Hochschulforum
Digitalisierung

Whitepaper No 65 / November 2022

Digital Assessment in Higher Education

Perspectives of a European Community of Practice

Editors

Matthias Bandtel/ Matthias Baume/ Rasmus Benke-Aberg/ Elena Brinkmann/ Svenja Bedenlier/ Jannica Budde/ Benjamin Eugster/ Andrea Ghoneim/ Tobias Halbherr/ Malte Persike/ Florian Rampelt/ Gabi Reinmann/ Zaim Sari/ Alexander Schulz

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Table of contents

Practical examples

Hochschulforum Digitalisierung

Hochschulforum Digitalisierung (German Forum for Higher Education in the Digital Age, abbreviated: HFD) not only monitors, shares and acts as a source of information on important (inter)national developments in Higher Education. Through a range of programmes and projects it also offers strategic consultancy services and builds key competences of higher education professionals across the country. Independent yet connected with a network of stakeholders from different sectors, including education and IT professionals, EdTech leaders, students, policy-makers and digital learning experts, it is uniquely placed at the heart of the digital transformation of higher education in Germany.

The HFD was founded in 2014 as a joint initiative by the Stifterverband, CHE Centre for Higher Education and the German Rectors' Conference and is funded by the German Federal Ministry of Education and Research (BMBF).

For more information see: https://hochschulforumdigitalisierung.de/en

Summary

Florian Rampelt, Jannica Budde

Digital assessments have become a central issue in higher education – at least since the Corona pandemic. Since early 2020, new opportunities for, but also serious challenges of, digital assessments have become apparent. Even after several predominantly virtual semesters, higher education practice is characterised by a variety of legal, pedagogical, logistical and technical uncertainties that need to be addressed through exchange, collaboration and co-creation.

In order to strengthen a practice-oriented exchange and jointly discuss innovative solutions, the Hochschulforum Digitalisierung (HFD) initiated a community working group with over 80 members from Germany, Austria and Switzerland in the spring of 2021.

Due to the diversity of topics and perspectives, these members of the HFD community established smaller working groups according to their thematic interests (pedagogy, third-party applications, e-portfolios, etc.), which are explored in depth in this joint publication.

As the result of the community-driven collaboration, the white paper "Digital Assessment in Higher Education" specifies overarching concepts and terminology, discusses pedagogical, technical and organisational dimensions of digital assessments and presents scenarios for practical use in teaching and learning (cf. Figure 1).

The German-language version of the white paper was published in September 2021. Due to positive feedback from the community and an increasing exchange on the topic at European level[1], it is now available in English as well. Contributions from over 40 authors reflect the status in 2021 in Germany, Austria and Switzerland and remain largely unchanged in terms of content. Accordingly, it serves as an impulse for in the ongoing discourse, adding a range of European perspectives.

Special thanks to Rasmus Benke-Aberg and Channa van der Brug for their support in the translation process.

The chapters of the white paper are divided into an introductory section, a section on conceptual foundations, and a large section dealing with concrete assessment scenarios from a practical perspective.

[1] HFD was one of the initiators of an intensified European collaboration on digital education. Since 2021, the European Commission has taken this up with the European Digital Education Hub. In its Communities of Practice, topics such as digital assessments are also to be taken up, discussed, and further developed across educational sectors. Further information: https://education.ec.europa.eu/focus-topics/digital-education/about/digital-education-action-plan/digital-education-hub

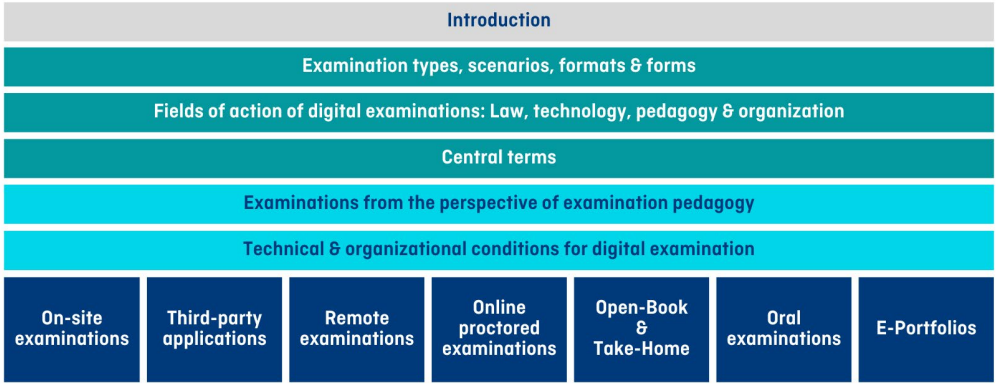

Figure 1: Contributions to the white paper "Digital assessments in higher education"

In the general "Introduction" to the white paper, Florian Rampelt et al. outline the genesis of the community working group, selected developments in Germany, Austria and Switzerland, as well as overarching preliminary work and perspectives of the Hochschulforum Digitalisierung.

Dagmar Willems and Katharina Engel of the German Academic Exchange Service (DAAD) reflect on the relevance of assessment for international exchange and present current developments as part of the general "Introduction".

The second part discusses some of the fundamental concepts for digital assessment. Florian Rampelt et al give a short overview of "Key terminology" as well.

Alexander Schulz examines and specifies in "Legal aspects, technology, pedagogy & organisation" the fields of activity of digital assessments. He describes their respective characteristics and interdependencies.

Svenja Bedenlier et al. cover different design features of testing and the suitability of testing forms in relation to teaching-learning objectives in "Examinations from the perspective of examination pedagogy". They use the SAMR model to present a simple heuristic technique for lecturers.

Malte Persike et al. complement this with a brief presentation of the "Technical and organisational frameworks of digital examinations". This chapter introduces digital examination infrastructures and e-examination systems and their associated examination workflows.

The introductory chapters are followed by chapters with further scenarios, insights into and recommendations for digital examination and assessment practices.

Malte Persike et al. discuss "Digital examinations as on-site examinations" and consider, among others, room infrastructure requirements based on practical examples from RWTH Aachen University and ETH Zurich.

"Practical examinations with third-party applications" by Tobias Halbherr et al. focuses on the opportunities subject-specific software offers, such as authentic, subject-specific assignments.

"Digital distance examinations" by Malte Persike et al. presents different implementation methods for online and distance examinations.

Matthias Baume et al. share the Technical University of Munich's best practices for "Online invigilated exams", one particular examination scenario frequently discussed in this context.

Benjamin Eugster et al. deal with alternative examination scenarios in the chapter "Digital open-book and take-home examinations", and share possible implementation methods.

"Oral online examinations" with a focus on the use of video conferencing systems are covered by Malte Persike et al.: a (distance) examination scenario already used at many universities:

Elena Brinkmann et al. cover "e-portfolios" as formative and summative assessment and evaluation instruments and include comprehensive recommendations for implementation of e-portfolios.

The international perspective – International re-assessment of assessment

Dagmar Willems, Katharina Engel (DAAD)

Why have an introduction to this white paper on digital assessments in higher education that considers internationalization?

Internationalisation is a strategic priority among German higher education institutions (HEIs)[2], and internationalisation policies as well as practices at German higher education institutions (HEIs) are changing: **digitalisation transforms international academic cooperation and exchange.**[3] HEIs' strategies and curricula now integrate internationalisation in its digital formats: from digital research collaboration and joint learning offers, to virtual exchanges as well as virtual and blended mobilities. As the **disruption caused by the Corona pandemic** sees many HEI international activities significantly challenged, with international mobility most severely affected, digital means to engage in international academic collaboration and exchange have experienced a further boost.[4]

In this context of digital international education and flexibilised student journeys, assessment needs to undergo re-assessment. At an institutional level, HEIs as well as HEI networks, such as the European University Alliance, need to define their role in the global market of digital learning. They need to tackle questions of recognition, new forms of credentials and degrees in line with respective national qualification frameworks and quality assurance requirements. At teaching level, international and digital learning paths require an adapted coordination of learning objectives, teaching activities and assessment practices. Relevant skills and competencies that students acquire in online international learning scenarios need to be defined and their development monitored.

Addressing both levels, this introduction is based on the German Academic Exchange Service's (Deutscher Akademischer Austauschdienst, DAAD) experience as the world's largest funding organisation for international academic cooperation and the

[2] Resolution by the German Rectors' Conference (HRK), 2020: https://www.hrk.de/fileadmin/redaktion/hrk/02-Dokumente/02-01-Beschluesse/Beschluss_Leitlinien_und_Standards_HRK_Praesidium_6.4.2020.pdf

[3] Global Learning Council (2021), *Digital Transformation of Higher Education—Global Learning Report.* DOI: 10.21241/ssoar.73580

[4] Deutscher Akademischer Austauschdienst (DAAD) and Deutsches Zentrum für Hochschul- und Wissenschaftsforschung (DZHW), *Wissenschaft weltoffen 2021. Facts and Figures on the International Nature of Studies and Research in Germany and Worldwide*: https://www.wissenschaft-weltoffen.de/en; DAAD Working Paper (March 2021), *COVID-19 and the impact on international student mobility in Germany. Results of the second DAAD survey of International Offices in the winter semester 2020/21*: https://static.daad.de/media/daad_de/pdfs_nicht_barrierefrei/der-daad/analysen-studien/corona_ap_final_engl.pdf

international exchange of students and researchers. The following considerations illustrate how **digital assessments, as flexible remote solutions, are likely to meet specific requirements of international (online) learning and how they cater to the needs of diverse groups of (digitally) mobile learners** at different stages of their international student journey (cf figure 2):

Figure 2: Student Journey: Establishing International (Digital) Learning Pathways © DAAD

Studies and mobilities

Starting off in the middle of the student journey by considering the needs of students who take part in **physical international mobility**, digital assessments can provide much-needed flexibility in cases where assessments or examinations[5] are scheduled when the student is no longer on campus. Data from a recent DAAD study suggests that such offers might even have positive effects on learners' openness towards international mobility.[6]

In the context of international **digital** education, much effort is put into moving away from the replication of on-site formats to develop **remote collaborative scenarios** that allow for interdisciplinary and intercultural learning. Lecturers designing such **virtual exchanges**, in which international student teams work together in an online setting, frequently introduce research-oriented topics and offer challenge-based learning in project work. With the characteristic flexibility in how learning is realised in virtual exchanges, also in terms of time and location, lecturers need to identify and implement suitable ways of documenting, reflecting on the learning process and assessing learning achievements.

- Considering that assessments are important for both the learner and teacher, **integrating learners into the development of and decisions on digital a/synchronous assessment formats** promises to be mutually beneficial. In international settings in particular, this helps to create learner-centred formats that meet the needs of a diverse group of learners from different cultural (and

[5] In line with its use in this white paper, (digital) assessment is the broader term while (digital) examination shall underline that the assessment entails legal consequences.

[6] The SUNY COIL Centre is among the pioneers promoting Collaborative Online International Learning and provides support to educators and institutions in realising COIL and virtual exchange. The DAAD's funding programme International Virtual Academic Collaboration (IVAC) fosters virtual exchange at German HEIs and offers support to lecturers by sustaining a Community of Virtual Exchange Practitioners.

potentially disciplinary) contexts. This includes explaining the purpose and clarifying the assessment criteria for a classroom of students from different learning cultures.

- Lecturers may consider moving from a singular high-stakes exam (summative assessment) to a system of multiple digital assessments. In Collaborative Online International Learning (COIL) scenarios, **formative digital assessment** methods, such as e-portfolio solutions, allow learning progress to be documented through artefacts created over the course of a virtual collaboration. Besides getting a more nuanced impression of learners' development, lecturers receive feedback from the learners that allows them to reflect on and adjust their teaching practice, if necessary.
- As COIL formats build on working together in teams, the **digital assessment of team efforts** becomes more prominent, e.g. in the form of group presentations, group portfolios of jointly created digital artefacts, such as podcasts, videos or blogs. Whether individual assessments can be replaced or are supplemented by such group assessments involves a pedagogical decision to be made for each case, which includes considering the HEI's examination regulations.
- Learners can change their role from being assessed to assessing their learning progress in **self-assessment**, or by integrating **peer-feedback** – giving learners yet another opportunity to learn from each other and priming further competences.
- In addition to subject-specific learning, international online collaboration also provides learners with transversal skills and competences for their personal and professional lives in the context of digital and green transitions. Accordingly, **digital assessments should cover the development of these skills and competences**.

Orientation and admission

We now go back to the beginning of the student journey. Considering the needs of students interested in earning a degree abroad, **diagnostic forms of assessment**, such as placement tests, can help define and document prior knowledge as well as language skills and facilitate admission procedures. In this situation, digital assessments hold many advantages: they usually do not require travel on the part of the learner, save costs and lower the administrative burden of preparing for studying abroad. Thus, they help to make international degree mobility increasingly sustainable for and available to diverse learners.

In addition, digital placement testing (as a form of self-assessment) can provide the basis for orientation and tailor-made recommendations of suitable study programmes. Learners can be guided towards (online) resources to prepare for the targeted study path, which helps increase their chances of success in their studies abroad. With their flexibility and adaptability (to learners' needs), digital formats of assessing prior knowledge/learning make international exchange more accessible.

Graduation and lifelong learning

The third stage of the student journey is concerned with credentials, degrees and continuing education: with the rise in online learning offers on the global education market, learners increasingly expect their **learning achievements to be assessed in adequate digital formats, independent of time and location** – and they expect digital assessments to result in certification that is **internationally recognised**, e.g. digital credentials. At the same time, learning and being assessed does not stop at graduation. Demand for flexible lifelong learning in the form of short online learning courses, micro-credentials, MOOCs (massive open online courses) or entire online degree programmes rises and, therefore, the need for adequate, accepted digital assessments and certifications.

Hence, digital assessment standards, degrees and digital credential formats, as well as their quality assurance, are topics that need attention within HEIs and at national policy level. In the case of inter-institutional collaboration, mutual understanding of respective requirements and finding ways to adapt to these is required. This can go as far as determining joint assessment examination regulations, a joint grading system and issuing a joint digital credential.

As the number of **HEIs collaborating** in offering joint digital programmes and lifelong learning offers increases – for example, the European University Alliance – **knowledge and practices of digital assessment will continue growing at a fast pace**. A steep learning curve is to be expected, especially with international Communities of Practice evolving further, bringing together peers and their good practices. While creating the conditions to make use of the potential of digital assessments for international education described above, openness towards different alternatives and joint reflections on technical, legal, logistical challenges are key in the process of adapting solutions to local realities.

In future international exchanges on the topic, the DAAD proposes to re-assess assessment in international online learning as a means to:

- ease access with flexible solutions adapted to learners' needs;
- align collaboration in online learning with increased collaboration for (digital) assessment;
- make skills and their development visible;
- pave the way towards seamless mobility for lifelong learners.

In this spirit of collaboration and mutual learning, the DAAD congratulates the HFD working group on the publication of the English version of their insightful white paper that presents perspective(s) from Germany, Austria and Switzerland to the international community. We hope that the white paper and the impetus in this contribution will inspire its readers to engage in international exchanges on the policies and practices of digital assessment. The re-assessment of assessment for international collaboration is a joint venture!

1 Introduction

Florian Rampelt, Jannica Budde, Zaim Sari

1.1 Why this whitepaper?

In times of Corona, examinations have become a central issue in higher education. Under the conditions of the pandemic, many possibilities for, but also serious challenges of, digital assessment became apparent. After several predominantly virtual semesters, HEI practice in the field of digital examinations is still characterised by a variety of legal, pedagogical, logistical and technical uncertainties. While some HEIs continued to rely on on-campus examinations, others quickly tested a variety of remote online examination scenarios.

The ad hoc measures on digital assessments implemented at HEIs in Germany, Austria and Switzerland often did not appear out of nowhere, but built on numerous pilot projects and implementation activities from the years before the Corona pandemic. The topic has also been a focus of discussions in the HFD since 2015, but these have often been limited to a core group of a few committed pioneers. Whether digital on-site examinations or digital remote assessments, their potential was often tested, but not implemented on a broader scale. Before the pandemic, for example, it was often the case that online courses could only be linked to on-site examinations for curricular recognition (Rampelt et al., 2018), even if the basic technical, organisational and pedagogical possibilities for digital examinations outside of the HEI would certainly have been available.

Accordingly, before the Corona pandemic, many innovative projects on digital examinations often did not even manage to reach their own HEIs on a broad scale. This changed fundamentally from 2020 onwards. Scientific and pedagogic preliminary studies, tried-and-tested infrastructures and networks, and experienced HEI staff, in particular, ensured that many institutions were able to mitigate the effects of the pandemic comparatively well in the higher education sector as a whole.

However, it is now becoming increasingly apparent how necessary it is to analyse the experiences and successful measures and to clarify further development needs.

The central question here is how it can be possible to create orientation and incentives for pedagogically sound digital examination scenarios and to make use of the possibilities of digital technologies both in the context of on-site scenarios and in the context of online settings in a way that meets the needs.

1.2 Assessments in times of Corona

The Corona crisis hit Germany, Austria and Switzerland at the transition of the winter to the summer semester 2020 and thus, for many HEIs, in the middle of the examination period. This initially meant that many examinations in March 2020 were suspended and postponed until the summer; HEI administrators and lecturers assumed a massive backlog. At this point, the technical and legal possibilities of digital remote assessments

as an alternative to on-campus assessments were already being examined. But there was no uniform conceptualisation: in Germany and Austria, the discourse was strongly influenced by the term "online examinations", while in Switzerland the term "remote examinations" was used. The pivotal point of the discussion from the perspective of HEIs and lecturers was: how does legally secure examination supervision succeed when students are not on site?

Insofar as an overview of the diverse situation at the HEIs is at all possible, it can be stated for the summer semester 2020 that digital distance examinations were rather the exception in Germany. Most HEIs stuck to on-campus examinations. Some HEIs and faculties, however, did pilot digital remote invigilation ("online invigilation"), while others relied on alternative examination scenarios that did not require (remote) supervision, such as open-book and take-home examinations. In this context, digital examinations were often offered in Germany to students as an alternative and were intended to conserve room capacities, which were even more scarce due to strict hygiene concepts (Budde, 2020). Then again, some German HEIs solved the problem of scarce space in a completely different way and rented additional rooms off campus for thousands of students.

For Austria, the impression is that there have been almost no on-site examinations since March 2020, and that remote examinations in very different settings have quickly become the new normal. A number of HEIs even managed to switch to digital distance examinations entirely (Berger, 2020; Chen et al., 2020). The admission tests for medical studies in Austria, which were conducted in August 2020 under strict security concepts in exhibition halls throughout the country as a "paper-and-pencil test", caused a media sensation.

A mixed picture also emerged in Switzerland: examinations in exhibition halls, electronic on-campus examinations in large computer rooms and invigilated and unsupervised remote examinations with and without the use of online invigilation. Open-book formats and digital exams with limited invigilation were also conducted with special browsers that restricted access.

There were also oral digital remote exams and presentations via video conferencing systems.[7]

The conditions and thus the necessities of a digital design for examinations once again intensified drastically in the winter semester 2020/21. While the semester began with the hope of an early return to on-site formats – and thus also on-site examinations – the situation was different at the beginning of 2021: the renewed lockdown extended into February, which also had an impact on how examinations were conducted.

Some federal states in Germany only allowed on-campus examinations in a few exceptional cases, while individual HEIs tightened up the general political framework once again and implemented digital examinations exclusively. At other institutions, on-campus examinations continued to be taken.

[7] https://www.switch.ch/de/stories/exams-during-coronavirus/

However, especially where examinations were conducted in remote settings, not everything went smoothly. For example, there were fundamental reservations among lecturers and students at some HEIs about certain examination scenarios, while at other HEIs there was also a lack of clarity about the design options and limits of the "open-book examinations", which were often discussed as a data protection-compliant alternative.

As early as the summer of 2020, students in Germany, in particular, had criticised measures for digital examination supervision with reference to data protection and privacy.[8] In spring 2021, students at two HEIs filed lawsuits against the monitoring of their exams or the storage of audio and video recordings. In both cases, however, the courts rejected the applications.[9]

Thus, much remains unresolved, at least for the time being. We, furthermore, need a perspective on the design options not only immediately, during and after the pandemic, but also for the decade that has just begun. This involves the design not only of future-proof examination scenarios, but also of digitalisation in studying and teaching in general. The transition time out of the pandemic seems to be the right time to reflect on the diverse experiences of a year and a half of examinations in the age of Corona, and to explore the possibilities for a post-pandemic HEI world. This cannot be done without conscientiously reflecting on the diverse groundwork addressed and collectively drawing appropriate conclusions from experiences both before and during the pandemic. This guiding principle of the HFD also applies to digital examinations: Collaboration is the key to success! (Janoschka et al., 2021)

1.3 Examinations as the focus of the HFD

The German Forum for Higher Education in the Digital Age (HFD) was founded in 2014 to encourage HEIs in Germany to actively engage with digitalisation in higher education teaching. For this purpose, thematic groups were established for an initial period until 2016, which dealt with various issues of "Higher Education in the Digital Age". The thematic group "Innovations in Learning and Examination Scenarios"[10] also dealt at an early stage, with issues relating to the potential and risks of digital technologies in the implementation of examinations. In view of the diverse opportunities, but also challenges, associated with digital examination scenarios, the topic group published a study on "Digital Examination and Assessment in Higher Education" in 2015. On the basis of this study, initial recommendations for the use of digital examinations at HEIs were formulated, aimed at HEIs and teachers. The paper "Recommendations for Action for Higher Education Policy: E-Assessments as a Challenge" was intended to address higher education policy-makers at federal and state level (Hochschulforum Digitalisierung, 2015).

In recent years, the focus of the HFD has increasingly headed in the direction of a holistic approach to digitalisation in higher education, carrying out analyses involving all

[8] Germany: https://hochschulforumdigitalisierung.de/de/blog/pruefungen-pandemie-online -proctoring-is-keine-loesung; Switzerland: https://www.nzz.ch/schweiz/online-pruefungen-wenn -die-webcam-studenten-fotografiert-ld.1595806
[9] https://www.forschung-und-lehre.de/recht/gerichte-lehnen-klagen-zu-digitalen-pruefungen-ab-3553/
[10] https://hochschulforumdigitalisierung.de/de/themen/innovationen-lern-pruefungsszenarien

relevant fields of action and stakeholder groups and formulating corresponding recommendations. This is based on the experience that the digital transformation of higher education is an overarching process that affects teaching and administration, infrastructures and didactics, organisation and technology in equal measure and requires broad stakeholder participation (Rampelt & Wagner, 2020). This is particularly true for the area of digital examinations (see also Chapter 2.2. on fields of action for digital examinations).

In view of the pandemic situation, the HFD considered it necessary to take up the numerous preliminary works and considerations and to further develop them in a structured manner based on the diverse new dynamics and measures. In order to make the diverse institutional and individual experiences of the previous months, but also the preliminary work of the previous years, visible – to show old and new perspectives and to bring the practice-oriented discourse together to some extent – the HFD set up a working group during the transition from the digital winter semester to the summer semester 2021.

This Community Working Group (CWG) pursued the following main objectives in its work between March and September 2021:

- Discussion and analysis of the status quo on examination scenarios in times of Corona
- Structuring the discourse into central, exemplary and partial aspects
- Discussion and approach to conceptual and conceptual foundations
- Development of a white paper on digital assessments as a basis for further discourse and orientation for on-site assessment practice
- Publication of blog posts and discussion papers to give visibility to different perspectives and sub-aspects of the thematic focus
- Preparation of further exchange formats and discussion of future scenarios beyond the summer semester 2021 with reference to the period after Corona

More than 80 members discussed the current status of assessments and examinations in Germany, Austria and Switzerland as well as the central opportunities and challenges for a future-oriented design of different examination scenarios, with a focus on the opportunities and challenges of digital technologies.

The work of the Community Working Group with its individual thematic groups does not only come full circle back to the beginnings of the Hochschulforum Digitalisierung, but at the same time attempts a further differentiation of the thematic field, which is oriented towards concrete needs and also opportunities in pandemic and post-pandemic times. Accordingly, selected experts did work together on partial aspects, scenarios and forms that are particularly relevant from their own perspective.

At the same time, such a structured discussion of examinations in general, and digital examinations in particular, cannot be about pursuing a claim for general validity. The Community Working Group gathered perspectives from a wide variety of stakeholder and status groups, shaped by the framework conditions in educational systems and

institutions in the respective countries, some of which are more, some less, diverse systems and institutions. These perspectives are intended to provide a practice-oriented insight into what the focal points and needs may be in the current debate. This working paper therefore deliberately includes gaps (e.g. on legal issues), which will be addressed in further exchange forums, collaborative activities and publications as well as necessary educational policy measures in the coming years.

The Community Working Group hopes that this white paper, which was developed in a very collaborative manner, will be able to provide relevant perspectives and examples for HEI practice on the ground. In particular, the members of the CWG want to provide orientation for the pedagogically sound implementation of digital examinations in practice.

This publication and its individual contributions are intended to provide an impetus for further cooperation, constructive discussion and the innovative design of digital examinations. The assumption is that many challenges can clearly be identified, but that numerous opportunities and design possibilities for the future are also opening up. These will be discussed in the following chapters by experts from the various topic groups of the CWG and backed up with current examples from examination practice in Germany, Austria and Switzerland.

Selected literature

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2 Fundamental concepts

It became clear to the members of the community working group at an early stage that although a glossary of terms would add value, at the same time universally valid definitions do not exist and the scientific debate on terminology is ongoing.

We see value in these discussions and in the diverse perspectives thus contributing to the field of online assessment. Although the authors of this white paper have tried to use consistent wording throughout, readers might find minor contradictions in their articles, and might also find they use different terms in their professional contexts themselves.

A glossary of terms is not included in this white paper, however, four central fields of action for digital examinations will be outlined in detail in the following chapter.

2.1 Key terminology

Florian Rampelt, Malte Persike, Tobias Halbherr, Rasmus Benke-Aberg

Assessment

Oxford Learner's Dictionaries defines assessment as "the process of testing students and making a judgement about their knowledge, ability or progress".

Examination

While often referred to as a synonym to assessment, the two words have different meanings. In this publication we use examination (exam) for "a formal written, spoken or practical test, especially at school or college, to see how much you know about a subject, or what you can do" (Oxford Learner's Dictionaries).

Digital examinations

The term digital assessment covers all examination scenarios in which at least the proper processing of the examination tasks, including the submission of results, occurs in partially or fully digital form. In other words, whether we consider assessments as digital or not depends entirely on how they present themselves to the students. Therefore, a digital workflow during the phases of preparation, correction, inspection or archiving of an assessment is irrelevant to the classification as a digital assessment. An assessment is digital if the students come into contact with digital processing media during the performance of the assessment.

Remote examinations

A remote examination is one that is to be taken at a location of the student's choosing. In the context of the Corona pandemic, general use of the term 'remote examination' has focused on examinations typically taken at home or some other location of their own choosing that is not originally designated for the sitting of examinations. For the sake of

conceptual clarity, in this publication, the term remote examinations is used synonymously with online examinations and distance examinations.

Digital examinations with third-party applications

In the context of digital examinations, "third-party applications" designate software applications that are not, per se, examination systems. Typical third-party applications in digital examinations include software tools such as statistical software, programming environments, spreadsheets, CAD (computer-aided design) or geoinformation systems , but also PDF readers or web browsers for accessing information resources such as detailed case studies or online research databases, which are too complex to make available through the examination system itself (cf. Chapter 5.2).

Open-book examination

Open-book examinations (cf. Chapter 5.5) have emerged in an analogue world as a way of designing the written on-campus examinations. Students are allowed to use certain aids during the examinations. Open-book exams can also be conducted digitally at the HEI, allowing a wide range of aids. If the exam is designed so that not only local files (e.g. lecture notes) are accessible, but also resources accessible via the Internet (e.g. certain websites, online research databases), this is also referred to as an open-web examination. If open-book or open-web examinations are to take place under examination conditions, it must be ensured that only the resources that are expressly permitted can be accessed.

Take-home exam

The original examination concept of take-home examinations allows students to receive examination tasks and take them home to work on them there as the processing time (e.g. several days) on site would take too long. The examination performance takes place in the home setting and, in contrast to the mostly synchronous remote examination, is more comparable to homework, which can also be done without supervision. (cf. Chapter 5.5)

E-portfolios

E-portfolios are digital collections in which learners record, document and reflect on their learning process and learning outcomes. E-portfolios can be used as formative as well as summative assessment and evaluation tools (cf. Chapter 5.7)

Online proctoring / invigilation

The terms proctoring and invigilation originally refer to the (human) supervision of exams in order to prevent cheating. They are established procedures in almost all traditional examinations at HEIs. Online or remote proctoring / invigilation describes digital formats of examination invigilation, intended to realise a secure and reliable method of exam-taking and supervision, irrespective of where an exam takes place.

2.2 Fields of activity – Legal aspects, technology, pedagogy & organization

Alexander Schulz

This subchapter turns to the fields of activity that are central to a comparative examination of the transdisciplinary topic of digital examinations. These fields, outlined below, should be understood as a low-threshold proposal for a structural framework that is explicitly not exhaustive, nor can be exhaustive. Insofar as further dimensions are action-guiding for the respective concepts, it is of course in the sense of completion that these are named and presented in the corresponding subchapters of the white paper. However, as a structural framework when considering examination scenarios for digital higher education, the following four fields can be used as an overarching basis: legal aspects, technology, pedagogy and organisation (cf. Figure 3).

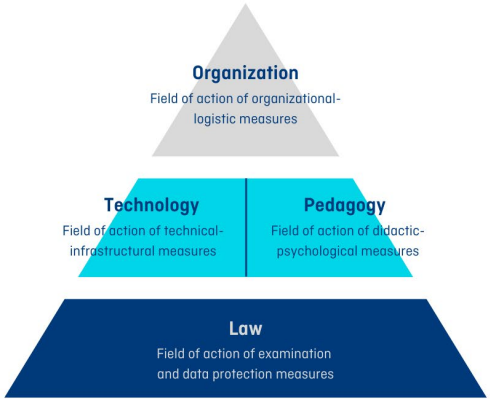

Figure 3: Four fields of activity of digital assessments

Characteristic of all fields is that activities within them can be implemented with varying ease and that they are interdependent. The implementation of digital assessments therefore takes place in an interplay of measures in all of them.

For example, summative digital examinations (also referred to as "e-examinations", cf. Schulz & Apostolopoulos, 2010, p. 27 ff.) are subject to special legal requirements (e.g. principle of equal treatment, specific normative basis), as summative examinations aim at the certificatory measurement of the learning level and have an impact on the freedom of career choice.

This legal starting position results in significantly higher requirements for the measures to be implemented in the technical field of activity (technical stability and security of the examination software), in the pedagogic field of activity (e.g. validity and reliability of the question items) and in the organisational-logistical field of activity (e.g. supervision of the examination candidates). Formative examinations, on the other hand, do not have any specific legal requirements because, as snapshots accompanying the learning process, they are aimed at determining the current state of learning and, as a side effect, are intended to improve "long-term retention" (cf. Roediger and Karpicke, 2006). Based on the legal requirement, the didactics for summative examinations therefore also

concern measures to be implemented, which, for example, ensure a valid construction of question items and thus also aspects such as "test wiseness" (cf. Millman et al., 1965); familiarity with the format of the question items alone can lead to better performance.

Measures can be taken directly in all fields of activity. However, the fields differ significantly in the speed at which measures can be implemented within them. Legal measures (e.g. changes to study and examination regulations) can be implemented quicker than logistical and organisational measures (e.g. the addition of further premises for conducting examinations). Similarly, technical measures (e.g. increasing server capacities) can be implemented quicker than legal measures, but slower than organisational-logistical measures (e.g. dividing the cohort into sub-cohorts that are examined one after the other). Due to the different speed of implementation of measures, it may be advisable to find out to what extent requirements from one field of activity can be met by converting them into measures from another field of activity.

2.2.1 Legal Aspects– Field of activity of legal measures

This field of activity includes requirements, conditions and measures that affect all legal aspects of digital assessments. This may include:

- Examination law requirements, conditions and measures – these concern the equal opportunities of examination candidates
- Data protection legal requirements, conditions and measures – these concern the scope and duration of the data to be processed or stored
- Legal requirements, conditions and measures affecting the assembly or gathering of people – ordinances regulating assemblies (e.g. regulations on places of assembly and hygiene).

Legal assessments differ significantly in some cases within the DACH region. For example, the legal classification of examinations in Switzerland and Germany currently differs significantly on the point of whether electronic examinations can be regarded as a variant of written examinations. In Germany, the current legal opinion is that a normative basis for "electronic examinations" is required (cf. Niehues et al., 2014, p. 13). Furthermore, education policy in Germany falls under the sovereignty of the federal states. These and the HEIs located there regulate legal aspects quite differently. In Austria, the legal basis for distance testing at the beginning of the Corona pandemic was the "COVID-19-Universitäts- und Hochschulverordnung" (COVID-19-HEIs and Higher Education Ordinance) (BGBl. (Federal Law Gazette) II No. 171/2020)[11], which was issued by the Austrian Federal Ministry of Education, Science and Research in April 2020. On the basis of the ordinances issued by the Ministry, the HEIs developed rules on how distance learning examinations are to be implemented. As of autumn 2021, the Austrian HEI Act 2002 (BGBl. I No. 120/2002) will be amended in such a way that online examinations at a distance will continue to be possible.

Another requirement is data protection. For the digital distance examination concepts implemented at many HEIs as part of the Corona pandemic (remote examinations), for example, more extensive data protection aspects must be considered than for digital

[11] European Legislation Identifier: https://www.ris.bka.gv.at/eli/bgbl/II/2020/171/20200422

face-to-face examinations. For digital distance examinations, therefore, either measures must be taken to create the legal basis for distance supervision (e.g. Bavarian Distance Examination Ordinance[12] or the new paragraph 32a on online examinations in the Baden-Württemberg State Higher Education Act[13]) or other measures (e.g. oral follow-up examinations for randomly selected examination candidates) taken to ensure the identity of the examinees and the legal reliability and validity of the examination. On the one hand, legal requirements may well limit the possibilities of measures in the psychological-didactic field of activity. For example, regulations for negative points are currently not legally permissible in Germany, although teachers sometimes consider them to be didactically helpful. On the other hand, changing didactic requirements – such as the need for location-independent examinations – may lead to a further development of the legal framework.

2.2.2 Technology – Field of activity of technical-infrastructural measures

This field of activity includes measures, requirements and conditions that affect the technologies used and the technical infrastructure used in digital examinations. These can include (cf. Schulz, 2017):

- Measures for the technical implementation of didactic requirements
- Measures for the technical implementation of legal requirements, e.g. technical stability and security of examination platforms and examination software
- Measures for the technical-infrastructural implementation of scalable digital examinations (e.g. technical infrastructure for examination centres, PC pools, decentralised implementation of examinations in departments or for distance examinations)
- Technical-infrastructural framework conditions (e.g. lack of PC pools)

In the technical-infrastructural field of activity, legal requirements (e.g. objective limitation of the examination time in the examination software for all examination candidates) and psychological-didactic requirements (e.g. random selection of equivalent question items in the examination software) are typically mapped in digital examination scenarios. For legal requirements that cannot be implemented technically or infrastructurally, further measures may be taken in the organisational field of activity (e.g. greater distance between candidates' seats when examining long essay questions).

It is also conceivable that, for technical and infrastructural reasons, not all candidates can be examined at the same time at the HEI (e.g. because the rooms are too small or there are too few supervising staff). If the examinees can only be examined in succession in sub-cohorts, the legal requirement of equal opportunities must be taken into account, which then ensures the reliability and validity of the examination by means of psychological-didactic measures, so that both sub-cohorts have to solve different questions with the same content but nevertheless with the same difficulty.

[12] https://www.gesetze-bayern.de/Content/Document/BayFEV/true
[13] https://mwk.baden-wuerttemberg.de/de/hochschulen-studium/hochschulpolitik/landeshochschulgesetz/

2.2.3 Pedagogy– Field of activity of didactic-psychological measures

This field of activity includes didactic-psychological requirements, measures and conditions concerning (digital) examinations. In a broader understanding of examination didactics, all measures can be located in this field of activity which, for example, focus on validity, reliability, a comprehensible design (e.g. taking into account the split attention effect) of summative examinations or a learning-friendly design of formative examinations (cf. Chapter 3).

Micro-level psychological-didactic interventions may include:

- Measures for the implementation of concepts that concern the didactic function of the goal of the examination, e.g. as a diagnostic, as a formative or as a summative instrument (cf. Crisp, 2007, p. 39 ff.)
- Measures for the implementation of concepts that precisely interlock examination content with teaching/learning objectives, e.g. in summative examinations (e.g. constructive alignment, cf. Biggs & Tang, 2011, p. 191 ff.)
- Measures to implement concepts that focus on improving learning and improve "long-term retention", e.g. formative examinations as "assessment for learning" (cf. Roediger & Karpicke, 2006)
- Measures to implement approaches that focus on improving learning and enhance "long-term retention," e.g. formative assessments as "Assessment for Learning" (Rösler, 2012, p. 255 ff.)
- Measures to implement concepts that reduce exam stress and anxiety, e.g. through transparent communication of exam procedures or provision of sample exams (cf. Schuster, 2017, p. 167 ff.)
- Measures to implement concepts relating to the quality assurance of examinations, e.g. to ensure the equivalence of examination questions in several versions of the examination as a preventive measure against cheating attempts (cf. Impara & Foster, 2006) or by considering test wiseness (Millman et al., 1965)
- Measures to implement concepts that improve grading

The didactic-psychological measures, requirements and conditions of digital examinations can be limited or made possible by legal, technical-infrastructural or organisational-logistical conditions.

2.2.4 Organisation – Field of activity of organisational-logistical measures

This field of activity focuses on the organisational-logistical measures, requirements and conditions of digital assessments. The logistics aspect is aimed at the scalability of digital examination concepts. The organisational measures refer to the processes that are implemented for digital examinations at universities.

In this field of activity, the following aspects, among others, can be considered:

- Measures for the implementation of concepts for the administrative organisation and planning of digital examinations (e.g. central control by an administrative institution or decentralised organisation by teachers themselves)
- Measures for the implementation of concepts for the performance of digital inspections (e.g. description of processes which ensure the safety of performance, description of procedures in the event of accidents, descriptions of hygiene concepts)
- Measures for the implementation of concepts for services for digital examinations (e.g. scope and type of services provided)
- Organisational framework conditions (e.g. concepts for the use of available personnel).

The organisational-logistical field of activity is determined on the one hand by the requirements of the HEIs (e.g. availability of room capacities for digital face-to-face examinations, personnel capacities for supporting distance examinations), but are also subject to certain legal requirements (e.g. upper limits of persons per room for face-to-face examinations). The organisational-logistical field of activity can also include measures to implement legal or psychological-didactic requirements that cannot be implemented in the technical-infrastructural field of activity. For example, personnel must be made available in order to take into account the legal requirement of the principle of equal treatment in those cases where, due to a lack of technical equipment, persons have to take part in digital examinations not at a distance but in a room at the HEI.

2.2.5 Conclusion – Fields of activity of digital assessments

Chapter 2.2 describes a proposal for structuring digital assessments. Since this white paper aims to provide concrete guidance for action, four interlinked fields of activity are described in which measures can be taken to implement digital assessments. The four fields include the legal, the technical-infrastructural, the didactic-psychological and the organisational-logistical fields of activity. It is important to note that measures in the individual fields can be implemented at different speeds. Changes and extensions to the legal conditions (e.g. changes to examination regulations) in the context of digital examinations are possible and desirable in principle, but usually take a long time. Technical-infrastructural conditions (e.g. setting up PC pools or expanding server capacities) or didactic-psychological requirements (e.g. designing and setting up extensive question catalogues) are also time-consuming, so these conditions and requirements from these fields may be translated as measures in the area of the organisational-logistical field of activity (e.g. conducting examinations in several sub-cohorts one after the other if the technical-infrastructural capacities are insufficient). Requirements and conditions from one field of activity can therefore also be implemented as measures in another field of activity if measures cannot be taken directly in the respective fields of activity. All fields are mutually interrelated and interdependent. Digital assessments are therefore usually implemented as an interplay of measures from all fields of activity.

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3 Assessment pedagogy

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3.1 Introduction – Perspectives on assessment pedagogy

Research on assessment results in scientific findings on didactics and didactic principles based on these findings are potential triggers and signposts for innovative developments in the field of assessments, which in turn trigger innovations of a technical, legal, organisational and curricular nature. Through digitalisation, the pedagogical spectrum for assessment is expanding. Changes in information and communication technology, the altered availability of knowledge, digital tools and working environments as well as the digitally mediated organisation of team performances contribute to a transformation of competence requirements in a "digital condition" (Stalder, 2016).[14] This change opens up the opportunity to fundamentally reflect on assessment in the context of higher education teaching.

We begin with a consideration of the different levels in higher education pedagogy, where relevant decisions are made with regard to assessments. Then, we discuss central "Gestalt dimensions" of assessments. We argue that digitalisation broadens opportunities for pedagogy but brings along major challenges as well. Assessment pedagogy in the context of digital higher education is thus neither limited to purely digital forms nor to specific scenarios, but is understood as a transversal issue for all assessment scenarios. The aim of this chapter is to use the Gestalt dimensions to highlight opportunities so that HEI teachers and support staff designers can make an informed, reflective decision about their assessment and its place within a curriculum.

3.2 Levels in higher education didactics with an impact on assessments

Pedagogy as the coupling of teaching and learning also includes the design of assessments. The core of didactics in the sense of "teaching as design" (Goodyear, 2015) focuses on the micro level of the teaching-learning process and thus on the design, implementation, updating and reflection of teaching in the form of materialised, social and epistemic environments. For a long time, however, there has been a plea for taking into consideration the dependencies of pedagogy on the micro level with decisions and conditions on further levels: even in 1975, Flechsig (1975) distinguished five levels of action (learning situations, courses, study modules, study programmes, framework conditions) and pointed out their mutual influences, which were not sufficiently taken into account. The demand for a connection of these levels runs through the discussion of higher education pedagogy (e.g. Merkt et. al., 2016; Wildt et al., 2013). Brahm, Jenert and Euler (2016) argue similarly and delineate three levels of pedagogical design: level of learning environments, level of study programmes, level of organisation. Both

[14] The changing competence requirements are expressed, for example, in systematisations such as the The Digital Competence Framework for Citizens (Carretero, Vuorikari & Punie, 2017).

propositions together can be well combined into an understanding of micro level (learning situations, courses, learning environments), meso level (modules, study programmes, curricula) and macro level (framework conditions of various kinds). Other authors have identified further influencing factors that can be located at macro level, such as political frameworks, changing understandings of competences or the qualification framework for German higher education degrees (Reis, 2014; Schaper et al., 2012; Szczyrba & van Treeck, 2018; Wick, 2011).

From the perspective of higher education pedagogy, the design of assessment must consider all three levels accordingly. Such a postulate expands the groups of people who play a role in assessment design (cf. Figure 4).

Figure 4: Levels and roles of those involved in assessment design

Design decisions at macro and meso level either enable or restrict decisions at micro level:

- **Macro level**. Any assessment design must take into account legal, technical and organisational framework conditions (cf. Chapter 2.2). Assessments with legal consequences are subject to federal and state laws in Germany, which can have a highly restrictive effect (e.g. with regards to the social roles and interactions in the context of assessments). Assessments that are technology-based are, for example, dependent on the technical infrastructure (and its logic) of a higher education institution or are required to take the students' equipment into account. However, infrastructure and administration on campus can also be conducive or obstructive for different assessment variants. Those who want to change assessment cultures must therefore also practice assessment design at macro level.

  On the macro level, university leadership/management and stakeholders from the policy sector contribute.

- **Meso level**. Structures and dynamics of study programmes are an important anchor of assessment design. The number of modules in a degree programme, their scope, how flexibly or sequentially they can be studied, how many (un)graded examinations have to be taken, which types of examinations are provided in the curriculum – all these factors influence the design of

examinations at micro level. Assessment design is therefore always also a task associated with the development, improvement or reform of study programmes.

On the meso level, university lecturers serving in programme committees and administrative staff are involved.

- **Micro level**. For HEI lecturers, the design of examinations is usually an integral element of didactics. Ideally, HEI lecturers align their courses as well as formative and final assessments to the learning goals they want to achieve together with the students. Concepts such as constructive alignment have rightly become widespread (cf. Chapter 3.4.1). However, the principle is still all too often disregarded in the design of teaching-learning arrangements, implemented mechanically, or is merely postulated without actually being realised (Loughlin et al., 2021). How freely and creatively teachers can design their examinations depends both on the decisions made at meso and macro level and on their own experience, knowledge and skills, as well as on intrinsic restrictions and design options of different assessment types.

  On the micro level, lecturers responsible for the examinations of their courses play a role.

Taking these levels into account suggests the need for a distinction between examination types at macro level to offer a manageable number of generic forms of examination and, at micro level, to support lecturers/teachers in creating pedagogically sound examination scenarios and in sharing them with one another (cf. Chapter 2.1).

3.3 Changes in the conditions for knowledge

In order to participate in societal development in an increasingly technologically permeated world, learners must be able to deal with these mechanisms in a competent, responsible and critical way. HEIs are responsible for considering the digital condition (Stalder, 2016) in learning, teaching and testing.

Stalder (2016) describes the digital condition with the three characteristics of communality, referentiality and algorithmicality, which can be applied to assessment contexts: communality raises the question of the extent to which traditional assessment scenarios, with their prohibition of communication and collaboration, are suitable for preparing students for the central competence requirements of today's working and living environments. Referentiality refers to changed and, above all, accelerated production conditions of knowledge, in which negotiation processes take place less exclusively and also in a broader public sphere, which has so far all too often not been reflected in the assessment context. Algorithmicality illustrates the autonomy of a digital medium, independent of the participants. It has a kind of perspective of its own, for example, when different users are provided with specific search results and views – a feature, yet rarely considered for digital assessments.

The digital condition requires reflection on the concept of knowledge and competence as well as on the conditions and objectives of assessments.

In this context, the concept of transfer of learning (Barnett & Ceci, 2002; Bransford & Schwartz, 1999; Goldstone & Day, 2012) is of central importance. It emphasises that assessments should require more than merely a successful reproduction of what students have learnt, but rather a demonstration of successful application as "knowledge in use" (e.g. Pellegrino, 2018): HEIs ultimately intend to prepare students for competent action in new contexts "in the world" beyond textbooks and HEI curricula. Meaningful assessment of learning objectives therefore depends on confronting students with novel tasks of varying degrees of unfamiliarity. Transfer tasks in assessments should therefore relate to specific problems students are familiar with from course activities, but deviate from them to a greater or lesser extent in essential aspects such as the problem statement, task context, available resources, etc. The greater the deviation from familiar problems, the greater the required transfer of learning – often referred to as "near" versus "far" transfer – the greater the task difficulty, and more time is usually required for students to solve the task.

The digital condition and the concept of transfer point to the necessary changes in assessment culture. Specialist knowledge, social competencies, problem-solving skills, analytical and reflective skills as well as the use of disciplinary digital tools can only be measured to a limited extent in traditional paper-based formats with a fixed horizon of expectations (Halbherr et al., 2016). Instead, they require suitable alternative task formats and assessment environments and invite critical pedagogical reflection of learning objectives, assessments and the decisions that build upon them.

3.4 Guidelines for good practice assessment

With the constructive alignment and the SAMR model, two applied heuristics for assessment design are presented, which make the interconnectedness of the pedagogical levels clear and help to take them into account. Here, we explain how the quality of an assessment can be assessed on the basis of its validity and assessment-driven learning.

3.4.1 Learning Outcomes, activities, assessment tasks – constructive alignment

The constructive alignment (CA) of a course – or at module level in the case of modularised study programmes – postulates the consistent alignment of learning objectives (or intended learning outcomes), teaching and learning activities and assessment methods, initially at micro level. The CA starts the teaching-learning process from its objectives and aligns assessment with these. The teaching-learning activities are then planned and derived from the objectives (Biggs & Tang, 2011). In the course of CA, teachers make it transparent to learners what the learning objectives are and how they can be achieved. The design of the assessment determines the teaching and learning scenarios that enable learners to train and practice the necessary skills to achieve the learning objectives. A course designed using CA should promote deep and sustained student learning (Wang et al., 2013). This requires a meaningful and aligned choice of learning objectives, teaching/learning activities and assessments. Planning according to this model should have an impact on student learning strategies and learning outcomes and should – at least according to its proponents – lead to high-quality teaching (Biggs, 2014; Hailikari et al., 2021; Larkin & Richardson, 2013).

Such coordination processes are integrated into larger contexts and the culture of a HEI (e.g. teaching reforms, quality management) (Biggs, 2014). Biggs & Tang (2011) appropriately consider general, HEI-wide graduate profiles (macro-level), which are linked to the profiles of the degree programmes (meso-level) and the outcomes of the courses (micro-level).

3.4.2 Use of digital technologies in assessment scenarios – The SAMR model

The SAMR model (cf. Figure 5) represents a simple heuristic for teachers to weigh up the use of digital technologies in the design of learning and assessment scenarios (Puentedura, 2006). Four levels of the use of technical aids are distinguished:

1. **Substitution**. Analogue teaching materials or assessment questions are replaced by digital equivalents. For example, a paper-based assessment with multiple-choice questions is converted into an electronic examination with the same types of questions. In doing so, some benefits such as efficiency gains (e.g. automatic item statistics) for the teaching-learning process can be realised.
2. **Augmentation**. Digital tools with their respective functional scope are integrated into teaching, learning and assessment scenarios. For example, the change from drafting an essay on paper to creating a text on the computer is accompanied by a transformation from a largely linear way of working to a non-linear process. In contrast to handwritten essays, in the electronic environment, text passages can be sketched more easily according to keywords, elaborated more flexibly and restructured straightforwardly.
3. **Modification**. Digital technologies are becoming an integral component of teaching, learning and assessment scenarios. This is the case, for example, when assignments explicitly require the use of digital research, data collection, evaluation or visualisation programs. The communicative and social possibilities of digital technologies can also be used, e.g. in the form of collaboration tools, to meet the characteristics of the digital condition, such as communality.
4. **Redefinition**. Teaching, learning and assessment scenarios are designed in a way that would not be practically possible without digital technologies. Assessments can, for example, involve the production of digital artefacts, simulations or VR/AR elements, as well as making it possible to enter programming code in a runnable environment by using third-party applications (cf. Chapter 5.2). In this way, authentic, competence-oriented assessment scenarios can be developed which would be more difficult or impossible to present in purely analogue contexts. Regarding the requirements of the digital condition, the redefinition level opens up access to the characteristic of algorithmicality, for example.

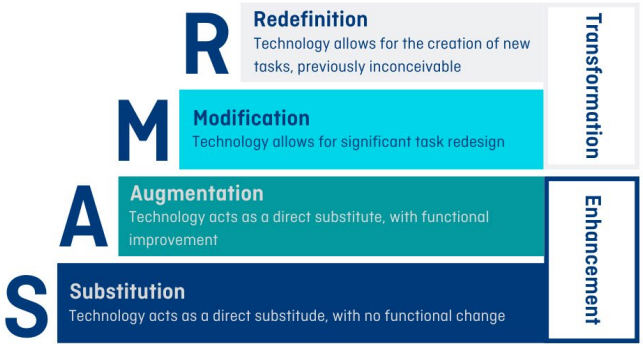

Figure 5: The SAMR model

3.4.3 Quality criteria

The quality criterion of validity refers to the extent to which a measurement method actually measures what it claims to measure (Messick, 1990; Ruch, 1924). In terms of assessments, validity means the extent to which a performance evaluation enables a meaningful assessment of the extent to which the learning objective has been achieved. Usually, validity represents the central quality criterion of any assessment. Concerns such as fairness or equality can be regarded as subsets of validity. Necessary yet insufficient prerequisites for validity are reliability (reliable reproducibility of performance evaluations) and objectivity (independence of performance evaluations from circumstances and persons involved). Validity is usually a compromise: estimation or evaluation errors can be reduced, but never completely avoided.

The quality criterion of assessment-driven learning refers to the purpose of all educational activities at a higher education institution: students should become competent (in the subject-specific and cross-disciplinary sense) and assessments should contribute to this objective. Formative assessment or an "assessment for learning" prioritise the goal of assessment-driven learning (Baird et al., 2017). However, highly selective, summative assessments with legal consequences influence student learning and are therefore often referred to as the "hidden curriculum" (Baird, 2013; Halbherr, 2020; Sambell & McDowell, 1998). It is therefore recommended that, in addition to validity, the assessment-driven learning aspect of examinations should also be taken into account as a matter of principle. For example, psychology students will prepare differently for a statistics exam if they know that they will then have to statistically analyse real empirical data sets on a computer and interpret the results. Such changes in exam conditions have significant repercussions for students' exam-preparatory learning (Halbherr, 2020), altering teaching/learning activities throughout the semester.

3.5 Objectives and design features of assessments

3.5.1 Objectives of assessments

The discussion on the objectives of assessment in higher education is not new (Flechsig, 1976; Huber & Reinmann, 2019; Reis & Ruschin, 2008). The function that an assessment should fulfil regarding a specific teaching-learning arrangement, the programme in which it is embedded and the individual must be clarified in order to make informed decisions at various levels of higher education pedagogy (Section 2). The determination of assessment objectives is also central in the discussion about the necessity of assessments with legal consequences (Reinmann, 2012), since the main concern in legal terms is "to determine as accurately as possible the true knowledge and skills of the examinee in order to provide the basis for an accurate assessment" (Niehues, Fischer & Jeremias, 2018, para. 127; trans. the authors).

Pedagogical objectives of assessments in a narrower sense

With regard to pedagogy, assessments (ideally) have a performance-diagnostic and learning-enhancing function. They implicitly set learning goals and exert a strong qualitative, as well as quantitative, influence on student learning (Baird et al., 2017; Sambell & McDowell, 1998). In this function, assessments have the potential to contribute to good or better learning. However, assessments that are not conducive to learning can also severely disrupt the learning outcomes that are actually intended. Assessments provide important information on the current learning status for students and teachers, offer transparent learning incentives and define binding objectives for the learning process (Wiliam, 2011).

On the one hand, self-tests, quizzes, exercises or tasks accompanying the course, which are designed in the sense of a formative learning evaluation, can contribute to a dynamisation of learning content and structuring of learning processes. Summative module assessments, on the other hand, are seen more as necessary "quality benchmarks" that connect modules within a study structure. They can thus help to create a content-based structure of meaning for the learners over the entire course of study. It is crucial that actions are connected with content and build upon each other, as well as the possibility for the learners to control their own knowledge and competence development.

Last but not least, assessments can contribute to the improvement of teaching scenarios if the constructive alignment of a course is consistently taken into account (cf. Chapter 3.4.1). The use of digital media and the potential of digitalisation can be useful here, with reference to the SAMR model, in order to enable the development of subject-specific competencies and the so-called Future Skills (Stifterverband, 2020) or to implement performance-based assessment scenarios – such as live coding in computer science.

Socio-political functions of assessments

Assessments are extensively interconnected with the education system and socio-political developments, which must always be taken into account in the planning and

design of assessments at macro, meso and micro level. Beyond the HEI context, assessments serve as proof of competence for external parties. In the sense of the recruitment function, assessments locate the candidates to be tested in a cohort (placement into and selection from). Qualifications and grades determine the distribution of career and life opportunities as well as resources (Reis & Ruschin, 2008).

With this in mind, assessments fulfil a function of power and socialisation by contributing to the reproduction of social relations and power structures (Bourdieu & Passeron, 1971). However, they can promote social mobility in the sense of meritocratic principles. Last but not least, assessments fulfil a legitimising function: HEIs can distinguish themselves from other institutions via assessments, and individuals receive certification and access to limited professional or further educational opportunities via degrees.

3.5.2 Design features of assessments

Digitalisation opens up potential for the design of higher education assessments at micro level. In this section, we explain the selected characteristics of time, space, product, interactions and social roles, following an instructive heuristic (ELAN e.V., 2014; Raue, n.d.), that we adopted and expanded (cf. Figure 6).

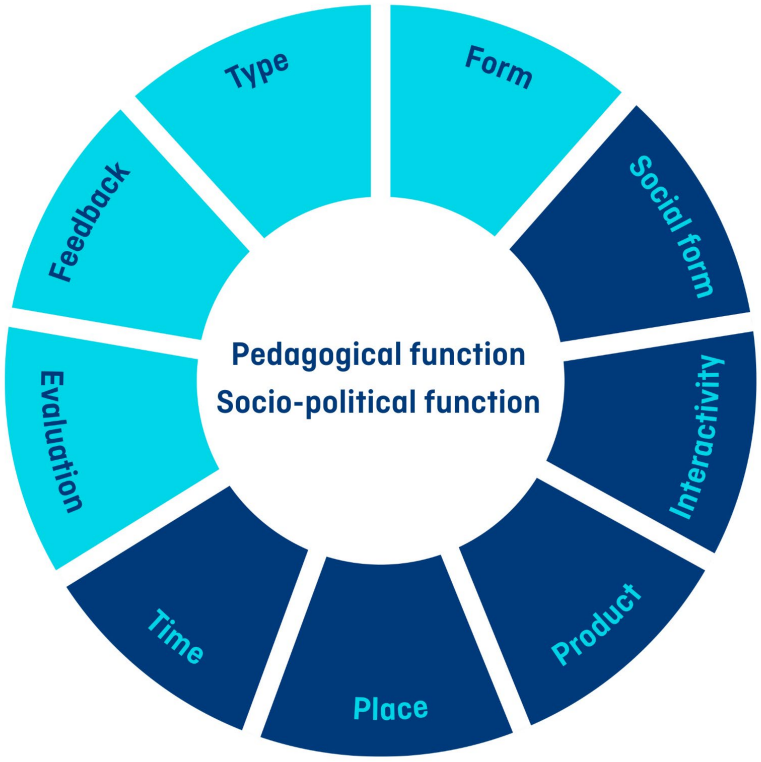

Figure 6: Design Characteristics of Testing (own model, based on ELAN e.V., 2014 and Raue, o.J.)

Time

With regard to the dimension of time of assessments, new potentials for on-site, digital or hybrid scenarios emerge. First of all, assessments can be set at multiple points of time during the course of the semester (formative) or just once, either at the end of the course (summative) or at the beginning (diagnostic). In addition, the frequency of assessments can be adjusted (once or several times).

Another aspect of the time dimension relates to the predefined duration or time span of assessments in which a task is to be solved or an objective has to be achieved. Tight time limits can be set, for example, for electronic or analogue assessments, but wider time corridors can also be defined (Horn & Schmees, 2020). In the case of take-home assessments(cf. Chapter 5.5), for example, the examinees can freely choose the starting time within a given time frame.

In addition, the temporal dimension can be made more flexible by using asynchronous as well as synchronous assessment scenarios, so that the social interaction between examinees and examiners takes place either simultaneously or subsequently (Horn & Schmees, 2020, p. 6). In the case of oral and many practical assessments, for example, teachers are in direct communication with the students throughout the entire assessing period. In contrast, essays and term papers are designed in such a way that students only receive feedback at certain points in time or only after submitting the written work. Formative examination scenarios, which include asynchronously offered, iterative exercises, self-tests and quizzes, can be completed by learners independently in terms of time.

Finally, the complexity of assessment tasks is related to the duration. Therefore, the timing and iteration of assessment scenarios must take into account the teaching-learning objectives in their complexity (Chapter 3.4.1; cf. also the taxonomy of learning objectives according to Reis, 2021). The cognitive learning goal level "application" can be assessed, for example, in the form of a so-called "serious game" (i.e. games that primarily pursue an educational purpose, Michael & Chen, 2006), a business game or a case study which can be carried out during the semester. For an explicit assessment on the level of “knowledge”, a summative assessment like a written exam is more suitable (Stieler, 2011).

Space

The concept of space is undergoing fundamental change. Teaching, learning and examination spaces are emerging on campus, in students' homes or in hybrid settings. In addition, digital technologies are enabling entirely new spaces for collaboration.

Digital teaching and learning formats provide learners with a higher degree of temporal and spatial flexibility in the processing of tasks, especially through asynchronously provided content, tasks and interaction possibilities (Bridgland & Blanchard, 2001). So far, this flexibility has hardly been used – instead, it has even been explicitly restricted in the design of examinations: if digital assessments take place under supervision, for example, in order to ensure students' individual performance, the spatial and temporal flexibility is usually limited. In addition, the implementation of digital assessment requires (significantly) more infrastructure than conventional paper and pencil

assessments, such as stable Internet access, available hardware and software. This applies to both assessments that are conducted digitally on-site as well as those that are conducted digitally remotely (cf. Chapters 5.2 and 5.5). The situation is different for written assessments without direct supervision or with fewer time constraints, which open up a spatio-temporal corridor for learners (cf. Chapter 5.5). Digital assessments move along a continuum between complete spatial fixation and extreme flexibilisation. The latter can be realised with assessment scenarios that evaluate performance in a formative way – such as e-portfolios (cf. Chapter 5.7) – or those that demand students' own products.

Product

The products created for the purpose of assessments are – along with the process – the main instrument for assessing learners' performance. The more standardised the design of assessments, the easier it is, for example, to derive more objective evaluations, to use procedures for automated assessment or to form grades. In this way, however, standardised questions and the resulting products primarily serve efficiency requirements and accommodate institutional conditions (time-economical processing of assessment and evaluation). It deserves critical reflection that the products of such assessment scenarios are not necessarily more valid, i.e. they do not capture or evaluate what they are supposed to (cf. Chapter 3.4.3). Constructive alignment becomes even more important here if we think of it in terms of assessment. While for some learning objectives the use of closed questions is suitable, this is not the case for others. Due to the anticipatory nature of some learning objectives, it cannot be clearly determined whether sustainable learning processes have taken place, if closed tasks with predetermined expectations are employed.

In contrast, products of open assessment formats are first and foremost an expression of the learning process and the possible acquisition of competences. In some disciplines (e.g. engineering, mathematics or design), artefacts of authentic activities can also function as assessment products. Their role as a documentation of the assessment, visible to teachers, is secondary. At the same time, implementing assessments with more open products can be understood as an expression of orientation towards assessment-driven learning for the student learning process. However, questions of validity and objectivity arise here as well (cf. Chapter 3.4.3).

Digitality is not a necessary prerequisite for open assessments and corresponding products, but it promotes an opportunity for the assessment culture. That is, the possibilities of information and communication technology and media make it easier to document learning processes of very different kinds and at the same time make them accessible to teachers. For example, an e-portfolio with multimedia learning products (e.g. videos, mind maps, texts, illustrations) can document both creative skills and digital skills to a much greater extent than the form of an assignment or a written exam. In the same way, graphic modelling or the creation of 3D or VR models can be used to demonstrate that someone has grasped the subject matter in its depth much better, as opposed to a conventional written or oral examination without the integration of digital resources. This is another positive aspect of a changed assessment culture, because time spent on performance evaluation is then also experienced by the teachers as being more interesting and meaningful (Jopp, 2020).

Interactions

Digital assessment environments allow the design of complex interaction spaces, where students work on authentic tasks using authentic disciplinary digital resources. This promises advantages regarding both validity and assessment-driven learning (cf. Chapter 4.1.3).

Students prepare differently for assessments that require complex, interactive problem-solving than for assessments that focus on the mere reproduction of knowledge: rote memorisation of content is deemphasised in favour of practising complex problem-solving, which in turn fosters deep and sustained learning (Halbherr, 2020). Authentic interactive examination environments are consistent with more recent models of cognition and learning, such as embodiment (Pfeifer & Bongard, 2007; Shapiro, 2011), situated or distributed cognition (Clark, 2011; Lave & Wenger, 1991), which reject the notion of our thinking and problem-solving as constrained to our cranium but instead conceive them as emergent from the dynamic interaction between individuals as cognitive agents and the socio-technical environment with which they interact (Mislevy, 2018; Vygotskiĭ & Cole, 1978). From this perspective, when a mathematician solves a mathematical problem with pen and paper, the problem-solving cognitive unit is not constituted by the mathematician's brain alone, but instead by the entire system constituted by the mathematician's brain-body as well as the pen and paper with which the mathematician is interacting. Consequently, valid, competence-oriented assessment requires interaction spaces that authentically replicate how problems are solved in professional practice (Halbherr, 2020; Halbherr et al., 2019, Chapters 5.2, 5.5 and 5.7).

Such complex interactive tasks can be combined with all varieties of established response formats. Most frequently, a product (e.g. CAD model, program code) is submitted for assessment. However, the combination of interactive tasks with essay, short answer or multiple-choice response formats is also possible: students analyse an interactive climate model in an essay, enter calculated statistical parameters in short answer tasks, document solution approaches or answer multiple-choice questions on the medical history of a simulated patient. Technological architectures for assessments with third-party applications (see Chapter 5.2) are a flexible solution for conducting assessments with authentic professional interaction spaces.

Social roles

As such, higher education provides for the participation of all groups of any status and formulates the superordinate goal of teaching to enable students to act responsibly and democratically (cf. legislation on the institutions of higher education of the German federal states). Students bring their own objectives into the HEI and are at the same time the target group that trains competences and applies them in non-HEI fields.

Relevant factors for academic success are identification with the course, self-efficacy and academic integration (Schubarth et al., 2018); therefore, a partnership between lecturers and students is highly important. Whilst this is often practised in courses and students are required to work cooperatively and independently, assessments are usually planned by lecturers alone and taken by students individually. In the sense of constructive alignment (cf. Chapter 3.4.1), this does not initially represent a

contradiction. Following a participatory approach, it is possible, for example, to include forms of peer quizzing (StudentQuiz, etc.) at the level of assessment design[15], to incorporate collaborative formats such as project work or group presentations at the level of assessment formats and to integrate forms of peer feedback and the joint definition of assessment criteria at the level of evaluation. Social learning and learning in communities (Horn & Schmees, 2020) can thus be taken into account for the examination in addition to the teaching-learning context.

3.6 Conclusion

From the point of view of assessment pedagogies, the decisive factor for digital assessments is first and foremost the suitability of the design of assessment and teaching/learning objectives. This means that a large variety of assessment forms and scenarios are necessary in order to be able to adequately map the increasing number of subject-specific and transversal learning objectives. The design of assessment scenarios can sometimes place high demands on teachers, which also goes hand in hand with new demands on students. This is even more applicable to digital scenarios. It is essential to know how and for which goal digital technology potential should be used: technology is not an end in itself, but should rather support teaching, learning and testing in the best possible way from a pedagogical point of view.

For the different scenarios, the teacher qualification for assessment design increases in importance. On the one hand, this includes qualification that creates the framework for pedagogical reflections and discussions. On the other hand, the qualification portfolio also includes training courses that prepare teachers, for example, for the use of specific assessment software, in the use of third-party applications in secure assessment environments and in the correct handling of technical problems during an assessment in accordance with the corresponding legislation. The learning objectives remain the focus of all pedagogical and digital developments: assessments should evaluate in the best possible way whether and to what extent teaching and learning objectives have been achieved.

Depending on the objective, in some cases a "traditional" design of assessment types such as written (written exam, term paper) or oral assessment may be appropriate. In other contexts, further development of the design of these basic types as well as their supplementation may be required. At meso level, this also explicitly includes questions of course development. Therefore, the systematisations and considerations are therefore explicitly directed not only at those teachers who are continuously developing their teaching and examination design, but to all teachers – and beyond that, also to the stakeholders – who act at the meso and macro levels of higher education pedagogy.

The main aspects of the further development of digital teaching, learning and assessment scenarios are, in addition to openness to creativity, the further development of legal framework conditions and the creation of transparency with regard to different assessment requirements. Dealing with requirements does not only imply raising awareness in teachers regarding the design dimensions of assessment in an HEI teaching characterised by digitality and involving them actively and constructively.

[15] https://moodle.org/plugins/mod_studentquiz

Students – as central stakeholders in HEI assessments – are also faced with the necessity to deal with these new possibilities and to position themselves in relation to them. This includes both the preparation for (digital) assessments, for example, by using other learning strategies and collaborative work, as well as (on the part of the institution) ensuring the infrastructure and access to it for learning. Last but not least, there is a need to be aware that changes and possible breaks in existing (assessment) practices can be accompanied by strains and reservations at different levels. It is a central task to consider them and to channel them productively into mutual support and co-creative processes. In doing so, the path is paved to rethink assessment in higher education.

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4 Technical and organisational framework conditions of digital examinations

Jannica Budde, Malte Persike

4.1 Introduction – Digital examination infrastructures

In order to conduct digital examinations, suitable personnel as well as a spatial, technical and organisational foundation is needed in the sense of a digital examination infrastructure. This chapter focuses primarily on technical and organisational issues of examinations and how digitalisation is changing or influencing the fields of action of technology and organisation (cf. Chapters 2.2.2 and 2.2.4).[16]

Digital examinations can be performed in a variety of different scenarios and settings. Different design features must be taken into account, not only from a pedagogical perspective (see Chapter 3). There are also certain design horizons to consider at a technical and organisational level.

Digital examinations are provided in oral, written or practical form. They can be differentiated, for example, by the aids permitted (cf. Chapters 5.2 and 5.5) or measures to prevent attempts at cheating, such as synchronous (digital) examination proctoring (cf. Chapter 5.4). Digital examinations can be taken in a dedicated e-examination system and/or with third-party software, including a simple video conferencing system as in the case of digital oral examinations. Hybrid processing with analogue and digital tools is also possible, for example, paper-based processing with a subsequent digital submission.

Digital examinations can be taken in any rooms of the HEI, in dedicated centres for digital examinations at the HEI or even in the student's home or any other non-HEI location. Often, devices provided by the HEI are used for this purpose. Bring-your-own-device (BYOD) scenarios are also possible.

4.2 Technical framework – E-examination systems

A wide variety of software systems can be used to conduct digital examinations. All established learning management systems (LMSs) such as Moodle or ILIAS provide corresponding functionalities for various task formats. However, digital examinations do not necessarily require such dedicated platforms. Third-party applications such as

[16] For reasons of complexity reduction, legal framework conditions are not analysed in depth in this chapter. Due to its high degree of uncertainty in the area of digital examinations, the field of law requires conscientious reflection from a legal perspective, which will be pursued in a well-founded manner in separate publications and discussion formats.

development environments from the field of statistics or programming (including Jupyter notebooks) are also suitable for conducting digital examinations.

However, as soon as it comes to the legally compliant taking of digital examinations in the sense of HEI examination law, e-examination systems are often used that are configured precisely for this purpose. Common LMSs are generally suitable as e-examination systems and are particularly attractive if they are used for both learning management and examination administration. The technical continuity between the learning and examination environment ensures efficient processes for teachers, students and the service institutions involved. However, LMSs "out-of-the-box" are usually not yet suitable as a basis for digital examinations and in some cases require extensive configuration changes to be able to be used for the regular implementation of digital examinations. This is different with proper e-examination systems.

E-examination systems generally integrate the preparation, execution, correction and routinely also the viewing of a digital examination in a single software system. As a rule, they provide several task formats. The quasi-standard includes the so-called closed tasks such as yes/no questions, multiple-choice questions and assignment tasks in which options must be assigned to one or more answer categories.

Furthermore, practically all established e-examination systems offer so-called semi-open task formats. These include closed tests and tasks for entering results. Open task formats include input options for longer texts and upload options for any file format. The Center for Teaching and Learning Services at RWTH Aachen University has compiled an overview of the most important commercial and non-commercial e-examination systems in use at German HEIs, together with the task formats they contain.[17]

E-examination systems must implement a range of technical and organisational measures that are required, amongst other things, by data protection, data security and examination law (cf. Persike, 2021). In addition, they must meet high standards in terms of quality-of-service criteria, such as availability and fail-safety, the absence of errors in functions and other aspects of quality of service. The core aspect here is the preservation of input data in the event of technical malfunctions, e.g. the failure of the network connection. Student solutions must be preserved and their delivery must be ensured.

4.3 Technical and organisational measures to prevent deception

An important point at the interface between technical and organisational framework conditions is the securing of in-house services. The aim here is to grant equal opportunities. Corresponding measures are optional and depend on the legal framework and requirements of the respective HEI. E-examination systems can provide support in this respect, for example, through options such as the randomisation of tasks or the parameterisation of task content. However, e-examination systems should also provide interfaces for online proctoring systems and/or offer additional tools to prevent cheating, such as a lockdown browser during the examination.

[17] https://t1p.de/lcb0

4.3.1 (Synchronous) invigilation / proctoring

The supervision of examinations and the associated establishment of identity in digital examinations in on-site settings is no different from non-digital face-to-face examinations (cf. Forgo et al., 2016). For digital remote examinations, the chapter on online proctored examinations (Chapter 5.4) explains the possibilities and limits of (synchronous) proctoring.

4.3.2 Restriction of utilities and lockdown browser

Using special browser applications, such as the open source software Safe Exam Browser[18], access to selected online resources, programs and system functions can be restricted or prevented. A detailed description of how to restrict the tools can be found in Chapter 5.2.

4.3.3 Declarations of originality or honour and plagiarism checks

This is a legal assurance that the work has been prepared by the student or only with the help of the listed aids. The declaration of originality is used, in particular, for project or seminar papers and essay-like examination scenarios. The procedure is based on an actively demanded culture of good scientific practice.

While plagiarism detection software can sometimes provide information about undocumented third-party citations, third-party authoring can rarely be detected. Many universities threaten legal consequences if plagiarism is detected.

4.4 Lifecycle and assessment workflow with e-assessment systems

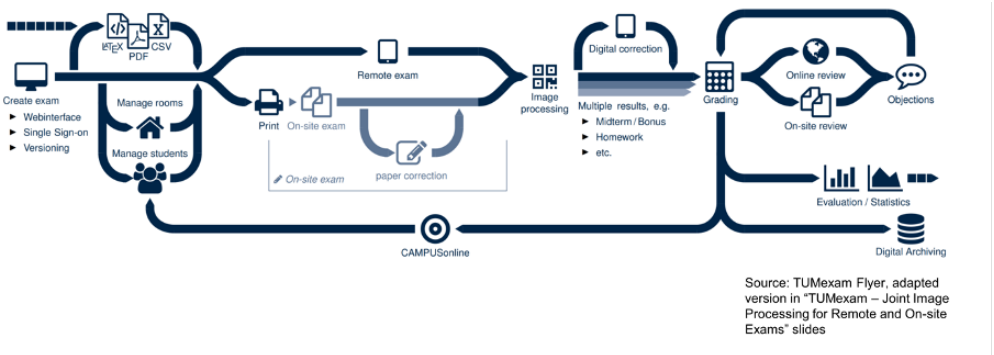

Figure 7: Schematic representation of an examination workflow (source: TUMexam)

Conducting a digital examination differs greatly from the traditional process of creating an examination. The individual process steps are described below using the example of an examination in an e-examination system.

[18] https://safeexambrowser.org/

4.4.1 Design of examination tasks

The design of a digital examination begins (1) with deciding on the type of question, which often has a different format than in the written, non-digital examination. Closed question types such as multiple-choice tasks are particularly popular, but new, interactive question formats are also possible in digital examinations. If the question and task format is changed, teaching (e.g. in tutorials) should also be adapted accordingly.

Once the nature of the questions has been determined, e-examination systems can assist in (2) designing the actual examination procedure, and in turn have different requirements for doing so. For example existing question pools can be used. If you develop your own questions, please note that for some types of questions, such as multiple choice, the solutions usually have to be stored directly in the system when the examination is created. These cannot be changed after the examination.

Rodriguez (2005) describes examination question writing as an art in itself: "Item writing has been, is, and always will be an art. However, sophisticated, technically oriented, and computer-generative techniques have been developed to assist the item writer." Good examination questions are usually the result of design and revision processes of varying complexity and effort.

4.4.2 Quality assurance

(3) Quality assurance must not only ensure that the correct competences are tested at the correct level with suitable questions, but must also ensure the correctness of the stored solution (including the aspect of possible different [number] formats). Furthermore, it must be checked that the digital examination procedure also functions technically. After this review process, the corresponding release of an examination question or the revision usually takes place.

After the examination, questions can be optimised via feedback from examinees in the course of correcting and grading examinations, for example, supported by learning analytics, and as part of general quality assurance of examination questions.

The scope of the technical examination also depends on whether the digital examination is carried out with computers provided by the university (e.g. PC pool) – i.e. in a controlled technical environment – or whether a BYOD approach is taken. For unsupervised (digital) remote examinations, in particular, a review should also be carried out with regard to the susceptibility of examination questions to cheating. For example, the answerability of an examination question via search engines on the Internet or using online course materials are relevant factors in this regard. The feasibility perspective is always crucial in all processes of generating, reviewing and optimising examination tasks, as the time resources are available to those involved is limited.

Depending on the subject complexity, scope, learning objective taxonomy level addressed (cf. Anderson et al., 2001) and the examiners' competence, experience shows that the creation of a new, good examination question requires at least 30 to 60 minutes. This estimate does not include the time for professional and technical review. If materials or media are required for an examination question, e.g. high-resolution images,

audio recordings or data sets, the creation, preparation and embedding of this content will take additional time.

Alongside quality assurance, a guide should be produced for examinees to familiarise themselves with the technical and other features of digital examination. After quality assurance, it is advisable to use the system together with students within the framework of a mock examination. In this way, typical user errors can be identified, ambiguities in the instructions can be uncovered and confidence in the examination environment can be built up among the students. In addition, higher system loads can be simulated if this could not be tested in advance in terms of IT technology.

4.4.3 Implementation, evaluation, inspection and archiving

For the actual (4) execution of the examination, a distinction must be made as to whether the digital examination is performed on-site or remotely. In the first case, it is comparable to a traditional exam. In the second case, a communication channel must be established that students can use for technical or subject-related questions.

The next step in the process (5), grading, is broadly similar to a traditional examination, only the way in which the examiner's comments are documented is significantly different. It must also be ensured that changes to the grading scheme, which may be necessary but are not technically supported by the e-examination system, are documented in a legally secure manner.

This is followed by (6) the viewing, which on the one hand depends on the technical possibilities. On the other hand, in addition to the legal claim, university culture often plays a certain role with regard to the implementation of the disclosure of examination tasks and sample solutions.

The process concludes (7) with the archiving of the assessment results. Here, questions of legally compliant storage, readability and timely resolution are important.

4.5 Conclusion

Digital examination infrastructures encompass both the technical and the organisational perspective on the subject of digital examinations. These relate to the entire workflow of an examination, from preparation to execution to archiving, and were discussed here using the example of e-examination systems in general. Specific aspects of the digital examination infrastructure are described in more detail for the individual examination scenarios.

At the level of individual examination design, there are differences to non-digital forms of examination, which are closely related to pedagogical questions (cf. Chapter 3). This particularly affects the creation of examination tasks, as digital examinations enable new types of questions. Quality assurance and review processes for examination tasks and procedures thus become more relevant.

Regardless of the scenario of a digital examination, the technical infrastructure must be designed in such a way as to ensure reliability and, at the same time, equal opportunities.

Digital examination infrastructures must therefore be provided at a central level and are therefore part of the strategic organisational development of HEIs.

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5 Digital examination practice – scenarios, perspectives, recommendations

5.1 Digital on-campus examinations

Malte Persike, Tobias Halbherr, Sven Slotosch, Christian Rößler, Julia Dohr

5.1.1 Introduction to the topic

If digital examinations are to be taken on campus under supervision, there are various ways to implement this. One possibility is the establishment of HEI examination pools. An examination pool can consist of a room with fixed computer workstations or a mobile pool that is set up in different rooms. Different HEI stakeholders need to be involved in the planning process. Meister and Oevel (2017) provide checklists for the initiation process and the involvement of different stakeholders.

So-called electronic testing systems and the e-tests that can be carried out on them are of particular relevance to on-site digital testing. Their common feature is that the distribution, execution and processing of the assessment must take place in the same information technology system. Only this last part distinguishes them from the more general definition of digital examination. Only when the student input in the context of an examination does not leave the e-examination system does the classification as an e-examination even come into question in terms of examination law (Niehues, Fischer & Jeremias, 2018). In practice, this means that only examinations that are carried out in a dedicated e-examination system are considered e-examinations in the sense of examination law.

In addition to technology, there are important aspects that need to be considered when planning the space and infrastructure (Piendl et al., 2014). For example, air conditioning, blackout and sanitary facilities are important factors to ensure a smooth process. The cost of an exam pool varies depending on the model. For example, Schulz (2017) compares the cost, effort and flexibility of different pools in a table. Here, the investment costs are higher for a fixed pool compared to a mobile solution. The source cites, for example, the construction and equipment of an e-assessment centre with 150 seats as a total cost of approximately 1.2 million euros. Servers and clients have to be renewed approximately every five years, which is estimated at 230,000 euros. The running personnel costs amount to about 200,000 euros per year. In the case of the mobile solution, the operating costs are estimated to be higher. There are different solutions at the HEIs. Some HEIs have fixed test centres, while others work with mobile pools.

Instead of setting up examination pools, various HEIs also use bring-your-own-device (BYOD) models, in which students bring the computer used for processing to the

examination. Basically, there are different ways to implement a BYOD approach in practice (Küppers & Schroeder, 2016). These differ predominantly in two aspects:

- What software is used on the end devices?
- How are the terminals connected?

With regard to the software used, the student terminals can either be used as workstations or as "thin clients". In the first case, applications required for the examination are run directly on the device, for example, an integrated programming environment in a programming exam. In some cases, even a pre-configured operating system is distributed to the students via USB stick. In the second case, the device is used to connect to a remote desktop server provided by the HEI.

Whether and how the student terminals are connected to a (wireless) network depends on the general conditions of the examination. Essentially, it has to be considered that a missing network connection reduces the possibility of cheating, but also prevents the uploading of answers to an exam server. Therefore, in practice, a special exam network is often used, which only allows a connection to an exam server. Alternatively, a completely unrestricted network can be used, but often in combination with technical restrictions, e.g. a lockdown browser. Intermediate forms of server- and client-side restrictions are also conceivable.

However, regardless of the details of a BYOD approach, there are also some issues that must always be considered (Küppers et al., 2016, 2018):

- Student responses must be protected from manipulation.
- It must be possible to clearly identify the originators of individual answers.
- Differences between the end devices of individual students should have no influence on success in an exam.
- The reliability of the entire test system must be guaranteed.

There are technical solutions for these points, such as the use of digital signatures to ensure the integrity of uploaded answers or the use of artificial intelligence to verify the author of individual exam answers. How these technical solutions can be integrated into a concrete BYOD scenario depends on the remaining parameters of the scenario and cannot be answered in general terms.

5.1.2 Opportunities and challenges

The opportunities and challenges of digital on-site examinations can be considered in comparison with traditional or analogue face-to-face examinations in particular, but also in comparison with electronic remote examinations. These are also discussed accordingly in the following chapters.

Digital On-site Exams	Opportunities	Challenges
Pedagogy	On-site digital examinations enable the design of a variety of examination scenarios, including those that are competence-based.	The adequate digital implementation of typical analogue examination tasks (e.g. making sketches, form input) is in part non-trivial. Students need to test the e-examination system and its functionalities if they are not familiar with it. For many lecturers, the switch to digital examinations is accompanied by an increased use of closed question types and a reduction or complete abandonment of open task formats.
Technology	When the entire examination infrastructure with corresponding e-examination systems is provided by the examination provider, there is complete standardisation and thus, as a rule, simplified maintainability. The on-campus examination supports possibilities for finding solutions to technical challenges during the testing.	Procurement, construction, operation and maintenance of the technical infrastructure may require additional ressources. Bring-your-own-device models lead to greatly increased complexity in service. Software errors may invalidate exams.
Legal aspects	Possibilities of deception control correspond to the analogous on-campus examination and are thus to be assumed as legally secure.	Measures must be taken to maintain data security and data integrity so that the history of student activity in an examination can be traced at any time and proven beyond doubt. Certain forms of digital examinations should be subject to enhanced procedural requirements (e.g. handling of guessing probability in multiple-choice examinations).
Organisation	The form of presentation of the examination is standardised and is thus carried out for all those involved in the examination in a manner that conforms to expectations and can be repeated in a standardised manner. Since lecturers must be accompanied by the service provider during digital on-site examinations, direct points of contact are created which enable an exchange and consultation between the HEI and the lecturers on questions of examination design and implementation of examinations.	Suitable premises and infrastructures are needed, e.g. they have to be booked in time or newly built. Support and service during an assessment are complex and require personnel with both technical and content knowledge. Digital examinations, as face-to-face examinations, can have limitations in stakeholder acceptance, especially at the beginning.

To date, with the significant increase in the number and widespread use of digital examinations throughout the Corona pandemic, questions about the didactic opportunities and challenges of digital forms of examination have also intensified. Competence-based tasks can increase the authenticity of exams and the close link to learning objectives can give rise to high-quality exams. Making examination participation more flexible in terms of location and time can increase the inclusivity or accessibility of examinations. At the same time, digital on-site examinations with standardised technical infrastructure and support enable equal opportunities for the examination situation. Concomitantly, however, its use also poses challenges, especially for the HEI. These include the costs of additional personnel and technical equipment, the time required to become familiar with the technology and for the creation of examinations, a certain dependence of the results on individual technical expertise, the need to ensure the integrity of the examination in a special technical way, data protection issues and the preservation of equal opportunities. For example, it should be ensured that the examination systems are known to the students and, if necessary, practised beforehand.

In many cases, opportunities and challenges are difficult to separate – the same feature of e-assessments attracts benefits and costs alike. The most important of these features are discussed in more detail below.

Standardisation

In particular, e-exams, as a subcategory of digital exams, lead to greater standardisation of exams and exam scenarios, especially when conducted on-site. The e-examination system specifies access routes, procedures and task formats. For all those involved in the examination process, and especially for the students, this creates greater transparency and reliability in the conduct of e-examinations. The use of tasks with automatic correction also increases the objectivity of evaluation since the determination of right or wrong is no longer tied to human judgement. The embedding in an overarching lifecycle also guarantees that not only the execution of the examination itself, but also the preceding and subsequent process steps are carried out in a standardised procedure.

However, standardisation can be dangerous. Innovations in task formats become more difficult because they first have to be implemented in the e-examination system. In addition, the range of task formats in the current e-examination systems is still limited and does not satisfactorily cover higher levels of competence, e.g. tasks such as drawing or sketching, the production of complex mathematical derivations, design tasks, the use of third-party applications such as programming environments or the production of work samples. There is a danger that teachers do not align their examinations with the requirements of competence assessment but with the available task formats, which leads to examinations that are not satisfactorily valid or conducive to learning. Here, continuous support from the service institution entrusted with the administration is indispensable. Teachers must be supported in the creation of e-exams, both technically and didactically, and be actively informed when new functions or task formats are introduced.

Enabling trouble-free communication during a digital assessment

During an examination, students want to be able to write calmly and concentrate, on the one hand, and, on the other hand, clarify comprehension questions when they arise for them. Most questions of understanding about organisational content can already be clarified before the examination, e.g. by adhering to a quality control procedure when developing examination questions (especially in the case of closed question formats), by offering practice tasks and mock examinations, and by providing information material on the structure of the examination and the examination systems. The examination statement itself should contain precise information on the desired level of detail of answers and indications of the expected format of the answer.

In such a prepared examination setting, there is actually no need for a communication channel during a digital examination. However, some HEIs always provide for the presence of a subject supervisor for the examination. Even in the case of face-to-face examinations, the invigilator is not so much there to supervise but to answer technical questions about the examination. However, the e-examination setting brings in the handling of technology as a new requirement. During the examination, students must be able to take the examination on their own terminal device (or one provided by the HEI) with as little interruption as possible and also to connect – at least occasionally – to the examination server. Whether this is possible depends on the individual hardware, software configuration and network bandwidth as well as, on the organisational side, the functioning of the examination system and server accessibility. Experience has shown that students increasingly request technical support during an e-examination; this applies to both on-site and distance examinations.

In the face-to-face setting, students give a signal and the subject supervisor goes to them and decides on a case-by-case basis which questions are to be answered. If many students have questions at the same time, perhaps because an examination question is worded in an ambiguous way or it is unclear what kind of answer is desired, then this brings unrest into a face-to-face examination. Students have to wait for their turn to ask their question and the invigilator rushes from one student to another to answer questions.

The variety of possibilities for organising communication around exams digitally represents a great opportunity for target-group and needs-specific testing. Even in face-to-face settings at the PC, the continuation of digitally supported communication can offer added value in examinations. In addition to general room invigilators, the presence of a single subject invigilator would suffice here. This invigilator would not even have to be present on site, as questions can also be answered remotely. Students could ask their questions individually via the approved media channels while everyone else works undisturbed on their exams.

Dynamic task formats

E-examination systems allow the dynamisation of examination content in two places. On the one hand, e-exams can be automatically assembled if a large pool of questions is available. This can happen either once per examination date or even within an examination date for all examinees, so that no examination consists of identical items. If historical solution data is available for the items, many e-testing systems can ensure

that the item difficulty is comparable during automatic composition. On the other hand, a so-called parameterisation of tasks can take place, which is of great interest especially in examinations in STEM subjects. A practical example (programmatically individualised examinations at the Zurich University of Applied Sciences) is given in Chapter 5.2. In a task, given numbers or whole data sets are no longer fixed due to parameterisation, but are randomly generated for each examinee based on given rules. The task text remains the same, but the numerical material to be processed varies randomly between the test items. Both variants are not without effort. The construction of large task pools, which cover as much of the content of the subject as possible, requires a considerable amount of time and a high level of expertise. In addition, continuous monitoring is required to detect problematic tasks and remove them from the pool. When parameterising numerical material, it must be ensured that random selection does not result in tasks of varying difficulty. One example from mathematics is borderline cases where the selection of certain numbers for a given task leads to particularly easy or difficult solutions.

Acceptance

The degree of acceptance among the stakeholders involved is of decisive importance for the sustainable establishment of digital examinations. The introduction of new forms of examination is often accompanied by scepticism, which can be didactic, technological, data protection-related or ethical. Technology acceptance research has produced a number of empirically well-validated models to explain the acceptance of new technologies when they are introduced, both among teachers (Kuikka, Kitola & Laakso, 2014) and students (Doukas & Andreatos, 2007). It is found that adoption is dependent on a variety of variables (Zheng & Bender, 2019) and, in particular, students who initially have low or negative expectations show a significant increase in their acceptance after using the electronic infrastructure (Looi et al., 2014). Accordingly, at institutions where digital examinations are already established and underpinned by a suitable examination infrastructure, a high level of acceptance is found among students and, in the majority, also among lecturers (Halbherr, 2020). These results suggest that the acceptance of the introduction of digital on-site examinations by both teachers and students cannot be increased by communicative formats and training courses alone, but also requires practical handling of the systems (cf. ibid.).

5.1.3 Examples from practice

5.1.3.1 Hybrid exams

Description	Hybrid exams – Quick-E-Scan as a scanning examination for the digitisation of analogue examination materials
HEI	RWTH Aachen University
Subject	For example, STEM subjects

Pedagogy	• Enabling the handwritten preparation of sketches, etc. oriented to the subject or teaching of sketches, calculations, etc., while at the same time using digital transmission and communication channels • Direct assignment of paper-based copies to digital tasks
Technology	• Scanning devices at all testing stations for continuous scanning • Quick-E-Scan as own development with Raspberry Pi as control unit • Devices themselves have no operating elements, control by e-testing system
Organisation	• Reduction of effort for staff by distributing the scanning process to all students • Efficient process of correction and examination viewing through digitisation of analogue examination materials
Link	https://www.youtube.com/watch?v=ud6bbpV4bEk

When carrying out digital assessments, there is an increasing need to combine an e-examination in the legal sense with alternative processing methods. In this case, both a dedicated e-examination system and other processing media are used within the same examination. This section deals with this form of hybrid examination. In practice, it mainly occurs in two variants: on the one hand is the combination of task processing in an e-examination system with the use of third-party applications. This variant is presented in detail in Chapter 5.2. On the other hand, the term hybrid examination is used to describe the combination of digital and analogue task processing on paper. This variant is examined in more detail below.

The combination of digital and analogue processing media within the same examination will remain indispensable in many subjects for years to come. In the technical and scientific disciplines in particular, there is still no equivalent alternative to paper for the rapid handwriting of technical sketches, mathematical drawings or arithmetic operations.[19] The bring-your-own-device "scan exams" used in many places during the pandemic have shown one way in which hybrid exams can be successfully implemented. In such scanned exams, students typically complete an exam on paper and then use a smartphone to generate scans of the exam sheets to hand in digitally. In this process, many teachers have found that digitising analogue exam materials in the form of photographed documents in this way can make the process of correcting and later reviewing exams highly efficient and without media disruptions.

For examinations in rooms of the university or examination centres, however, taking pictures of the exam paper with your own smartphone is not the best solution. Scanning the papers handed in after the exam also has its limits in hybrid exams, because hybrid exams require the direct linking of digital and analogue task parts. One example is examinations in STEM subjects, where only intermediate or final results of calculation processes are entered digitally in the e-examination system and then automatically

[19] Task plug-ins (e.g. Moodle freehand drawing question type at ETH Zurich) or third-party applications for the electronic capture of hand sketches require the use of digital input tablets. The operating behaviour differs significantly from paper-based transcription and needs to be practised before the performances using tablets are comparable to those using paper (e.g. Gerth et al., 2016a, 2016b).

corrected, while the elaboration necessary to generate the results takes place on paper. In the event of incorrect results in the e-examination system, the associated handwritten records can then be checked in order to award partial points if necessary. In these cases, it is essential that paper-based sketches and supplementary calculations are linked directly and immediately (as scans) to the corresponding digital tasks. Experience has shown that digitisation and allocation afterwards is not only unreliable, but causes a considerable amount of work for service staff and teachers.

Hybrid examinations therefore require students to digitise their papers themselves and to include them as a scan in the correct places in their e-examination. Such a workflow can only exist with scanning devices at all examination locations, with which the students themselves can scan their paperwork during the examination. The requirements for such scanning devices in the context of exam delivery are complex. They must be fast and noiseless, which usually implies the absence of moving parts. They must not take up too much floor space, as the available space at examination stations is usually limited. They must be robust and operable by students without any training. They must also integrate seamlessly into the e-examination system in use. They should also be low-cost, as they are installed at each exam station. Available systems for digitisation such as flatbed or document scanners do not meet these requirements.

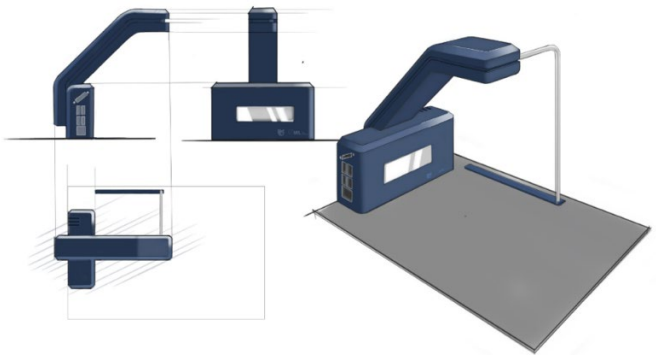

Figure 8: Quick-E-Scan for performing hybrid checks to easily turn handwritten copies into part of a digital task in a simple way

RWTH Aachen University has therefore developed "Quick-E-Scan", a low-cost system to enable students to scan handwritten papers during an exam in the simplest way possible (cf. Figure 8). The device operates on a footprint of about an A4 page with no moving parts and uses an 8 MP camera to scan documents. There are no controls on the device itself; all control is provided by the e-verification system. By using a Raspberry Pi as the control unit, it is possible to run web-based e-examination systems on the device. Monitor, keyboard and mouse are connected to Quick-E-Scan so that a dedicated exam PC can be omitted.

5.1.3.2 Room infrastructure for digital on-campus examinations at ETH Zurich

Description	Room infrastructure for digital on-campus examinations at ETH Zurich
HEI	ETH Zurich

Subject	All subjects
Pedagogy	• Analogous to traditional paper examinations, examinations with third-party applications, digital open-book and open-web examinations
Technology	• Safe Exam Browser, Moodle • Remote management client device
Organisation	• Use of computer labs • Temporary computer examination halls with desktop computers • Examinations with laptops or mobile devices in lecture halls or seminar rooms
Link	https://ethz.ch/staffnet/en/teaching/academic-support/performance-assessments/online-examinations/online-pruefungsraeume.html

Figure 9: Temporary computer examination hall with desktop computers at ETH Zurich for up to 240 students (Image: Alessandro Della Bella)

ETH Zurich has been offering digital on-campus examinations (referred to by ETH Zurich itself as "On-Campus Online Examinations"[20]) as a university-wide service since 2010 (Piendl et al., 2014). In addition to a Linux-based and a Windows-based environment for examinations with third-party applications (cf. 5.2.3.1 Examinations with virtual desktop infrastructure at ETH Zurich), ETH operates an environment based on Moodle and Safe Exam Browser[21] (SEB) for "conventional" e-examinations (Halbherr et al., 2014). In order to facilitate an efficient use of existing resources and a scalable Online Examinations service, ETH has developed three different operational concepts for service delivery to campus room infrastructure (1) using existing computer labs for digital examinations, (2) setting up large temporary examination rooms with desktop computers in flexible auditoria, makerspaces and other large, flat-floored rooms that are used for hands-on learning activities during the semester, and (3) operating large pools of mobile devices (Yoga laptops) with custom-built equipment carts for digital examinations in traditional lecture halls and seminar rooms.

Initially, ETH conducted its digital examinations in six existing student computer labs in the HEI main building, with a maximum capacity of 20 to 40 candidates per room.

[20] https://ethz.ch/staffnet/en/teaching/academic-support/performance-assessments/online-examinations.html
[21] https://safeexambrowser.org/news_de.html

Building on existing room infrastructure, this setup incurred only minimal additional costs, thereby contributing to comparatively economic development and piloting of the first digital examinations during an initial project phase until 2010. However, the capacity of the pre-existing computer labs soon no longer sufficed to keep up with the rapidly growing demand for digital examinations. Furthermore, examinations with larger candidate numbers had to be conducted across up to six different examination rooms and/or conducted in two directly subsequent cohorts – thereby effectively doubling the capacity of existing room infrastructure, but also incurring the need to ensure no contact between students from the different cohorts. These measures enabled the concurrent assessment of up to 160 students (up to 320 students in a two-cohort examination). However, these measures incur substantial logistical complications and organisational effort, both in terms of the number of personnel required and the complexity of organising and conducting the examination. Finally, increased use of the computer labs for examinations also led to increasing conflicts of use: the increasing number of digital examinations meant the computer labs were often occupied and therefore unavailable to students as computer labs, while at the same time, due to the very same digital examinations, the demand for use of the computer labs for study and examination preparation also increased.

In order to increase overall capacity and to be able to examine large groups of students more efficiently, a former drawing hall for engineering students in the ETH main building was put into operation as a large temporary digital examination room, starting in the autumn semester 2012. During the semester, the mechanical engineers use the hall as a makerspace; during the semester breaks, all furniture is replaced and a temporary digital examination hall is set up for the four-week examination sessions that take place twice a year. In order to ensure a standardised and therefore efficient service, both the technical setup of the client computers as well as the entire operational concept are identical to the computer lab wherever possible, with only minor modifications. With this new room, capacity for 160 additional concurrent users was created for the duration of the six-monthly examination sessions – overall room capacity was doubled. Large examinations could now be conducted more efficiently and more examinations conducted simultaneously. Moreover, economy-of-scale effects enabled a de facto growth in the number of examinations far exceeding a twofold increase. With a continued increase in demand, as of the autumn semester 2017, a second temporary examination room was brought into service in the same manner, with capacity for yet another 240 students (see Figure 9).

In order to increase the still very limited capacity for digital examinations during the semesters (and increase overall capacity further still) as well as to make campus room infrastructure usable for both digital examinations and teaching on an ad hoc (i.e. half-day or hourly) basis, a solution with Windows laptops as "mobile devices" was developed and put into regular service operation starting in the spring semester 2018. The examination computers are stored in custom-built equipment carts (cf. Figure 10). The carts connect the laptops to power and the network and enable remote management of the devices by IT services. The lecturers apply for and register their digital on-campus examination, are then given access to the storage room by means of their ETH card and can collect the carts from the storage room on their own. They then transport them to the designated lecture hall in which the examination will take place and distribute the examination laptops within the hall. The computers are prepared remotely by the service

managers and are already booted in an appropriate examination configuration. On the one hand, these "mobile examinations" enabled flexible access to lecture halls and seminar rooms as additional room infrastructure for digital examinations. On the other hand, this mobile setup has enabled further simplification of the process of conducting a digital examination for lecturers, thereby further reducing the need for on-site support.

Since the examination computers are not connected to the power supply during the examination and since they are connected to the network via WLAN instead of a physical LAN cable, this setup required some technical adjustments in order to remain sufficiently reliable against technical complications. Amongst other things, a WiFi resilience plug-in was developed for Moodle, which ensures that students can continue their examinations undisturbed even in case of temporary network failures. Furthermore, examinations with third-party applications cannot be offered in the mobile examination setup since both the relevant Linux-based and VDI-based architectures at ETH require reliably and permanently stable network connections. Conversely, the mobile devices are equipped with integrated digitiser pens, which, in combination with the Moodle "Freehand Drawing (ETH)" question type developed specifically for this purpose[22], enable the integration of digital hand sketches and drawings into the digital examinations. The examinations using mobile devices are currently available at the two main HEI campuses (Zentrum, Hönggerberg), with an overall capacity of up to 280 concurrent candidates across both locations.

Figure 10: Custom-built equipment carts

The three infrastructural pillars of computer labs, temporary computer examination rooms with desktop computers and examinations with mobile devices in seminar rooms and lecture halls have enabled ETH Zurich a timely and cost-effective scale-up of its on-campus online examinations service. Currently, more than 300 on-campus online examinations with approximately 30,000 individual tests taken are conducted annually in this infrastructure – with the majority of these taking place during the two annual four-week examination sessions. A modular service organisation, both in terms of service technology and accompanying organisational processes, facilitates the ongoing improvement and development of the service – both in terms of increased efficiency and pedagogic innovation. Measures that increase efficiency, such as the automation of processes or the training of lecturers to independently supervise on-campus online examinations, are usually first developed for the setup with Moodle and SEB on mobile devices and piloted here. If successful, these are gradually adopted for the other service setups (i.e. examinations with desktop computers in computer labs or temporary examination halls and/or examinations with third-party applications in the Linux or VDI architecture). Conversely, pedagogic innovations such as the design of novel authentic disciplinary examination environments are usually first prototyped and piloted with one of the setups for examinations with third-party applications. If there is sufficient demand, these

[22] https://moodle.org/plugins/qtype_drawing

examination environments can then be suitably standardised and the tested efficiency-enhancing processes from the mobile examinations (e.g. training courses) can gradually be adopted.

5.1.3.3 The bwLehrpool at the University of Freiburg

Description	Electronic testing with bwLehrpool
HEI	University of Freiburg
Subject	All subjects
Pedagogy	• E-exams of different competence levels can be implemented • E-examination scenarios ranging from simple knowledge queries (MC questions, free text questions, etc.) to programming tasks, etc.
Technology	• Networked architecture of the basic system for easy system management • bwLehrpool server (satellite server) – delivery of the basic Linux system, virtual environments and computer configuration. Rooms individually configurable, switchable to exam mode with advanced security. Security largely configurable by teaching staff (Internet or network access, autostart of a specific environment, authentication for testing via Auth-Server or LMS etc.) • bwLehrpool client computer – basic system via netboot, virtual environments via dnbd3, smb or nfs. Great flexibility and relief of the admin staff, as virtual environments can be created and configured by teachers • Various options for submitting exam results (from LMS to secure submission network drive, etc.)
Organisation	• The organisation of the e-examination is done by the teachers themselves • The Computer Center of the University of Freiburg provides technical support in the use of bwLehrpool or in the implementation on the e-examination server (ILIAS) • Examinations on-site in the teaching pools of the HEI, but also possible remotely
Link	https://www.bwlehrpool.de/wiki/doku.php https://www.lehre.uni-freiburg.de/notizblog-lehre/elektronisch-pruefen-mitbwlehrpool-praxisorientiert-und-multimedia

Starting in 2013, various scenarios of digital exams were tested at the University of Freiburg, and since 2016, these have regularly taken place in the existing pool rooms of the Computer Center and other institutions.[23] This is made possible by the use of bwLehrpool, a system for the flexible use of computer pools by means of desktop virtualisation. On the basis of operating systems booted via the network, it is possible to

[23] https://uni-freiburg.de/lehre/thema/notizblog-lehre/

work on the pool computers with any software environment equipped with pre-installed programs for teaching and examination purposes. Different working environments do not have to be pre-installed on the PCs and thus allow a multifunctional use of PCs and pool rooms for various teaching and learning scenarios as well as for electronic examinations. The exam mode allows further security measures, e.g. with regard to network access and the use of removable data carriers such as USB sticks. The changeover of the pool rooms to examination mode is controlled centrally via a web interface and takes only a few minutes. This allows the highly flexible use of existing PC pools for examinations even during the lecture period. Instead of going into off-peak hours, free time slots can be used efficiently. On the other hand, the rooms continue to be available for seminars and student use during exam periods.

After the "common pool and E-Exam center" with about 160 PC workstations was opened in April 2019, it was also possible to hold examinations with well over 100 participants. Currently, e-exams are mainly taken on about 320 computers in three buildings. In order to further expand these capacities, scenarios around the use of mobile supplementary pools and BYOD will be tested in the coming years by means of various projects (including the joint project PePP).

A separate ILIAS environment is used as an independent and specially secured examination server. It is advantageous here that students are also accustomed to dealing with the ILIAS software having used the central learning platform. By installing ILIAS as a separate examination server, the system becomes independent of the update and maintenance cycles of the teaching ILIAS. In combination with the bwLehrpool exam images with pre-installed Safe Exam Browser, this combination offers a very high security standard for the execution of exams.

With the systems used at the University of Freiburg, four different formats of electronic examinations are currently possible: e-examination, e-examination plus, VM examination as well as examination on an external server.

E-examination	E-examinsation plus	VM examination	Examination on external server
The "classic" e-exam is most similar to the paper exam. The examination is created and also carried out on the examination ILIAS. The examination computers in the pool rooms are connected to the server via bwLehrpool. access.	This form of examination is based on the "classic" e-examination. In addition, further software such as "R", Office and the like is activated and used. The examination ILIAS can be used for the submission of the processed tasks or tasks are combined with other question types on the examination platform.	In a VM-based e-exam, the virtual machine used for training can be used for testing without any special modifications. For example, for examinations on special software, GIS programs or for programming tasks. The exam is thus taken in the familiar learning and working environment.	In this form of examination, the computers are connected to an external server on which the examination takes place. Here, a bwLehrpool image with installed SEB serves as the basis for establishing a secure connection to the exam server and preventing access to other network resources.

In the course of the Corona pandemic, the concept, which had been established for years, also facilitated the HEI-wide offering of online examinations remotely, since a system was already available with the dedicated examination ILIAS on which online examinations could be taken without delay. By equipping the PC pools with bwLehrpool and thanks to a sophisticated hygiene concept, it was possible with little effort to offer hybrid scenarios in case individual examinees were unable or unwilling to take an online exam. These persons were offered a place in a PC pool where they could sit the exam at the same time as their fellow students. This also had the advantage for the lecturers that they did not have to design a second examination and arrange new dates for the on-campus examinations in person.

Selected literature

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5.2 Digital examinations with third-party applications

Tobias Halbherr, Florian Mosböck, Kristina Piecha, Josef Spillner, Manfred Meyer, Georg Braun, Kaja Hoffmann

5.2.1 Introduction

The increasing digitalisation of professional and academic practices (cf. also Chapter 3 "digital conditions") introduces a concurrent need to also adequately reflect digitally mediated disciplinary practices in examination settings. "Assessments with third-party applications" represent a powerful and flexible technological solution to this pedagogical concern.

In "conventional" computer-based examinations (CBE), the computer serves as a task delivery and task recording device. In examinations with third-party applications, the computer also serves as an authentic disciplinary working environment in its own right where students process the examination tasks. Psychology students, for example, may analyse empirical data sets in statistics software or computer science students may develop solutions to algorithmic problems in an integrated development environment. Examinations with third-party applications thus transcend the distinction between

"written" and "practical" examinations. In the remainder of this introduction, "examinations with third-party applications" will be discussed as a complex concept from a pragmatic, learning sciences as well as a technical-organisational point of view. Opportunities and challenges are then discussed from a pedagogical, legal, technical as well as organisational perspective. This is followed by a presentation of implementation examples. The chapter concludes with a collection of concrete recommendations for the development, implementation and rollout of examinations with third-party applications at HEIs.

5.2.1.1 The pragmatic view – The computer as a disciplinary working environment

From a practical point of view, examinations with third-party applications offer a direct and obvious way to enable authentic examination practices in digitally mediated disciplines. Improved authenticity, in turn, ensures alignment between intended learning outcomes, assessments and learning activities in the sense of constructive alignment or the SAMR model (cf. Chapter 3.4.2; Crisp et al., 2016; Bennett, 2015). The focus therefore lies in bringing technologically mediated disciplinary working environments into a secure examination context as directly and authentically as possible and to leave paper-based work behind where it has become an anachronism. As illustrated in Figure 11, examinations with third-party applications fill a gap in the examination portfolio. As we will discuss in more detail, they combine a high level of control in ensuring students' academic integrity while sitting an examination with authentic disciplinary tasks and working environments. In other words, examinations with third-party applications enable assessment (technologically mediated) competencies in the context of high-stakes invigilated "written" examinations that could previously only be tested by means of largely non invigilated work such as theses or projects.

The concept of authentic examinations is central to this perspective (Gulikers et al., 2004; Halbherr et al., 2016; Wiggins, 1990). It postulates that an "authentic" (sic) alignment of examinations with associated disciplinary practices and learning activities will on the one hand ensure assessment validity and the acceptability of examinations and, on the other, will furthermore have beneficial effects on students' assessment-driven learning. Specifically, this perspective offers clear indications for where we may expect improvements in examination pedagogy from digitisation –- and where we may not. For example, in some areas of mathematics – such as calculus – paper and pencil still constitute the tools of the trade. Accordingly, when following the idea of authentic assessment, such examinations should remain paper-based.

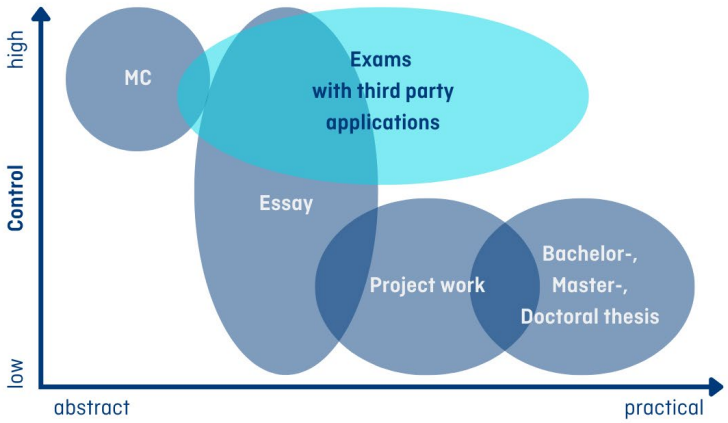

Figure 11: Classification of examinations with third-party applications (schematic representation). Due to the digitalisation of academic and professional practice, authentic, practice-oriented examinations that ensure student performance ("control") are no longer possible with conventional examination formats. Examinations with third-party applications can help to close this gap.

5.2.1.2 Cognitive and learning sciences perspective

The cognitive and the learning sciences provide additional arguments in support of assessment with third-party applications. Conventional perspectives regard human cognition as emergent upon activity internal to the human agent, more specifically, activity in the human brain. More recent perspectives such as embodiment, situated or extended cognition extend this view and argue for the embodied human agent *in conjunction* with the socio-technical environment with which they situationally interact during a cognitive activity (e.g. when problem-solving) as the relevant system upon which corresponding cognitive phenomena are emergent (see Chapter 3; Clark, 2011; Lave & Wenger, 1991). This can be illustrated by the example of mathematics. In the conventional view, the mathematical formulae that a mathematician puts down on paper while problem-solving merely represent physical correlates of fundamentally internal cognitive processes. In the extended view of cognition, however, the mathematical formulae form a constitutive part of the very cognitive process that underlies the problem-solving. In other words, the cognitive system that produces and sustains the mathematical thought process does not consist of the mathematician alone, but of the whole system consisting of mathematician, paper and pencil.[24] In this example we are therefore looking at a technologically mediated competence[25], and it follows that a valid competence assessment would depend on paper and pencil being available to the mathematician when problem-solving in the assessment. This core argument can now be easily applied to any technologically, socially or otherwise mediated cognitive activity (Halbherr, 2020; Mislevy, 2018): writing a text, statistically analysing a psychological study, discussing empirical research in a group, forming an opinion on a political issue through web research, programming an algorithm, etc. In other words, in this context it is a fundamental property of human thinking that always unfolds from a concrete situational context, whereby the whole is more than the sum of

[24] The validity of this argument can be seen, for example, in the fact that without access to paper and pencil, the mathematician is no longer able to successfully solve similarly complex mathematical problems as the system as a whole.
[25] Paper and pencil are the mediating technology.

its parts – that is, the situational context constitutes a co-constitutive element of the human thinking processes themselves. According to this argument, granting candidates access to authentic disciplinary resources is a universal necessity in examination design and not only limited to professional licensure examinations, for example.

5.2.1.3 Technical and organisational perspective

From the technical and organisational point of view, we are interested in the technical infrastructure as well as the accompanying service provisions – notably the organisational processes and the people that coordinate them – required for the successful integration of third-party applications into the electronic examination environment, while maintaining the desired legal (e.g. ensuring academic integrity), pedagogical, methodological (e.g. no impairment of student performances by technical complications) and organisational (e.g. costs) boundary conditions.

Examinations with third-party applications therefore constitute a conceptually simple, operationally challenging and highly flexible technical solution to an important pedagogical concern: complex and practice-oriented assessments by means of granting students access to authentic disciplinary tools such as specialist software, datasets and/or web-based resources. Most technical setups for secure and fraud-proof examinations with third-party applications also support the operation of secure and fraud-proof open-book examinations.

5.2.2 Opportunities and challenges

The challenges with regard to examinations with third-party applications are primarily of a technical and organisational nature and, where applicable, of a legal or regulatory nature. Opportunities and advantages are to be found in particular in a more complex and authentic assessment practice with improvements in validity and assessment-driven learning.

Opportunities and challenges are first presented in the following table as an overview and then differentiated in more detail below.

Third-party Applications	Opportunities	Challenges
Pedagogy	Complex, authentic disciplinary tasks, improved validity, improved assessment-driven learning	Scoring frequently more complex, more time-consuming assessment tasks and examinations therefore take longer
Technology	Integration of existing specialist software ensures high flexibility in design	Security, stability, complexity
Legal aspects	Ensures effective safeguards against ghostwriting and other forms of academic misconduct in complex and authentic disciplinary settings	Existing regulations can make implementation difficult or impossible

Organisation	Sustainability of digital pedagogical innovations often hinges on appropriate implementation in examinations also	Cost, complexity, risk management, testing and incident handling

5.2.2.1 Pedagogy

As a basic requirement, third-party applications used in examinations must have a meaningful relationship with the learning objectives and all students must have the opportunity to practice with the third-party applications before the examination. Accordingly, third-party applications to which students have no or only limited access are not suitable for such an examination setting.

The integration of third-party applications enables the design of competence-oriented tasks, which are closer to academic, professional and specialist practice than e.g. classic knowledge-oriented or essay-type tasks. The use of real-world problems increases the degree of authenticity of the examination (Gielen, Dochy & Dierick, 2003). The often-prevailing discrepancy between the intended depth of understanding formulated in learning objectives and a much shallower depth of (rote) learning required to succeed in a respective examination can be reduced substantially by incorporating third-party applications. The use of authentic disciplinary tasks can also have a positive effect on students' motivation to learn, as they perceive such examinations as more meaningful and relevant due to the better alignment with practice (Gulikers, Bastiaens & Kirschner, 2004). In particular, they provide students with incentives in a transparent way to prepare for the examination by means of appropriate authentic disciplinary learning activities and to engage more deeply with the learning objectives through concrete practice and problem-solving (Halbherr, 2020). To the same extent, they reduce the incentive to prepare through superficial, "bulimic" rote memorisation, as such strategies promise little success. Even in the case of non-application-bound disciplinary practices, authenticity and practice-orientation can often be better established by means of third-party applications than that which is possible in paper-based or conventional computer-based examinations by using suitable third-party applications for e.g. interactive simulations of subject practices (e.g. virtual herbarium, virtual patient).

Through improved alignment and authenticity, examinations with third-party applications also promise substantial benefits in terms of the valid assessment of students' achievement of learning objectives (Halbherr, 2020; Halbherr et al., 2019). Moreover, from the perspective of extended models of human cognition, this is not merely a desirable, but rather a mandatory prerequisite for valid competence assessments. Conversely, tasks that have to be processed in third-party applications are usually time-consuming and complex. Accordingly, a combination of technologically mediated and "conventional" non-technologically mediated examination tasks can be quite sensible and recommendable, whereby the former focus on assessing the achievement of learning objectives in their depth and the latter on assessing the achievement of learning objectives in their breadth.

By creating authenticity and closeness to professional practice, examinations with third-party applications make it easier for lecturers to design high-quality examinations. In particular, the expertise of the examiners in their subject areas can be brought to bear in

the design and evaluation of examination tasks in a more direct way than would be the case in paper-based or conventional computer-based examinations, which are often comparatively abstract and somewhat removed from actual practice. For example, in a computer science examination in which programming is actually carried out, it is not only easier to formulate authentic and subject-relevant tasks, but their assessment is also generally possible in a way that is closer to the subject.

5.2.2.2 Regulations and legal aspects

From a legal and regulatory point of view, it is important to ensure that students take their examinations independently and without unauthorised aids.

Technical and organisational as well as pedagogic measures can contribute to this. In particular, it is advisable to combine several complementary measures. In the case of unsupervised take-home examinations, these issues – in particular, the problem of ensuring students' own performance – are dealt with in detail in the chapters on open-book and take-home examinations and on online invigilation.

If it is to be adequately ensured that students' own contributions are submitted, the assessment should be carried out as an on-site assessment under supervision and with appropriate technical safeguards. In particular, the use of communication channels must be effectively prevented in order to effectively prevent ghostwriting and/or the exchange of solutions or approaches. There are a number of technical (e.g. lockdown browsers), organisational (e.g. examination supervision), pedagogical (e.g. individual parameterisation of examination tasks) and analytical approaches (e.g. downstream forensic analysis). In particular, a combination of several of these approaches is recommended in order to reduce the temptation and probability of success of dishonest behaviour.

The use of third-party applications creates additional opportunities for dishonest behaviour compared to other digital on-site examinations (cf. Chapter 5.1). In some applications, for example, the Internet can be accessed through an integrated web browser. In addition, system resources can often be accessed and/or other unintended applications started by means of the third-party application; unauthorised files can be stored on the computer or the third-party applications can be used as a communication channel to third parties. Unauthorised access to programs or networks can be prevented by a lockdown browser or controlled and monitored by special assessment desktop interfaces. In addition, the third-party applications themselves, as well as the operating system, can be configured according to the assessment specifications. In this context, the use of virtual machines for assessments with third-party applications has proven its worth. For example, only those programs that are actually required for the test can be installed on these virtual machines. In addition, they can be configured as desired without having to change the settings of the local computers. In contrast, securing third-party applications in BYOD scenarios is particularly demanding (or even impossible), depending on the software used, which is why the use of virtual test computers is particularly worthwhile here. There is basically no fail-safe protection against fraud attempts. A reasonable benchmark for the protection of exam computers is "conventional" fraud attempts: if dishonest behaviour by means of a mobile phone or a classic cheat sheet is clearly more likely to succeed than dishonest behaviour by circumventing the secured examination environment, the latter may be regarded as

expediently secure. Concrete implementations as well as further literature on securing exams with third-party applications are presented in the practical examples below.

In addition to the technical measures, suitable invigilation is therefore absolutely essential to ensure that students abide by academic honesty. As with conventional paper-based examinations, the use of communication channels outside the actual examination computers, such as mobile phones, paper messages exchanged under the table or the simple reading of solutions from the computer screen of other candidates, must also be prevented. In addition, the invigilator needs to verify the identity of the students present and the name under which they submit their work. Figure 12 schematically illustrates different communication options in examinations with third-party applications. Communication possibilities in the physical examination room are prevented by examination invigilators, while communication possibilities in the "virtual" examination room on the examination computers are secured by suitable technical measures. Both third-party applications and operating systems usually contain functionalities that enable intranet or Internet access. Technical protection can be implemented at application, operating system, LMS and/or network level.

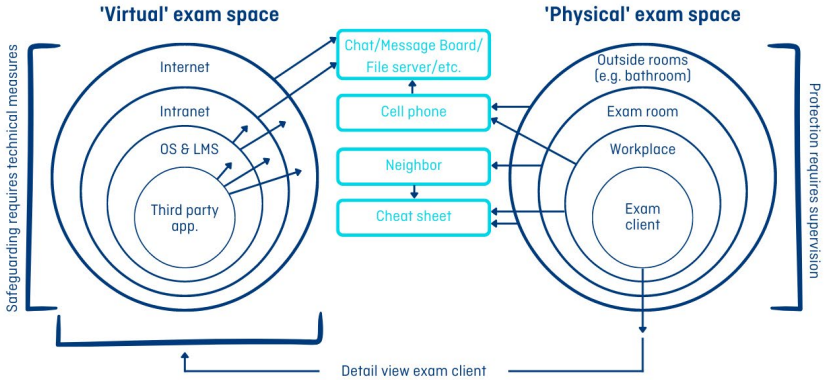

Figure 12: Communication options in examinations with third-party applications

Taking measures to prevent cheating attempts is possible, for instance by varying how tasks (assignments) are structured, or by offering tasks with different possible solutions. However, it takes more time and effort to develop exams in this way. For example, in a statistics examination, the raw data of a dataset to be evaluated can be varied in such a way that the statistical parameters to be calculated differ between the candidates (e.g. different decimal places in correlations) without the associated statistical findings differing from each other (cf. also parameterisation options in Chapter 5.5).

5.2.2.3 Technology

An important issue for all scenarios of examinations with third-party applications is to ensure robust and reliable assessment environments that enable students to work on their examination tasks unimpaired by any technical complications. Examinations with third-party applications bring with them an inherently high level of technical complexity and, as a result, an increased probability of technical complications. These must be

addressed through appropriate technical architectures, testing, support and incident handling processes.[26]

With digital examinations, there is always a risk of technical problems. The more complex the setup used (e.g. use of programming software with access to system-related functions), the higher the risk of severe technical complications during an examination. In order to enable a fair, robust and scalable examination practice with third-party applications, this frequency of complications must be effectively reduced to near zero. This requires supplementary measures in the form of technical and organisational redundancies as well as standardisation, and also clearly defined update and test processes as well as precise process flows for the procedure in the event of a technical problem. The provision of a suitable technical infrastructure for tests with third-party applications alone is not sufficient. During the examinations, technical personnel must be available on site or on call in order to react to any problems that may arise. Minor or well-known complications can also be solved directly by trained invigilators.

Conversely, the approach of testing with third-party applications provides a flexible and efficient method of providing complex, authentic, disciplinary assessment environments. Once the challenge of setting up a reliable and suitably secure basic infrastructure has been mastered, almost any third-party application or combination of third-party applications can be easily integrated into the exam or examination setting.

5.2.2.4 Logistics and organisation

An important success factor for examinations with third-party applications is the creation of suitable organisational conditions. Operating a service for examinations with third-party applications is significantly more complex and demanding in terms of technology and support than for "conventional" computer-based examinations. In addition to purely monetary aspects, it should be noted that the operation of corresponding technical services requires considerable know-how, which usually has to be built up internally first.

In addition to the costs for skilled personnel and technical infrastructure, there are also organisational and reputational risks, which are based on the demanding task of ensuring that the examinations are carried out in a fraud-proof and fail-safe manner. It should be noted that the risk of an examination being cancelled, e.g. due to technical complications, can never be excluded in principle, but can only be minimised. However, it should be noted that, for example, even conventional paper-based examinations are never conducted without residual risks (examination papers are lost, no light in the examination room due to a power failure, etc.). Apart from this, regulatory or legal hurdles can make it even more difficult to conduct examinations with third-party applications. All in all, these aspects can contribute to the fact that examinations with third-party applications are not carried out and the digitalisation gap in examination practice is not closed.

In contrast, however, there are a growing number of HEIs that are successfully mastering this technological change and demonstrating that the aforementioned obstacles can be overcome. The provision of a limited number of standardised examination setups in

[26] i.e. processes for effective and timely handling of technical complications, e.g. during an ongoing test.

place of custom-designed individual examination setups can help to reduce the support, testing and administrative effort, but also the risk of technical complications. Examiners can choose from a variety of pre-built configurations, but customisation is not possible, which is why not every test setting can be covered. On the other hand, individual, custom-designed setups enable a detailed implementation of the desired examination scenarios, but the required support and administration effort is greater. Examiners must be closely accompanied during the process of finding the appropriate scenario and the custom-built setups must be tested individually.

Examinations with third-party applications during the Corona pandemic were a particular challenge. At many HEIs, on-campus examination operations were not possible, which meant that these exams were also administered remotely in online settings. One problem here is access to the required programs for students. In addition to the required licences, the third-party applications have certain system requirements that cannot be met by every student's computer. There is also the issue of equal opportunity. Students' computers may vary in size and speed, giving some students an advantage and others a disadvantage for the examinations. This problem can be addressed, for example, by having a backup pool of on-demand loan devices. Another solution is the use of virtual machines on which the required software is installed. For this, students only need to install the appropriate view client software to be able to connect to the virtual machine. Other solutions establish a remote connection to a HEI-owned machine in a lockdown browser, which is then used to assess in the third-party application. The creation of such settings continued to allow competence-oriented examinations to be administered using third-party applications during the Corona pandemic. Nevertheless, in all of these cases the question remains as to how far technical interventions on student computers can go.

5.2.3 Examples from practice

5.2.3.1 Examinations with virtual desktop infrastructure and Safe Exam Browser at ETH Zurich

Description	Exams with virtual desktop infrastructure, Safe Exam Browser and Moodle
HEI	ETH Zurich
Subject	All subjects
Pedagogy	• In principle, any third-party application can be integrated into the environment (e.g. R-Studio, Matlab, NX, Eclipse, Jupyter notebooks, etc.) • Secure open-book examinations with a PDF reader or secure open-web examinations with whitelisted access to defined websites • Ability to integrate any third-party applications ensures maximum flexibility in pedagogical design

Technology	• Examination environment based on virtual desktop infrastructure (VDI), • Safe Exam Browser (SEB) and Moodle • Strong safeguards against technical failures (redundant server architectures) as well as against dishonest behaviour • Flexible engineering and secure examination environments through infrastructure based on SEB, VDI and Moodle
Organisation	• Examinations take place on campus in regular computer labs or dedicated examination halls of the HEI under the supervision of lecturers • Physical and virtual workstations for examinations with over 800 students • Technical first-level, on-call, on-site support during the examinations • Second-level on-call support available radio • Standardised support processes for handling technical incidents
Link	https://ethz.ch/services/de/lehre/lehrbetrieb/leistungskontrollen/online-pruefungen.html

Since 2012, ETH Zurich has been operating a service for on-campus online examinations with third-party applications, which is based on a virtual desktop infrastructure (VDI), Safe Exam Browser (SEB)[27] and Moodle. Halbherr et al. (2014, 2016) and Piendl et al. (2014) discuss pedagogical and organisational aspects of this setup, while Lüthi et al. (2019) and Reuter & Halbherr (2015) provide a detailed overview of the relevant technical infrastructure. The examinations take place on campus on centrally managed computers secured by SEB in student computer labs or in dedicated examination halls (cf. Chapter 5.1.3.2).

SEB is a freely available open source software that secures computers for examination purposes (Safe Exam Browser, 2010). The kiosk component of SEB locks the physical client device down and loads a VDI view client that provides access to a virtual desktop. This virtual desktop is the "actual" computer on which students work. All the necessary third-party applications are installed here and the virtual desktop is again secured with an SEB. This second SEB accesses the Moodle learning management system by means of a browser component. The Moodle quiz module is used to deliver the examination questions and to record the student's work (e.g. by file upload). The advantages of this setup are a high level of protection against failures due to redundant server architectures (VDI, Moodle) as well as simple administration and testability, since instead of dozens or hundreds of physical examination computers in the VDI, only a single master parent of an individual setup needs to be configured and tested.

[27] https://www.safeexambrowser.org/news_de.html

Figure 13: Secured Open-Web Exam with Third-Party Applications, Virtual Desktop Infrastructure and Safe Exam Browser at ETH Zurich (Photo: Alessandro Della Bella)

At ETH Zurich, such "VDI examinations" always take place under the supervision of the lecturers. In order to pre-empt technical problems, the examiners test the examination by doing an entire run-through, solving all examination tasks in the third-party applications on the virtual desktops created no later than one week before the examination date. In addition, technical first-level support is on-call and on-site during the examination and second-level support is on-call via radio. Students' work is backed up at regular intervals, and can be restored immediately during the ongoing exam by means of simple and robust procedures. The support processes and technical redundancies are standardised so that the vast majority of technical problems can be solved by restarting the third-party application, restarting the virtual desktop or restarting or changing the physical examination computer. Examination time lost as a result of technical incidents is documented and immediately credited back to affected students on an individual basis. Consequently, students are generally not entitled to the cancellation of their examination in the event of technical problems.

The examination infrastructure based on SEB, VDI and Moodle enables the comparatively simple and highly flexible engineering of custom-built and secure examination environments. In principle, any third-party application can be easily integrated into the secure environments – provided sufficient virtual desktop system resources exist – e.g. for statistics exams with R-Studio, numeric with Matlab, CAD with NX, computer science with Eclipse or Jupyter Notebook, but also for secure open-book examinations with a PDF reader or for secure open-web examinations with whitelisted access to defined websites. The examination infrastructure is currently scaled for examinations with over 800 concurrent test takers, including a sufficient number of physical and virtual spare clients. Currently, more than 100 examinations with third-party applications with over 9,000 individual tests taken are conducted at ETH each year, with the VDI setup described here being used most frequently.

5.2.3.2 ExaHM – A framework for competence- and application-oriented digital examinations at the HM Hochschule München University of Applied Sciences

Description	Digital examination with ExaHM in presence and as distance examination
HEI	HM Hochschule München University of Applied Sciences
Subject	Measuring with IoT and Apps" – Mechatronics and Technical Physics
Pedagogy	• Students learn to acquire, store and evaluate measurement data in the context of the "Internet of Things" (IoT) • For this purpose, both OpenSource frameworks are used as well as own programs in the Python programming language • The basic knowledge of network technology required for this will be will be imparted in the course of the lecture
Technology	• Local IoT development environment with VSCode as Python IDE, local MQTT Server with MQTT Explorer • Free text form for comprehension questions about the basics of network technology • HTML viewer for assignments and lecture notes as aids
Organisation	Remote ExaHM version is developed and used for digital remote exams. This allows students to take an ExaHM exam from their home office via a secure and encrypted connection. Supervision takes place via webcam, e.g. on an additional smartphone.
Link	https://www.hm.edu/allgemein/lehren/dp/index.de.html

With EXaHM (application-oriented, digital examination system at Munich University of Applied Sciences), any Windows programs (so-called third-party software) can be examination individually. Access to other programs is blocked, as are communication options via the Internet or to neighbouring computers. Students' exam files are regularly backed up, versioned and automatically collected at the end of an exam.

ExaHM was developed at the Munich University of Applied Sciences and has been offered to all faculties by the department for innovative teaching since 2018 to all faculties for competence and application-oriented examinations. In addition, within the framework of a QPL project (Quality Pact for Teaching)[28], examination-legal, data protection-legal and infrastructural prerequisites for regular operation were created. In particular, the ExaHM competence team accompanies[29] teachers from idea to implementation of a digital examination with ExaHM. For face-to-face examinations, existing computer rooms are used, which are also used in normal teaching. the computers are booted up and put into examination mode using automated processes.

Since the summer semester 2020, the Remote EXaHM extension has been developed and used for digital remote exams. This allows students to take an EXaHM exam from

[28] https://www.hm.edu/allgemein/lehren/zug/index.de.html
[29] https://www.hm.edu/allgemein/lehren/dp/index.de.html

their home office via a secure and encrypted connection. Supervision takes place via webcam, e.g. on an additional smartphone.

5.2.3.3 Programmatically individualised examinations at the Zurich University of Applied Sciences

Description	Programmatically individualised tests
HEI	Zurich University of Applied Sciences (ZHAW)
Subject	Computer Science, Engineering
Pedagogy	• Competence orientation is achieved by generating electronic work media such as source texts in programming exercises • Complex tasks, such as graph reduction or unit tests, provide constructive alignment with the internship content of the semester
Technology	• Individualisation of tasks within a chosen framework • Generation of text files or PDFs depending on the examination modality • If required, identification of copied solutions with hidden text patterns • Including semi-automated solution evaluation
Organisation	Particularly suitable for examinations with a high number of participants but low invigilator availability. Reduces the need for invigilation while lowering the risk of collaborative cheating.
Link	https://github.com/serviceprototypinglab/fipe

For increased protection against unauthorised assistance among participants in an examination (collaborative cheating), especially in situations with limited supervision, individualised examination tasks and corresponding solutions can be considered. In addition to randomisation and calculation functions already supported in most LMSs (e.g. via question banks or calculated questions in Moodle), programmatic individualisation, in particular, is applicable to an extended range of tasks. This applies to all written tasks including graphical representations, but is generally associated with increased correction effort. In the special case of generating files for processing with third-party applications, this disadvantage can be compensated for through partially automated solution verification (Spillner, 2021).

At the Zurich University of Applied Sciences, two departments use such solutions – for statistics testing with R in life sciences and for programming with Python and software development for clouds in computer science. In statistics, R/Exams, developed at the University of Innsbruck[30], is used. Using this, individualised PDFs can be generated, printed and scanned again for handwritten presence exams. In contrast, the generation of R scripts, which can be edited directly in RStudio, for example, is adequate in terms of

[30] http://www.r-exams.org/

competence orientation. These files can then be collected or inserted as answers in a Moodle exam.

In computer science, the in-house developed solution "FIPE" is used[31]. In addition to rich templates for controlled variability of text, numbers and graphs, FIPE contains functions which support downstream analysis for fraudulent results (at the level of the generated files). It is a possibility to manipulate variables in non-essential places, or to insert invisible fingerprints into the files. In any case, the use of third-party applications which process or execute the generated files is very practical – right up to the extent of a fair self-test for students to see if their file has been processed correctly.

Figure 14 illustrates the basic process of programmatically individualised checks, independent of the implementation.

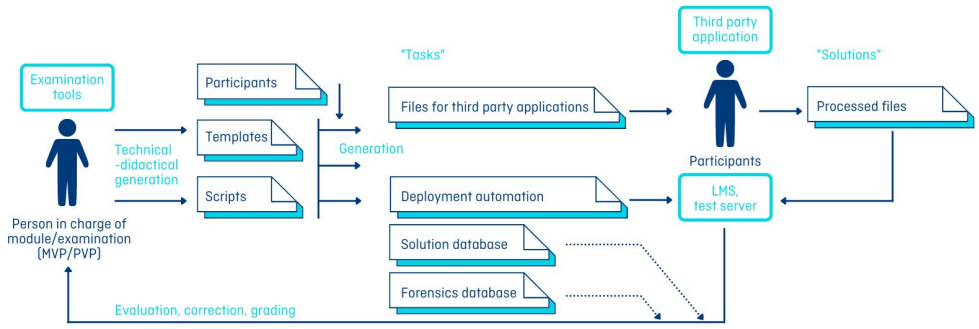

Figure 14: Schematic flow of programmatically individualised tests (own representation)

5.2.3.4 Location-independent competence-oriented programming examinations at the Westphalian University of Applied Sciences

Description	Location-independent competence-oriented programming exams
HEI	Westphalian University of Applied Sciences
Subject	Computer Science
Pedagogy	• Use of an integrated development environment (IDE) to ensure competence orientation and constructive alignment of the exam
Technology	• Examination takes place on students' PCs • Use of IDEs • Download/upload of tasks and solutions (program code) via Moodle • Dashboard for assessment invigilators
Organisation	• Supervision by scientific staff via ZOOM in a 1:4 ratio • Max. 40 participants

[31] https://github.com/serviceprototypinglab/fipe

In programming examinations, the use of an integrated development environment (IDE) such as Eclipse, IntelliJ or similar as a third-party application is now widespread in order to ensure competence orientation and constructive alignment of the examination. This takes place in the laboratory environment at the HEI on uniformly configured examination computers which are networked in a local WLAN with a printer but are separated from the Internet. Students work on programming tasks with the development environment already familiar from the practical course, can use locally installed resources (documentation) and, in addition to electronic submission (e.g. on USB storage media), can also print out their results and thus submit them as a paper document in order to comply with the formal requirements of a written examination.

One particular challenge arises when this tried and tested form of examination cannot be carried out at all, or cannot be carried out for all participants on site, at the HEI. In order to ensure validity, reliability, comparability and fairness of the examinations, especially over time, i.e. compared to examinations on campus, examination in the students' homes must be organised as equally as possible with regard to aids and obstruction or detection of acts of deception: the examination takes place on the participants' own computers (as is already the case for the practical courses) with the use of an IDE and download/upload of a task or result (program code) via Moodle. The participants are supervised by the HEI's research assistants via Zoom with video and screen sharing (analogous to the examination in the laboratory), who communicate via an online dashboard (OPA) (Figure 15). A ratio of one research assistant to four examinees has been found to still be practical (Meyer, 2021).

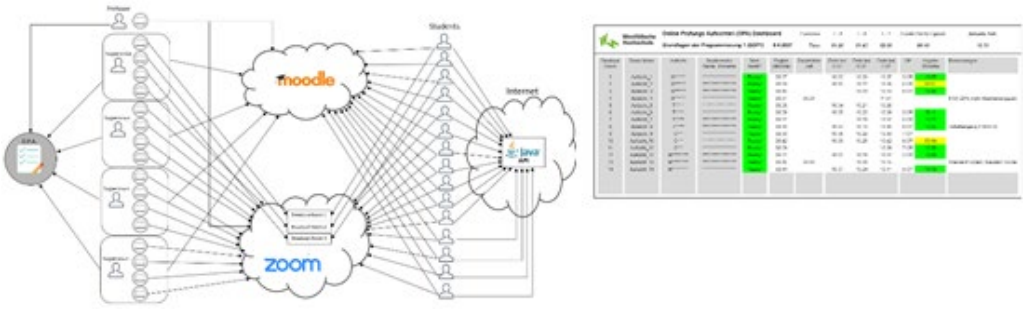

Figure 15: Setup for programming exams from home / Dashboard for exam supervisors/OPA

Although this approach is only suitable for manageable examination cohorts (tested in practice for examinations with up to 40 participants in two groups) due to the required 1:4 supervision ratio, it represents a fair and valid option in the event that examinations cannot be conducted on campus at all temporarily (pandemic) or in individual cases (e.g. during a semester abroad). This makes the competence-oriented programming examination resilient with regard to local implementation conditions while maintaining all requirements.

5.2.4 Recommendations

5.2.4.1 Pedagogy

This chapter has discussed how examinations with third-party applications enable improvements in the authenticity, competence-orientation as well as practice-

orientation of examinations and thus promise substantial improvements in terms of validity and assessment-driven learning. Because they have a significant impact on students' preparatory learning, they not only lead to a cultural change in examination practice, but often also in teaching and learning practices during the semester. This change is promising and desirable, but it also takes time.

From a pedagogical point of view, in particular, a gradual transition from conventional examinations to examinations with third-party applications is therefore recommended. In particular, working on tasks with third-party applications is usually much more time-consuming and complex than working on conventional tasks. This is almost always significantly underestimated by the examiners. It is therefore advisable to initially design only part of the examination and with only a few tasks with third-party applications and to extend the examination time by at least 50%. A mixture of conventional tasks and tasks with third-party applications is also recommended for other reasons. Tasks with third-party applications are well suited to assess the achievement of learning objectives validly thoroughly (in the sense of e.g. Bloom's learning objectives taxonomy). Since they are time-consuming, however, they are only suitable to a limited extent for covering the thematic breadth of learning objectives.

Examination tasks with third-party applications can, in principle, be combined with all established answer formats – from open-ended, constructed and divergent to convergent short answer formats, to closed choice answer formats. For example, in an examination on environmental systems science, a question can be answered by means of an essay task using a landscape depicted in GIS; mechanical engineers analyse machine parts depicted in CAD, computer science students complete skeleton code that is automatically evaluated by comparing it with predefined test cases, psychology students write the results section of a scientific paper by evaluating statistical data sets and mathematics students program numerical solutions that they enter into the exam software and are automatically corrected there.

5.2.4.2 Technology and operation

Due to the comparatively high technical complexity of examinations with third-party applications, it is advisable to start by establishing a service for conventional computer-based assessments without third-party applications first. This will allow institutional knowledge to be developed and experience to be gained in the operation of computer-based assessments and the establishment of the necessary operational structures. With the successful implementation of the first examinations without third-party applications, it is then possible to begin to expand the service in parallel to include examinations with third-party applications. Ideally, when setting up, designing and developing the technical infrastructure, the legal department and data protection authorities can be involved from the outset in the design and development of the technical infrastructure so that legal and data protection pitfalls can be taken into account at an early stage.

In order to minimise the risk of critical failures during an examination, various complementary measures have proven effective. These can be divided into four main groups: (1) technical and organisational redundancies, (2) standardised testing procedures, (3) flexible incident-handling processes and (4) ergonomics and alignment.

Technical redundancies, e.g. at network, server and client level, ensure robust operation of the technical examination infrastructure – even if individual subsystems fail. This includes, in particular, the provision of a sufficient number of spare client computers (usually 5-10%) as well as the creation of regular backups of students' examination work during the ongoing examination. Organisational redundancies relate, for example, to personnel planning in the support area in order to avoid examination cancellations due to short-term sickness absences.

Standardised test procedures ensure that the examination environments function in a fundamentally stable and reliable manner. In this context, it can make sense to impose an update freeze on the entire testing infrastructure (network, server, clients, third-party applications) after successful testing. Furthermore, testing needs to ensure that the individual examinations run without complications. To this end, it is advisable for the examiners to run through and solve their entire examination once, as technical problems often arise from the interaction between the task, the third-party software used and the actual examination environments. The aim of all testing activities is to ensure that any technical problems surface beforehand in the tests and can then be addressed either technically (e.g. bug fix) or organisationally (e.g. adaptation of the examination task or student instruction).

Incident handling procedures ensure that even if technical problems occur during an examination, it can be continued and completed in a regular and orderly manner. It is essential that students are instructed to report technical problems to the examination invigilators immediately and that the time lost due to the technical problem is documented and subsequently credited to the student concerned. Also crucial for effective incident handling is the timely availability of on-call or on-site first-, second- and, if necessary, third-level support (e.g. by radio or telephone). Lengthy interruptions during examinations due to technical problems are to be prevented in order to guarantee that students can sit their examination as unimpaired as possible, even in the event of technical problems.

Standardisation ensures quick and effective action and avoids complex stressful ad hoc problem-solving during an examination in progress. In addition, simple but effective standardised incident-handling processes enable examination invigilators or first-level support to successfully manage most, if not all, incidents that might occur during an examination independently. If a technical problem occurs, it can usually be resolved by restarting the third-party application or by restarting or changing the (virtual or physical) client device due to the appropriate technical redundancies. Student work is either stored server-side anyway or restored from backups on an ad hoc basis. The lost time is credited back, i.e. the examination duration is extended.

The majority of (technical) problems in examinations with third-party applications arise from the handling of third-party applications by students who want to perform as well as possible in the examination. The students must be sufficiently familiar with both the handling of the third-party applications and the examination environment, since "simple" handling errors in particular, such as the empty over-saving of files or the overloading of third-party applications due to improper handling, cause technical problems. The third-party applications must therefore already be familiar from the semester activities and access for practice and learning purposes must be available to all candidates. The handling of the third-party applications in the context of the

examination environment can be demonstrated either in a mock examination or in a short tutorial.

5.2.4.3 Organisation and legal aspects

Due to the high demands on technology and know-how and the associated considerable financial and personnel investments as well as possible opportunity costs in the form of failure risks, it is advisable to support and regulate assessments with third-party applications as early as possible in the organisation.

Due to the high demands on technology and know-how and the considerable financial and personnel investments as well as possible opportunity costs in the form of failure risks, it is advisable to support and regulate examinations with third-party applications as early and as high as possible in the organisation. Since examinations with third-party applications do not differ in principle from conventional paper-based examinations from a pedagogical point of view --the students work on tasks under defined working conditions and generate artefacts in the process – it may be possible to also keep existing regulations (for paper-based examinations) for examinations with third-party applications.

Since, from a measurement point of view, examinations with third-party applications do not differ in principle from conventional paper-based examinations – students complete tasks under defined working conditions and produce artefacts which are subsequently assessed – existing regulations for paper-based examinations can be adopted for examinations with third-party applications. The greater the correspondence between the regulations for examinations with third-party applications and those for conventional examinations, the fewer the operational and organisational obstacles for change to this examination practice.

Opportunity costs and failure risks can be best mitigated by appropriate change and risk management. In particular, a phased rollout is recommended in the following order: (1) development of working prototypes and/or proofs of concept, (2) piloting of first mock-examinations without credits, (3) piloting of first for-credit examinations, (4) standardisation and transition to regular service operations and, finally, (5) scale-up. Ideally, developments take place iteratively, in the sense of a continuous service improvement, in small modular steps, whereby steps (1) to (3) each take place within one semester. For steps (2) and especially (3), it may be worthwhile to have a plan B ready (e.g. paper examination, if legally possible, or examination in an established computer-based setting) to minimise reputational risks (examination cancellation).

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5.3 Digital remote examinations / online examinations outside the HEIs

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5.3.1 Introduction to the topic

Digital remote examinations are conducted outside of the HEI and outside of on-site supervised face-to-face settings. In this white paper, they are also equated with "online exams" according to the definitions provided in Chapter 2.

In most cases, students are free to choose where they take the examination. Digital distance examinations can be divided into supervised and unsupervised, written, oral and practical scenarios. Several forms and scenarios of examinations are considered in further detail in the following chapters with a specific focus on the respective CWG topic groups. This chapter focuses on general technical and organisational aspects of implementing digital distance examinations that differ from face-to-face settings.

5.3.2 Technical and organisational implementation

Deception monitoring

Both unsupervised take-home examinations and supervised distance examinations, in most cases, require cheating monitoring during the examination or sufficiently effective measures to prevent cheating that are already set up before the examination in order to reduce students' tendency to want to cheat. A large number of national and international cheating scandals, even at universities with a high reputation, show the relevance of the topic.[32] Incidentally, students are also extremely critical of the implementation of digital take-home exams without any monitoring of cheating (Jervis & Brown, 2020).

Distribution of assessment materials

The distribution of exam materials for unsupervised digital take-home exams or supervised remote exams can be timed online at the beginning of the exam period. This is often implemented via the automated release of exam materials via an LMS or e-exam

[32] News on scandals: https://en.wikipedia.org/wiki/2012_Harvard_cheating_scandal; https://www.nytimes.com/2007/05/01/us/01duke.html and; https://www.mercurynews.com/2015/03/27/stanford-university-looks-into-allegations-of-cheating-by-students.

system. Some instructors also choose to manually release the materials at the announced start time of the exam. Exam materials can be divided into three fundamentally different types:

1. The actual tasks
2. Auxiliary materials for inspection by the students, which are not handed in, e.g. data sets or collections of formulas
3. Pre-filled examination documents, e.g. coordinate systems or sheets already provided with a code but otherwise blank

First of all, the distribution of the exam materials as integrated task types via an e-exam system comes into question. If the examination is taken using an e-examination system, the entire examination process takes place on an integrated software platform which takes over the presentation of the examination tasks. In most cases, the processing of the tasks also takes place entirely within the e-examination system, so that additional distribution channels are not necessary.

In many cases, however, the distribution of examination materials is required to take place, at least partially, outside the e-examination system. This is necessary, for example, if certain examination tasks are not to be distributed via the e-examination system but in another form (e.g. as part of an Excel file). It may also be necessary to provide auxiliary materials such as formularies or partially completed examination sheets that are not suitable for display in an e-examination system.

This is where the second option of distribution as a download via an e-examination system or, potentially also, a general learning management system comes into play. The availability of the materials can be time-controlled so that access outside of the examination time is not possible. The download can be implemented in two variants: firstly, as a direct download from the respective system or, secondly, as a link to an external storage medium such as cloud storage.

Finally, distribution via email comes into consideration. Access then takes the form of an email attachment or a download link to cloud storage. It is strongly recommended that this is sent with sufficient notice before the start of the exam period. Delayed email deliveries or full mailboxes should not disrupt the exam. When distributing by email, a decision should be made as to whether it is necessary to provide it in encrypted and password-protected form. The password is then provided at the start of the examination, which may be done verbally, as part of a presentation, or as an overlay in the examination system. The handling of such files should definitely be practised before the examination, e.g. by means of demo examinations, as many students have little or no experience in opening encrypted file formats.

Printing of examination materials

When providing exam materials outside of an e-exam system, it is imperative to consider the processing method. In many digitally distributed take-home and distance examinations, the presentation of the examination tasks themselves takes place digitally, but examination materials are to be processed analogously, mostly with pen and paper. However, not all students have a functioning printer and access to copy shops

has also been significantly limited in some cases due to the pandemic. Examination papers that require paper-based processing must be sent out accordingly with a significant lead time. The challenge arises here that certain content may provide clues as to exam topics, e.g. if a collection of formulas contains only selected formulas or if an empty logarithmic coordinate system or a schematic drawing to be completed is enclosed. In such cases, it is advisable to enrich the relevant materials with unnecessary "distractor content" so that no direct inference to examination content is possible.

Hybrid testing – simultaneous analogue and digital processing

The concept of hybrid assessment has already been introduced in the chapter on digital assessments in presence.

A characteristic feature of hybrid examinations is that, in addition to the digital processing of tasks, analogue artefacts such as written papers are also produced. These analogue materials must be returned by the students to the examination invigilator. In the context of take-home or distance examinations, this is now commonly done by students digitising the material themselves. There are two challenges to be solved here: how are analogue examination papers digitised by students? And how and when are the digitised file formats returned to the examination invigilator?

Digitisation of analogue examination documents in the BYOD principle

In contrast to face-to-face examinations, the digitisation of analogue examination materials in take-home or distance examinations must be carried out using the students' existing equipment in the sense of the bring-your-own-device principle. Here, students use their own smartphones or other devices to photograph or scan analogue materials such as paper-based preparations. It is usually assumed that a mobile device such as a smartphone is part of the students' basic equipment and can therefore be taken for granted. However, it has become apparent that there are a small number of students who do not have suitable devices and are reliant on loan devices. For this reason, many HEIs have set up a lending service.[33]

The term scanning has led to examinations where students are required to photograph analogue examination documents in their home offices, being referred to in many places as "scanning examinations". As outlined, this term is used ambiguously. Similarly, face-to-face examinations, where the examination papers handed in are scanned by service staff after the examination, are often called "scan examinations" or "scanner examinations".[34] For this section, however, "scanning exams" refer to those take-home or remote exams where students do the digitising themselves.

Scan checks with scan applications

Analogue assessment artefacts, such as handwritten records, are used in both unsupervised take-home assessments as well as supervised remote assessments. Remote examinations are usually digitised first. Here, the use of scanning applications

[33] e.g. https://www.projekte.hu-berlin.de/de/gnuHU/projekte/gnuhu-books and https://www.asta.rwth-aachen.de/laptop-verleih/

[34] An example of this form of scan verification is the corresponding functionality in the TUMexam project (https://www.tumexam.de/).

is optional. Such apps take over both the photographing with a mobile end device (smartphone or tablet) as well as the subsequent merging into a file. Suitable scanning applications have to meet a wide range of requirements placed on suitable scanning applications. They should be easy to use, unobjectionable under data protection law and free of charge. Further criteria are used without registration, no watermark, document recognition, perspective correction as well as, if necessary, filters for image and text.

For Android and iOS mobile operating systems, there are various third-party scanning applications that require prior installation. Alternatively, both iOS and Android offer the creation of scans with on-board tools, so that no third-party software needs to be installed. On iOS, the manufacturer's pre-installed Notes app can be used for this, on Android, the predominantly pre-installed app Google Drive, as well as the camera app on newer Android versions.[35]

When students use such scanning applications, several sources of error are to be expected, which make trouble-free use in regular operation almost impossible. Students are usually not familiar with the use of the apps and must be trained accordingly. In addition, at the hectic pace of submission, pages are often photographed twice or, on the contrary, not at all, as checking the documents generated on the smartphone can be confusing. Even after the instruction is complete, students' generated files can vary significantly in file type and size, as the multitude of apps and settings within them cannot guarantee consistency. Offering practice exams during the semester is therefore strongly recommended to familiarise students with the technical and logistical requirements.

Delivery of digital file formats

As soon as the processed exam is not automatically submitted on an integrated exam platform, options for submission must be created.

Typically, this is necessary if analogue examination materials are to be digitised before submission or if digital files are to be generated with third-party applications and then submitted.

Whereas hand-ins in the controlled setting of a face-to-face exam usually happen without a hitch, handing in digital documents in take-home and remote exams can include several obstacles:

1. **Delivery method**. In most cases, upload task formats in e-examination systems or learning management systems are used for the delivery of digital files which allow a convenient upload via drag-and-drop or the usual file dialogues. However, in the event of technical disruptions, alternatives should be provided for technical malfunctions, which enable submission even if the primary submission channel is not functional. Here, the first option to consider is submission via email, either as an email attachment or as a link to a file in cloud storage. Finally, direct file sharing is also conceivable by saving a file to a cloud.

[35] https://video.cls.rwth-aachen.de/gebrauchsanweisungen/#durchf%C3%BChrung-der-pr%C3%BCfung-f%C3%BCr-studierende

2. **File formats**. In addition to the delivery method, file delivery format must be defined. When using scanning applications, PDF format is recommended in many cases. It offers a uniform examination workflow for both teachers and students (in particular correction and inspection) and is also suitable for long-term archiving after conversion to PDF/A format. When using third-party applications, the software itself usually determines the file format. Nevertheless, it should be explicitly determined in which format uploads are to be made[36], so that incompatibilities do not arise as a result of different file formats. Most e-examination and learning management systems offer the possibility of restricting the permitted file types for upload tasks so that, for example, only files with the extension ".pdf" can be uploaded. Students must be informed of this, as error messages in a stressful exam situation will otherwise lead to great uncertainty.
3. **File sizes**. For scanning exams using personal smartphones, in particular, upload sizes are difficult to calculate and depend on various factors, including the camera resolution set on the smartphone, the file format used or the scanning application used for processing.

   At RWTH Aachen University, for example, file sizes ranging from a few megabytes to well over half a gigabyte were observed for the same exams. Such file sizes cause considerable problems, not only in the time-consuming upload by the students, but also in the correction by lecturers. Many upload tools allow you to set a maximum allowed file size, which, if exceeded, will cause the upload to fail. Such an upload limit is not recommended because many students do not have the necessary technical expertise to produce a smaller file if this limit is exceeded.
4. **Bandwidth and connection stability**. The bandwidth available for uploads by students is often limited. In addition, unstable Internet connections must be expected. Students are then confronted with lengthy upload times or disconnections. Appropriate instructions for the use of the upload tool and the option of alternative delivery options should therefore be provided. Load measurements at the RWTH show that the same digital submission path from the home office leads to a multiplied waiting time compared to submission from the HEI examination pool.
5. **Control of uploads**. If files are uploaded for submission, there is a risk of file confusion on the part of the student. Instead of the processed examination materials, the wrong documents can be uploaded. An analysis of about 2,400 exams in the subject Psychological Statistics at the Johannes Gutenberg University Mainz looked at the frequency of file mix-ups in an exam where an Excel file had to be uploaded from the students' own desktop for submission. Without a test exam, the percentage of incorrect uploads was between 2% and 4%; after the introduction of a test exam, the percentage was reduced to about 1%. Thus, incorrect upload submissions are difficult to eliminate. Therefore, students should have the opportunity to check the correctness of the file to be submitted after uploading.

[36] https://www.pdfa.org/resource/iso-19005-pdfa

6. **Malware**. Files provided by students should generally be classified as untrustworthy. A systematic check of all uploads for malware should definitely take place before further processing.

5.3.3 Opportunities and challenges

Digital Remote Exams	Opportunities	Challenges
Pedagogy	Enabling examinations to be carried out independent of place and, if necessary, time using a variety of systems that can meet the teaching/learning objectives (application-oriented or authentic).	Diverse conditions on site (e.g. with disturbances) cannot always be adequately prepared; performance measurement can be impaired as a result. Technology for remote examinations must always be checked for didactic benefit (cf. SAMR model).
Technology	Students take exams on devices they are familiar with. No hardware needs to be organised by the HEI.	Hardware and also Internet infrastructure can significantly influence the individual assessment performance significantly and create new barriers.
Legal aspects	Location-independent testing can create equal opportunities for all.	Opportunities for cheating are greater than in face-to-face exams. Location-independent exams can hinder equal opportunities for all.
Organisation	Students can organise and set up their own examination venue according to their own needs. HEIs do not have to maintain large premises.	Communication during the test is considerably more difficult and the support effort is high.

5.3.3.1 General opportunities and challenges

In principle, digital distance examinations enable the design of diverse examination scenarios, including those that are close to the competencies. Exemplary possibilities are presented in the following chapters, e.g. in the context of open-book examinations or oral examinations. The challenges of digital distance examinations are primarily of a technical and organisational nature. Access to the technology must be available to all. Appropriate hardware and a stable network connection are necessary in order to be online without interruptions during a remote assessment. The responsibility for technical success lies with the HEI. Quiet, disturbance-free workspaces are also not always a given in the home environment. While this requirement can usually be met without difficulty in the case of digital examinations in presence in the rooms of the HEI, it becomes a further challenge at home and possibly also an additional burden for students. Digital examination unquestionably offers many opportunities to make studies accessible. However, it is also important to consider the associated risks.

5.3.3.2 Diversity justice and inclusivity

According to UN Convention on the Rights of Persons with Disabilities (CRPD) Article 24, inclusion in the field of higher education means equal access and non-discriminatory participation in higher education.[37] In the implementation of barrier-free teaching, digital examinations can, in principle, be a means of compensating for individual impairments as well as structural disadvantages. However, digital examinations are not only associated with potential opportunities, but also with risks. The opportunities clearly lie in the temporal and spatial flexibility of the digital formats. Theoretically, students with disabilities can take an exam from home in a familiar environment using familiar digital aids. However, the prerequisite for this is that the aids can be used compatibly with the digital examinations and that, for example, examination software must always be accessible without barriers. The responsibility for this always lies with the HEI.

On the other hand, this flexibility can reduce the stigmatisation of students with disabilities and/or chronic illnesses, especially with regard to invisible impairments and mental illnesses. In addition, new developments in computer linguistics, sensor technology, AI, improvements in automatic transcriptions, text-to-speech technologies and input aids for the inclusion of students with disabilities and/or chronic illnesses mean a gain in terms of barrier-free participation, particularly in digital examinations and digital teaching.

In addition to many advantages, however, there are also risks or new barriers created: barriers that are not yet known or cannot yet be fully assessed. While digital examinations can simplify and standardise many processes, compensation for disadvantages, for example, remains something that is highly individual and cannot necessarily be implemented in the digital examination setting (especially in the home environment). For example, it must remain technically and organisationally possible for people with certain impairments to take longer breaks during an examination. People with partial performance disorders or developmental disabilities, for example, often have general problems with the structuring of examinations. Dealing with individualised breaks, which are granted as compensation for disadvantages, e.g. for students with Asperger's syndrome, or ADHD, can break down the fixed time grid. The supposed compensation for disadvantages then becomes a further barrier. The pros and cons must always be carefully weighed up.

5.3.4 Examples from practice

5.3.4.1 Simultaneous digital and paper-based remote exams via TUMexam

Description	Simultaneous digital and paper-based remote exams via TUMexam
HEI	Technical University of Munich

[37] The explanations are based on an expert interview on diversity justice and inclusion in digital exams on 09.07.2021 with Michaela Kusal (Head of the Beratungszentrum zur Inklusion Behinderter (Advisory Center for the Inclusion of Disabled Persons) of the Akademisches Förderwerk) and Sebastian Frassa (Service Manager for Inclusion, IT.SERVICES, Ruhr-Universität Bochum).

Subject	All subjects
Pedagogy	Remote exams via TUMexam include all the features of a traditional paper exam plus additional options such as automatic multiple-choice recognition and digital text input or pen input in the PDFs.
Technology	• Web interface for administration, planning and creation of the test • Web interface for download/upload of exams by students • Ensuring that working time is respected • iPad app for digital correction of exams for teachers • Web interface for online examination viewing with feedback option
Organisation	TUMexam covers the entire life cycle of an exam. It is a system for planning, creating, conducting, following up and archiving exams. In addition, there is the possibility of online viewing and conducting.
Link	https://tumexam.de/en/

TUMexam is a system used at TUM for planning, creating, conducting, following up and archiving exams. Originally intended as a system for scan exams with online viewing, it was expanded into a system for remote exams at the beginning of 2020. Here, students receive the (optionally randomised) exam details via TUMexam as a PDF at the beginning of the working time, which can either be edited digitally (text/pen input) or printed out, solved on paper and then scanned in. The submission is then also made via TUMexam.

Multiple choice is automatically recognised by TUMexam and evaluated according to the predefined criteria. Free text tasks can be corrected either in the TUMexam online editor or by means of the Correction App on iPads.

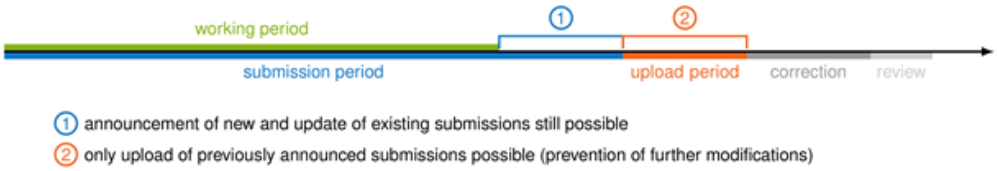

Figure 16: Remote examination procedure with TUMexam

The basic concept of a remote exam with TUMexam is shown in Figure 16. At the beginning of the working time (green), students can download the specification as a PDF. The system easily scales up to more than 1,000 students.

At the end of the working time, a so-called submission period (blue) follows, during which students are supposed to digitise their exam (if necessary) and then upload it. This period is comparable to the collection of exams in conventional exams. It is not necessary for the upload to be completed within this period.[38] Rather, a cryptographic checksum is determined locally from the submission, which is transmitted to the server and

[38] Contrary to what is stated, a scanned or photographed exam may well be dozens of MB in size, which takes some time to upload if the Internet connection is slow. In addition, the simultaneous upload of several hundred such exams also causes a significant load on the server side.

announces the submission. The server then assigns students to a queue for the upload in order to prevent possible load peaks with large cohorts.

Finally, during the upload period (orange), previously announced submissions can be submitted, with students always being shown their position on the waiting list, their upload status and the result of the upload.

Working time plus 15 minutes for the submission period and 30 minutes for the upload period have proven to be a good time frame. A larger time window for the upload period does not have any negative effects, but it delays the start of the correction for no reason. In the case of the submission period, longer time windows result in students continuing to work in the case of unattended examinations and thus potentially gaining an advantage.

In principle, the procedure can also be supervised. For this purpose, TUMexam offers the possibility to assign students to video conference rooms (such as Zoom or BigBlueButton), each of which is then led by an invigilator. While this does not offer complete protection against attempted cheating, it does have two significant advantages:

1. Student identity can be checked just as easily as in the lecture hall by means of a student ID card.
2. It can be ensured that students also stop working on the submission at the end of the working period. In this case, the decision can be made to extend the submission period to give students enough time to scan or photograph.

TUMexam supports a variety of additional functions, such as the blocking of submissions (e.g. after early submission or when students leave supervision), the extension of individual processing times (e.g. to compensate for disadvantages) and the logging of events. Based on this concept, more than 45,000 remote examinations have been conducted at TUM during pandemic periods (as of Summer 2021).

5.3.4.2 Scan checks with integrated apps using Telescope as an example

Description	Scan checks with integrated apps using Telescope as an example
HEI	RWTH Aachen University
Subject	All subjects
Technology	• Examination sheet scan by students via Telescope app using a smartphone camera from home • Upload of any file format for checks via drag-and-drop
Organisation	• The application is integrated into the examination workflow of the existing e-examination system Dynexite
Link	https://telescope.dynexite.rwth-aachen.de

In order to eliminate the sources of error that occur when students use scanning apps, such an app was developed at RWTH Aachen University that is seamlessly integrated into the e-examination system and controls and standardises the entire scanning process from there for both remote and on-site examinations. In the Dynexite e-examination system at RWTH Aachen University, this task is performed using the Telescope app. Each task type in Dynexite can be supplemented by an upload option, and upload-only tasks are also possible. The upload can include any file format, which can be selected via drag-and-drop or via the usual file dialogues. In the case of paper pages to be photographed, the Telescope app offers a special workflow. Students are asked in the e-examination system, which is usually run on the student's PC or notebook, to pick up their smartphone and open the Telescope web app on the web browser there. No installation is required. After logging in using single sign-on, the Telescope app then automatically connects to the student's current exam. The app now takes full control of the smartphone camera so that image size, resolution and quality cannot be altered by the student. One or more pages can then be photographed. These are transferred to the e-examination system on the PC or notebook and appear there in large format in a page overview, where they can be checked once again for scan quality and completeness.

The technical disruptions during scan exams at RWTH Aachen University could be massively reduced by this workflow.

5.3.4.3 Digital communication via MS Teams during distance learning (WU Vienna University of Economics

Description	Digital communication via MS Teams during remote assessment
HEI	WU Vienna University of Economics and Business
Subject	All subjects
Technology	• In the run-up – use of the LMS for asynchronous communication • During the exam – use of MS Teams for synchronous communication
Organisation	• Communication channel during a remote test • Sending announcements to all subjects

At the WU Vienna University of Economics and Business, communication during the examination is organised as follows: students receive information on the procedure and structure of the examinations in advance via the LMS. During the exam, MS Teams is used for communication. For this purpose, each exam is assigned its own MS Teams team with a logo specially designed for each semester. The content is designed in English or German and is always structured in the same way: the channel "General" is moderated and is used to send announcements to all students. The channel "Content questions" is bidirectional and is used to ask comprehension questions about exam content. The channel "Technical problems" is bidirectional and is used either only as a reporting tool or for technical support during the exam. When reporting, students send a short abort message if they are no longer able to take the exam due to technical problems, or they also report a resumption of the exam if they have solved the technical problem on their own. The information given here also decides whether or not the

examination will be assessed. Technical support is provided by Digital Teaching Services for students with more than 150 participants and when using WU's own invigilation solution. Further private channels can be used by subject supervisors for internal consultations during the examination, or as a discussion channel between selected examination participants with compensation for disadvantages and their writing assistants.

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5.4 Online invigilated exams

Matthias Baume, Alain Michel Keller, Nils Thiessen

5.4.1 Introduction to the topic

The significant expansion of remote online examinations, on the one hand, and the enhanced functionalities of technical infrastructures, on the other, have led to new forms of electronic examinations, particularly in recent years. With the aim of increasing the integrity of unsupervised remote online examinations, ways of supervising such examinations have been developed and also implemented in a practical manner for mass use.

In the meantime, millions of online supervised examinations are being processed worldwide – also due, in particular, to the pandemic situation – and a further significant increase is expected in the coming years (cf. Patterson, n.d.; Draaijer, 2017, p. 20; Li & Lalani, 2020).

5.4.1.1 Definition of online invigilation

The biggest difference in online invigilated exams compared to just providing exam questions in an online platform is the aspect of supplementary invigilation features. Through the additional invigilation it is possible to supervise examinees during the entire examination process, either directly during the examination itself or afterwards.

Invigilation
In international usage, the two English terms "proctoring" and "invigilation" have become established for the supervision of exams. While the original meaning of "proctor" referred to a responsible person, e.g. in the university or church (see Figure 17), in current development the term is largely associated with the meaning "supervisory person" (Patterson, n.d.). Accordingly, the terms "online proctoring", "remote proctoring" or "online invigilation" are commonly used to refer to the topic.

Figure 17: Proctor at Cambridge University in 1815

In summary, online invigilation is the supervision of electronic examinations attended by examinees from different locations via the Internet. Invigilation takes place exclusively via digital means. For example, video and audio signals, screen content and other examinee data can be transmitted. Supervision can take place live, by later reviewing the recordings and/or by automated evaluation of the data. (cf. Sietses, 2016, p. 8).

In addition to the supervision function, further features are often offered by corresponding software tools in order to secure the examination computer and to prevent the use of other unauthorised sources of information as far as possible.

In order to guarantee the realisation of such exams, the appropriate technical infrastructure and a high-performance Internet connection are necessary to process the integrated data streams accordingly and, if necessary, to store them. Foster & Layman (2013) therefore also include the basic processes in their summary presentation:

> *Online proctoring, sometimes called remote proctoring, generally refers to proctors monitoring an exam over the Internet through a webcam. It includes as well the processes, occurring at a distance, for authenticating the examinee as the person who should be taking the exam. Adding to the definition, online proctoring includes any automated processes that help to secure a test administration event. (Foster & Layman, 2013, p. 2)*

5.4.1.2 Types of online invigilated exams

The supervision of online examinations can be ensured in different ways. In practice, a basic distinction is made between three variants (cf. Sietses, 2016, p. 7 ff.):

1. Human supervision
2. Record and review
3. Automatic supervision by software

Human supervision

This form of supervision is most comparable to a standard lecture hall examination. Depending on the framework conditions and the service contract, the invigilators can be provided either by the examining institution or also by the provider of the supervision software. Both solutions are common practice. In the simplest case of invigilation, the examination is taken with paper and pencil at home and supervision is conducted with the help of video conferencing software (Zoom, BBB, etc.).

Depending on their qualifications and experience, human invigilators bring very different prerequisites to the examination process when it comes to recognising suspicious circumstances. In addition, due to the limited perception capacity (one person can reasonably supervise a maxi–um of 10-15 persons online), many invigilators are required for very large examination cohorts. In the end, this is usually associated with increased costs for qualified supervising staff. However, nothing has to be recorded during the examination and the examination process is – comparable to a face-to-face examination – completed immediately after the exam is handed in.

Record and review

In this supervision mode, the examination is automatically recorded and stored. After the assessment recording is completed, human "supervisors" review and evaluate the recording. In the process, potential suspicious facts are usually marked and classified according to the severity of the suspected fraud. A post-exam assessment review partially removes the time commitment for human resources, as no live supervision is required directly during the examination assessment. However, the storage of sensitive personal data (e.g. video of the examinee) is necessary, which is often viewed very critically from a data protection perspective. In addition, the final assessment of the examination is delayed.

Automatic supervision

Due to the aforementioned disadvantages of the two previous supervision variants, scalable software solutions have expanded to fully automated supervision, especially in the recent past. When using such tools, both the process of direct examination and the evaluation are performed by software. This means that the examination (and thus the activities of the examinee) is recorded and stored either with randomly scheduled photos or continuously as video.

At the same time or directly after the examination, an automatic analysis of the recorded video and audio material is carried out with the aim of identifying and flagging potential suspicions of fraudulent behaviour and classifying them according to severity. This is usually accomplished without human intervention by complex algorithms.

However, the final decision as to whether or not fraud has occurred must always be made by the person responsible for the assessment. The software therefore only has a supporting function and does not make any final assessment decisions.

Nevertheless, fully automated supervision is the most demanding option concerning technology and data protection because it requires the recording, processing and analysis of sensitive personal data.

Combined solutions

In order to be able to better adapt the advantages and disadvantages of the different supervision methods to the respective assessment scenario, various providers have started, especially recently, to make the aforementioned supervision types combinable.

In practice, this means that, for example, a human-supervised online examination can be simultaneously recorded in an automated manner or, conversely, in the case of a fully automated supervised examination, a human invigilator can be "switched on" if necessary to provide support in the event of problems.

5.4.1.3 What can be controlled?

Depending on the invigilation software used and the settings applied in the software, different data sources can be controlled. In addition, it depends on the software and the settings applied therein as to whether the data check is carried out live by the exam invigilators or whether the data is recorded and subsequently checked automatically, e.g. AI-supported and/or by invigilators (cf. e.g. pruefster.com, n.d. (a); proctorio.com, n.d. (a)).

- **Webcam**. The webcam can be used to check which students are taking part in the examination. This can be done, for example, by comparing the students' photo IDs. Furthermore, the webcam can be used to check whether there are any other persons in the students' rooms. By transmitting several camera images, e.g. from the webcam of the laptop and a smartphone placed to the side or behind the students, it is possible to check whether the students are using other aids in addition to the computer.
- **Audio**. By transmitting the audio signal, it is possible to check whether students are talking to others during the examination.
- **Screen**. By transmitting the students' screens, it is possible to control whether they are accessing other resources on the computer in addition to the exam platform.
- **Access to existing resources**. In some invigilation software, it is possible to define which programs and/or websites students are allowed to use. This allows more complex examination tasks, while still supervising the entire examination process.
- **Data transfer**. By recording students' data transfer, it is possible to determine whether they access other web services, such as messengers, in addition to the websites allowed for the exam.

- **Examination location**. Depending on the supervision solution used, the location of the examinees taking part in the supervised remote examination is analysed.

5.4.1.4 Basic technical equipment

With regard to the basic technical equipment for the use of invigilation software, a distinction must be made between the HEI as the institution conducting the examination and the examination participants (teachers and students).

Implementing institution

The HEI must either host an examination platform (learning management system or e-examination system) itself or have commissioned a service provider to host the examination platform. The invigilation software is then integrated into the examination platform, usually via an interface or plug-in. Both systems are usually maintained by the computer centre or a similar central unit of the HEI and made accessible to teachers and students.

Examination participants

Depending on the exam platform and invigilation software used, examinees need the following basic equipment to take an exam (cf. pruefster.com, n.d. (b); proctorio.com, n.d. (b)):

- Computer/tablet with Internet connection
- Webcam
- Microphone
- Current browser for accessing the examination platform
- Depending on the proctoring software – possible installation of browser plug-in or the proctoring software on the computer/tablet
- Possible second computer/tablet/smartphone with camera for image transmission from several angles

5.4.1.5 Online invigilated examination procedure

The online invigilated examination procedure from the examinee's point of view is, in principle, relatively similar for most solutions. The guidance through the examination process itself takes place with human supervision by the assigned invigilator, with automatic solutions; on the other hand, the examinee is usually guided through different screens, which contain the individual steps of the examination preparation and execution procedure with the help of illustrations and written instructions.

I Preparation and authentication

The first step is usually the disclosure of the examination conditions by the software or the invigilator. This is often accompanied by the installation of an invigilation tool or a browser extension. Subsequently, the examinee authenticates him/herself by means of an appropriate identification document, usually either an identity card or student ID.

Depending on the requirements, parts of the document can also be concealed for data protection reasons. Special authentication methods such as a finger bone scan ("knuckle scan") are now also available, but do not play a major role.

II Technology check

In order to ensure the technical requirements and prerequisites directly before the start of the exam, an individual check of the examinee's infrastructure is carried out. Depending on the exam settings and available tools, the Internet connection, the camera and/or the microphone, for example, are checked.

III Declaration of consent

Once the preparations for the examination have been successfully completed, the examinee is shown a declaration of consent which he/she must actively confirm. This usually specifies the framework conditions and the legal basis that the examinee must accept in order to proceed to the actual examination. For data protection reasons, the active granting of consent is especially necessary if sensitive personal data is recorded and processed in the course of an automatically supervised examination. This may only be done with explicit consent.

If a supplementary alternative examination takes place in the lecture hall for reasons of data protection law, consent to the "home" examination variant can also be requested or granted by means of the declaration of consent.

IV Examination and support

The examinee experiences the examination itself largely identically to an unsupervised examination variant. The examination content is normally presented and processed by the examinee without being influenced by the supervision functions (Figure 18). Depending on the solution, the invigilator or the examinee themselves can reduce their video image in size or fade it out completely so that the examination atmosphere is affected as little as possible.

If there are any ambiguities in the content ("Question XY doesn't make sense") or technical problems ("My Internet is down"), support staff can usually be reached. In the case of fully automated examinations, a telephone hotline or an accompanying video conference is often set up for this purpose in addition to the general technical support for the software solution.

V Submission and completion

With the active submission of the exam (usually by clicking the submit button) or at the end of the exam time, the use of the supervision functions also ends. These are completely deactivated and the accompanying software can subsequently be uninstalled if required.

In contrast to lecture hall examinations, the examinee has a significantly higher degree of self-responsibility in digital online examination scenarios, especially in invigilated examinations: Whilst only a functioning writing tool and, if necessary, a calculator or a

collection of formulae are sufficient for the proper execution of the examination in a lecture hall examination, in an online invigilated examination the examinee is required to implement all technical and organisational framework conditions (computer, Internet connection, empty desk, undisturbed environment, etc.) for the examination independently and responsibly so that no problems or interruptions are to be expected.

5.4.2 Opportunities and challenges

Online invigilated examination formats have been in use in many scenarios around the world for several years and open up a wide variety of possibilities for examination design and support due to the supplementary functions. At the same time, however, such examinations are technically complex, more error-prone overall than unsupervised formats and are often evaluated very critically due to aspects of examination and data protection law. In the following, various opportunities and critical aspects are listed for better classification and further discussion.

Digital Remote Exams	Opportunities	Challenges
Pedagogy	Question types that are particularly critical for cheating without supervision can be used more easily online with supervision. Electronic question types with invigilation offer a variety of pedagogically interesting possibilities for competence-based exam design.	Invigilated exams are not completely fraud-proof, so ways to make it more difficult to cheat should always be used to discourage cheating, such as randomisation, random questions, etc.
Technology	Due to the very large distribution of suitable devices and a good Internet connection, examinees from all parts of the world can participate in invigilated exams.	Online invigilated exams are technically demanding and prone to problems due to the complex infrastructure. They must therefore be very well prepared and tested before use.
Legal aspects	Invigilated exams serve to ensure exam integrity and equal treatment of examinees through globally comparable online exams and frameworks. Supervised examinations may also be allowed in exceptional situations (e.g. pandemic).	Due to the personal data required and the invasion of privacy, online invigilated exams are controversial and are classified as legally questionable by various experts. Depending on the legal situation, for example, an alternative exam must be offered in parallel at the same time in the lecture hall.
Organisation	Exams with a very large number of examinees or international students in particular can be organised, conducted and evaluated with the help of invigilated exams with a manageable amount of personnel.	If a large number of online supervised examinations are to be implemented, major preparatory technical and organisational measures are required (LMS, suitable provider, concepts, interfaces, templates, etc.).

5.4.2.1 Opportunities – Invigilated exams as enablers

Invigilated online exams can help better support current developments and examinees with specific needs.

Internationalisation of education and education markets

Due to the increasing internationalisation of the entire education market and growing mobility, many educational institutions and companies are faced with the problem of providing online learning modules, online seminars or entire online degree programmes as well as the associated performance measurement online without neglecting the integrity of the exams and the authentication of the examinees. For example, participants in Massive Open Online Courses (MOOCs) can attend suitable courses from anywhere in the world and obtain verified certificates for further education.

Overlapping study periods for semesters abroad

In many degree programmes it is common or even a requirement to spend one or more semesters abroad during your studies. However, both the start of the semester and the respective exam periods are varying in different countries. In the case of on-site courses or examinations, it is almost impossible to cope with the final examinations of one HEI at the same time as the studies in the next semester abroad have already begun.

With supervised online examination formats, international students can already start studying for the next semester and still, if necessary, complete examinations at their previous institution conveniently from their new place of study. However, it is generally important for internationally participating examinees to take into account the respective local legal situation and the data protection conditions in the examination process.

HEI networks and international locations

For many years, HEIs have attempted to provide supervised examinations at different locations through networks and partner HEIs. However, in order to enable worldwide examination participation, such efforts were often very quickly pushed to their limits. Examinees in remote locations may then have had to be provided with (very likely inexperienced) exam supervising staff at the nearest church or public institution (Bentley, 2017).

Examinations that can be held under online supervision anywhere in the world do not require local supervision and are therefore much easier to organise and conduct.

Support for a wide range of scenarios and participant groups

Invigilated exams can help support a diverse student body in its academic progress. As they are not dependent on location or time, invigilated exams make it easier for students with home commitments, health restrictions or work commitments to take the exam. Invigilated exams can be particularly relevant for the following groups of participants:

- **Participants with home responsibilities (family, care, etc.).** Examinees with family members or small children to care for often cannot easily come to the campus for the exam at any time. For single parents or single persons with care responsibilities in particular, exams at home offer an easier solution than organising care and nursing.
- **Examinees with disabilities.** Examinees with mobile disabilities often have great difficulty attending exams on site. If the exam is available at home with online invigilation, examinees with disabilities can attend the exam in a familiar environment and with any necessary supportive medical equipment.
- **Competitive athletes.** International competitions are organised without reference to study times or examination dates. Therefore, in many cases, participation in on-site examinations is associated with additional effort and disadvantages for internationally active athletes. In contrast, such competitors could participate in the examinations without any problems, even in the hotel of an Olympic venue.
- **Executives with tight schedules.** Many educational institutions are developing continuing education programmes for adults who are already in the workforce.

  Examples of this are executive MBA courses. In particular, continuing education participants in responsible positions and in large international companies are highly exposed to a busy schedule and notable travel activity. Supervised online examinations can be taken more easily with a full schedule, as there is no need to travel to the examination venue.

Provisioning of examination conditions outside the lecture hall

Examinations of any kind only form a secure and comprehensible basis for assessment if they are held under the appropriate legal framework conditions for measuring performance. Important aspects for this are the integrity of the examination and equality for the participants.

- **Examination integrity**. Academic integrity plays a major role in examinations in higher education. If examinations relevant to studies are held without any invigilation function, neither the identity of the examinee nor his or her actions and the aids used can be seen afterwards. If, for example, a person other than the actual examinee sits at home in front of an unsupervised online examination, an individual examination performance (not a copy) is created, but the realistic performance measurement with regard to the actual examinee is worthless.
- **Equal opportunities for participants concerning cheating.** Important motivators for cheating are pressure to perform, opportunity to cheat and likelihood of success (cf. e.g. King et al., 2009). While both the opportunities for cheating and the chances of success are very high in unsupervised examinations, cheating attempts are made much more difficult in supervised online examinations (cf. e.g. the study overview in Harmon et al., n.d.; Watson & Sottile, 2010). Examinees with no interest in cheating are thus much more likely to receive a grade adequate to their performance within the exam cohort.

5.4.2.2 Challenges

Legal situation and data protection

Basics

Since most HEIs in Germany only started to deal with distance examinations in general and invigilated examinations in particular in the context of the Corona pandemic, the associated legal aspects were also only intensively examined in this context. Therefore, there are currently (summer 2021) still some unresolved legal issues.

The extent to which individual functions of invigilation software, e.g. recording of audio, image and data streams and their automated analysis, are permitted under data protection and assessment law still needs to be clarified with the involvement of legal advisors, data protection officers and through negotiation in court, as in some cases quite different positions are currently held by lawyers (cf. e.g. Hoeren et al., 2020; Schwartmann, 2021).

HEIs that already use invigilated exams or are planning to use them should, in any case, observe the requirements of the HEI laws, ordinances and examination regulations that apply to them.

Regulations in Germany

Digital examination supervision is intended to comply with the principle of equal opportunities under examination law (Article 12(1) in conjunction with Article 3(1) of German Basic Law (GG)), but it poses a threat to the protection of students' privacy. Ultimately, only a voluntarily declared consent from the students can circumvent the high justification requirements. Rather, the right to informational self-determination protects – irrespective of the physical location – the right of the individual person to determine for himself or herself the disclosure and use of data concerning him or her (cf. BVerfGE (Federal Constitutional Court Decision) 65). Since the mere audio and video surveillance of students already constitutes processing of personal data, virtual examination supervision proves to be an encroachment on fundamental rights (cf. e.g. Botta, 2020).

The view into the private study room affects the right to inviolability of the home (Article 13(1) GG). This also includes the use of acoustic and optical aids. Justification experiences such as encroachment outside of the scope of application of Article 13 para. 2-5 GG only under the strict requirements of Article 13 para. 7 GG, for example, to combat an epidemic danger. Even in the case of consent to acoustic and optical surveillance of the private workplace, other fundamental student rights may also be affected. This applies, in particular, to their right to informational self-determination, which the Federal Constitutional Court (BVerfG) defined in its 1983 census judgement as a special manifestation of the general right of personality under Article 2.1 of the German constitution. In addition, their right to their own image is also affected (cf. BVerfGE 65, 1 ff.).

HEI law and examination regulations

For the state HEIs in Germany, the legal framework conditions are partly regulated at federal state level. Therefore, independent regulations also apply to the supervised distance learning examinations. Bavarian HEIs, for example, are given the respective legal framework within the framework of the Bavarian Higher Education Act.

The HEIs themselves regulate the examination process in detail with their own regulations and examination regulations. For example, the forms of examination and the examination design are framed by the General Examination Regulations; in addition, there are often subject-specific examination regulations.

European Data Protection Regulation (GDPR), BayFEV, etc.

Supervised remote testing formats – especially the solutions with automated recording – have been subject to criticism, in some cases significant since their availability due to the high relevance of data protection issues. For such examinations, compliance with the existing regulations is therefore of very high importance. At European level, the General Data Protection Regulation (GDPR) and, at federal level, the Federal Data Protection Act (BDSG) provide the legal framework. Subsequently, more precise specifications for supervised remote assessments have been or are being developed at federal state level.

Example: Bavarian distance examination ordinance

On 16 September 2020, the Bayerische Fernprüfungserprobungsverordnung (BayFEV, Bavarian distance examination ordinance) was published This regulation applies to electronic distance examinations at state and state-recognised higher education institutions in Bavaria. It came into force on 20 April 2020 and will expire on 30 September 2024. The ordinance explicitly serves to test supervised distance learning formats and provides a precise legal framework for this purpose. For example, in addition to the supervised online examinations, an alternative on-site examination must be offered at the same time, and students must be informed in a precise and comprehensible manner about the processing of their personal data and the technical requirements.

Invigilation of the students' room in the form that is common in the international context must not take place. Many other precise requirements, some of which are comparable to higher-level data protection requirements (e.g. from the GDPR), have also found their way into the regulation (cf. BayFEV 2020).

Technical problems

With invigilated exams, as with other types of electronic distance exams, technical problems can occur. Only in the rarest of cases does the exam platform fail. As a rule, problems only occur with a few exam takers. These can be hardware, software or network problems, e.g. defective camera, browser crash, Internet connection failure. Most technical problems can be identified and solved some time before the real examination by means of a demo examination. If further technical problems occur

unexpectedly during the real exam, these must be solved within a short time by technical support or experienced examiners (see the following section).

In order to avoid the negative effects of technical problems on the execution of the examination (e.g. examination cancellation), the HEI should provide technical support during the examination periods. Ideally, this support should also be available to students and lecturers by telephone, so that they can also receive help in the event of a computer or Internet connection failure.

In order to be able to provide effective technical support, the support staff should be informed about when which examinations are being carried out and have direct contact with the examiners during the examination in order to be able to agree on whether individual students should, for example, be given a time extension due to technical problems.

Supervision and support during the test

While the organisation and preparation of invigilated exams can be done relatively independently in terms of time, during the exam the examinees need support that is professional and quickly available if problems arise. On the one hand, this support can be provided by the provider of the invigilation solution; on the other hand, it is particularly useful to have a contact person on site for institution-specific problems and questions. If some of the examinees use the alternative examination in the lecture hall (which is usually the case), local support or human supervision is necessary anyway.

In practice, it has been shown that the majority of problems and exam interruptions can be eliminated during the exam. The aim is always to support all candidates through the examination process successfully and under the same conditions as far as possible.

Evaluation of examination records and false positives

In the case of invigilation solutions with automatic recording (e.g. ProctorExam, SMOWL, Proctorio) in particular, it is necessary to examine the recorded examination events in retrospect and to evaluate suspicious facts. If necessary, legal consequences must also be incurred should clear fraudulent behaviour become apparent.

In order to avoid having to sift through and evaluate many hours of video material during continuous recording, invigilation solutions in most cases offer various functionalities to filter suspicious facts and keep the evaluation effort low. Software analysis (e.g. AI-supported algorithms) is used to flag potential suspicious facts, which can then be assessed by a human person responsible for the examination. However, the software itself never makes a decision, but serves to filter and narrow down behavioural anomalies for subsequent human assessment.

In practice, it is often not easy to distinguish "real" fraud from normal examination behaviour (looking into the air, moving fingers or hands), so ultimately only the really clear cases (e.g. smartphone visible, additional person present) can be legally prosecuted.

Possibilities of cheating in online invigilated exams

Deception in on-site examinations and in unsupervised online examinations has been extensively studied in recent years and documented in literature. Deception is more common in unsupervised online exams than in supervised on-site exams (D'Souza & Siegfeldt, 2017; see also the earlier sources in the chapter). The possibility of cheating in unsupervised online examinations is stated by students to be significantly easier.

However, even with online invigilated exams, the possibility for cheating cannot be completely excluded, although there is normally constant supervision of the examinee. Due to the technical infrastructure of online invigilated exams and monitoring with a webcam, completely new technical possibilities for cheating arise in addition to the traditional forms such as cheat sheets or manipulated notes: these range from false identities to technical manipulations (e.g. multiple screens) to hidden mobile devices out of the camera's field of view (cf. Binstein, 2015; Smith, 2016; Tweedy, 2016).

- **Restriction of the camera angle**. The restriction of the camera's viewing angle makes it possible to place documents appropriately, undetected (Figure 18).

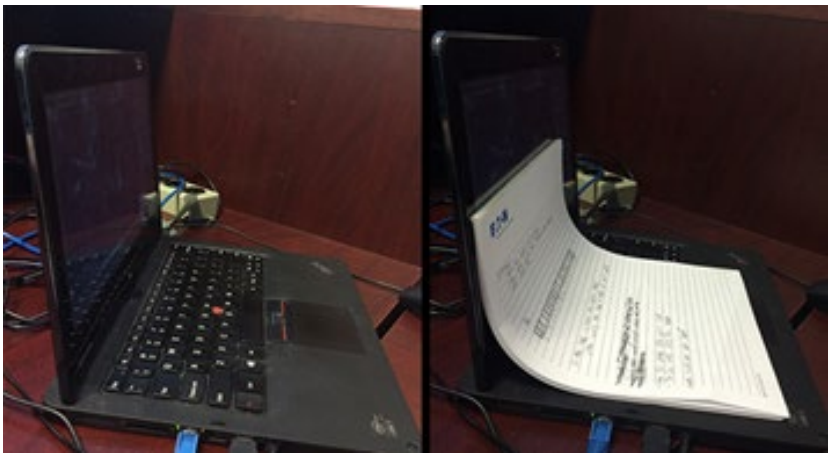

Figure 18: Aids outside of the camera's field of view (Source: Binstein, 2015)

- **Technical manipulation possibilities**. Due to the complexity and power of computers and infrastructures, it is not always possible for proctoring solutions to detect technical manipulations as a means to commit fraud. For example, depending on the proctoring, additional screens can be integrated, false camera signals can be provided (Figure 19) or virtual machines can be used to disguise fraud attempts (e.g. in Tweedy, 2016; Binstein, 2015).

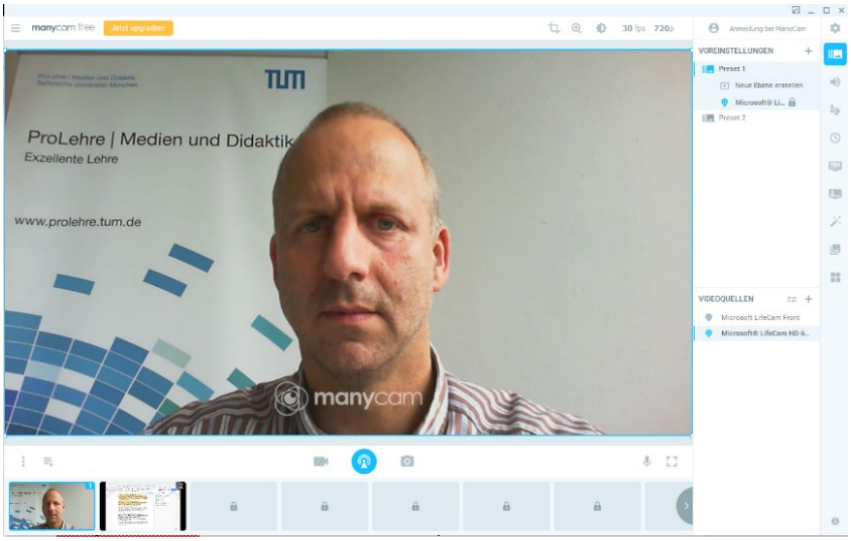

Figure 19: Embedding a "harmless" video signal to conceal fraud (Source: screenshot of ManyCam for the integration of different video signals)

5.4.3 Examples from practice

5.4.3.1 Invigilated exams at the Technical University of Munich

Description	Online invigilated exams
HEI	Technical University of Munich
Subject	All subjects
Didactics	• Depending on the subject area and the content to be tested, different question types or taxonomy levels can be used • Practical exam questions, e.g. programming tasks, are also possible • Intensive pre-information and demo exams allow examinees to test the technical requirements and exam question types beforehand
Technology	• The exam is created in the central TUM LMS Moodle • A wide range of import formats means that questions and entire exams can also be imported from other courses and exam editors • Depending on the testing scenario, blocking and supervision tools (e.g. video, audio, screencast) are selected for suitable framework conditions • In the case of very large examination cohorts (500-1,000 participants), it is necessary to check how many examinations are running at the same time in order to not overload the servers

Organisation	• In the pre-planning stage, after examination registration, the appropriate premises for the on-site variant of the examination are booked • Depending on the size of the examinee cohorts (online or on-site), the appropriate support (support in the lecture hall, or in the video conference) is provided
Link	https://hochschulforumdigitalisierung.de/de/blog/online-proctoring

Invigilated exams have become increasingly relevant in today's examination environment. In practice, however, it is often not easy for those who are responsible for examinations but inexperienced to gain initial access to established exam solutions. In the following, various practical aspects of invigilated exams are therefore addressed and explained.

Organisation of an invigilated exam

For classic, paper-based exams in the lecture hall, mature processes and structures have been developed and refined over years, decades and centuries. In the case of invigilated exams, such processes have only been developed and used for a few years.

The Technical University of Munich has developed and published an overarching process for the organisation and handling of online supervised examinations (Figure 20).

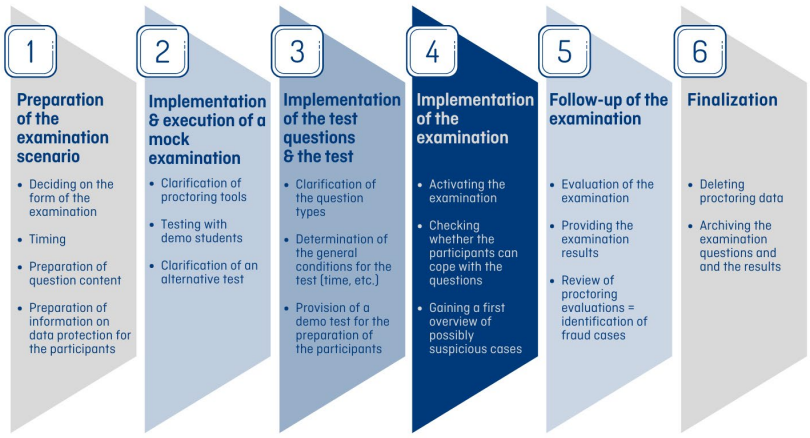

Figure 20: Organisation and implementation of invigilated exams at TUM

After the preliminary considerations and the overall planning, a demo test is carried out for the participants to try out. This practice variant with an identical technical scenario is usually provided a few days in advance to give the participants the opportunity to eliminate any problems at their leisure. Meanwhile, the real exam questions are prepared and integrated into the exam. When the "real" exam finally takes place, the examinees are familiar with the exam situation and have the appropriate equipment available. During the exam, in addition to the provider's standard support, an experienced person responsible for the exam is ideally also available in case content-related or technical questions arise.

Exam courses in the learning platform

If, at the beginning of the work with invigilated exams, only very few exams are processed, these can be prepared and supervised individually – each one by itself – in the learning management system. However, as soon as the number increases significantly, concepts for scaling and (partial) automation become necessary in order to keep the capacity requirements for personnel within limits. An important building block for this is the preparation and duplication of technically tested and legally compliant examination course templates. These templates, which, if possible, already contain the entire practical work with the examination, are then merely copied for each examination and keep the creation and support effort manageable (see Figure 21).

5.4.3.2 International online invigilation solutions

In an international comparison, several other examples of different examination solutions for online invigilated examinations can be identified, some of which are already being tested at German HEIs. The following brief examples are intended to provide initial impressions of further possible use in practice.

- **Live invigilation. Example: Pearson | VUE**

  This example shows how a human-supervised remote check is carried out in practice. The typical process flows such as preparation, authentication, room scan and execution are clearly illustrated.

  Link to the demo video: https://vimeo.com/268081803

- **Record & review with 2 cameras. Example: ProctorExam**

  This video example shows the possibility of using two cameras (one on the laptop, the other on an additional mobile device) to supervise the examinee from multiple perspectives and thus allow significantly less room for attempted cheating. With such solutions (as in the other examples), the participants' equipment and the applicable data protection framework conditions must always be taken into account. At TUM, the use of two cameras is not permitted due to the requirements of the Bavarian Distance Examination Ordinance (BayFEV).

  Link to the demo video: https://www.youtube.com/watch?v=zlePW7DrcD0

- **Automated invigilation. Example: SMOWL**

  The fully automated solutions are implemented differently in practice. While photos of the test object are sometimes taken and compared randomly, other solutions work with continuous recording (e.g. video, audio, screen). The solution shown in the video belongs to the first group and takes a photo with the webcam at random intervals of a few seconds in order to ensure the identity of the test object during the entire test.

  Link to the demo video: https://www.youtube.com/watch?v=pXcoJxV5Ykg

5.4.4 Summary and recommendations

Online invigilated distance examinations increasingly contribute to the digital examination process at universities and thus make a valuable contribution to guaranteeing a legal framework for examinations with invigilation outside of the lecture halls. Online invigilation, however, does not offer complete protection against attempts at cheating (cheat sheets, group work via Messenger or assistance from other persons). Therefore, ideally, question formats adapted to the content of such online examinations should be used, or such examinations should be used in combination with open examination forms (e.g. open-book examinations) and individual tasks. In such settings, invigilation can help to establish the identity of the test takers and provide a legal framework during the examination.

The following section concludes the chapter by presenting various findings and practical insights for assessment implementation.

Pre-thinking and pre-testing

Due to the complexity of the technical examination framework conditions, good preparation and good pre-testing are always a fundamental part of implementation for online invigilated examinations. This starts with the consideration of the exam content (question types, representations, formulas, etc.) and ends with the exact testing of the prepared exam with a test student account.

Info material and demo test

In the case of online invigilated examinations, the examinees' participation also plays a decisive role in the smooth running of the examination. Therefore, on the one hand, students should be informed as precisely as possible in advance about the technical and legal framework conditions and, on the other hand, opportunities should be offered to experience or try out the examination conditions technically (examination settings) and in terms of content (e.g. form presentations, specific question types) even before the actual examination.
Well-structured self-learning material or even explanatory videos (e.g. with a demonstrated examination run-through) are helpful in order to cope with a large number of examinations without a high input of human resources. At the same time, initial hurdles are reduced and acceptance is increased.

Individual advice

In the introductory and rollout phase, in particular, individual advice for interested lecturers is a crucial factor for successful examination implementation. This can initially be implemented by central contact persons with appropriate training, and also in the long run by experienced colleagues as multipliers.

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5.5 Digital open-book and take-home exams

Benjamin Eugster, Silvia Fath-Keiser, Susanne Leist, Mathias Magdowski, Johanna Friederike May

5.5.1 Introduction to the topic

In the development and implementation of examination scenarios, a strong polarisation into more restrictive and more permissive examination formats can be observed. Under the conditions of testing at a distance, in particular, the tensions between data protection and equal opportunities tend to escalate into conflicts between control and trust, which are crucial but not very constructive from a didactic point of view.

In this chapter, the focus is on the description of types of examinations that are characterised by the opening up of the classic closed examination. Building on the chapters on digital on-site examinations and digital remote examinations or online examinations, special attention will be paid to digital open-book examinations in presence and digital take-home examinations from a distance. They will be reflected upon against the background of established forms of examination such as essays or student papers with the associated concrete opportunities and challenges.

5.5.1.1 Definition

Often, the term take-home exam is used interchangeably with the term open-book exam. In order to sharpen the terminology of the examination scenarios, this chapter expressly distinguishes between the two settings on the basis of the different place of execution (in presence or remote) and the form of supervision (personal supervision, without supervision). Open-book and take-home examinations can be conducted in both analogue and IT-based settings. In the following, the term "digital" is used for the two examination scenarios to highlight specificities of a digital implementation of the formats.
As an established form of examination that is unsupervised and involves a high degree of individualisation and personal effort, classic student papers can be used as a comparative example.

	Digital open-book exam in presence	Digital take-home exam	Term papers
Venue	on campus	not established	not established
Technology	HEI's own end devices or BYOD	own terminals, loaned devices, PC pools	own terminals or loaned devices
Invigilation	in-person invigilation	none	none

Resources	limited access to pre-defined auxiliary resources	unrestricted access to aids	unrestricted access to resources, clear citation rules
Duration	1 to several hours	flexible (1 hour to several days)	several weeks

Open-book exams

Open-book exams have emerged in an analogue world as a way of designing written exams. Students are allowed to use certain aids during the examination in the examination room, which are either laid out there or brought along.

Open-book exams can also be conducted digitally on campus, allowing a wide range of aids that would be difficult or impossible to use in a non-electronic examination setting. In computer labs, for example, computers can be set up so that only a predefined set of resources such as specific literature or Internet sites can be used during the examination. In the case of open-web examinations, there are no restrictions given on what sites may be accessed. While it cannot be controlled, collaboration and communication with other examinees during the examination are not allowed. If the use of certain released aids is not only helpful for the successful completion of examination tasks (e.g. lecture notes) but indispensable (e.g. identification of a gene sequence in an online gene database), we can also speak of resource-mediated or resource-rich testing (cf. Halbherr, 2020, or the section on interactivity in Chapter 3).

Take-home exams

Take-home examinations are also an examination scenario that essentially does not require digital implementation (cf. Weber, McBee & Krebs, 1983). The original examination concept of take-home examinations allows students to receive examination tasks from the examiner and take them home to work on them there, as the processing time (e.g. 24 hours to a few days) would take too long on site. The examination performance takes place in the home setting, comparable to homework without supervision.

For a long time, digital processing has made it possible for these exams to be taken not only at the desk at home, but on the PC at home. The nature of the classic take-home examination can change considerably due to the possibility of electronic transmission and processing of the examination tasks. The spectrum of possible didactic implementations can range from examinations with individualised examination questions to essay examinations consisting of a number of questions which have to be worked out in more detail. In the latter case, a declaration of independence is usually required, comparable to the classic term paper, with which the student's own performance is to be ensured.

Take-home examinations that are carried out digitally or completely online can be designed in very different ways, both technically and didactically: due to the simplified provision and submission, the time requirements can vary from only one hour to a few days, and the processing form ranges from the download-processing-upload variant via email to the use of learning platforms with free-text and multiple-choice tasks.

Term papers / project-based assessment

In many disciplines, the term paper is an integral part of established examination practice. As an individualised examination performance, it not only serves as the personal consolidation of thematic focal points in the course of study, but also the practice of standards of academic integrity. As a rule, term papers are written independent of location over a period of several weeks. In some examination regulations, the possibility of revising the term paper within the same examination attempt is also guaranteed. All in all, term papers are prototypical for highly individualised examination performances, which can be used to test competences such as scientific writing, analytical skills and the penetration of the subject matter. For each term paper, the author guarantees, within the framework of a declaration of independence, that all text passages from third parties are marked as quotations with a reference to the source. This procedure is based on a culture of good scientific practice that is actively demanded and promoted in teaching. While plagiarism detection software can sometimes provide information about unidentified third-party citations, writing by third parties in the sense of "ghostwriting" can rarely be detected. However, this is not an obstacle for the legally secure anchoring of term papers in the curriculum, from which certain freedoms for the design of alternative examinations can also be derived. Thus, in the examination-legal framework of the term paper, even project-based term papers can be assessed in some cases, which partly draw on collaborative group work within the framework of a course.

5.5.1.2 Technical implementation

In addition to the extended possibilities, digital execution also entails some aspects that make an execution more complex. For this reason, the technical specifics of digitally performed tests will be briefly discussed below.

- **Digital open-book examinations in presence** can be taken both on the HEI's own computers and on the students' mobile devices (bring your own device – BYOD) on the HEI's premises. As a rule, these examinations are taken on the HEI's examination or learning platform. If access to tools or to certain resources is to be restricted, appropriate settings should be made, such as the integration of a lockdown browser[39], which allows targeted access to selected online resources by defining filters (see e.g. Eugster, 2019a, resp. Chapter 5.2). In BYOD settings in particular, a number of precautions need to be taken into account, including online access, network stability and the requirements for the end devices brought along.[40] In the Scandinavian region, experience with corresponding settings has already been gathered for several years (see e.g. Eugster, 2019b). At most German HEIs, with a few exceptions, experience with examinations on student devices was only gained in the context of COVID-19-contact restrictions and with corresponding recommendations and support measures.

[39] As an open source variant for Windows, MacOS and iOS, the Safe Exam Browser (https://safeexambrowser.org) is recommended here, for example.
[40] See, for example, the handout from the University of Würzburg: https://casetrain.uni-wuerzburg.de/eservice/laptops/.

- **Digital take-home exams** are taken at home on the student's terminal equipment. As a rule, all aids are permitted and the examination takes place without technical supervision. The submission of assignments can be made in a very low-threshold manner, similar to the submission of a term paper, via the email account provided by the HEI; it is also possible to download the assignments from the HEI's own file-sharing server. For clear structuring and evaluation of the submissions and the extension of the feedback possibilities (e.g. with evaluation grids), the corresponding activities in the HEI's own learning management systems are particularly suitable. These can also be used for the organisational aspects of the examination, such as a declaration of independence, which must be completed by examinees as a prerequisite for access to the actual examination.

In both cases, the processing of the tasks can also be completed via handwriting, depending on the specifications. However, due to the hybrid setting, this is associated with considerable additional technical and organisational effort in submission and correction. Such a hybrid submission of all or additional documents can, for example, be made via a scan or a mobile phone photo (see chapter Scan checks). In order to avoid this media discontinuity, if possible in terms of the required design, electronic processing using standard software (e.g. for word processing or spreadsheets) is also conceivable. This is installed outside the actual examination system, either on the students' own devices or is made available to them by the HEI in a virtualised environment (e.g. online statistics software RStudio) (cf. Chapter 5.2). The solutions are only stored locally and only submitted as a file at the end.

As with classic digital examinations, the solutions can also be entered directly into an examination or learning management system. It is important for these online examinations to be sufficiently tested and practised with students in advance (cf. Stollhoff & Jeremias, 2020, p. 10). The upload of files at the end of an exam, in particular, demands the scalability of the system as well as the technical equipment and skills of the students. In the case of take-home or BYOD examinations on HEI premises, it is also important to ensure that equal opportunities are maintained. Any functional deficiencies or malfunctions of the student devices should be identified at an early stage and appropriate loan devices or even examination rooms should be provided as an alternative or, if necessary, compensation for disadvantages should be granted (cf. Morgenroth, 2021, p. 126).

5.5.1.3 Didactic design principles

What the open-book and take-home examinations have in common, in both their analogue and digital forms, is a competence-oriented set of tasks. With open knowledge and examination questions, the focus of the competence examination can be placed on application, analysis, synthesis and/or assessment performance.

The didactic understanding behind this is oriented towards the design of authentic examination scenarios in the sense of practical orientation, which make targeted use of the interactive possibilities of digital settings for researching and analysing information (see interactivity in Chapter 3.5.2). The didactic design aims at a real work setting in which a variety of resources, directly accessible knowledge and other aids are always available for the time-bound processing of tasks. From this perspective, the classic

examination represents an artificial situation that essentially measures competencies that are exclusively required to master this artificially created situation.

In line with the SAMR model (see Chapter 3.5.2), the expansion of permissible aids for open examination scenarios not only leads to existing content and procedures being digitally replaced (substitution), but also to fundamental goal and design dimensions of examinations being rethought (redefinition). While in some disciplines open examination formats such as homework, open-book or take-home examinations are already widely established, in other disciplines the classical examination is the undisputed standard. In these areas especially, the opening of the examination setting and the resulting development of transfer tasks can have a thoroughly transformative character, changing not only the examination culture but also the learning culture of a subject. For this reason, the didactic conception and the organisational implementation of authentic examination tasks are associated with great challenges.

A widespread misunderstanding and a possible cause for poor examination results is the assumption that the approved aids make the examination easier (cf. Fernuni Hagen, 2020; Halbherr, 2020; Durning et al., 2016). Since many students were not sufficiently prepared for this kind of exam in terms of subject matter and exam didactics, it was even possible to observe during the Corona pandemic how corresponding exam results turned out worse.[41] This experience coincides with the observation in literature that the performance of examinees is very closely related to expectations and corresponding preparation (cf. Eilertsen & Valdermo, 2000).

The transformative character of these examination scenarios is reflected in the didactic design at all levels. When formulating tasks for open-book or take-home examinations, it is particularly important that they do not contain any obvious clues that would lead to a solution in a quick search in relevant networks. While at micro level an increased complexity of the tasks has to be expected, at meso level a stronger individualisation of the individual examinations is targeted. Many HEIs have published handouts and recommendations regarding these design options (e.g. FernUni Hagen, University of Cologne, Leipzig, Bonn, Münster and University of Sydney, ETH Zurich). These recommendations for increasing the complexity and difficulty of tasks are based on concepts such as constructive alignment (Biggs, 2014), authentic testing (Halbherr, 2020, cf. Chapter 5.2) and competence orientation (Frey, Spoden & Born, 2020).

In the concrete implementation of examination tasks, it is recommended to fall back on case studies and to formulate transfer tasks as well as situational problems in the sense of "ill-structured problems". Design- and reflection-oriented approaches to constructive tasks have also proven their worth, as have tasks that focus on technically sound research and analysis skills.

In the case of examination tasks with a high degree of complexity, in particular, care should be taken to ensure that they are formulated as linguistically complex as necessary, but otherwise as simple as possible. In this way, tasks testing general language competences instead of the specific subject competences can be avoided and

[41] https://j3l7h.de/blog/2021-05-31_18_31_Mathe-Kompetenzen

thus, for example, unduly disadvantage students with poorer skills in the language of instruction.

An individualisation of the examination can be achieved in different ways: from the randomisation of exam questions from a larger pool of questions to the automated creation of task variants, to the integration of individual student's prior work. Large-scale contract cheating, i.e. the commissioning of third parties to solve one's own examination, is thus also made more difficult because the solutions obtained cannot be used for several examinees.

However, it is essential to ensure that the degree of difficulty (i.e. similar learning content, similar number and difficulty of calculation steps) and the time required are comparable. This is a task that requires quite a bit of test time for task variations in exam design (see e.g. Magdowski, 2020; cf. practical example in Chapter 5.2.3.3). From the submission of handwritten solutions or approaches to solutions to the combination with shorter oral examinations, different framing measures can be set up to increase the degree of individualisation of examination tasks and performances.

5.5.2 Opportunities and challenges

In contrast to established homework, open-book and take-home examinations are sometimes controversial topics, as they put to the test numerous aspects that are classically associated with examinations and individual performance control, from the use of aids to the facilitation of collaboration. In this respect, the following areas present both great challenges and opportunities for the innovative design of examination settings. And although open-book examinations and take-home examinations overlap in many areas, the specific challenges will be listed separately. While there are many overlaps from a didactic point of view, the technical and organisational implementation poses different challenges.

Digital Open-Book Exams	Opportunities	Challenges
Pedagogy	Incentive to test competences instead of reproduction	Effort in conception and correction of the task can increase
Technology	Use of tools available online	Technical provision of additional aids in a controlled setting
Legal aspects	Incentives for a transformative assessment culture	Maintain equal opportunities, check originality of solutions
Organisation	Digital aids can be used without additional logistics	Recommendations for useful approved aids enable students to use them in a targeted and safe manner

Digital Take-Home Exams	Opportunities	Challenges
Pedagogy	Incentive to test competences instead of reproduction	Effort in conception and correction of the task can increase
Technology	Use of tools available online	Infrastructure cannot always be assumed for students. Create comparable technical requirements for BYOD setting
Legal aspects	Incentives for a transformative assessment culture	Equalise opportunities
Organisation	Flexibilisation of the place and period for carrying out examinations	Deadlines for submission require clear agreement and coordinated organisation

Against the background of these opportunities and challenges, the legal classification of more open examination scenarios strongly depends on the concrete didactic design and the organisational-technical examination setting. For this reason, the challenge of legal classification will be discussed in more detail below before the integration of additional aids and, ultimately, the challenges of cheating prevention and the opportunities of an examination setting based on trust and self-responsibility are discussed.

5.5.2.1 Legal aspects – Integration into the examination regulations

If an open-book or take-home examination is to be included as a module examination in a degree programme, this must be specified accordingly in the examination regulations applicable to that degree programme. The higher education acts specify which aspects of the examination procedure must be regulated in the examination regulations of the higher education institutions. As a rule, the subject of the examination and the type of examination are specifications that must always be determined. Which further regulations regarding the procedure for open-book and take-home examinations are to be laid down in the examination regulations can vary greatly. The aspects mentioned below therefore only provide indications of what might need to be regulated.

Open-book and take-home examinations are written papers, which are classically distinguished in examination law between homework and supervisory work (examinations). Most examination regulations provide rules for the conduct of these common types of examinations, which then apply accordingly or can be referred to (for the general requirements, see Jeremias, 2015).

Both analogue and digitally conducted open-book examinations, as defined above, can be classified under supervisory examinations. In this case, the provisions on academic integrity and the admissibility of aids would have to be regulated in the examination regulations.

A take-home examination conducted in an analogous manner counts in the broadest sense as written, domestic examination work. Its relevant provisions, in particular, with regard to the declaration of independence, then apply accordingly. If the examination

regulations provide for regulations regarding the processing time of written domestic papers, care would have to be taken to ensure that the shorter processing time for a take-home examination of, for example, one to two days is supplemented.

In some cases, a digital take-home examination can be designed in a very similar manner to the written examination format with regard to the duration of the examination or the assignment. Since it can thus be positioned between a term paper and an examination, it "therefore deserves recognition as an independent type of examination" (Morgenroth, 2021, p. 127) in order to clarify the specific handling with regard to the preservation of equal opportunities. Provisions on the duration of the examination, declaration of independence and aids would have to be formulated accordingly.

If open-book or take-home examinations take place digitally, provisions for dealing with technical malfunctions should be added (cf. Heckmann & Rachut, 2021, p. 198), which may explicitly refer to the conditions of a BYOD setting.

If the examination design provides that the pass mark can be achieved (i.e. more than 50%) exclusively by marking the correct or incorrect answers, then it is an examination in the multiple-choice procedure (multiple-choice examination). The special requirements of the jurisdiction with regard to evaluation and quality assurance concerning this examination design would have to be referred to accordingly, or must be supplemented.

To prevent cheating, a supplementary oral examination may be provided. Reference should be made to the relevant provisions on the oral examination (in particular protocol, group examination, presence of other persons) and on combined examinations (in particular, assessment and repetition).

5.5.2.2 Organisation – Design of authentic examination settings

Common to these open types of examinations is the admission of aids which form the basis of an authentic examination setting. The selection of aids classically includes collections of formulas or laws, technical literature or learning scripts; however, it can also go so far that free research on the Internet or the use of software available offline or online is permitted (cf. Chapter 5.2). The tasks are designed in such a way that they cannot be solved by a quick look-up or a short search alone. A trial-and-error approach always presents this claim as a challenge in view of the increasing prevalence of intelligent software.[42] Approved tools can vary in complexity, degree of customisation and scope. A comprehensive definition of all possible aids is neither feasible nor meaningful at this point, but a few aids are listed here to illustrate the breadth of the spectrum and give an impression of the new didactic possibilities that arise from it.

[42] https://j3l7h.de/blog/2020-06-13_10_24_Internet-feste%20Fragestellungen

Standardised aids	• Lecture notes • Digital course materials • Formula collections
Individual aids	• Cheat sheet with the most important information in a small space • Personal brief notes • Individually prepared case studies
Interactive tools	• Searchable databases, passive (!) use of forums • Online programs for the computation of complex tasks • Programs installed on the (student) computer for the computation of complex tasks

This also involves a learning process on the student side. Students realise that not all tools are useful and that questions can be answered more efficiently and in a more complex way on the basis of prior knowledge. For this reason, there are also approaches that proactively view the very act of looking up, evaluating and using online information and software as part of information literacy and thus as an integral part of an examination task and integrate them into it. In some disciplines, students learn to use certain software tools anyway (for example, circuit simulation with SPICE, evaluation or calculation of formulas with MATLAB, Octave and Wolfram Alpha or the use of programming languages, for example, with the aid of Jupyter Notebook) (cf. Chapter 5.2). Examinations can be designed in such a way that the use of these software tools is necessary.

From the point of view of examination law, students must have been clearly informed before the start of the examination about which aids may be used and about the general citation obligations or, in the case of a pragmatic simplification, about the indication of the aids used.

In practical terms, this raises the question of which cases and what level of detail used bodies of knowledge must cite as the intellectual property of others or used aids must be indicated. The definition of these aspects can vary greatly depending on the discipline and must be appropriate to the general standards of scientific integrity.

Students should be informed that the examination performance must be completed independently and that any exchange between students is therefore not permitted. A corresponding regulation would, for example, clearly exclude chat functions or the active use of collaborative sites, such as question forums, from the permitted aids. If another person's performance is passed off as one's own, it is a case of deception, which can result in appropriate sanctions.

5.5.2.3 Didactics – the role of deception prevention

Examinations serve as proof of the examinee's qualification. If an external performance is passed off as one's own, this is a deception of one's own ability. In addition to the use of unauthorised or undisclosed aids, the unauthorised use of third parties is also considered to be cheating. In order to satisfy the principle of equal opportunities (Article

3(1) GG) and the significance of the examination required under Article 12(1) GG, care must be taken to ensure that deception is only possible with difficulty (cf. Fischer & Dieterich, 2021, p. 110).

Regardless of the type of examination, students should generally be encouraged not to cheat, e.g. through "case studies of cheaters where cheating later had negative consequences, a culture of honesty, and clear communication of what is considered cheating and how it is punished" (cf. Stollhoff & Jeremias, 2020, p. 15)[43]. Measures such as an examination invigilator do not serve solely to prevent cheating through control and deterrence. By making cheating more difficult, students are, on the one hand, required to be more committed and, on the other hand, a framework is created for them to be honest with their fellow students. In addition to this influence on a personal level, cheating can be prevented or made less effective through the content and technical implementation of examinations.

Digital open-book examinations take place under supervision. In addition to the usual precautions taken during invigilated examinations, further preventive measures of a technical nature are possible. For example, the electronic end devices can be prepared in such a way that the students only have access to the aids that are permitted. It should also not be possible for students to use chat functions. In this way, exchanges between examinees or with third parties, as well as the use of unauthorised aids, can be prevented. However, the prevention of plagiarism is all the more difficult to enforce the more extensively the use of aids is permitted. This situation is also found in take-home examinations and in homework in general.

In contrast to open-book examinations, **digital take-home examinations** take place without supervision and therefore pose comparable challenges to classical homework. Deception concerning one's own performance is thus possible via exchanges with other examinees or third parties as well as via plagiarism. The measures suggested by Schollhoff and Jeremias (2020) to prevent cheating are transferable to take-home examinations and include the use of open-ended questions, individualised assignments (sequence, content), tight time limits, handwritten papers, a declaration of independence, plagiarism detectors or supplemental oral examinations. Based on recent experience with take-home exams, there is a plethora of suggestions on how exam design should be designed to prevent cheating.[44]

Across the board, the best remedy for cheating is said to be competence-based questioning, as this requires far more than simply copying third-party answers. However, the issue of cheating also has far-reaching implications for the transformative nature of examination cultures that focus on trust rather than pure control. Heckmann and Rachut, in their elaboration on the Bavarian Distance Examination Ordinance, point to the social potential of open examination scenarios in this regard as follows:

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[43] Original in German: "Fallbeispiele von Betrügern, bei denen der Betrug später negative Konsequenzen hatte, durch eine Kultur der Aufrichtigkeit und durch eine klare Kommunikation dessen, was als Betrug angesehen und wie dies geahndet wird".

[44] See, for example, https://video.cls.rwth-aachen.de/wp-content/uploads/2021/02/Analyse_Taeuschungsszenarien_Pruefungen_published.pdf or https://hochschulforumdigitalisierung.de/de/blog/digitale-pruefungen-take-home-exam

> *Control is good, trust is better. One can make a virtue out of the need for weak controllability in examinations in private homes and place a greater degree of trust in the students than may still be the case here and there at present. One risks perhaps a cheating act here and there, but one enriches the relationship of the HEIs (representative for the state) to the students (as part of the society) by the readjustment of the examination (open book, fair examination organisation, appeal to fairness etc.). The trust placed in them is capable of shaping the young people's character in a positive way - just as decided mistrust (especially in the case of the degrading request for a 360-degree pan of the camera through the apartment) tends to degrade the students to the object of state action. The free constitutional state lives on preconditions that it cannot guarantee itself. With this sentence, Ernst-Wolfgang Böckenförde also addressed the deliberate imperfection of law enforcement and the great importance of acceptance in a free society. Where could this principle be better learned and taught than at HEIs? (Heckmann & Rachut, 2021, p. 200)*[45]

The societal potential addressed here points to the transformative character of changed examination cultures (SAMR, see Chapter 3.4.2), which can be tapped through the comprehensive use of digital possibilities of a networked knowledge society. The trust and personal responsibility demanded of students associated with this are oriented in particular to examination settings that serve to determine the student's level of competence and not primarily strong selection. In the case of highly selective examinations, in particular, it can be assumed that the willingness to deliberately cheat increases considerably due to the forced selection function. Corresponding aspects must be taken into account in the choice and curricular coordination of differently restrictive examination scenarios within a degree programme.

[45] Original in German: "Kontrolle ist gut, Vertrauen ist besser. Man kann aus der Not der schwachen Kontrollierbarkeit bei Klausuren in privater Wohnung eine Tugend machen und den Studierenden ein größeres Maß an Vertrauen entgegenbringen als dies derzeit noch hier und da der Fall sein mag. Man riskiert damit vielleicht die eine oder andere Täuschungshandlung, bereichert durch die Neujustierung der Prüfung (Open Book, faire Prüfungsgestaltung, Appell an Fairness etc.) aber das Verhältnis der Hochschulen (stellvertretend für den Staat) zu den Studierenden (als Teil der Gesellschaft). Das entgegengebrachte Vertrauen vermag die jungen Menschen charakterlich positiv zu prägen – so wie dezidiertes Misstrauen (gerade bei der entwürdigenden Aufforderung zum 360-Grad-Schwenk der Kamera durch die Wohnung) die Studierenden eher zum Objekt staatlichen Handelns degradiert. Der freiheitliche Verfassungsstaat lebt von Voraussetzungen, die er selbst nicht kann. Mit diesem Satz sprach Ernst-Wolfgang Böckenförde auch die gewollte Unvollkommenheit der Rechtsdurchsetzung und die hohe Bedeutung der Akzeptanzstiftung in einer freien Gesellschaft an. Wo könnte dieses Prinzip besser gelernt und gelehrt werden als an den Hochschulen?"

5.5.3 Examples from practice

5.5.3.1 Limited open-book checking with Safe Exam Browser

Description	Open-book examination on campus
HEI	Zurich University of Applied Sciences (ZHAW)
Subject	Applied Psychology, Basics of Application Testing
Pedagogy	• Single-choice and open-ended exam questions in 90 min • In advance of the exam, collaborative group projects were created and uploaded to the cloud along with notes and course materials • The respective project work was the basis for answering the individualised tasks. This preparatory work as well as the course documents could be accessed during the examination
Technology	• Provision of student preliminary work, notes and course documents via Nextcloud with PDF preview • Additional access protection with Safe Exam Browser, which only allows access to the Moodle text and Nextcloud • Archiving – download of the exam solutions via Moodle Export and archiving of the student's preliminary work as PDF
Organisation	• BYOD test with 10% replacement devices • Three parallel examination rooms for necessary distance
Link	https://tube.switch.ch/videos/5b2fcaff

In this open-book examination, it is an examination scenario that was conducted as part of the introduction of digital examination scenarios at the Institute of Psychology at Zurich University of Applied Sciences (ZHAW). The prerequisite of the exam was that students could only access the course materials as well as a preliminary paper from individualised group work during the exam. The technical solution chosen was a configuration of the Safe Exam Browser that defined access to the Moodle examination platform as well as to a Nextcloud-based storage location to which students could upload their documents and use them during the examination.

5.5.3.2 Digital take-home exam with result opload

Description	Take-home examination as down- and upload via Moodle
HEI	University of Hamburg
Subject	All subjects
Pedagogy	• Different types of examinations possible. Example: Six open questions (application and transfer) to be answered with 350 or 500 words each

Technology	• Time buffer for down- and upload 10-15 min • Declaration of independence as upload • Archiving – download of the exam solutions and archiving separately • via Moodle also
Organisation	• Before the test – integrate the data centre to prevent server congestion • During exams – examiners are available for students by phone and via chat • Hotline for teachers
Link	https://dl.min.uni-hamburg.de/de/anleitungen/moodle-the/

During the digital semester, examinations were conducted at several HEIs according to the classical procedure for take-home examinations, or as digital take-home examinations with uploading of the results. A more detailed description using the example of unsupervised take-home examinations can be found in Chapter 2.2. An exemplary setting is listed in the table above.

5.5.3.3 Take-home exam with automated question generation

Description	Take-home exam with upload of handwritten solution
HEI	Otto von Guericke University Madgeburg
Subject	Electrical Engineering
Pedagogy	• 10 subject areas, for each of which a task is randomly selected from a pool of approx. 10 to 30 possible variants, thus allowing a very large overall variety • Secondary condition – total number of points and workload within certain limits
Technology	• Automated creation of exam sheets in MATLAB from LaTeX sources in PDF files, one task per page • Link and QR code to the submission form in Moodle • Automated dispatch by email, declaration of independence in Moodle
Organisation	• Telephone hotline and Zoom conference for technical and content-related questions • Timely submission of checksums with subsequent upload for slow Internet connections • Archiving – ZIP archive of the submitted original solutions and the commented/evaluated variants
Link	https://mathiasmagdowski.wordpress.com/2021/05/05/online-take-home-elektrotechnik-pruefung/

In this take-home examination, very similar tasks were used to those in previous face-to-face examinations for the same course in order to achieve good comparability. In

order to do justice to the take-home format, the task sheets were individualised, i.e. all participants were given their own tasks, which were, however, comparable in terms of difficulty, scope and subject areas. Since the students have more opportunities to solve the problems at home (e.g. they can use numerical and simulation software), the number of tasks increased from 9 to 10, whereby the processing time was three hours as before. The students then worked out handwritten solutions. Submission, correction and inspection, however, took place completely online.

5.5.3.4 Take-home exam with automated question permutation in the LMS at TH Köln University of Applied Science

Description	Scenario of a digital take-home exam with randomly selected formula questions of comparable difficulty and with broad content coverage for a basic technical subject.
HEI	TH Köln University of Applied Sciences
Subject	Electrical Engineering
Pedagogy	• Approx. 40 different question types according to topic and difficulty, each with 5-50 variants, of which one variant each is selected by the LMS and is asked in a different order • Permutation of the variable values for calculation questions (formula questions), thereby very large overall variety possible • Secondary condition – same total score and comparable difficulty (computational effort and subject matter) for the variants within the question types
Technology	• Creation of exam questions in Excel and transfer to the LMS format (ILIAS), upload of a question pool per question type to the LMS • Creation of an exam with random question selection (one question from each question pool, random order, without specifying the question title), students can load and answer questions in any order, enter the result as a numerical value (calculation question) or selection value (single choice) • After testing, downloading of the random number values and student results in a result file and post-correcting with the above-mentioned Python tool (post-correcting rounding errors and question errors) • Declaration of independence in ILIAS • For inspection overview of the student results (sorted by matriculation numbers) per task as well as the post-corrected results and the corresponding score as well as a time-limited view of the uncorrected exam in ILIAS • Archiving – PDF printout of the exams created in ILIAS and saving of the exported result files, the question pool xlsx, the correction script (Python) and the correction results (xlsx)

Organisation	• During the semester, the assignments are created and corrected several times by the team of lecturers until the value ranges make sense and ambiguous formulations or formula errors are eliminated • Accompany inspection as well as testing with a Zoom team so that questions (technical, content, etc.) can be answered in breakout rooms • In case of large numbers of test takers, split into several cohorts and start at intervals of 10 min to limit the initial load on the test servers • Principally 5 min extra time for technical problems
Link	https://github.com/TPanteleit/ILIAS---Test-Generator/blob/master/ILIAS%20-%20Aufgabengenerator%20Handbuch.pdf

The examination scenario was offered at the TH Köln University of Applied Sciences in different examinations (electrical engineering, wind energy, electrical networks) with slight variations by different lecturers. The experiences with the administration and evaluation of assignments with ILIAS can be found in a field report by Johanna May, Tobias Panteleit, Patrick Lehnen and Eberhard Waffenschmidt.[46] The described procedure for the conception and execution of the examination was inspired by the approach of Tim Metzler and Mohammed Wasil.[47] The described setting was carried out during the digital semester; it builds on experiences with digital semester-accompanying interim tests prior to the pandemic.[48]

To enable the students to take the exam in the same system as the intermediate tests, it makes sense to also offer the exam in ILIAS with formula questions. In the future, further question types with graphical components (e.g. drawing the operating point on the characteristic curve) are planned with plug-ins such as STACK. The aim is to make the exam as close to the job, i.e. if the student's competence is sufficient, digital tools should be used. In addition, we would like to see networking in basic subjects so that elaborate, quality-assured questions can be used across HEIs.

5.5.4 Recommendations

Digital open-book and take-home examinations are examination scenarios that exhibit a high degree of diversity and accordingly require a high degree of flexibility from all those involved. For their systematic and long-term use, clear awareness of the didactic and technical design options as well as the legal requirements is required at all levels in order to ensure that equal opportunities and didactic consistency are maintained. The possible responsibilities required for this and corresponding recommendations for action are summarised below in a target group-specific manner.

[46] Offline task management and evaluation for exams in ILIAS (to be published https://tag-der-digitalen-lehre.de/ausstellung-28-09-2021/#track3).
[47] Electronic Examination using Jupyter Notebook with JupyterHub and nbgrader: https://cfp.jupytercon.com/2020/schedule/presentation/149/electronic-examination-using-jupyter-notebook-with-jupyterhub-and-nbgrader/.
[48] See Martin Hiertz, Johanna May, "Effectiveness of electronic interim tests": https://www.th-koeln.de/mam/downloads/deutsch/hochschule/profil/lehre/prasentation_von_may_und_hiertz.pdf.

For teachers

As examiners, teachers are responsible for the pedagogic definition and the corresponding embedding in the sense of constructive alignment. Through the didactic weighting of competence-oriented examination tasks, they play a central role. Teachers should also be encouraged to reflect on their own workload and that of students and to present this transparently.

In addition to the continuous further training of teachers within the framework of HEI and media didactic training courses on examination design and technical implementation, mutual exchange and open and (self-)critical discussion of experiences with this type of examination are also part of sustainable quality assurance. For the critical development of competence-oriented examination tasks, it is advisable within specific disciplines, in addition to creating one's own examination tasks, to share, assess and maintain examination task catalogues and examples of good practice within and, if necessary, across HEIs.

The teachers determine the assessment basis and present the assessment criteria transparently to students and examination offices. The didactic integration of the examination scenarios also involves these as well as possible transfer tasks being available to the students for the content-related as well as technical exercise as early as possible. This also includes informing students about compliance with good scientific practice and the sanctioning measures in the event of cheating.

For students

Students have a special responsibility in the described examination scenarios, which they must be made aware of and prepared for. Compliance with good scientific practice is in the foreground, comparable to the preparation of written work. Students should have the opportunity during the semester to familiarise themselves with the format of transfer-oriented examination tasks as well as the digital aids permitted for the examination. Adequate preparation also makes students aware that the shift to transfer-oriented examination tasks does not primarily relieve them of the learning process, but merely places a different emphasis on the skills of networked and analytical thinking. Therefore, it is all the more advisable for them to deal with effective knowledge management strategies in preparation for examinations in addition to the content-related and methodical examination of the examination material.

For those responsible for examination regulations and organisation

If the described examination scenarios are used systematically, it is advisable to include them as an examination type in the examination regulations. At most HEIs, the examination regulations are adapted by the departments or faculties. If there are framework regulations in which general examination regulations are laid down for the entire HEI, these must also be approved by the senate in addition to the examination regulations for the specific course of study.

The extent of the necessary changes to the (framework) examination regulations can differ considerably. The implementation process also varies from HEI to HEI. Due to its complexity, the amendment process should be closely followed by the responsible bodies (e.g. examination board and legal department).

Persons responsible for HEI pedagogy

HEI pedagogical consulting can contribute to general information about the discussed examination scenarios as well as support conception in specific cases of application. For this purpose, results-oriented training offers for the creation, administration and quality management of competence-oriented examination tasks are recommended. In addition to consulting and training, it is advisable, whenever possible, to coordinate the exchange on the didactic design of examinations from this perspective in order to promote both subject-didactic and cross-curricular approaches.

Those responsible in engineering

With regard to support offers and infrastructure, the recommendations for digital open-book examinations and take-home examinations are largely based on the same principles as those for classic e-examinations. In the case of time-sensitive BYOD examinations, the provision and maintenance of loan devices should also be considered in order to maintain equal opportunities.

When selecting and further developing the virtual examination infrastructure (examination software, LMS, interfaces, incl. plug-ins to peripheral systems), it is particularly advisable to pay attention to the flexibility that permits the integration of aids of different types into a partially closed examination setting.

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Universität Köln: Merkblatt digitale Open Book Klausuren (für Lehrende) der Uni Köln: https://kjll.jura.uni-koeln.de/sites/kjll/user_upload/Open_Book-Klausur_Lehrende.pdf .

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Universität Leipzig: Digitale OPEN-BOOK-Klausuren der Uni Leipzig (mit Szenarien für Moodle und ILIAS): https://www.uni-leipzig.de/fileadmin/ul/Dokumente/2020_Lehre-digital_Digitale-Klausur.pdf.

University Sydney: Open-Book and Take-Home Exams of the University of Sydney: https://student.unsw.edu.au/open-book-and-take-home-exams.

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5.6 Online oral exams

Malte Persike, Florian Rampelt, Jannica Budde, Silvia Fath-Keiser

5.6.1 Introduction to the topic

Online oral examinations enable direct audiovisual communication between examinees, examiners and guests in different locations. They are predominantly carried out with the aid of commercially available videoconferencing systems.

In general, data protection and data security-compliant transmission must always be ensured here, whereby examination contents with a special need for protection, e.g. in casuistry examinations, systems with extended encryption features or access protection can be used. Digital oral examinations based on online video conferencing are considered by many HEIs to be a practical alternative to the face-to-face oral examination. However, participation from a distance is often only voluntary.

The examination situation appears authentic, which allows the assessment of social and communication skills. Students also prefer oral to written examinations (Huxham, Campbell & Westwood, 2012). Literature only partially covers the assumption of equivalence of online-based and presence-based analogue oral examinations. Studies suggest that in terms of examinee stress levels, there may even be advantages to the virtual setting (Akimov & Malin, 2020; see also Lu, Goodale & Guo, 2014). On the other hand, there is evidence that the visibility of an individual's video image has a significant distracting effect and can greatly unsettle students with a corresponding predisposition (Wegge, 2006).

Online oral exams in times of Corona

As a caveat, it should be noted that the vast majority of research on online oral examinations dates from before the pandemic, when the use of video conferencing systems for teaching and examination was a novel concept. The extent to which the results can be replicated with students who are accustomed to video conferencing in teaching is unclear. However, experience from the pandemic shows that, despite students' experience of video conference-based teaching, there is often a lack of clarity about how they should properly conduct themselves in the context of online oral examinations from a distance so as not to arouse suspicion of cheating. Is it necessary to look at the camera or is it acceptable to look at the images of the examiners in the video conference? Is it acceptable to look further away?

Do hands have to be visible and what actually happens if strangers appear in the picture?[49] Together with the novelty of the scenario of oral online examinations, this increases the uncertainty on the part of the students. Furthermore, oral online examinations are not trivial from the perspective of examination organisation and require the clear coordination of examination phases and examination, waiting and discussion times and waiting and meeting rooms (Eugster, 2020).

Overall, however, recent studies suggest that online oral examinations are a suitable substitute for face-to-face oral exams (cf. e.g. Goodman, 2021) across disciplines as examples from chemistry (Giordano & Christopher, 2020), computer science (Lee, Kurniawan & Choo, 2021) or economics (Akimov & Malin, 2020) demonstrate.

Synchronous and asynchronous online oral exams

Oral examinations can be digitally synchronous (via video conferencing systems) or asynchronous (via audio or video files). A synchronous digital oral examination (i.e. an

[49] Di Gesú and González (2020) report a case where a student took her digital oral exam in the kitchen while her partner prepared a coffee in the background.

oral online examination) is the classic oral examination using a digital transmission medium, usually a video conference tool. The examinee and the examiner conduct an examination discussion in a live setting, i.e. without any significant time delay between the spoken contributions of the two parties. Different competences such as oral communication skills and interaction skills (cf. Niehues/Fischer/Jeremias, 2018, p. 16) can be tested. Furthermore, students should be given the opportunity to reveal their thought processes in the examination and to demonstrate transfer skills.

Presentations are oral monologues in which, amongst other things, presentation skills are tested. They can be conducted in digital form both synchronously and asynchronously. In the asynchronous case, the examination lecture is recorded in advance by the students, either as a podcast or a slide presentation set to music or with a visible speaker. Students submit the audio or video file online as an examination performance, which is assessed by the examiners. The advantage of asynchronous digital delivery of the presentation is the avoidance of individual performance fluctuations on the day of the examination as well as the increased tolerance of technical disruptions. In addition, the examinees are given the opportunity to perform outside of the stressful examination situation. The disadvantage of asynchronous execution of digital presentations is that the lecturers and students do not have the opportunity to spontaneously ask comprehension questions or to conduct a scientific discourse afterwards. However, it is precisely this that primarily serves to check whether the presentation has been prepared by the students themselves or by third parties, or whether the presentation topic has been understood in depth. It therefore seems to make sense to combine the asynchronous presentation of the paper with a short oral examination. In this case, one part of the examination is performed asynchronously, while the other part takes place in a live setting on site or online.

5.6.2 Opportunities and challenges

Oral Online Exams	Opportunities	Challenges
Pedagogy	Authentic exam situation, also with reduction of the stress load, if necessary	Uncertainties among students regarding "appropriate behaviour"
Technology	Students and teachers take exams on devices they are familiar with. The university does not have to organise any hardware	Hardware and also Internet infrastructure can considerably influence the individual
Legal aspects	Location-independent online exams can create equal opportunities for all	Possibilities for deception are higher than in the context of face-to-face examinations. Consent forms or alternative tests may be required
Organisation	Students and lecturers can organise and set up the place where examinations are held according to their needs	Teachers may have an increased need for support in conducting examinations with video conferencing systems

Examination of international students and students with non-classical study profiles

Oral online examinations allow resource-saving local flexibility of the examination without a significant loss of authenticity. International students as well as students with non-classical study profiles, e.g. working students, are often named as target groups.

Spatial flexibilisation has other positive effects. For example, in video conferencing-based examinations, international students demonstrate an at least equal, and in some cases better, performance compared to on-site oral examinations (Liu & Chen, 2018).

Connection with practical parts

In oral presence examinations, examinees often have the opportunity to use the writing material provided, e.g. to produce auxiliary calculations or sketches. In some cases, the creation of such a sketch is also part of the examination performance, or the examiners themselves create handwritten notes and present these to the examinees as part of a question.

The transfer of such scenarios into a digital online setting is not without challenges. Examiners as well as students need to be able to create handwritten notes first and then transmit them as an image in a video conference. For students in particular, the only way to realise this is to record the drawings with a smartphone. However, even then the workflow is rather clumsy. The smartphone must be able to transfer images into the video conference. With common systems, this usually causes some effort on both sides.

Dealing with technical errors

Oral online distance examinations require a permanently active Internet connection between examiners and students with sufficiently large bandwidth. Experience at HEIs shows that disconnections cannot be avoided and that the causes can lie with both examiners and students. For students, such disconnections lead to highly stressful situations because they fear that the exam will be invalidated.

Therefore, clear guidelines should be defined and communicated for oral online examinations. This concerns, above all, the still acceptable frequency and duration as well as behaviour in the event of malfunctions. For example, it can be agreed that students should immediately establish telephone contact with the examiners if the Internet connection is interrupted and then continue with the examination in the presence of the examiners. Further measures are described in Chapter 5.4.

Legal challenges

From a legal point of view, oral online examinations are electronic distance examinations which are regulated by state ordinances in most German states (see Chapter 5.4.2.2). The respective requirements are to be implemented accordingly in the examination regulations. In the case of asynchronously conducted examinations in which the examinee and thus his/her home can be seen, appropriate regulations (e.g. declaration of consent/alternative examination types) should be integrated.

5.6.3 Examples from practice

5.6.3.1 Videoprüfung@home at the FernUniversität in Hagen

Description	Videoprüfung@home
HEI	The FernUniversität in Hagen
Subject	All subjects
Technology	The Videoprüfung@home may be carried out with the software products approved by the HEI (e.g. Adobe Connect).
Organisation	• The time required is the same as for the oral examination in person • Appropriate time buffers must be planned for testing the technical connection and for reacting to possible connection faults • A Videoprüfung@home is conducted by an examiner with the assistance of a competent assessor in a virtual examination room
Link	https://www.fernuni-hagen.de/mi/studium/pdf/leitfaden_videopruefung_at_home.pdf

At the University of Hagen, oral examinations could take place as online examinations, during the summer semester 2021. These oral exams were performed with video conferencing software without the presence of an invigilator at the student's location. Examiners could determine for each oral examination whether they also offered it as a so-called Videoprüfung@home. In this case, students could choose the form of examination.

5.6.3.2 Oral video conference examinations at Karlsruhe Institute of Technology (KIT)

Description	Oral video conference exams
HEI	Karlsruhe Institute of Technology (KIT)
Subject	All subjects
Technology	• Big Blue Button as an open source video conferencing web application • Provision on KIT servers
Organisation	Conducting the examination via video conference is only possible upon written request of the examinee. The decision on the acceptance of the examination is the responsibility of the examiners.
Link	https://www.zml.kit.edu/corona-muendliche-pruefung.php

5.6.4 Recommendations

Universities should develop overarching guidelines for what behaviours are allowed in online synchronous oral exams. Natural behaviour (e.g. looking around with your eyes) should not be restricted.

These requirements should be well communicated to teachers and students. Teachers must also receive reliable pedagogic and technical support and preparation when conducting examinations in video conferencing systems.

In scenarios with asynchronous service provision, technical specifications and restrictions must be observed. Using the recording function of video conferencing systems or special software for screen recording can massively reduce the file size, often by a factor of 10 or more, so that the upload only takes a few minutes. Therefore, specifications for students, such as the definition of the recording tool for asynchronous oral online examinations, are of essential importance.

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5.7 E-portfolios

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5.7.1 Introduction to the topic

At the time of progressive educational movement (more than a century ago) there were already initial approaches to working with portfolios in educational contexts (Hericks, 2020) – for the organisation and documentation of self-directed learning. In educational science courses, in particular, analogue and digital portfolios have played an important role for a long time. Meanwhile, however, portfolio work has also increased across disciplines (Baumgartner et al., 2009; Himpsl, 2010; Breuning, 2020). The EUROPORTFOLIO project (European Network of ePortfolio Experts and Practitioners)[50] attempted to make work with e-portfolios more visible from 2013 to 2016. E-portfolios are very versatile and can be used as a teaching as well as an evaluation and assessment tool (Reinmann & Sippel, 2011). In 2020/21, they were used as an alternative examination format, e.g. at the Berlin School of Economics and Law (Mey, 2020).

5.7.1.1 Definition

E-portfolios are digital portfolios in which learners collect, document and reflect on their learning outcomes.

> *E-portfolio is a digital collection of 'skillfully made works' (=lat. artefacts) of a person who thereby wants to document and illustrate the product (learning outcomes) and the process (learning path/growth) of his/her competence development in a certain period of time and for certain purposes. The person in question has independently made the choice of artefacts, and organised them in relation to the learning objective. She (he), as the owner, has complete control over who can see how much information from the portfolio at what time. (Hornung-Prähauser et al., 2007, p. 14).*[51]

Furthermore, e-portfolios can be used as formative as well as summative assessment and evaluation tools. For example, students can reflect on their own learning process

[50] http://eufolio.eu

[51] Original in German: "Portfolio ist eine digitale Sammlung von 'mit Geschick gemachten Arbeiten' (=lat. Artefakte) einer Person, die dadurch das Produkt (Lernergebnisse) und den Prozess (Lernpfad/Wachstum) ihrer Kompetenzentwicklung in einer bestimmten Zeitspanne und für bestimmte Zwecke dokumentieren und veranschaulichen möchte. Die betreffende Person hat die Auswahl der Artefakte selbstständig getroffen, und diese in Bezug auf das Lernziel selbst organisiert. Sie (Er) hat als Eigentümer(in) die komplette Kontrolle darüber, wer, wann und wie viel Information aus dem Portfolio einsehen darf."

(formative), but also document final learning outcomes (summative) (EUROPORTFOLIO, 2015). The possibilities for implementing e-portfolios as an examination instrument can be found, for example, in the framework examination regulations for Bachelor's and Master's degree programmes at TH Köln University of Applied Sciences. They also provide important information on the required didactic embedding:

> *A learning portfolio documents the student's competence development process by means of presentations, essays, excerpts from internship reports, tables of contents of term papers, lecture notes, to-do lists, research reports and other performance representations and learning productions, summarised as so-called "artefacts". Only in connection with the student's reflection (in writing, orally or also in a video) on the use of these artefacts for the achievement of the learning objective previously made transparent by the examiner does the learning portfolio become an examination object. During the creation of the learning portfolio, the examiner will provide feedback on development steps and/or artefacts in the course of the semester. As an examination performance, a revised form of the learning portfolio – usually in electronic form – is submitted after the feedback (TH Köln University of Applied Sciences 2018, p. 18).*[52]

5.7.1.2 Basic differences to paper-based portfolios

Just like paper-based portfolios, e-portfolios primarily serve the active and reflective examination of the experience gained in one's own learning process in dealing with the performance requirements imposed by a course of study. Portfolio-work also has the implicit goal of increasing (extra-)functional competencies that should be conducive to later professional practice. These competences (e.g. digital operating competences) must be taken into account when becoming familiar with e-portfolio tools in order to enable equal opportunities (this also applies to other digital examination scenarios).

The central differences between an e-portfolio and a paper-based portfolio are the location- and time-independent use, also mobile, as well as the usability of multimedia content such as videos, images or linkable content. In addition, there are aspects of interaction and feedback possibilities within the framework of e-portfolios that, in contrast to paper-based portfolios, can be used very flexibly in the respective learning setting. In addition, collaborative work and targeted release of the e-portfolio for specific users is possible (EUfolio, 2015). For reflection on the learning process, the integration

[52] German Original: "Ein Lernportfolio dokumentiert den studentischen Kompetenzentwicklungsprozess anhand von Präsentationen, Essays, Ausschnitten aus Praktikumsberichten, Inhaltsverzeichnissen von Hausarbeiten, Vorlesungsmitschriften, To-Do-Listen, Forschungsberichten und anderen Leistungsdarstellungen und Lernproduktionen, zusammengefasst als sogenannte „Artefakte". Nur in Verbindung mit der studentischen Reflexion (schriftlich, mündlich oder auch in einem Video) der Verwendung dieser Artefakte für das Erreichen des zuvor durch die Prüferin oder den Prüfer transparent gemachten Lernziels wird das Lernportfolio zum Prüfungsgegenstand. Während der Erstellung des Lernportfolios wird von der Prüferin oder dem Prüfer im Semesterverlauf Feedback auf Entwicklungsschritte und/oder Artefakte gegeben. Als Prüfungsleistung wird eine nach dem Feedback überarbeitete Form des Lernportfolios – meist in elektronischer Form – eingereicht"

of learning diaries (e.g. in the form of blogs) into e-portfolios is a common and often technically supported practice (Buß et al., 2017).

The special feature of digital portfolios from the learners' point of view are the extended possibilities of designing, administering and sharing developed portfolio folders. The advantage for teachers is that portfolio work can be planned and implemented in a more structured and efficient way through the use of digital tools.

5.7.1.3 Types of e-portfolios

Baumgartner et al. (2009) distinguish between presentation, development and reflection portfolios, which they further differentiate in terms of ownership structure and orientation. The presentation portfolio is used for external presentation, the development portfolio shows one's own competence development and the reflection portfolio is differentiated into a learning portfolio to support and document one's own learning progress and into an assessment portfolio in the sense of the examination and assessment of learning progress (Quellmelz & Ruschin, 2013).

The portfolio types also differ in terms of whether they are more results-oriented or development-oriented (summative/formative). It is important to design the work with and through the e-portfolio in such a way that appropriate tasks guide the work with the e-portfolio and learners who create e-portfolios are supported by systematic feedback. The basis for this is the systematic reflection of individual learning and competence goals (Bräuer, 2014). Differences also arise in the design of e-portfolio assessment. It must be made clear to the students in advance which parts will be graded and which parts will be included in the assessment without a grade. The discussions on the assessment of e-portfolios with highly reflective content differ, but also highlight the danger of "over-reflection" when students only focus on themselves (Reinmann & Sippel, 2011).

5.7.1.4 Tools for the creation of e-portfolios

Just as diverse as the types of e-portfolios are the tools that can be used to create them. Entry into the e-portfolio work can technically be very low-threshold, for example, with common applications such as word processing programs, presentation software or authoring tools. The developed e-portfolio products can then be distributed via email or stored on websites or learning management systems. This solution is particularly suitable if a low-barrier solution is desired. Common e-portfolio systems usually do not meet the accessibility criteria.

If the users have advanced technical knowledge, they can program e-portfolios themselves with both simple (MS editor) and special editors. Otherwise, there are a number of web-based applications, some with special e-portfolio plug-ins, which can be used. When using applications that are not self-hosted, it should be noted that it is usually difficult to ensure the protection of the data and privacy of the e-portfolio creators (i.e. the students). Also, the sustainability of the use or further development of an e-portfolio created via a web service is not easy to ensure. Among server-based e-portfolio tools, both learning management system solutions (e.g. an e-portfolio tool for ILIAS) and pure e-portfolio systems such as Mahara (which is often linked to learning management systems via single sign-on) are used in HEIs (Barrett, 2012). The collection

presented in Figure 21 shows a selection of different tools that can be used for e-portfolio work.

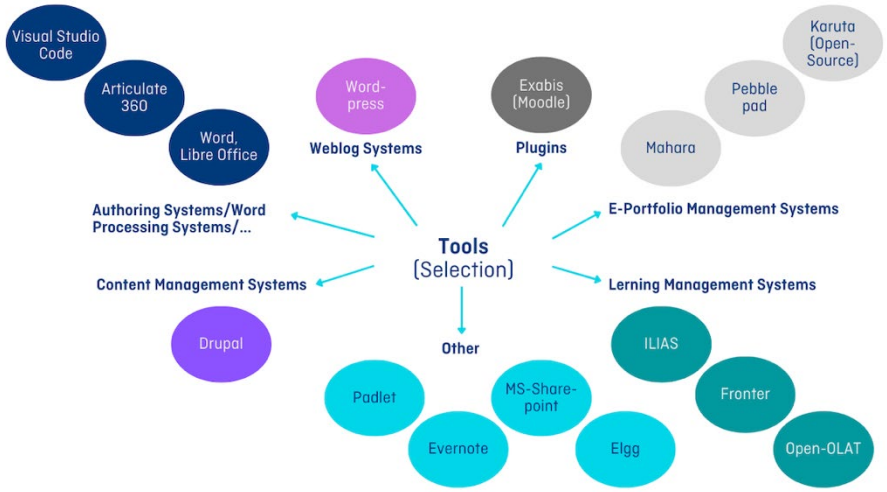

Figure 21: Possible tools for e-portfolios, own representation, based on Hornung-Prähauser et al. (2007) and Barrett (2012)

In the following, two e-portfolio systems that are frequently used in German-speaking countries will be presented in more detail.

Implementation of e-portfolios with Mahara

One possibility for an e-portfolio platform is Mahara. Mahara has been developed since 2006 as an open source project from New Zealand and can be linked to Moodle and other learning management systems via single sign-on (mahara.org, 2021).

Mahara enables students to create multiple views as collections of artefacts and to keep a blog/learning diary. With its functions, the platform enables the creation of presentation, reflection and development portfolios. Students can open these for viewing by specific individuals or groups. The three basic areas of Mahara are (1) the e-portfolio, in which students create said views as collections of different files and learning diaries; (2) the individual profile, in which information about the student, his or her biography and, if applicable, learning objectives and plans are stored; and (3) groups, which offer forums for exchange in Mahara – both at course level and for other purposes – and the possibility to create a group portfolio and share views and collections with teachers and fellow students. Portfolio pages and the profile are created and edited via a CMS editor. Content elements called "blocks" are available – e.g. texts, images/video/audio, files – which can be integrated into the portfolio. Learning plans, achievements and the development of competences ("SmartEvidence" feature)[53] can also be documented in the portfolio.

Teachers can control portfolio processes, for example, by having their own e-portfolio or by offering a pre-formatted, copyable e-portfolio template. They receive a system notification as soon as a view or collection has been released to them by students.

[53] https://mahara.org/view/view.php?id=4

Assignments can also be made available as a file if it needs to be stored in an unchangeable form (retention period). Group members (students) also receive the release message as soon as the views or collections have been shared for a group and can then write feedback within the comment function.

Implementation of e-portfolios in ILIAS

The learning management system ILIAS was developed in 1998 as part of the VIRTUS project at the University of Cologne and has been available as open source software since 2000. The e-portfolio functionality in ILIAS was initiated in 2009 by the University of Bremen and developed for the winter semester 2011/12 (Wilkens, 2011). ILIAS enables the design of presentation, reflection and development portfolios.

Two basic areas are available to students in ILIAS for the implementation of e-portfolios. On the one hand, users can use a personal workspace to store and structure documents and certificates. Personal blogs can also be created in the workspace. All objects stored in the workspace remain hidden until the owner releases them for other people or courses/groups (internal/external) or submits them to a teacher. On the other hand, different views/folders can be created in the portfolio area. These folders can be structured and designed either freely or based on a template provided by the teacher.

The editing of both the portfolio pages and the blog is performed via the ILIAS-specific page editor. The operation requires little training time. A number of content elements are available, including texts, images/video/audio, tables, which can be integrated into the portfolio. Learning successes and competencies achieved can also be documented in the portfolio.

Teachers have different options for the technical control of portfolio processes. On the one hand, ILIAS offers teachers the possibility of submitting blogs/portfolios via the "Exercise" functionality, which are controlled by automatically set submission deadlines. The submission is documented in the learning management system. In addition, the teacher has an overview of all submitted portfolios at any time and can give the learners both feedback and a grade for the submission. Furthermore, teachers can issue certificates, distribute badges or assign competences (e.g. from competence grids) to grade/assess achievements and thus make the competence profile or the competence growth of a learner visible. The "360° surveys" item is available to set up more extensive feedback.

5.7.1.5 Didactic embedding

The planning of a course (ideally a curriculum for a study programme) must didactically consider the e-portfolio process. Based on Häcker (2007), the following process steps are recommended for working with e-portfolios:

- **Context definition.** Starting point for portfolio creation (e.g. the learning objectives of a course)
- **Collection.** Collecting learning products/artefacts and structuring them (e.g. in the file repository of an e-portfolio software)

- **Reflection.** Reflection/commentary on each deposited learning product and presentation of this contextualised collection in an e-portfolio view. This reflection process should be accompanied by peer reviews and formative assessments by the teachers (for concrete examples see Bauer & Baumgartner, 2012)
- **Presentation.** Selected artefacts, possibly revised and re-contextualised on the basis of peer feedback, are submitted as an assessment-relevant performance (e-portfolio examination) or serve as the basis for a final (oral) presentation (Häcker, 2007; Himpsl-Gutermann, 2012).

The use of e-portfolios as an examination instrument points to a perspective change in the perception and assessment of individual learning achievements and thus also to a change in understanding of roles in higher education, in which learners are perceived not only as recipients but also as actors acting on their own responsibility. It becomes clear that the acquisition of competences is a multi-layered process that cannot be assessed solely by means of a summative examination, but requires recourse to the individual examination of one's own learning process. In particular, reflective engagement, in which the linking of biographical, professional and practical action is stimulated, can be seen as good preparation for entry into later professional life (cf. Chapter 3). Van den Berk & Tan (2018) see the aim of an e-portfolio examination as the exemplary representation of one's own competence and personality development based on previous academic achievements in a process that has a research-discovery character. As an examination performance, e-portfolios are complex, since, in many cases, both process and product are part of the assessment. Hornung-Prähauser et al. (2007) point out that "assessment equity" is higher. The focus of e-portfolio examinations is on an extended preparation phase, in particular, on the basis of which the later examination can take place nevertheless (van den Berk & Tan, 2018). As part of the teaching research project E-Port DUAL, teachers developed an event-driven process chain (EPC) for the process of course planning with e-portfolios (E-Port DUAL, 2021) (Figure 22). In summary, the event-driven process chain shows relevant aspects that are (to be) included in seminar planning. There are different areas, like getting familiar with an e-portfolio platform, the selection of tools and the selection of tasks (the viewing and collecting tools are especially suitable for public e-portfolios). The presentation of assignments can be requested on an assignment-by-assignment basis and/or seminar-by-seminar basis. The tasks can then be graded/ungraded as a course or examination performance. The choice of examination method is also fundamental. This can either be exclusively written, a learning portfolio, a reflection portfolio or a presentation portfolio, or the examination can also take place in combined form with an oral part. It is also possible to design an examination format consisting of several parts, in which different partial performances are to be given throughout the semester (Mey, 2020). In this case, task formats are selected, such as peer feedback, development of learning modules or examination questions for other students, which demand an intensive examination of the course content and can thus lead to more sustainable learning successes.

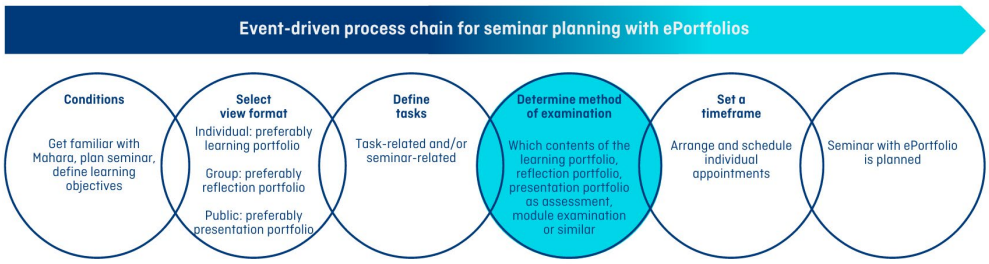

Figure 22: Event-driven process chain for seminar planning with e-portfolios

The e-portfolio can be submitted as a written examination or serve as the basis for an oral examination (presentation of the e-portfolio and/or questions from the examiners about the e-portfolio). An oral examination should instead be considered if the development process is in the foreground. If, on the other hand, the focus is on providing evidence of academic engagement with the subject content, van den Berk and Tan (2018) recommend the additional use of a written summative examination to conclude the portfolio work. Special attention in the implementation of e-portfolio examinations is given to the operationalisation of assessment criteria in order to account for the special format. They go on to name as possible assessment criteria: "(1) the fit and justification of the selection of artefacts, (2) the content and methodological accuracy and consistency of the presentation, (3) the level of abstraction achieved, and the (4) reference back to models and theories."

5.7.1.6 Assessment regulations

If an e-portfolio examination is to be included as a module examination in a degree programme, this must be specified accordingly in the examination regulations applicable to that degree programme. The higher education acts stipulate which aspects of the examination procedure must be regulated in the examination regulation. The subject of the examination and the type of examination are usually specifications that must always be determined.

- **Written examination.** If the submission of written or multimedia artefacts is required as an e-portfolio examination performance, this examination falls under the written, domestic examination performances, whose relevant regulations (on submission, extension, declaration of independence or group work in particular) should then apply accordingly. Regulations regarding the handling of technical malfunctions would have to be supplemented in the examination regulations if these have not yet been integrated.
- **Oral examination.** If the actual examination of the e-portfolio is an oral examination, the relevant provisions of an oral examination (e.g. concerning the preparation of a protocol, group examination or presence of further persons) should apply accordingly.

- **Combined examination.** If the e-portfolio examination consists of the assessment of the written artefacts and an oral examination discussion, specifications regarding the possibility of a combined examination are necessary in the examination regulations (in particular, regulations regarding assessment and repetition). An example of regulations for such a combined examination is given in the blog of the Berlin School of Economics and Law (Mey, 2020).

At most HEIs, the examination regulations are adapted by the departments or faculties. If there are framework regulations in which general examination regulations are laid down throughout the HEI, these must also be amended accordingly by the senate in addition to the examination regulations specific to the degree programme. The extent of the necessary changes in the (framework) examination regulations can vary significantly. The implementation process also varies from HEI to HEI. Due to its complexity, the amendment process should be closely followed by the responsible bodies (e.g. examination board and legal department).

5.7.2 Opportunities and challenges

In the following, typical opportunities and challenges for the implementation of e-portfolios are summarised. Empirical evidence can be found in Hericks (2020); Domann, Truschkat & Volk (2020); or Truschkat, Volk & Domann (2020), amongst others.

E-portfolios	Opportunities	Challenges
Pedagogy	Learning and development process in the foreground Acquisition of methodological and digital competences Use even after graduation, e.g. as a competence or application portfolio Individuality of the evaluation criteria Promotion of self-directed and independent learning	Considerable assessment or monitoring effort (depending on the portfolio process, mentoring is required, formative feedback, etc.) Assessment fairness (doing justice to individual performance on the basis of general assessment criteria) Comparability of results is not always given Communication (e.g. via comment function) must be actively initiated by the teachers

Technology	Individual, multimedia and creative design possibilities	Effort of familiarisation with more complex e-portfolio tools Increased time expenditure for students due to the use of a technical solution (creation and editing of digital artefacts such as images, videos, etc.) Dependence of the outcome of students' and teachers' technical skills Maintenance and support costs Increased safety precautions required Active use after leaving the HEI only possible in a few systems so far
Legal aspects	Legal assessability of complex learning processes	Consultations for teachers and students (data protection, copyright) are time-consuming (Framework) examination regulations must be adapted
Organisation	Enabling distributed learning across the course of study/semester/module	Communication via the e-portfolio platform in addition to communication in the LMS can become confusing Media-adequate storage/archiving of e-portfolios

5.7.3 Examples from practice

As explained above, e-portfolios can be developed in very different ways. It is also possible to create e-portfolios with little technical support, e.g. on the basis of word processing programs or presentation software, although in this case separate templates and/or workflows are required for accompanying processes (self-assessment, peer feedback, feedback by the teachers).

In the context of inclusive higher education teaching, these variants of e-portfolios are to be recommended because of their extensive accessibility (less/no training effort, clearly specified workflow, however, with a restriction of creative freedom).

Although the training effort is greater, the use of personal e-portfolio tools enables the implementation of e-portfolio processes with optimal support of creative design and workflow (e.g. features for learning plans, peer feedback etc.) by software.

In the following section, two application examples from HEI practice are presented.

5.7.3.1 E-portfolios in the Düsseldorf Curriculum of Medicine

Description	E-Portfolio Düsseldorf Curriculum of Medicine
HEI	Heinrich Heine University Düsseldorf
Subject	Medicine
Pedagogy	• The main objective of the e-portfolio work is to align the subject-specific and interdisciplinary competences learned in the practical parts of the study programme with one other through reflective discussion, to sharpen them through expert and peer feedback and to thus prepare future doctors in the best possible way for their later professional practice • The e-portfolio is designed as a study-accompanying instrument (1st to 6th year of study)
Technology	• ILIAS – portfolio, workspace, blog, test, learning modules, exercises
Organisation	The e-portfolio consists of a series of individual portfolios that are developed in different clinics during the course of study. In particular, through the implementation of an electronic collection folder, students are supported in collecting and organising their academic achievements acquired during their studies, findings and reports developed on practical experience, as well as other personal texts, materials and media intended to document their own development process. Upon successful completion of the portfolio, students receive a certificate for the completed e-portfolio.
Link	https://www.medizinstudium.hhu.de/duesseldorfer-curriculum-medizin/kompetenzorientierung/eportfolio

5.7.3.2 E-portfolios in the Applied Science Lab at the University of Hildesheim

Description	E-Portfolio in the Applied Science Lab, Master's in Social Services
HEI	University of Hildesheim
Subject	Social Sciences, Social and Organisational Pedagogy
Pedagogy	• Through well-founded recognition of the organisational structure, the diagnosis of processes and system interrelationships, students in integrated degree programs are able to analyse the potential for change and make challenges visible, which leads to appropriate problem-solving strategies. The institutional as well as individual learning process contributes to a reflection on the theory-practice relationship and the development of an independent professional attitude
Technology	• Mahara – e-portfolio, blog, forum, peer feedback

Organisation	This module includes didactic elements of reflection questions, assignments and discussion suggestions from teachers as well as feedback from peers and teachers. The module is divided into two sub-modules (SM), each of which runs over two semesters. In addition to the accompanied practical activity, both sub-modules include regular systemically oriented supervision. SM 1: Describe, document and analyse the professional role and organisational processes. SM 2: Interpret, evaluate and assess the professional role and organisational practice on the basis of theoretical knowledge.
Link	https://www.uni-hildesheim.de/fb1/institute/institut-fuer-sozial-und-organisationspaedagogik/studium-lehre/studiengaenge/ma-soziale-dienste/

Another example of a study-related e-portfolio created on the Mahara platform is the e-portfolio in the eEducation course at Danube University Krems. Reflections on this, the implementation thereof and examples of e-portfolio views can be found in Himpsl (2010) and Baumgartner & Ghoneim (2014).

5.7.4 Recommendations

Since the implementation of e-portfolios can be designed as a bottom-up as well as a top-down process, implementations can turn out very differently depending on who initiates the introduction and what the respective structures of one's own institution look like. In principle, however, a multi-perspective view should be taken in order to properly meet the challenges of introducing e-portfolios and to enable different types of learning and examination e-portfolios.

In addition to organisational, technical and didactic opportunities and challenges, the legal anchoring of e-portfolios can be seen as a cross-cutting issue that must be considered at all levels, since not only questions of examination law but also data protection and copyright law play an important role in the implementation of e-portfolios.

We have compiled a series of target group-specific recommendations for action that take into account the central dimensions and can be used as a checklist (Figure 23).

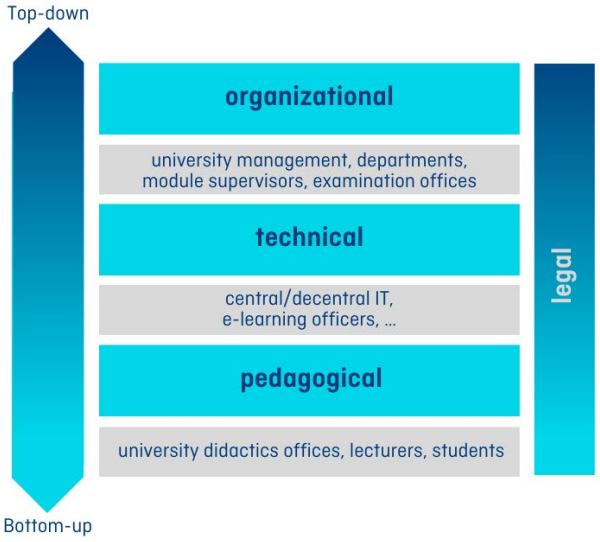

Figure 23: Target groups for recommendations for action (own representation)

HEI administrations

For the successful and possibly comprehensive use of e-portfolios in teaching/learning and examination scenarios, a strategic decision or a commitment by HEI management is recommended in order to make the implementation of e-portfolios possible in the first place, by providing financial and organisational resources in particular. In addition to the creation of a technical infrastructure, the financing of personnel support (by tutors), for example, is a worthwhile incentive system for the implementation of e-portfolios.

Persons responsible for examination regulations and organisation

The implementation and adaptation of examination regulations with a detailed description of the performance is indispensable before the implementation of e-portfolio examinations. In this case, responsibility lies with the departments and those responsible for examinations. After the examination regulations have been changed, e-portfolios can be included in module handbooks as an additional form of examination.

Persons responsible for technology and digital teaching-learning support

The inter-institutional use of suitable e-portfolio software is recommended in order to offer better support and advice services for teachers and students through the establishment of a central infrastructure. Those responsible for technology and digital teaching and learning support can advise on the selection of suitable software. Technical support is an important prerequisite for the successful implementation of e-portfolio examinations. Both teachers and students should be trained in advance on the e-portfolio management systems used and have access to support services during the process.

HEI didactics and teachers (examiners)/students

In addition to media competence, both didactic embedding and content creation play an important role in the implementation of e-portfolio work and examinations. In this respect, it is necessary to provide further qualification offers for teachers/examiners as well as for students.

For teachers/examiners, the focus should be on developing qualification offers that deal with the didactic embedding (e.g. process, constructive alignment), moderation of e-portfolio processes, coaching of students and the development of assessment criteria. In particular, coaching and transparent communication with students is of high importance, since e-portfolio work usually involves an increased workload, which must be clearly presented at the beginning and kept in view during the process. In addition to the examination regulations, the legitimation of a heavy student workload can take place via the overarching competence extensions, the aspect of sustainability and diverse use (also outside the HEI).

In the qualification of students, writing, reflection and feedback skills should be further developed in addition to media technology skills.

E-portfolio examinations require good planning and structuring of the process and the partial performance tasks in advance. Both formative and summative elements can be used. Teachers are required to adapt their course planning to the (new) e-portfolio form of examination. This also includes the revision of the learning content, learning objectives and structure of the course.

Furthermore, student guidance and support during the entire e-portfolio process is recommended in order to anticipate both subject-related, communicative, legal and technical problems at an early stage and to maintain an overview of the workload. Assessment and correction processes take place continuously throughout the semester and can be carried out by both the lecturers/examiners and as peer feedback.

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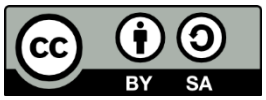

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