Ottilia FÜLÖP – Marcell NAGY

Teaching Mathematics Online with Increased Empathy in the COVID-19 Pandemic

Introduction

"We should remember when things go back to normal, people will not remember the educational content delivered, but they will remember how they felt, how we cared for them, and how we supported them." (Bozkurt & Sharma, 2020).

The COVID-19 pandemic has posed significant challenges for every stakeholder in the higher education ecosystem. Higher education institutions across the world had to close their campuses and reconsider their 2020 spring courses. One of the most challenging problems was to find the most appropriate strategy to move face-to-face university courses online as rapidly and efficiently as possible. The analysis and assessment of different responses of higher education institutes have received tremendous research interest recently. Several studies have been published in the past few months all over the world exploring various instructional strategies for the transition to online learning, including, e.g., India (Shenoy et al., 2020), Georgia (Basilaia and Kvavadze, 2020), Nepal (Thapa et al., 2020), Pakistan (Mahmood, 2020), Portugal (Flores and Gago, 2020), and the Philippines (Cahapay, 2020; Toquero, 2020). Crawford et al. (2020) give a comprehensive overview of how universities responded to the pandemic in 20 countries. Six specific instructional strategies are presented by Bao (2020) to summarize current online teaching experiences. A case study from Germany suggests that most university courses can be rapidly transformed into a digital format (Skulmowski and Rey, 2020). Alqahtani and Rajkhan (2020) identified the critical success factors for e-learning during the pandemic based on interviews with e-learning managers. They found that support from management and increased student awareness are the most influential factors. Mishra et al. (2020) studied the perceptions of teachers and students on online teaching-learning methods. They investigated how educational institutions can effectively transform traditional (offline) education into online education by portraying the example of an Indian university. Zhang et al. (2020) describe the implementation of the Suspending Classes Without Stopping Learning policy launched by the Chinese government, while Demuyakor (2020) analyzes the online education of China from the perspective of international students. Murphy et al. (2020) investigated student perceptions about the transition to virtual classes in the Northeastern United States. Olszewska (2020) surveyed students at different Polish universities, and they found that although students prefer traditional learning, they did not experience any serious issues with online learning during the pandemic. Moreover, the author also emphasizes that particular care should be devoted to first-year students since they must face a double challenge: the transition from secondary school to university and from in-class education to online learning. In another related work, Carrillo and Flores (2020) analyzed 134 empirical studies to provide a review of the literature on online learning and teaching strategies in teacher education.

Qadir and Al-Fuqaha (2020) provide a primer for students to thrive and learn effectively in engineering education during and beyond COVID-19 times. The authors argue that coachability is a key skill, which refers to the ability to seek and accept feedback and act accordingly.

However, only a few studies have focused on online mathematics education in the COVID-19 pandemic. Malizar et al. (2020) analyzed the opinion of secondary school mathematics teachers on e-learning implementation in Indonesia and found that student-level barriers had the highest impact on e-learning. Johns and Mills (2020) investigated the performance of online mathematics tutoring during the pandemic based on the experiences of 28 tutoring centre leaders from the US. The authors recommend tutoring centres to increase flexibility and relieve issues of access by offering both real-

time videoconferencing with shared whiteboards and asynchronous options. Johns and Mills (2020) also emphasize that tutors should be trained to adapt their tutoring style to the new environment.

This paper joins the discussion on the transition to online education by presenting a case study about first-year mathematics education at the Budapest University of Technology and Economics. Although the term, online education" is used with slightly different meanings, in most cases, the term refers to education that is mediated by the Internet (Rapanta et al., 2020). Our approach to online education was to provide real-time online classes together with their recordings and written e-learning materials with worked-out problems and detailed step-by-step explanations.

This paper is organized as follows: in the subsequent two sections, we outline the main steps of the transition to online distance education of a Mathematics 2 course taken by business and economics students, taught by the first author of this paper. We intended to offer our students more than emergency remote teaching (Bozkurt and Sharma, 2020; Hodges et al., 2020). In the fourth section, we review students' feedback on these steps, and where possible, we conclude as the popularity of distance learning is expected to increase in the future (Koksal, 2020). An increasing number of people pursue their studies after obtaining their university degrees to keep up with the rapidly emerging tools and techniques in science and technology. During the implementation of distance learning in the 2020 spring semester, we kept the maximum attention to facilitating students' online learning. The question is, do our students think the same? This emerges from the second half of the article, where we give space to their opinions. We believe that their feedback will assist us in improving online learning.

Important initial steps

The World Health Organization (WHO) declared the new coronavirus (COVID-19) pandemic on March 11, 2020. On the same day, a national emergency was declared in Hungary. University campuses – including the Budapest University of Technology and Economics – were evacuated, and an educational break was ordered for March 12-13, 2020, at several Hungarian universities. The spring break period was brought forward to allocate time to the organization of the transition to online education. Although based on a survey from 29 countries, Izumi et al. (2020) concluded that roughly half of the higher education institutions lacked adequate preparedness for the pandemic, Hungarian universities acted quite quickly, and the transition was relatively smooth.

Subsequently, in the spring semester of the 2019/20 academic year, nine teaching weeks had to be conducted online at our university. In addition, the midterm exams, makeup exams, and final exams were also conducted online using ICT (information and communications technology) tools. First, instructors chose the most appropriate communication channels, online platforms, and appropriate software programs. After that, the most critical task was to communicate with students and comfort them. Namely, we implemented the following measures:

- Following the Quality Matters Emergency Remote Instruction Checklist (Quality Matters, 2020), our top priority was explaining how the small class will be organized. First, a message was sent for the students, in which we invited everyone to join the Microsoft Teams group of the course, and we informed them that all lectures and seminars would be held on Microsoft Teams in real-time, which will be recorded as well.
- The updated Course Requirements were uploaded to the instructor’s website and MS Teams Class materials, which described the online examination procedure and the new dates of the midterms.
- Further worked-out problems were uploaded, and additional free e-learning materials were recommended that were assumed to aid learning from home. Our approach aligns with the recommendations of Johns and Mills (2020) since we offer both synchronous and asynchronous, text-based options to increase flexibility and alleviate access issues.

Solidarity with students

As it is also pointed out by Murphy et al. (2020), students are used to a face-to-face classroom experience; hence they need exceptional instructor support and guidance when shifting to an online learning environment. Therefore, we felt that in these turbulent and demanding times, an essential task of instructors was to assist students and make them feel that the university cares for them. To this end, we took the following steps at our Mathematics 2 course:

- we immediately informed the students about the future form of online education and examinations; moreover we reassured them to avoid uncertainty and distress,
- moreover, we provided instruction on how to install and configure MS Teams platform using their academic account,
- the instructors prepared written lecture and practice materials with plenty of worked-out problems, including much more detailed step-by-step explanations,
- we encouraged students to take advantage of the online office hours, especially before exams,
- the instructors stimulated learning activities by frequent communication (MS Teams chats, conversations before and after classes),
- furthermore, we asked for feedback from students during the academic year, and
- we processed the received opinions and ideas and acted accordingly.

Fig. 1 The distribution of the answers for the question: ”How do you think your grade reflects your true knowledge in mathematics?”.

Results of the survey – the students' feedback

At the end of the spring semester, after the finals period, a survey was sent out to all of the students (269) who took the Mathematics 2 course that covers the following topics: improper integrals, complex numbers, linear algebra, multivariable calculus, sequences, and series. Overall, 124 students completed the survey, and on average, it took them 8 minutes to fill it. All the students participating in the survey consented to the processing and communication of the results.

In the survey, we asked for the students' weighted grade point average (WGPA) in the 2019 fall semester and the 2020 spring semester. The average WGPA of the students in the fall and the spring semesters were 3.68 and 3.94, respectively, i.e., the average WGPA of the students increased; however, finding the reason behind this increment is out of the scope of this work. Note that a five-point grading scale is used in Hungary, where 1 is the failing grade, and five corresponds to excellent.

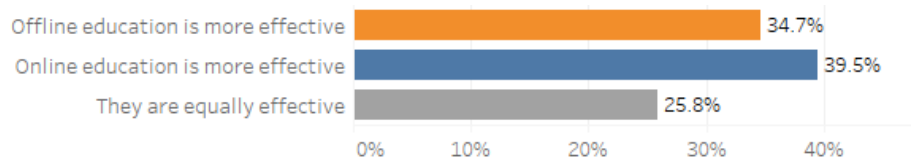
The fact that 95.2% of the students were delighted with the written lecture and practice materials uploaded few days before the lecture shows that the students appreciate learning materials with worked-out problems and much more detailed explanations. Fortunately, many (52%) answered that their exam results matched their math skills; however, slightly more than one-third (38%) of the

students felt that they know more than what is reflected in their grades. The distribution of the answers is depicted in Fig. 1.

The difference between the average grade in Mathematics 1 (taught in the fall semester of 2019) and the average grade in Mathematics 2 is smaller than the deviation of the average WGPAs in these semesters. According to the survey results, the average grade in Mathematics 1 was 3.0, and that of Mathematics 2 was 3.19. In case of the Mathematics 2, the difference between the mean grade of the questionnaire respondents and the mean grade of the entire class was negligible. While the average grade of the respondents was 3.19, the class average was 3.05.

The lecturers remarked that, similarly to previous semesters, the students could pick up those topics more efficiently, not based on the mathematics material of the preceding semester. According to the students' point of view, it is easier to follow and learn those topics, which do not require a deep and lexical knowledge of the course material of the previous semester. However, all the non-trivial concepts are discussed in the current semester. For example, these topics were the theory of complex numbers and linear algebra in the spring semester. The students achieved significantly larger scores (75% on average) on the midterm exam that involved the topics mentioned above than on the final exam (61.8% on average). In order to improve the students' performance, we will collect, summarize, and publish the most important and most frequently used definitions and theorems of the prerequisite courses. For example, we believe that students could pick up the concept of improper integral more efficiently with the help of a brief practical review of the integration rules of single-variable functions, especially the rule of integration by parts and the indefinite integral of rational functions.

Fig. 2.: The distribution of the replies for the question ”What do you think, which form of education is more efficient to learn mathematics?”.

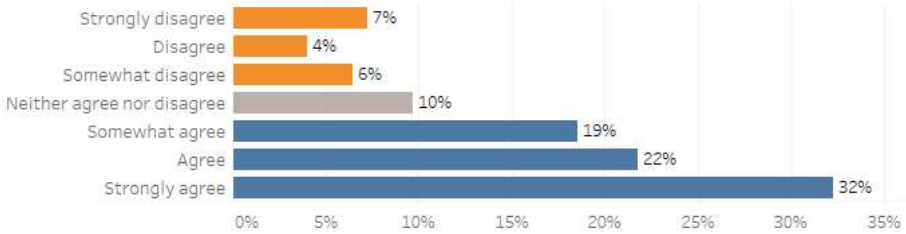


Furthermore, according to Fig. 2, the majority of students (65.3%) replied that the online education of Mathematics 2 was at least as effective as the traditional offline education.

We believe that the MS Teams' interface, especially the chat feature has brought students even closer to the instructor and to each other. Compared to the previous years, we observed that many questions were posed in chat and the comment section that would probably not have been asked personally or in a more formal email. Most of the discussions were open to everyone so other students could also profit from those questions. These functionalities surely contribute to the fact that 43% of the students reported that in online education their relationship with the lecturer can be maintained exactly the same way as in the case of traditional face-to-face education, moreover, 32% of them answered that the contact between the instructor and students was more direct and closer during online distance education than before.

As Fig. 3 suggests, the majority (73%) of students participating in the survey agreed that the two forms of education could be mixed in a non-pandemic era in the future, for example by having two-third of the lectures and seminars offline and the remaining one-third online.

Fig. 3.: The distribution of the answers to the question, whether they agree that the online and offline education forms could be mixed after the pandemic.



Finally, 72% of the students agreed that it is easier to get involved in online education than in the case of offline education because they would not miss classes due to traffic jams, getting up late, etc.

Students also provided some free-form text suggestions regarding our online mathematics teaching. In particular, most of them considered very useful the pre-uploaded written lecture and practice materials with extra explanations, recordings of the lectures and problem-solving classes. Many students suggested keeping the online office hours format in non-pandemic times as well.

The main goal of the questionnaire was to assess the students' opinions and experiences about the transition to online education, but we also inquired about the respondents' socioeconomic status. For example, it turned out that before the pandemic, 31% of the students had a job, and they typically worked 20 hours a week. However, after the outbreak of the COVID-19 pandemic, only 14% of the students had a job, but they typically worked 24 hours a week. Note that it aligns with the fact that Hungary's GDP fell by 13.6% in the second quarter of 2020 compared to the same period of the previous year (Hungary Today, 2020). Fortunately, the lack of a satisfactory Internet connection and an own proper computer was not a problem for the students, making the transition smooth. However, a few students (7%) reported, that the lack of their room and quiet environment made online learning difficult. Hence, due to the pandemic's effects, we suggest being as empathetic towards the students as possible.

Discussion

The spring semester of 2020 has been a big challenge for every stakeholder in higher education as the unexpected outbreak of the COVID-19 pandemic required an immediate transition from face-to-face classes to online education. The dedicated and disciplined work of both students and instructors as needed. It was a cooperative learning process in the spirit of mutually empathetic cooperation. The students were extremely helpful and understanding. However, our experience backed by student feedback suggests that university courses in mathematics can be efficiently transformed into a digital format in weeks. A surprising result is that students felt that communication with the instructor was more direct and closer during online learning than in the previous semester in face-to-face classes with the same instructor. An essential suggestion from the students was to move office hours online after the pandemic as well.

Although the grade distribution of the course does not differ significantly from that of the previous semester, a precise analysis of whether the learning outcomes had been met during the spring semester with the transition to online classes goes beyond the scope of this study. We also did not touch upon how learning mathematics changed with the transition to online education, which we propose for future research.

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