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Coping with teaching under corona conditions at one of the smaller universities

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Abstract

Die Technische Universität Ilmenau versucht auch unter „Corona-Zwängen“ durch Kontakteinschränkungen in Kombination mit begrenzten Lehrkapazitäten Seminare, Übungen und Praktika angemessen durchzuführen und die Lehre nicht zu vorlesungslastig werden zu lassen. Die Seminar- und Praktikumsräume gaben jedoch auch unter intensiver zeitlicher Raumbewirtschaftung von 7 Uhr bis 21 Uhr „zentral“ wie durch die Fachgebiete bei Einhaltung der Hygienevorschriften keine ausreichenden Kapazitäten zur Durchführung in Präsenz her.
Der Beitrag berichtet daher über von uns getestete Möglichkeiten zur Umsetzung der etablierten Lehrformate in Onlineformate. Zusätzlich werden Lösungen zur sicheren Realisation von Präsenzprüfungen unter Pandemie-Bedingungen dargestellt.

The Technical University of Ilmenau tries to conduct seminars, exercises and practical courses appropriately even under "corona constraints" due to contact restrictions in combination with limited teaching capacities and not to let the teaching become too lecture-loaded.
The seminar and practical course rooms, however, did not provide sufficient capacities for the implementation in presence even under intensive time management from 7 a.m. to 9 p.m. "centrally" as by the departments in compliance with the hygiene regulations.
The article therefore reports on possibilities tested by us for the conversion of established teaching formats into online formats. In addition, solutions for the secure realization of face-to-face examinations under pandemic conditions are presented.

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1. Framework

Prior to the first Corona wave, digital instruction at our university was tried out only sporadically under experimental clauses. GOLDi [1] has gained visibility across the university. Like many other institutions, we as the people forming "the university" were thus forced to move rapidly at the beginning of the first corona wave and were not adequately prepared for the situation. In this regard, due to the process of reviewing data privacy security and legal aspects, the decision which videoconferencing system to use as the "backbone" of online teaching was made rather late and then became mandatory for classroom use for all of us. In the selection process, there was no participation of users or of usability experts, who are well represented among the university. experts.

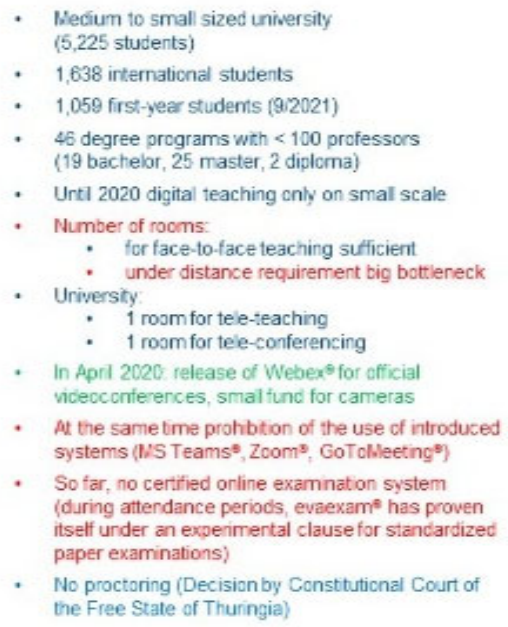

Fig. 1: Framework conditions for digital teaching at Technische Universität Ilmenau at the beginning of Corona pandemic.

Since many groups had already established other videoconferencing systems on their own initiative and had prepared the lessons in time for the start of lectures, the short-notice changeover resulted in considerable friction losses and significant additional work. The situation was similar during the audit period. For reasons of data protection and legal certainty, the existing Moodle communication platform was used as a tool for conducting examinations in accordance with the rules, the limited usability of which also led to unnecessary additional work for examiners and examinees. In the next term, these organizational problems mostly were eliminated.

Support for the introduction of educational software (or integration as far as already used by individual subjects before the pandemic) did not take place due to lack of resources. For further details, see Fig. 1.

Therefore, measures of teaching unit self-support should be reported below.

2. The largest problem: converting face-to-face internships into online formats

In biomechatronics, practical experiments naturally also contain a bio-component on the object side. Due to the support of "Biomedical Engineering" course alongside the "Biomechatronics" course and in view of the job profiles of both courses, non-invasive observation experiments with measurements on humans are also carried out, whereby the test subjects are the students themselves in turn - anyone who wants to carry out investigations on humans must know the perspective of the test subject from their own experience. This is the only way to ensure a user-oriented design of experiments with humans (ensuring biocompatibility), starting with the aspects "stress/strain" (teaching content of our occupational science courses) and "reasonableness". If interested, our students learn about observational experiments with animals in qualification theses supervised together with the Institute of Systematic Zoology and Evolutionary Biology at FSU Jena (e.g. as a preparation for the construction of bio-inspired robots).

All of these experiments have so far only been feasible in the presence of people and could not be realized under contact prohibition. The following example illustrates the adaptation to pandemic conditions (Figs. 2, 3).

In three experimental parts, working capability is first established in the use of an Arduino®-µC (reading in sensor data); the prior knowledge of the students varies greatly here due to the lack of suitable training units in the

courses of study. Then the familiarization with a commercially available demonstrator for a single-joint exoskeleton (EduExo®) with EMG sensors takes place. In the third part, the Arduino® training is supplemented by the control of actuators, a control loop is set up that lets the EduExo® follow the arm movements of the subjects.

Fig. 2: Practical course "Fundamentals of Biomechatronics" in presence: Design of a control loop for controlling an exoskeleton with EMG data.

Fig. 3: Supplementing the control loop for controlling an exoskeleton with EMG data by means of a remote connection (IP4).

A fourth part was added to the experiment for online use.

The system is connected via IP to a remote measurement and control computer. Depending on the conditions provoked by Corona pandemia, either the online access can be made directly via the university internal (IP4) network or, if the university buildings are off-limits, via VPN from the student home office. The combination of both variants and the possibility to compare them due to the presence of the supervising internship assistant near the hardware at the university leads to animated discussions about the observed latency times and the state of broadband expansion in Germany.

In the next extension, a control option via a mobile terminal (G5 standard) will follow. The overall construct will also continue to be used during presence times.

Lesson learned: "Corona" as an innovation impulse

While the mechatronic part of the training was relatively easy to adapt to online teaching by using mechatronic solutions, the Bio-X part posed significantly larger problems.

For both of the above-mentioned courses of study, anatomical and physiological knowledge is the professional basis. Therefore, since the foundation of the department in 2002, lessons tailored to the target group of engineers have been offered. Until about 2010, anatomical demonstrations in the dissecting room of Anatomical Institute at FSU Jena (two of the FG staff members had extensive experience in supervising courses in macroscopic and microscopic anatomy) were offered on a voluntary basis. Due to newly emerging insurance restrictions (conducting student missions outside the Bologna Excel® table of curricular events; risk of accidents in the dissection room), we had to switch to the use of abattoir material for independent dissection by students in 2010. Insurance coverage has been reinstated for performances in our teaching rooms.

The view into other institutions, which is necessary for interdisciplinary teaching, was thus once again successfully prevented.

Fig. 4: Knee joint - top: Anatomical demonstration on the dissection room - bottom: independent dissection on slaughterhouse material (pig).

The preparation is performed in groups of three students (holding and positioning the material, preparation, assisting with the preparation), with the roles being regularly exchanged (Fig. 4).

Under the spacing requirements of Corona Prevention, implementation was not possible.

As a substitute, the use of software for the virtual dissection of a human being (f/m - this deserves special mention, most products even today only offer the male anatomy) was tested and found to be very helpful by all participants (Fig. 5).

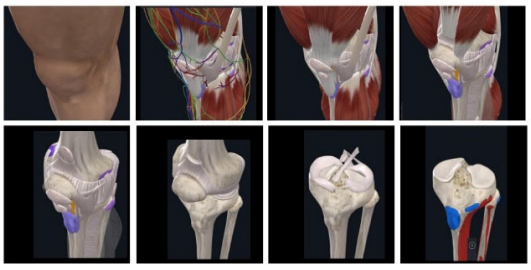

Fig. 5: Knee joint - independent virtual dissection on humans (f/m) in Complete Anatomy ® (Elsevier), own screenshots.

The acquisition took place in January 2022 (the time of the conclusion of this article), now only data protection hurdles have to be overcome for the deployment (advised from summer term 2022, then two years will have passed since the beginning of the pandemic).

From summer term 2022 the change from study subjects (3 LP) to study modules (5 LP) is complete. The new module "Anatomy and Physiology" will consist of lectures and an additional offer of virtual (!) dissection on humans. The module "Human Serving Systems" will also offer focused virtual dissection on humans as a preparation for and accompaniment of practical courses and will be supplemented by dissection on slaughterhouse material.

Lessons learned:

- Objective constraints are inventive and accelerate developments that have been planned for a long time. - Digitization requires the cooperation of all stakeholders to achieve the goal.
- The triad - "theory - practice in presence - both accompanied by software" - promises maximum learning effect (also through subject-specific addressing of students in different ways with focus according to individual preferences).
- The already occurred arithmetical increase of the teaching scope (previously four hours of teaching per week = 2 x 3 LP = 6 LP, now 5 LP, leading to 20% more workload for students) with the same teaching capacity (thus also 20% more teaching capacity required) will foreseeably be offset with the "lower effort for digital teaching" (corresponds to the starting position of all "digital naives").
A small university like ours thus runs the risk of becoming undercritical in terms of human resources and therefore also in terms of subject matter due to shrinkage.

3. Adaptation of lectures and seminars to online conditions

Various technical problems are associated with the compulsion to use video conferencing systems. Here, we can only refer to the different user orientation in the development of

such commercial solutions for the industry. The readers will be able to contribute their own experiences in dealing with the five "big" offers after the pandemic. None of the systems is really adapted to the needs of teaching. Ob-

jectively, "hybrid" teaching is particularly burdensome: face-to-face lectures in the lecture hall (which is too small for pandemic conditions) and their simultaneous online transmission. The lectures with two dates per week were divided into a "Monday group" and a "Thursday group" (attendance days). The (subjective) stress of the lecturers could be reduced in view of teaching rooms not equipped for this after optimization by using two transmission chains (laptop video-audio beamer and laptop video-internet), but the use of a "virtual board" (iPad to MacBook) leads to a similar stress level as playing a "hooked" organ. The "Pingo" queries during lectures, which were common in presence, were completely skipped; this would have required two people to operate the technology.

After the cancellation of the face-to-face classes for larger groups, the again online-only lectures were video-documented and made available via "Moodle" to avoid any disadvantages for the students who had meanwhile started attending other courses on the other date of the week.

It should also be noted that for mobility-impaired instructors, transporting two complete sets of computer equipment to each event date causes significant physical strain.

Biomimetics has become a routine method in those twenty years since the bionics competence network "BioKoN" was founded, thanks to the high level of commitment of the German biomimetics community.

With the onset of the pandemic, the long-time lecturer in the subject "Technical Biology and Bionics" had to retire prematurely due to health reasons. As he lived this course due to the didactic skills of the PhD biologist from the descriptive presentation "on the object" to excursions into nature, the takeover of the course by "non-biologists" was inevitably connected with a change of the didactic concept (see Fig. 6).

Since a partial integration of the contents of the subject into the new modules "Biologically oriented methods of engineering" and "Biomechatronics" is planned soon, the technical-biological part with the example considerations and the presentation of the bionics-oriented transfer methods incl. VDI guidelines was shortened to about half the scope in the terms until then, and agile methods (e.g. an adapted Scrum model) were introduced and applied in the other half. The participants first worked out concepts for "products" proposed by the group(s) "naively" and then step by step in three to four "sprints" (Fig. 6).

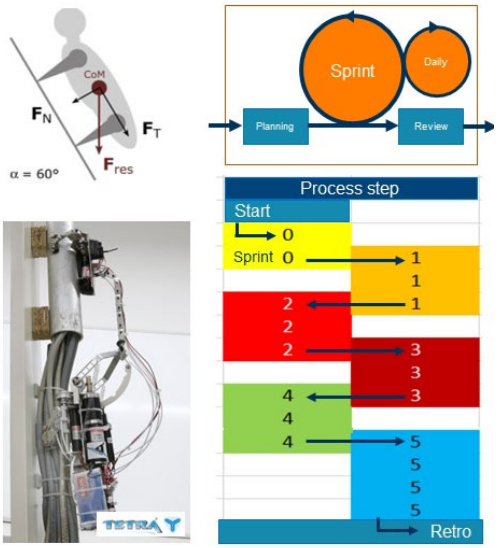

Fig. 6: "Technical biology and bionics" of climbing (left) complemented by group work with agile methods (right).

Due to the necessity of the guidance by a "Scrum Master" the personnel expenditure was doubled, in the end even more than doubled, because from week to week an adjustment to the course of the group work had to be prepared and followed up. The initial skepticism of the students trained in "waterfall methods" only slowly subsided, but in "learning by doing" more than half of the participants could be convinced to include agile methods in their repertoire in the future. In the first master's year, in which participants of the event are represented, we already see significant improvements in group work; previously it took about one semester longer until group work ran routinely.

Lessons learned:

Once again, it is shown that the direct linking of theory and one's own application of the

methods presented results in the greatest learning success (acquisition of knowledge and skills on an equal footing). "Alienation effects" are equally well-known means of motivation. Didactic concepts do not have to become "completely different" "because of digitization," but their implementation must be adapted.

4. Presence tests under corona conditions

In the first "corona semester", there were still face-to-face examinations. Organizational and technical adjustments were necessary to comply with hygiene regulations (see Figs. 7, 8).

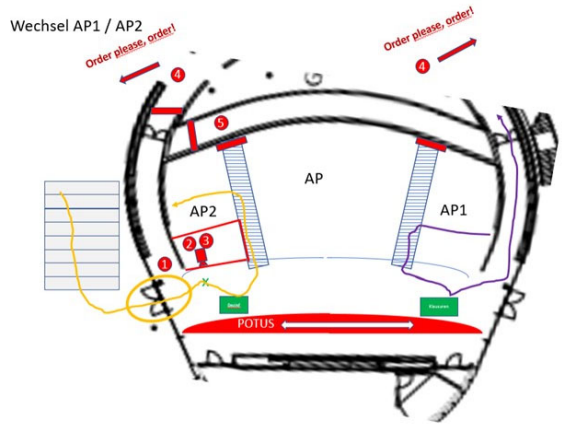

Fig. 7: Planning of inlet, feed-through and outlet during presence testing while avoiding contacts with distances < 2.50 m during the overall process: application of methods of logistics, production planning and control

The further examinations took place in "Moodle" as "Examination-Moodle", developed by the Computer Center of Technische Universität Ilmenau using a different spectrum of Moodle functions and orientation on guidelines of personal data protection and the codified examination regulations. The problems of missing possibilities for "proctoring" could not be compensated, there was nothing to be noticed of social loneliness of the students in view of the exam results, at least exam-related (obviously the students had learned very diligently in large groups in intensive information exchange).

Fig. 8: Admission to presence examinations avoiding contacts with distances < 2.50 m between examiners and students (with simultaneous control of the distances in the queue by "Chief Whips"). Realization of suitable devices and setups for identity control without computer-usable data storage (restriction to entry in attendance list on paper).

5. Unresolved issues

We have all suffered the problem of the "tile wall" (or also the "black hole") to a greater or lesser extent. Especially with larger groups of Bachelor students, the gray tiles proved to be increasingly "hardened" as the pandemic progressed; even after intensive requests by the instructors, no eye contact was made even by the questioners - most participants did not even have a video camera ready.

The well understandable argument was "If we all turn on the camera, the bandwidth is not sufficient". A technical evaluation would be desirable for this.

There is an increasing divorce into well-functioning social clusters and extensive segregation of lone wolves.

For online teaching, analogous to "netiquette", a (at least informal) code is urgently needed to counteract the social deprivation of all participants.

6. Lessions learned

In addition to what has been discussed so far, a number of other observations can be made, questions can be formulated from those and, in some cases, hypotheses can be derived.

- The initial problems with support from the employer provokes the "now more than ever" attitude of the teaching engineers and awakens creativity and the joy of experimentation ("We've wanted to ... for a long time").
- Long-planned changes in teaching ("We don't have time for that now") are triggered.
- The exchange between teachers and students becomes more subject-related, but there is hardly any reduction in the personal distance.
- In some cases, students do not identify with "my" university and "my" teachers. Exception: in the case of 1:1 supervision of qualification theses.
- Student grant requirements have increased sharply - problem with teaching capacity, research falling by the wayside.
- Our experience under pandemic conditions: the grade may be dropped - attendance at "less important" events decreases.
- Group formation works without problems, especially for exams via social media (which is prohibited), but not for the entry in planning lists for the organization of studies and thus relieving teachers.
- Students are still keen to experiment, but the typical initiative of engineering students is on the wane
  ("Just 'try it out!" is replaced by "Where's the animator here?")
- The versatile gifted students "take off". The "promotion of the gifted" only works when students are seeking contact and is not as pronounced among engineering students as it is in other courses of study. "Best selection" takes on a social Darwinian character.
- Corona discipline among students (as far as observable on campus) is higher than among many employees.
- Mystery: why is "home 3D printing at university" highly attractive during attendance times, but hardly in demand under home office conditions despite accessibility of the labs? Has "Corona" established "home 3D printing"?

Without reasonable tools for online exams, online teaching primarily is entertainment.

7. Bogus solutions and solutions: Awakenings

As always at universities, money is not everything, but without money everything is nothing. This applies equally to personnel capacities and infrastructure.

At the beginning of the pandemic, the lighthouse project for digitized teaching at Ilmenau University of Technology was "SIMGAM" (simulations and games in the self-learning phases of a blended learning basic course). The project is funded by the joint program "Fellowships for Innovations in Digital University Teaching" of the Donors' Association for the Promotion of Sciences and Humanities in Germany and the Thuringian Ministry of Economics, Science and Digital Society with 50,000 € for 12 months. Anyone who has the illusory giant Mr. Tur Tur in their mind's eye when they think of "lighthouse" is certainly not entirely wrong.

Why us and our institution were hit so "unexpectedly" by the need for digital teaching certainly has a variety of causes. This may be analyzed later by experts. However, in the third year of Corona, the Free State of Thuringia has still not provided any funding for digital teaching projects, and Technische Universität Ilmenau had to pull itself in front of the cart by acquiring foundation funds.

8. Next steps

In order not to sleep away the future in inactivity, we are working as a member of the Ilmenau team "examING" (as one of 139 projects funded by the Foundation Innovation in Higher Education in the federal-state program "Strengthening Higher Education through Digitization), in the project "DIGexam" a topic on the integration of digital teaching and exami-

nation materials. On the one hand, the aim is to examine how digital teaching aids can be integrated into the final examinations of modules, but on the other hand, students can also be introduced to the examination formats of the final examinations during the courses.

In DIGexam project, the possibilities for competence-oriented digital testing by means of EvaExam are to be used, evaluated, and substantiated by systematically collected data, and the existing possibilities are to be expanded by the use and integration of additional online learning software. Through this combination, new learning, exercise, and examination formats can be offered, the use of which should lead to an increase in competence among students. At the same time, the integration and use of the additional learning software should lead to an increase in user acceptance by both examiners and students.

The achievement of these two goals will be continuously evaluated through a systematic survey. The results will be used to revise and adapt the examination formats offered (Fig. 9).

After the revision, these newly created possibilities will be made available to all faculties and structural units. With selected subject areas from all faculties (target: one group per faculty), a final evaluation will be carried out as part of the regular examinations using the respective subject-specific online tools (e.g. simulation or CAD tools).

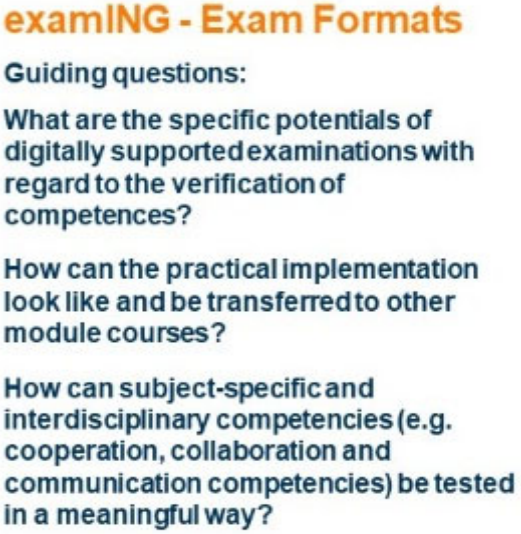

Fig. 9: Guiding questions in the examING project [2].

By using EvaExam online exams, new exam formats can be generated effectively, since existing and proven question catalogs can be accessed for further use. At the same time, there is the possibility of direct comparison of achieved examination performances (both semester-accompanying and final examinations), since a long-term continuous result tracking is available for the paper examinations conducted with EvaExam.

In a direct comparison between Moodle and EvaExam, the task-specific tool EvaExam proved to be both much more effective and efficient.

The extent to which the evaluation results at the end of the project will be influenced by the internal pressure built up over several years to use a solution favored by the infrastructure service provider (Computer Center) remains to be assessed separately.

The transfer of students to the newly created modules results in a necessary overlap period of one year, during which some of the courses are to be read in both the winter and summer semesters. For this purpose, a part of the relevant course will be delivered as blended learning via video-based online lectures accompanied by advising and commentary sessions. For this part, an evaluation is planned to determine to what extent the results of the comparison groups generally differ and in which areas possible differences become visible. In addition, it will be determined whether and to what extent the newly developed examination set is (better) suited for the student group with blended learning than for the comparison group.

The planned solution of combining EvaExam online exams with 3D Complete Anatomy (Elsevier) for teaching in the bachelor module "Anatomy/Physiology" (biomedical engineering course, currently 76 students) offers the possibility to raise the students' level of competence achieved so far after completion of the course series from pure understanding and first approaches of application to the level of analysis. By means of continuous practice examinations, students are made to independently check and learn to assess their level of knowledge. The one- and two-dimensional

teaching contents of the previous teaching and examination form are extended using 3D Complete Anatomy as a learning platform and examination tool to a (pseudo-)three-dimensional knowledge transfer and examination. Students recognize spatial positional relationships and apply them in independent digital "dissection exercises". This corresponds to an increase of the achievable competence from level K2 (taxonomy according to Bloom [3]) to K3 and partly as well K4. By means of the self-assessments carried out within EvaExam, this achieved level of competence is also made visible to the students.

After successful completion of the tests, analysis, and evaluation of the results as well as user surveys, subject areas from all faculties with similar requirements for the use of digital tools will be integrated into online examination scenarios and exemplary forms of examination will be jointly developed. Finally, these scenarios will be tested, and the results will be jointly analyzed. The experiences of the Biomechatronics group for the realization of user tests etc. from the own work of many years in the usability research are applied here.

Fig. 10 depicts the planned "weaving" of the digital tools via the envisioned interrelationships.

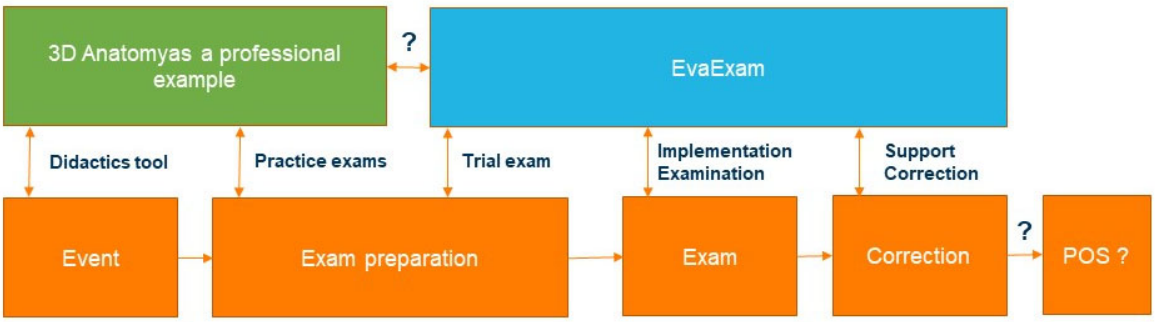

Fig. 10*:* Coordinated *use of software solutions for semester-accompanying teaching and testing. (POS: "Examination Online Server").*

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