bridging course for mathematics. The course called Mathe-Fit is part of a course and an internal project of TU Graz and represents a Massive Open Online Course (MOOC), which is provided by the iMooX platform². This paper is concerned with the design of the online mathematics bridging course.

The research question of this paper is: How should a mathematical online bridging course be designed to make it easier for first-year students to enter a technical course of study?

2 Background

This chapter gives an overview of the Mathe-Fit project, which consists of two parts: On the one hand the Mathe-Fit lecture, which has been offered for several years, and on the other hand the Mathe-Fit MOOC, which was offered for the first time in 2018.

2.1 Didactical concept

The didactical concept of the whole measurement is following mainly the concept of Inverse Blended Learning (IBL), firstly introduced by [4]. IBL describes more or less the opposite to Blended Learning and brings a pure online course back to face-to-face lectures, seminars, workshops or somehow else organised face-to-face meetings. Consequently, IBL is using the best of both worlds (digital and face-to-face), in the same way as the concept Blended Learning does, and brings a pure online-course back to the learners for socialising, interacting and discussing. Different research studies have already been carried out to foster the concept of IBL [5] [6] or similar activities like LearningHubs [3]. In this research study we were following the concept again and combined the MOOC with face-to-face lectures. The certification of attendance of the MOOC together with a final multiple-choice examination leads to the first credits of our beginners.

2.2 Organisation

The basic idea is that first-year students first complete the online course in order to close gaps in school mathematics at their own learning pace. The graduates of the online course will then attend the two-week lecture at TU Graz, in which the contents of the online course will be briefly repeated as well as supplemented by other important mathematical contents. The online course Mathe-Fit starts on 6 August 2018, contains seven course modules and therefore lasts seven weeks. For a successful completion of the Mathe-Fit course both course parts, the online course in MOOC format and the lecture, must be completed successfully. For this reason, registration for the electronic lecture examination on 3 October 2018 is only possible if the MOOC has previously been passed.

² iMooX, <https://imoox.at/> (last accessed 17. December 2018)

Effects of a Mathematical Bridging Course

2.3 Contents

This course tries to avoid distractions and to concentrate on the essential - the mathematical contents. The contents of the two parts of the course (online course and lecture) are not congruent - rather, the contents of the lecture are linked to those of the online course. The Mathe-Fit online course consists of 7 modules, which are as follows: Quantities and Numbers, Logic, Fractional Arithmetic, Linear and Quadratic Equations including Amount and Inequality, Functions, Vectors in Space, and Differential Calculus (optional).

During the selection of topics for this course there were preliminary talks by the teachers. A university assistant was consulted for the implementation of the mathematical contents, which was based on the contents of the previous MINT bridging course Mathematics³. The project team for the implementation consisted of an E-Learning Expert, an Instructional Designer, an Expert for Video Production and an Expert for Mathematical-Didactics. In addition, the project team continuously sought the advice of a teacher for mathematics, who is also head of the Mathe-Fit course.

Since the Mathe-Fit MOOC is part of a course at TU Graz in the winter term 2018/19 (see section 2.2), the mathematical contents of the online course are adapted to the one of the lecture. The lecture comprises the following contents: sets and numbers, complex numbers, linear systems of equations, vectors in space, analytical geometry (straight lines and planes, scalar product, length of vectors and angles between vectors, vector product) and the introduction to differential calculus⁴. At the request of the head of the Mathe-Fit course, certain (more in-depth) parts are not included in the online course. Particular importance is attached to the so-called basics so that the lecture can build on them.

3 Evaluation

At the end of the Mathe-Fit MOOC all graduates had to complete an evaluation questionnaire to pass the course, which will be analysed in this section. The answers - with the exception of the personal information contained in the questionnaire - are only recorded anonymously. Of 898 enrolled persons, 303 completed the course by 8 October 2018 and provided feedback on the MOOC by filling out the evaluation questionnaire. That is about 34%.

The questions about the reasons for participation show that, on average, many graduates participated in the Mathe-Fit MOOC because they were preparing for technical studies, were recommended a course by a university or needed confirmation that they had completed the course successfully. Rarely were the reasons for participation the preparation for their school leaving examination or

³ MINT bridging course Mathematics, <https://imoox.at/mooc/local/courseintro/views/startpage.php?id=33&lang=en>. (last accessed 17 December 2018).

⁴ Lecture Mathe-Fit, https://online.tugraz.at/tug_online/wbLv.wbShowLVDetail?pStpSpNr=216719&pSpracheNr=2&pMUISuche=FALSE (last accessed 17 December 2018).

Reich et al.

the online offer. From this it can be concluded that the desired target group of first-year students was reached for the MOOC.

The competences required by the MOOC were generally not rated very highly. Most of the graduates were challenged by independent learning. This confirms the hypothesis that a lack of basic knowledge must be compensated above all by one's own willingness to learn⁵. The ratings of the MOOC's organisation and content according to the Austrian school grading system show that almost all points were rated below 2.0 on average. Furthermore, none of the mean values is above 2.1. In particular, the course iMooX platform received an average score of 1.68 in the five possible criteria, which include structure, navigation, graphic representation, textual representation and overall assessment. Based on these results, a positive conclusion can be drawn regarding the design of the Mathe-Fit MOOC. From the answers to the open questions on the course contents, the following important points can be identified:

1. The course platform was positively highlighted by some people due to its structure and layout.
2. The modules Logic and Fractional Arithmetic were repeatedly rated as uninteresting.
3. Integral Calculus and Complex Numbers were missing for many participants.
4. The explanations of functions and their properties (injectivity, surjectivity, bijectivity) were frequently criticised.
5. The videos were praised very often, but criticised by some people - for example because of too long explanations or generally too long videos.
6. Some participants criticised that the quizzes were not aligned with the content of the videos and exercises and vice versa.
7. With regard to the quizzes, the unreadable information and the lack of detailed solutions were criticised.

One participant also mentioned that he or she was happy about the repetition of all the contents, since his or her school leaving examination "was a little farther back in the past". This confirms the hypothesis that people who acquire the ability to study a long time ago participate in a bridging course⁶. Certain topics of the Mathe-Fit MOOC were not uniformly evaluated by the course participants. These include functions (5x rated as not interesting and 10x rated as not detailed enough), logic (15x rated as not interesting and 4x rated as not detailed enough) or vectors (3x rated as not interesting and 7x rated as not detailed enough). For the modules Logic and Functions it was also stated that they are missing in the lecture notes. These divergent evaluations are due to

⁵ n-tv.de: "MINT subjects. Nobody needs to be brilliant.", <https://www.n-tv.de/ratgeber/Niemand-muss-genial-sein-article20531157.html> (last accessed 20 August 2018).

⁶ ORF, "Different courses of study at universities and universities of applied sciences", <https://oesterreich.orf.at/stories/2854988/> (last accessed 20 August 2018) or derStandard.at, "More and more first-year students do not have a classical Matura", <https://derstandard.at/1363239134600/Immer-mehr-Studienanfaenger-haben-keine-klassische-Matura> (last accessed 20 August 2018).

Effects of a Mathematical Bridging Course

the comparison of the Mathe-Fit MOOC with the Mathe-Fit lecture, since the modules Logic and Functions are the subject of the MOOC, but not the subject of the lecture. The topic of complex numbers is covered in the lecture, but not in the online course. Subsequently, complex numbers were indicated by the participants as missing or desired. With regard to the course offer, a positive conclusion can be drawn, since about half of the course participants plan to complete a further online course on iMooX, almost 90% will recommend the iMooX platform to others, and the overall iMooX concept was rated at 1.8 on average according to the Austrian school grading system. The open questions on topics and wishes for future MOOCs indicate that the participants had serious thoughts and are planning to take part in further courses. The evaluation results confirm the assumption about the target group. 260 persons, or 86% of all graduates of the MOOC, stated that they had become aware of the MOOC on the basis of personal recommendations or recommendations from TU Graz or HTU. The general information shows that about one third of all graduates are female. Furthermore, about 84% are not older than 22 years and 92.4% are students. This again confirms that the desired target group has been reached for this MOOC. In summary, the evaluation of the Mathe-Fit MOOC shows that the majority of the persons reached correspond to the desired target group. The feedback of the graduates on the Mathe-Fit MOOC was mostly positive.

4 Conclusion

Due to the difficulties of first-year students in mathematics observed by TU Graz in the recent years, an online mathematics bridging course was created by the Department Educational Technology in 2018 and embedded in an internal project. The Mathe-Fit MOOC, which took place during the summer holidays, was part of an internal project and a course at TU Graz and was thus aimed purely at first-semester students.

From the empirical investigation of the Mathe-Fit MOOC it follows that with about 34% one third of the registered persons completed the course and are part of the desired target group. The starting time of the Mathe-Fit MOOC shortly before the beginning of the study is ideal and the participation in MOOC and lecture is rewarded with 1 ECTS. From the evaluation results it can also be deduced that some of the students felt obliged to complete the MOOC through the cooperation of the lecture and MOOC. The quizzes should be revised, since the information was often criticised as unclear or illegible and some modules lacked detailed solutions. An even more precise coordination of the contents of the exercises and quizzes with the contents of the explanatory videos is also desirable.

Based on the assumption that the students will only be able to really assess which contents of the Mathe-Fit MOOC and the Mathe-Fit lecture are helpful for their studies after the first academic year and which are not, it is proposed to send out a further questionnaire to the graduates of the Mathe-Fit course towards the end of the second semester. This questionnaire should offer the

Reich et al.

possibility to evaluate all topics of the MOOC and the lecture individually on their usefulness. Based on the evaluation of this questionnaire, the content can be adapted for the Mathe-Fit course in 2019.

The research study further points out that the Inverse Blended Learning approach helped to attract many students. The high attendance rate as well as the high finishing rate shows that the combination of an online course and face-to-face lecturers is promising for the future of higher education institutions. Students can on the one side learn in their own place and on the other side interact with the lecturers face-to-face. In future more examples will be necessary to carry out more research results and to develop the IBL concept in more detail.

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