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Implementation of a synchronous exercise format in the digital teaching of two courses

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Abstract

Die Corona-Pandemie hat in den Jahren 2020/21 einen weitreichenden Einfluss auf die universitäre Lehre gehabt. Während es bei der Digitalisierung von Vorlesungen sogar mitunter möglich ist, eine verbesserte Wissensvermittlung im Vergleich zur Lehre in Präsenz zu erreichen, resultieren aus vielen Formaten des digitalen Übungsbetriebes deutlich Nachteile für die Studierenden [1,2]. In Ingenieurstudien-gängen sind aber gerade Übungen ein wichtiger Bestandteil der Stoffvermittlung, da hier auf individuelle Missverständnisse im Stoffverständnis eingegangen werden kann. Zudem gehören auch haptische Erfahrungen zu den wichtigen Lehrinhalten in der Ingenieurausbildung.
Dieser Beitrag behandelt die Umsetzung eines synchronen Übungsformats in zwei Lehrveranstaltungen.

The Corona pandemic had a big impact on university teaching in 2020/21. While improvements in teaching are possible by digitizing lectures compared to face-to-face teaching, many formats of digital exercises result in significant disadvantages for students [1,2]. In engineering courses, however, exercises are an important part of teaching, as they can address individual misunderstandings. In addition, haptic experiences are an important teaching content in engineering study programs.
This paper discusses a synchronous digital exercise format in two courses.

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1. Concept of the courses

The Mechatronics Startup Project (MSP) is a one-week project in the first semester of the Mechatronics degree program. Teams of 3-4 students each develop mobile Lego robots that solve a task using the sensor and actuator technology of LEGO® MINDSTORMS® EV3. Programming is done in the LabVIEW environment of National Instruments. Every year, 60-80 students, all first-year students in the mechatronics program, take part in the event.

The English-language course Kinematics and Kinetics of Multibody Systems (MBS) is attended by students of degree programmes Mechanical Engineering, Mechatronics and Computational Modeling and Simulation. It consists of 2 semester hours each of lecture and tutorial. The course concludes with a written examination. According to the course registration, 175 students took part in the course in the summer semester of 2021, with 73 students completing the course by attending the written examination.

2. The MSP on-site

In non-pandemic years the Mechatronics Startup Project (MSP) takes place in the large ballroom of the TU Dresden. All student teams work together in the room at large tables as shown in Figure 1.

Fig. 1: Class room version of the Mechatronics Startup Project in the large ballroom of the TU Dresden.

Each team solves one of four possible tasks. Two tasks require just an A0 sheet on the floor while the two other tasks need a material-intensive course to be set up. At course registration, students select their task based on a brief description. Four teams form a relay team in which each task is represented. Teams are divided and assigned to relays randomly. When the EV3 accessory boxes are handed out and returned, all individual parts are laid out by the students on prepared posters in order to check the completeness of the boxes.

The free working time for task processing takes up the very largest part of the project week. The officially scheduled working time with intensive supervision by research assistants and student tutors is from 9 a.m. to 6 p.m. each day. However, some tutors are available until 10 p.m., which is especially popular on the day before the final competition. After the box is handed over to the students and after an initial familiarization with the basics of the EV3 system on Monday morning, laboratory tours of the participating institutes take place. This provides a practical reference to the tasks.

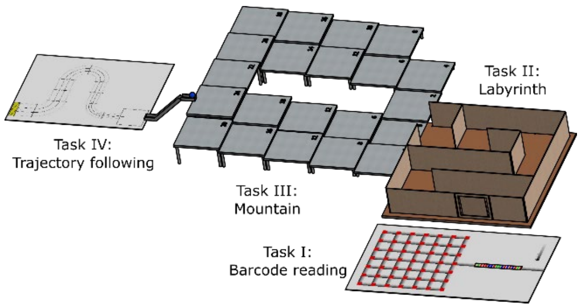

Fig. 2: Parcours of the MSP in the classroom semester containing 4 tasks

As a prelude to the actual work on the tasks, the presentation of the rules then takes place. During the project week, the teams present their progress within their relay under the guidance of a research assistant. The final event is the relay competition, in which the four robots of a relay team complete their respective tasks one after the other. A possible task course is shown in Figure 2. One robot triggers the start of the next robot in the relay. Two parcours examples are available to the students for testing purposes throughout the week.

In Task I, the robot is to be developed that can read a colored barcode. The bars in the barcode represent a sequence of movement commands that must then be executed within a grid. If the motions are executed correctly, the robot reaches a trigger flap at the start of Task II. The task takes place entirely on an A0 sheet with a printed barcode and motion grid.

Task II takes place in a labyrinth. The robot has to find the exit of the labyrinth autonomously after being activated by the trigger flap. The labyrinth consists of fields with an approximately square base and wooden walls. The arrangement of the wooden walls in the final competition version of the labyrinth is not known to the participants beforehand. When the robot reaches the exit of the labyrinth, the following robot is to be triggered in a self-selected manner.

In task III, the robot has to climb steps to reach the highest level of the task course. Three paths of varying difficulty can be used, each with the same step height (2cm, 4cm or 6cm) to reach the top step. Once on the top step, a ball is to be pushed, which then rolls down a slide. To work on this task, the teams receive an expansion kit with additional building blocks and traction elements to enable them to climb the steps and also allow for more elaborate constructions.

In Task IV, a ball is to be balanced on a Lego brick with a square base while following a given trajectory on an A0 sheet. The path followed is to be marked with a pencil. In the course of the trajectory, the allowed tolerance band within which the marking line should be located becomes wider and wider. At the end of the path, the robot is to be stopped within a specified target area.

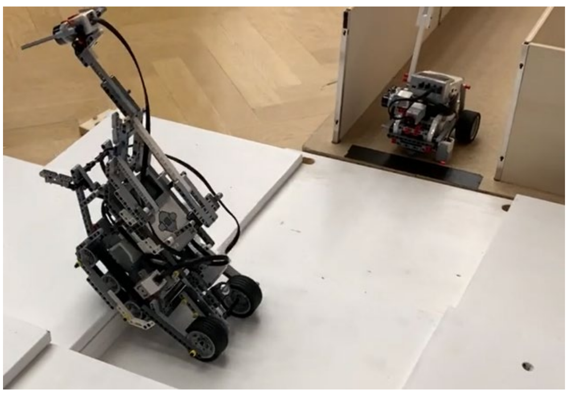

Fig. 3: A robot of task III (mountains) climbing a step, while a robot of task II (labyrinth) is stopped in its final position.

The robots are programmed in the software LabVIEW. Video tutorials produced for the course are available for learning the necessary programming skills.

Arrangements within the supervision team consisting of scientific staff of several professorships of the Faculty of Mechanical Engineering and student tutors are made verbally and informally. The work status of the individual groups is not documented separately throughout the week.

The MSP is a compulsory undergraduate course with 2 credit points. The prerequisite for passing the course is the completion of a technical solution that is suitable for the task in principle. Furthermore, continuous participation in the project is required, which is determined in the interim presentations.

3. The MSP in the digital semester

Holding the EPMT in a face-to-face format was not possible with the large number of participants due to the contact restrictions during the Corona pandemic in the winter semester 2020/21. Instead, a digital format was developed to provide the closest possible equivalent to the face-to-face project. In accordance with the applicable contact restrictions, the project was carried out in teams of two (in exceptional cases one or three) students each in their home environment. In contrast to the face-to-face project, students were asked to find a team partner on their own. The usual relay teams of four tasks were not formed. Instead, the two tasks I and IV were selected from the relay parcours which take place on an A0 course plan. Task II (labyrinth) would have entailed too much logistical effort to transport labyrinth setups to students' homes. Task III (Mountains) would also have involved handing out the extension boxes, which would have increased the effort a lot in handing out the boxes. Each team received a corresponding course plan of Task I or IV together with the brick box. An OPAL forum was set up to facilitate the team formation.

The box distribution and return with laying out the Lego components on posters was carried out in an institute building of the TU Dresden. The hand-out and return times were staggered and the participants were distributed among different rooms in such a way that the applicable distance and contact restrictions could be observed.

During the project week itself, a Zoom service conference was held over each of the project days. With the participation of all students, the general introduction on the first day, a start meeting on each project day and the final competition took place in the main room of the Zoom service conference. As part of the kickoff meeting, an online lab tour was conducted at one of the participating institutes. Further, a breakout room for each team was set up to spend time in during free working hours with at least one video-enabled device. In addition, there was a breakout room for supervisors and “ask for help” breakout rooms to signal to all supervisors that help was needed. The Zoom conference was configured so that each participant and supervisor was able to to move freely between the breakout rooms.

The video tutorials that were produced for the project in presence could be reused for the familiarization with LabVIEW. As in presence, the teams were supervised during free working hours by scientific staff and student tutors. The breakout room for supervisors was used for consultations among the supervisors. If students needed help, they could switch to a “ask for help” room or use a help button to send a signal to the conference organizer. The platform Matrix, which is provided by the TU Dresden, was used for the support organization. Here, short agreements on student help requests were made via the Matrix chat. In addition, a collaborative document (Etherpad) was used to maintain a supervision and progress history for each team. With the help of the chosen setup, it was possible for the supervisors to go from team to team in order to get an idea of the respective processing status. In addition to questions from the students, it was ensured that each team was visited by a supervisor at least twice a day in a organized round of visits. This allowed to identify fundamental problems in the students' solution approaches at an early stage. The progress documentation of the breakout room visits of the single teams also implied that no team was visited an unreasonable number of times and thus disturbed in its free processing. Beginning in the middle of the project week, the progress documentation was used to determine which teams needed close supervision in order to complete their task. The progress documentation of teams with sufficiently functional solutions was reduced accordingly.

In the final competition, each team demonstrated in front of all project participants and supervisors how the constructed and programmed robot completed the task course in the main room of the conference.

A supervisor measured the course time in order to determine a winner team for the respective task. In some cases, the students used several devices in the video conference to show the robot from different perspectives in parallel. The option in Zoom to focus on the video stream of multiple conference participants made this presentation format possible.

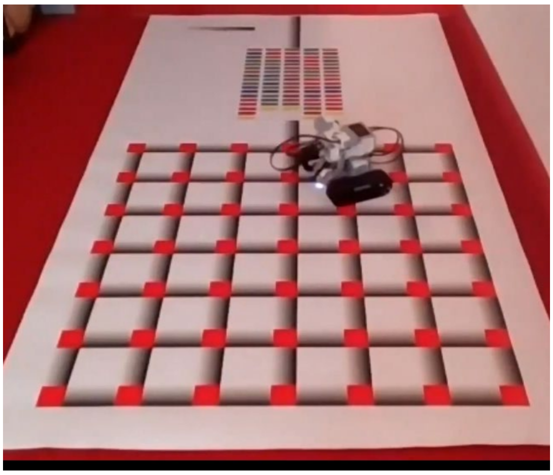

Fig. 4: Robot of the "barcode reader" task completing the course in the final competition of the MSP.

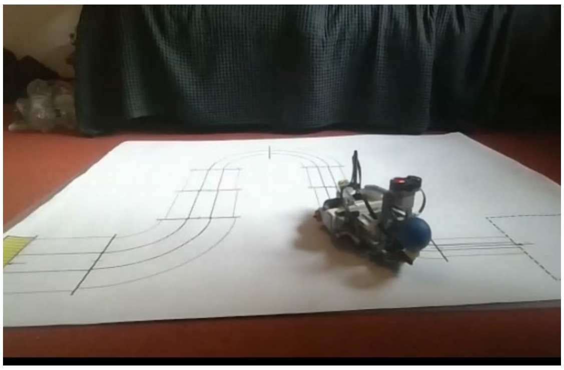

Fig. 5: Robot of the "trajectory following" task completing the course in the final competition of the MSP.

Figures 4 and 5 each show a robot completing one of the two tasks. Due to the larger number of teams, the final competition took longer than in the classroom. This also resulted from the fact that only one team at a time prepared for the upcoming presentation. In contrast, in the class room relay competition several teams prepare for the upcoming presentation and complete the parcours directly one after the other.

The presence of each team member during normal project processing times was explicitly added to the requirements for passing the project and communicated accordingly. The justified absencefrom this processing times was possible. Although the explicit presence of each team member was still only checked during the interim presentations, this regulation created a high commitment, which is otherwise rather unusual in engineering courses. Accordingly, even small justified absences of the students from the compulsory processing times were reported to the supervisors.

4. Evaluation of the digital implementation of the MSP

Even during the implementation of the MSP, it was noticeable that the vast majority of students worked on the task with high motivation throughout the project week. The number of robots that successfully completed the task in the final competition was comparable to the class room project. Afterwards, the project was evaluated with the help of a voluntary survey in which 23 of the 60 participants took part. The statement whether they liked the project very much was rated by 96% of the respondents as "completely agree" or "agree". The same rating was given to the statement whether the students received competent help from the supervisors at all times. The question of how often students were visited by supervisors in their breakout rooms received an 87% response of "exactly right number of visits". The statement whether the students really missed being able to look at the robots of the other teams during the project week was mainly rated as "Partly/partly" and "agree".

A similar picture emerged from the subsequent evaluation among the supervisors who were also familiar with the class room project. The supervisors were positively surprised that the digital alternative to the class room project largely worked smoothly and adequately. Only two students experienced major problems after deciding to solve a reduced task on their own without a team partner.

5. The exercise MBD on-site

The exercise MBS takes place weekly in attendance semesters. Due to the large number of students, two tutorials are scheduled, one in German and one in English. For the introduction into the exercise topic, ten-minute introductory videos are available, which should be viewed in advance of the exercise date. The exercise time is used for the students to work on the exercise tasks. There is the possibility to discuss solution approaches with the supervisors and to ask questions. In some cases, solutions are discussed with the entire group on the blackboard. Many students work on the exercise tasks individually and exchange ideas with other students during the exercise times. Participation in the exercise dates is not compulsory. Roughly speaking, more than half of the students who take the exams also participate in the exercises.

6. The exercise MBD in the digital semester

Following the positive experience of conducting the MSP digitally in the winter semester 2020/21, a similar format was tested in the MBD exercise in the summer semester 2021. Accordingly, a Zoom service conference with breakout rooms was used, between which the students could switch freely. The exercise started in each case with a short introduction on the general approach to the respective exercise task. Afterwards, the free working time began. The number of the available breakout rooms was sufficient students could decide whether to work alone or in a group. Another separate breakout room was set up for supervisors. There were also several “ask for help” rooms. Going to these “ask for help” rooms signaled to the supervisors that there was a need for discussion while solving the tasks. Furthermore, there was the possibility to request a supervisor for discussion through the help button of the Zoom service conference. In addition to a research assistant, the exercise was supervised by two student tutors.

7. Evaluation of the digital implementation

At the beginning of the semester, the exercise was attended by many students. Almost 100 students were present in the first exercise. In the following weeks of the exercise, the number of participants decreased substantially and stabilized at less than 30 participants. Since few questions were actively asked by the students, the supervisors systematically visited the breakout rooms in order to talk to the students about the tasks. One particularly well-prepared student caught attention by asking many questions in one breakout room, with more than 10 students at a time following the discussion without contributing. Frequently, students followed supervisors through the breakout rooms to hear all of the discussions being held, but without ever actively participating themselves. Thus, an active conversation about the respective exercise tasks took place with a maximum of 10 students per exercise.

There has been no evaluation of why so few students have taken advantage of the opportunity for discussion in the exercise for better understanding of the task.

8. Summary

In the MSP, a digital teaching format was realized that has represented an adequate alternative to the class room project. The transfer of the concept to the MBD exercise did not meet with the desired approval and accordingly did not represent an equivalent to the class room exercise. It is possible that the obligation to participate in the processing times of the MSP played a greater role here.

Literature

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