

COVID-19 pandemic study: ad-hoc reaction and premeditated transition of project-based product design courses

Nikola Vukašinić¹, Niccolo Becatini², Maximilan Schramek³, Manfred Grafinger³, and Stanko Škec⁴

¹University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia

²Politecnico di Milano, Milano, Italy

³TU Wien, Vienna, Austria

⁴University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia

Abstract

This paper examines and compares the ad-hoc reactions of educators in the product development domain to the first wave of the COVID-19 crisis. The aim of this study is to properly understand the difficulties educators struggled with maintaining their education process in a crisis and which practices, new digital tools and educational methods best supported the transition. The data was collected from the representatives of four universities from different European countries that are offering undergraduate and graduate product development courses.

The results showed that all the educators employed online teaching activities in direct response to the COVID-19 situation. The courses initially remained unaltered with respect to their content but were held online via videoconferencing tools for synchronous communication. Educators mentioned a reduced interactivity with students during sessions, making it difficult to objectively monitor students' learning achievements.

Later in 2020 educators systematically digitalized their courses. Initial findings hint at a shift of workload to the beginning of a teaching period as a result of educators preparing online teaching and assessment material in advance.

Keywords: Engineering Education, Emergency Remote Teaching, Online Learning, COVID-19, Crisis Scenarios

1 Introduction

In response to rising COVID-19 infection rates, product development educators in the higher education sector were faced with the problem that the ways in which courses can be offered changed within days or weeks. The health crisis forced a radical paradigm shift and necessitated educators to exclusively perform all courses online from one day to the next. The pace of these changes impeded a structured approach, rather it was necessary to immediately switch to a digital education and adapt the courses according to the best of one's knowledge and skills [1].

This paper examines and compares the ad-hoc reaction of educators in the product development domain to the COVID-19 crisis in spring 2020 and the planned transition to digital teaching activities in ongoing teaching periods. The aim of this study is to properly understand the difficulties educators faced maintaining the delivery of education in a crisis situation and which best practices, new digital tools and educational methods emerged to support the transition. The data was collected from the representatives of four universities from different European countries who offer undergraduate and graduate product development courses. To gain a holistic view, open-ended questionnaires were posed to lecturers responsible for teaching project-based courses. Based on the literature review and survey findings, the general model for ad-hoc adaptation of accredited course subjects to a new situation was developed.

There are several identified challenges when an accredited course has to be adapted to a new situation. First, the new situation, such as a pandemic outbreak requires fast decision-making and acting in an unfamiliar setting? Second, it requires immediate establishment and formalisation of new communication tools and protocols. Third, it requires adaptation of knowledge delivery to new communication tools and protocols. Fourth, it requires new methods for examinations which are compatible with above mentioned challenges, and fifth, all these shall stay within the rules defined by the accreditation of particular subject. The latter is also the most limiting factor, making crisis adaptation of existing subjects way more difficult than creating an (online) course anew which requires a completely different approach.

2 Research background

With the emergence of the COVID-19 pandemic, university educators worldwide started replacing physical with online learning spaces for delivering their courses. It posed various challenges to the existing online learning infrastructure, as well as teaching and learning practices. This transition often required significant modifications to the way these courses were conducted, while on certain occasions they even resulted in revisiting the overall course structure and implementing modified learning strategies and methods [2]. Of course, the whole transition was enabled by various digital tools which provided educators with the opportunity to deliver educational activities virtually. Still, as an initial step, educators had to familiarise themselves with the existing digital tools, thereby investing a lot of effort to be able to react in a swiftly manner due to COVID-19 pandemic [3].

Within the context of engineering education, the particular emphasis is put on creative activities, hands-on experiences and project-based learning, which encompass different skills and competencies [4]. These activities and experiences include the usage of equipment and laboratories, often crucial for fulfilling proposed engineering tasks. As such, this nature of engineering activities makes a transition within this context even more demanding and challenging. Students also prefer to learn complex engineering concepts in a physical environment [5] due to the lack of perceived value of digital support.

The sudden and ad-hoc transition to online teaching spaces caused many difficulties for engineering educators, since many teaching methods and approaches had to be implemented in short timeframes without appropriate consideration and evaluation [6]. Some studies indicated unpleasant, negative experiences due to sudden and unexpected shift to online learning [7]. In addition, reduced interactions with peers and educators, prolonged screen time and inefficient communication via digital platforms further aggravated the student experience. The urgency of the performed transition required a swift and unprecedented reaction by the educational community. However, very often these transitions led to an inadequate implementation of teaching strategies and methods, which were predominantly used in traditional face-to-face environment [6].

In order to address educational issues experienced by both students and teachers, there is a need to carefully explore and characterize the crisis situation and adapt course delivery strategies accordingly to reach planned learning outcomes. In addition, many scholars (e.g. [8]) claim that online practices introduced during the COVID-19 period will as well stay in a post-pandemic period, emphasizing the need for revisiting initial online education practices.

The main aspects required to deliver successful online engineering education consider the way a course is being designed, course support material and related access, and familiarity of educators and students with the given set of digital tools [3]. Previous studies were related to various surveys of student experiences and their satisfaction. However, the main objective of this study is to focus on courses that had gone through a sudden transition, as a first step towards systematic approach

for developing crisis-resistant engineering courses. In this paper, we are oriented towards exploring different aspects of engineering course design and course support material, which were used during the COVID-19 period. Using these insights, we are able to identify crucial drawbacks of transitioned online courses and new directions for course improvements in the post-pandemic period.

Online teaching vs. Emergency remote teaching

Scholars and educators differentiate various instances of online teaching and learning such as distance learning, distributed learning, blended learning, online learning, mobile learning, and others [9]. However, during the COVID-19 pandemic, what institutions really experienced and conducted was - emergency remote teaching [10]. It can be described as fully remote teaching which replaced previously face-to-face or blended teaching approaches, and will be abandoned after the end of the crisis. For that reason, there is a necessity to clearly distinguish between the terms emergency remote teaching and online teaching.

Different online teaching methods, tools and technologies have been developed for many years before the pandemic. Online learning can be defined as “learning experiences in synchronous or asynchronous environments using different devices (e.g., mobile phones, laptops, etc.) with internet access” [11]. As such, they include a systematic approach towards online teaching courses, which was often ignored during these sudden pandemic shifts. In general, these courses are developed as a voluntary and planned activity [12]. E-learning has been supported by various digital technologies like Web 2.0 applications and services, even before COVID-19.

All of the abovementioned aspects can be carefully considered when developing online courses, while Emergency Remote Teaching (ERT) requires a slightly different approach. Due to the nature of this transition, ERT includes the temporary online delivery of teaching and supporting material being prepared in a short timeframe.

3 Methodology

Although the Covid-19 outbreak offered an immense research opportunity to scholars of various backgrounds and professions, we decided to conduct a qualitative study, to investigate how did the sudden pandemic outbreak affect engineering design related subjects and how did educators from different institutions responded? What were the similarities and what the differences in their response? In order to get these answers, a survey was set-up to gather the insights from several different courses at four universities. The survey consisted of several open-ended questions. The questionnaire covered 1) the design of subjects prior to COVID, 2) which national and local Covid-19 related restrictions were first put in place, 3) how educators initially responded and adapted to said restrictions. Besides subject name and

type, the questionnaire additionally included the following set of open-ended questions:

- what was the pre-COVID design of the subject;
- what were the local Covid-related restrictions;
- what was the personal experience with adaptation; what was the students' feedback to adaptation;
- what were the expectations for post-COVID future design of the subject;
- when did you realize a change of course structure was necessary to ensure the delivery of education in the beginning of the Covid-19 pandemic;
- what difficulties did you face with the previous course design;
- what kind of course adaptations (short term) did you implement right away;
- how did you inform about strategies or methods to adapt your course, and which resources did you consider/were provided to you;
- who did you involve when transitioning your course to online teaching;
- did you make significant changes to your course design in the following teaching periods when preparation was possible;
- are there any best practices that evolved during the shift to online teaching (new software, tools, processes, etc.);
- how did you evaluate the suitability of course adaptations; which short-term adaptations were reversed and why;
- which elements do you plan to keep after the crisis?

The survey was then distributed among four teachers from four different universities in different European countries, teaching various engineering design and mechanical engineering courses. The above listed open-ended questions resulted in longer textual responses of cumulatively more than 5000 words, which were then thoroughly qualitatively analysed. The teachers were involved in several different subjects within their teaching teams, and thus providing broader insights about subject dependent activities and responses. This opened up insights into the similarities and varieties of responses to the first wave of the Covid-19 pandemic on political/country, institutional and also on the inter-personal levels.

The survey covered four different mechanical engineering subjects. Two subjects were from the field of CAD modelling and design, classes with 150-250 students, while the other two covered different aspects of integrated product design where the number of students was lower, between 50 and 150 per subject. These numbers can be considered relatively high for online learning and require specific approaches, especially for practical work, knowledge examination and communication with students.

The next step was to analyse the open-ended response to the aforementioned questions. The analysis of the response included a review and comparison of all textual responses and a qualitative search for differences, similarities, and identification and recognition of response patterns at different subjects and in different environments.

The latter proved to be the most valuable outcome of this research. There were some obvious similarities in response from all different subject and socio-political environments when it came to an emergency adaptation of existing, accredited, and even already running subjects to a new unforeseen situation. This identification led us to develop a general model of ad-hoc course adaptation to a new situation.

4 Results

The initial questions gave some basic insights into the pre-Covid structure of observed subjects in terms of group sizes, teaching and learning methods, evaluation and examination. As already mentioned, the observed subjects were from the field of CAD modelling and design, classes with 150-250 students, while other two subjects covered different aspects of integrated product design where the number of students was lower, between 50 and 150 per subject. All subjects were based on a face to face communication, the combination of theoretical ex-cathedra lectures and practical work, whereas practical work was usually done in classrooms, but included the use of modern digital tools already to some extent. Examination was done strictly off-line either in written or discussion form or in combination of these two.

The survey showed, that different countries initially took different measures to contain the pandemic, but in a matter of few weeks the conditions at all locations forced organisers of education processes to fully move to an on-line or virtual environment. Since the pandemic erupted almost simultaneously in all countries the results can be compared with regard to how timing influenced the response. It was the beginning of the summer semester in all observed countries, so the subjects scheduled for winter semester had some obvious advantage in terms of preparation period.

Furthermore, it quickly became obvious, that the transition to online teaching will not be as simple as switching locations from the classroom to the living room, but rather requires much more careful consideration. As one of the respondents said: “some teaching examples (e.g., specificities of case studies) that were shared usually during onsite lectures had to be abandoned due to the aspect of recording. We experienced a significant decrease of interaction, and it was harder to motivate students to share and disseminate their ideas”. However, the biggest change and challenge was how to assess the knowledge of the students. Having a pen-and-paper format approach several times a year in a supervised environment was no longer possible. Therefore, various techniques have been explored, which mostly resulted in Moodle-based exams (quizzes), seminar work and interviews with the students.

The survey results also indicate, that communication was crucial in the first days of the change. Generally speaking, all respondents indicated receiving similar information and instruction pattern: Basic decisions on how to switch to emergency remote teaching came from the university or faculty management. This information set the frame for the new reality and usually specified rough rules of conduct, e.g. what tools to use to communicate the subjects with students. Mostly they also

provided and standardised ICT tools, e.g. GoToMeeting, WebEx or Zoom. Out of these general guidelines the information was rather scarce, and teachers and technicians had to do their own investigation and work to establish an optimal combination of tools and methods which are tailored to specific needs of each subject. We also noticed, that all of the respondents already had some previous experience with some kind of online or remote teaching and with the use of digital tools for collaboration and education (e.g. Miro, online CAD tools, and digital classrooms such as Moodle). Not all of these tools have been standardised by general guidelines of local authorities, however, the experience of the staff made the transition somewhat easier and the availability of these tools enriched and eased emergency remote teaching.

A very important step when doing any changes to any curriculum is to track the effects of the applied changes. In the survey we asked respondents what methods they used to evaluate the suitability and the effectiveness of subject adaptations. The results showed two major techniques have been used: one is gathering the feedback from the students, which was done in several different ways. It can be done by formal students' questionnaires which they have to fill in at the end of semester and are part of regular curriculum evaluation, but some respondents performed also their own anonymous surveys to evaluate pros and cons of different aspects of the subject, such as technical aspects, knowledge exchange, time distribution and limitations and others. Many valuable feedbacks were obtained also by interviews and discussion with the students.

The other evaluation method is comparing students' success rate in passing the exams and grade distribution to pre-Covid period. This method serves more to adjust the demand and complexity of the examination process including grading criteria, however the method itself does not provide direct information what knowledge has been obtained by the students. Therefore, it must be combined with other qualitative methods of evaluation.

The final set of questions explored what happened during the second wave of the pandemic, i.e. in the next academic year and semester. The basic questions here are, what methods proved to be valuable, what methods were changed, and what findings proved to be valuable also for the future. This iterative adaptation can be considered an evolutionary adaptation to a new reality which was caused by a disrupting event as it will be shown in the discussion. Generally speaking the second semester and academic year within the pandemic already started with known procedures and communication protocols, so there was space and time available for fine-tuning the subjects, for production of additional, complementary and better teaching material such as tutorials, recordings and videos, to develop and test new examination methods and to explore, test and introduce different custom ICT and online working and collaboration tools tailored to specific tasks, activities and assignments of particular subjects or even only parts of the subject. Of course, all these adaptations needed to be properly communicated between teachers, students and technicians to work in a harmony.

5 Discussion and Conclusion

The aforementioned findings of the research confirmed that there is a major difference between the instantaneous digitalisation of accredited ex-cathedra courses deriving from the need to respond to a new situation and creating an online course from scratch and then accrediting it. Namely, the transfer to online teaching of existing subjects is framed and limited by the accredited procedures, resulting in outcomes and activities, just being transferred to a new environment. Therefore, all digital and online transformations at some point need to be self-evaluated to the accreditation document and re-adjusted if needed. To visualise the flow of these procedures, we developed a general model of ad-hoc subject adaptation to a disrupting situation which is depicted in Figure 1 and explained below.

We noticed, that all subjects were transferred online in several distinctive stages: first a decision was made on basic communication channels that are intended to be used for online teaching. This was done partially on an institutional level and partially also on the level of departments or even subjects, based on the specific requirements of the subject, but also based on the needs of teachers and students. The selection of ICT tools shall be reflected to the nature of a new situation.

The next step was the immediate adjustment of ex-cathedra work to online teaching. Here different levels of digitalisation are needed as some educators were giving explanations on green or whiteboards while some other teachers and subjects already had their material digitalised in the form of PowerPoint presentations or similar. Initially this work was done for one to a couple of weeks in advance. This stage required not only a digitalisation of “slides”, but also to rethink teaching and instructing methods to reach all the students and to motivate them in a new environment and finally to achieve all the goals of the accredited curriculum, e.g. interim presentations of results with subsequent group discussion.

There has been observed an additional, intermediate step of adjustment, which took place only partially in the first wave, but was more important in the second one. The first wave of response resulted in a bulk of recorded and prepared teaching material of good quality which was used also during the next study year. That gave educators time and an opportunity to prepare new, supplemental material, which students could use for better understanding of the matter and for self-learning, so they can pursue their own learning pace.

Probably the biggest challenge in the whole ad-hoc transition to online teaching was the establishment of examination methods and protocols and to provide sufficient plagiarism prevention and identification. It has been reported that this transition consisted of several trial-and-improve steps. It sometimes happened that within the same subject even two or more examination methods have been used and evaluated and methods many times vary drastically from in-person examination. For example, examination during ex-cathedra teaching was done as written exams on paper, this was no longer possible due to ease of copying and plagiarism when examination take place online. Therefore, different others tools were used, such as

quizzes and questionnaires with random questions. However, here the challenge arises in the need to stay compliant with the accredited examination protocols.

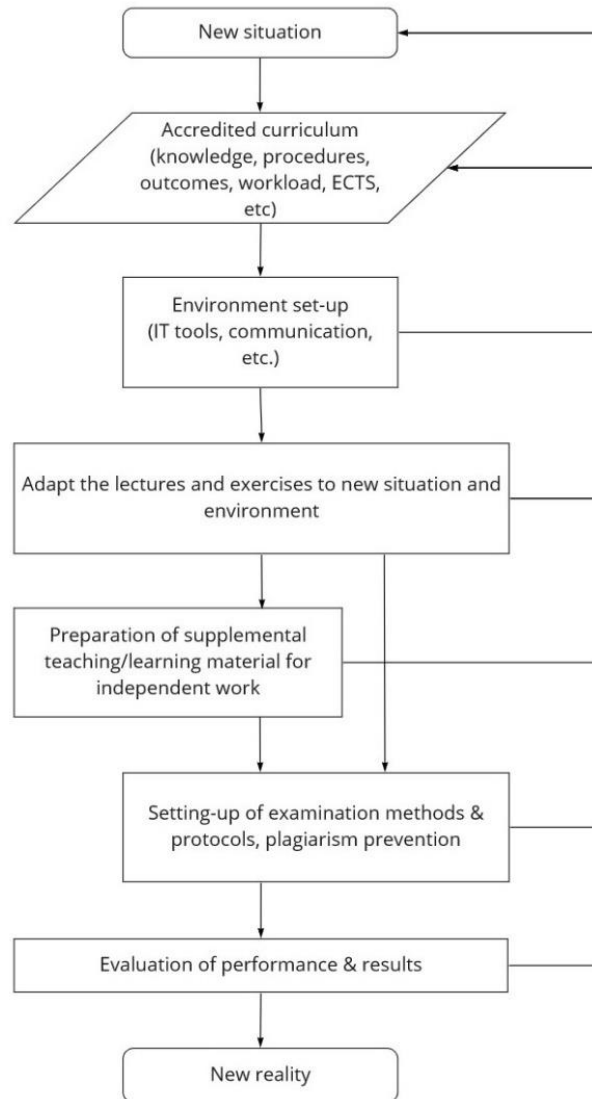


Fig. 1. General model of ad-hoc subject adaptation to a disrupting situation

The final step in this model is the evaluation of teaching results after the adaptation to the new emergency situation. A decisive consideration for such an evaluation of teaching results is the timing of adaptation within the semester period, as well as the magnitude of said adaptation. This evaluation is usually done on multiple levels and can be a subject of another research. From our survey we noticed that besides

the regular evaluations performed by home institutions, and which are usually required periodically by accreditation regulations, all respondents performed also their own analyses, which included among other questioning the students after they completed the subject, comparison of knowledge and grades through different years and also self-reflection based on the new experience.

Besides and because of all the difficulties these steps can bring, they have to be communicated clearly and in advance enough with all affected stakeholders, i.e. students, teachers and technicians involved in the subject.

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