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## Handbook to implement peer-to-peer learning in engineering studies (using the example of mechatronics)

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# Crossing Borders: Peer-to-Peer Education in Mechatronics

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## Foreword

The Erasmus+ project entitled *XP2P - Crossing Borders: Peer-to-Peer Education in Mechatronics* was developed in cooperation between Kaiserslautern University of Applied Sciences (HSKL), Cluj-Napoca University of Technology (TUCN) and Savoie Mont-Blanc University (USMB). The project started on 01 October 2019 and ended on 31 August 2022.

The project participants from the three universities set themselves the goal of integrating new teaching and learning methods into engineering education. Using mechatronics as an example, the aim was to research the influence of peer-to-peer learning in connection with an e-portfolio on the students' acquisition of competences. The project results from the conviction that peer learning, i.e. learning with and from each other, is one of the most important forms of learning to strengthen informal learning and promote self-learning competence. The associated e-portfolio served as an orientation and documentation of the students' learning progress and promoted a critical examination of one's own learning process.

We thank the ERASMUS+ programme of the European Union for the financial support of our project.

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## Introduction

The three project participants integrated new teaching and learning methods into engineering education as part of the XP2P project. Using mechatronics as an example, the influence of peer-to-peer learning in connection with an e-portfolio on the students' acquisition of competences was researched. The project results from the conviction that peer learning, i.e. learning with and from each other, is one of the most important forms of learning to strengthen informal learning and to promote self-learning competence. Since the peer-to-peer learning process requires the teaching staff to remain in the background, it was necessary to monitor the process while offering only instructional support. For this reason, an instrument - the e-portfolio - was chosen that documented the students' learning process, enabled them to critically examine their own learning process and gave the teachers the option to intervene specifically where assistance was needed.

The e-portfolio combined with the innovative approach of peer-to-peer learning should help students acquire improved cross-functional skills. These include:

- social skills (coordinating with others, negotiating, persuading, training and teaching others),
- Resource management skills (material resource management, time management)
- Systems competences (judgement and decision-making, systems analysis),
- technical skills.

Although the concept used in the project refers to the field of mechatronics as an example, the knowledge gained from it can be used independently of the subject area.

The handbook is one of the key elements to make the results of the project available in the long term. It was the intention of the three university partners to create a practical guide to disseminate the challenges and successes experienced. Since a full conversion to peer-to-peer education is not fully feasible for all, information is also provided on practical ways of partial implementation.

The authors have placed the reader's perspective at the centre of their considerations in the structure of the handbook. Readers should be able to read and work through the book according to their own interests without necessarily having to follow the chronological order of the handbook.

The main part of the manual refers to the three central elements of the XP2P project: peer-to-peer learning, the e-portfolio method and competence-oriented teaching. The chapters that refer to these main topics can be read independently of each other and do not build on each other in terms of content. Each chapter is divided into three levels. The first level is the theory level. Here the "What?" question is answered: each content element is briefly explained and gives the reader an insight into the theoretical background. The second level answers the "how?" question. The writers explain the practical and methodological approaches developed in the XP2P project and give examples of the implementation of each area. On the last level,

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the question "Why?" is answered. Here, the respective areas are examined in terms of a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis.

The final part of the manual refers to the practical implementation within the XP2P project. Two examples illustrate how the three central content elements could be linked and implemented within courses. The structure of the example chapters is based on a PDCA cycle (Plan, Do, Check, Act). Thus, an overview of the planning and implementation is given, insights into the feedback on the implementation of the methodology are presented and based on this, suggestions for improvement and implementation are formulated.

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## Peer-to-peer learning

### Theory

Peer-to-peer education, as understood in the XP2P project, refers to learning with and from each other. In peer-to-peer education, the focus shifts to the student learning process (Boud, 2001). Students share their learning experiences in interaction with each other (Boud, 2001) and through mutual support (Boud, 2001).

Unlike in classical teaching formats where students have to passively absorb knowledge and information, in peer interaction students are encouraged to actively acquire knowledge by sharing ideas, seeking common consensus and remaining open to the ideas of others (Damon, 1984). They have to rationalise their own pre-existing ideas and conceptions in joint discussions in order to make them comprehensible to others (Damon, 1984/ Boud, 2001) and thus learn to question pre-existing conceptions.

Through communication and feedback - whether formulating feedback or dealing with feedback received - students actively take responsibility for their own learning (Keppell et al., 2006), but also for each other's learning (Sampson et al., 1999).

Peer learning can take place both informally, i.e. in settings determined by the students, and formally, i.e. in group work set by teachers and at agreed group work times (Keppell et al., 2006).

Peer-to-peer education can develop in two different ways through appropriate assignments that are reflected in the roles of the students:

- In peer tutoring, hierarchies are predetermined or form in the course of collaboration (Sampson et al., 1999): students who act as experts in individual areas take on fixed roles (Boud, 2001). Here the focus is on learning from each other (Sampson et al., 1999).
- In Reciprocal Peer Learning, all students have a similar status (Sampson et al., 1999) and there is no fixed assignment of roles (Boud, 2001). Here the focus is on learning with each other (Sampson et al., 1999).

Teachers and staff remain in reserved roles in peer-to-peer education. They can either act as learning facilitators or only be involved in the initiation of learning activities (Boud, 2001). Through this type of education, teachers experience teaching from a different perspective and have the opportunity to adapt it to the needs of students and thus improve their own teaching.

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## Method

For the purpose of the XP2P project, a definition of peer-to-peer education was established in the previous chapter. It was pointed out that peer-to-peer education describes a multi-dimensional teaching and learning method. In the following chapters, the core elements of the method will be highlighted and linked with practical examples in order to provide teachers with a supportive framework for implementing the (X)P2P method. In addition, the following chapters offer tips and hints for activating peer activities and supporting students in the context of peer-to-peer teaching.

### P2P as a teaching/learning method (methodological content elements)

In connection with peer-to-peer education as a teaching/learning method, the social science literature offers a variety of different terminologies and definitions. For the purpose of the XP2P project, a definition was established that consists of three content elements and forms the basis for XP2P method. These three elements are the following:

- Reciprocal Peer Learning
- Peer tutoring
- Peer assessment

In the following chapters, the content elements will be explained and presented in relation to their practical implementation based on the authors' project experiences.

### *Reciprocal Peer Learning*

"Reciprocal peer learning describes a method in which students learn independently and at the same time contribute to the learning of peers by passing on knowledge to them and participating in group activities. This creates shared experiences and enables students to make equal contributions to group work (Boud, 2001/ Sampson et al., 1999).

The method builds on the natural behaviour of students to turn to each other first when problems arise, instead of consulting the teacher directly (Boud, 2001). This has many advantages for the students themselves, as they take responsibility for their own learning and learn to learn (Sampson et al., 1999).

Excursus lecture "Lightweight design":

In lightweight design, many optimisation factors must be weighed against each other simultaneously. For active work with these individual variables, it is important that students engage in a discussion and learn to assess the simultaneous changes in the individual factors. Discussions among peers have the advantage that students are not immediately asked

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about the "correctness" of an assessment. In addition, there is often less shyness to present and defend one's own ideas to peers. By estimating, calculating and comparing, an optimum is sought, which can then be discussed with teachers, peers or checked in real life. (For more information, see the chapter *Practical implementation and recommendations for action (transfer example)*).

Reciprocal peer learning takes place simultaneously in formal and informal learning pathways (Boud, 2001/ Keppell et al., 2006). Informal peer learning takes place in self-determined learning environments initiated by students. Formal peer learning, on the other hand, is explicitly integrated into courses by teachers (Keppell et al., 2006). For the peer-to-peer method to be successful, it is essential that peer learning does not take place in isolation from the course, i.e. that it is not only initiated informally (Boud, 2001), as otherwise it is not perceived by the students as a serious part of the teaching and cannot be accompanied by the teachers.

In the peer learning process, students have no fixed defined roles (Boud, 2001, p. 10) and all students have an equal status in the group situation (Sampson et al., 1999/ Keppell et al., 2006/ Clark & Andrews, 2009), which makes them equal learning partners, even if the group members differ in competence or knowledge level (Fricke et al., 2019).

Keppell et al. describe six qualities of peer partnerships that are crucial for peer learning. These include voluntary participation, trust, absence of hierarchies, duration and intensity of the partnership leading to a close relationship, reciprocity and authenticity (Keppell et al., 2006).

Teachers remain mainly in the background in this method (Boud, 2001).

Informal P2P learning activities take place right from the start of the course, e.g. in the form of joint maths assignments. Learning through teaching, taking responsibility for one's own learning and that of fellow students, strengthens social coherence. This in turn promotes motivation and academic success.

Formal P2P learning activities are often used to learn how to work in groups and to carry out larger tasks. Stumbling blocks typically occur in different ways and at different points for project participants. P2P learning environments offer a way to quickly help each other in a decentralised way.

### Peer tutoring

In peer tutoring, one party takes on the role of expert in a subject area and teaches another party who still has little knowledge in the same subject area (Damon & Phelps, 1989). Students take on specific roles that they maintain in the course (Topping, 2005). This role allocation can take place between students of the same semester or between older and younger students.

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The only prerequisite is that "asymmetries in relevant knowledge" (Haller et al., 2000) are present, which are perceived by the students as obstacles to be overcome and which therefore lead to teaching activities by the students (Haller et al., 2000). In doing so, students turn away from an individualistic approach to learning and build interdependencies among themselves (Clark & Andrews, 2009).

It is beneficial for learning development that peer tutors do not have the same authority, level of knowledge or didactic competencies of teachers, so that a sense of equality can develop among students (Damon & Phelps, 1989). This sense of equality increases self-confidence among students and leads them to dare to freely articulate their ideas, questions and opinions (Damon & Phelps, 1989) and interact in discourse without fear of negative curricular consequences.

The learning method can thus strengthen the bond between students, increase their confidence in their fellow students and in themselves, so that new knowledge and skills can be built together.

The tutors benefit from this as they also learn by teaching and reflect on their own learning habits and ideas, which also increases their self-confidence (Clark & Andrews, 2009).

### *Peer assessment*

In peer assessment, students evaluate each other. The mutual feedback can take place formally or informally. The following criteria can be used for a formal peer assessment:

"(...) the amount, level, value, worth, quality or successfulness of learning outcomes or products contributed by each individual member of the group" (Keppell et al., 2006).

However, there is a danger that by formalising the assessment, too much focus is placed on it and the group dynamics are thus inhibited (Keppell et al., 2006), which is detrimental to the peer-to-peer idea.

To encourage peer assessment, it is important to include it in teacher assessment so that students perceive feedback as an essential part of the curriculum (Keppell et al., 2006).

The advantages of the peer assessment are that

- Students taking responsibility for their own learning (Keppell et al., 2006/ Bostock, 2000)
- The quality of learning is improved (Bostock, 2000)
- Subject-specific communication skills are improved (Keppell et al., 2006)
- self-reflection skills are strengthened (Bostock, 2000)
- Lifelong learning is stimulated (Bostock, 2000)

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- Students gain an insight into the informal assessment activities that occur in the world of work (Boud, 2001/ Bostock, 2000)

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## Activation methods

The following chapter describes activation methods that were used during the XP2P project to stimulate, structure and facilitate peer-to-peer activities. These methods can be used as tools by both teachers and students.

### *Creativity techniques*

Creativity techniques can be used in peer-to-peer education to initiate initial getting-to-know-you and working processes. Here, students are divided into small groups or can form small groups on their own. Within the groups, subject-specific idea-finding processes can then be stimulated, which promote exchange among each other. Particularly heterogeneous groups benefit from this, as different levels of knowledge of students favour necessary impulses and thus promote a lively exchange of ideas.

In the following, a selection of creativity techniques is presented that the participants of the XP2P project consider suitable for peer education. No claim to completeness is made here.

### Brainstorming

In brainstorming, the members of a group are given a problem or task. In the first phase, the participants have to collect all the associations and ideas that go along with the task. Students can inspire each other through their contributions and encourage new creative ideas. Through different perspectives and levels of knowledge, new and creative ideas are promoted that go beyond the horizon of individual work. To avoid obstacles, it is advisable to refrain from criticism in the idea generation phase. Students should therefore neither judge each other nor each other's ideas, but keep the flow of ideas going. In a second phase, the collected suggestions and associations of the group members can then be sorted out and systematised so that a result can be presented. In this process of negotiation, the students have to deal intensively with their ideas and the ideas of the others and settle on a solution that is accepted by the whole group.

It is a group work that can be done in presence or online (forum/chat). It makes sense to introduce this method at the beginning of the semester in the lecture and to use it with the students. This gives them a methodological tool that they can use later in their small groups if they have creative difficulties and lack new impulses.

### ABC method

As with brainstorming, the ABC method also starts with a problem or task. However, in order to find ideas, the structure of the alphabet is given in advance. Students write down their associations in such a way that they are associated to the letters of the alphabet, for example,

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on the basis of animal names or objects. In order not to slow down the flow of ideas, the ideas do not have to be written down in alphabetical order: jumping back and forth between letters is possible and desirable so that the flow of writing is not interrupted. It is useful to set a time limit for completing the list before starting the method. As soon as the time has expired, the results can be compared and discussed within the small groups.

It is advisable to introduce this creativity technique to students at the beginning of the semester: this allows them to get to know each other and initiates initial group work processes. The method has the advantage that it requires little effort to participate and thus also involves students who usually hold back in courses.

Once the students are familiar with the ABC method, they can use it later on outside the course. This gives them a tool that they can use independently if they are not making progress in their group work phases. Since the individual performances of the students remain traceable even after the method has been completed, there is no danger that individual students can withdraw from responsibility or that particularly good individual performances are lost in the group.

### 6-3-5 Method

The starting point for the 6-3-5 method is similar to brainstorming and the ABC method: six group members are given a problem or task and have to formulate ideas and possible solutions. However, here the students are given pre-structured sheets consisting of six rows with three columns each. Each group member is then given the opportunity to formulate three ideas on the task in a maximum of five minutes. After the time has expired, the sheet is passed on to the next group member in a clockwise direction, so that new ideas have to be formulated again in a maximum of five minutes, which differ from the associations already noted down on the respective sheet, but build on them.

The sheets are passed on a total of five times until 18 ideas have been written down on each task sheet. In this way, up to 108 ideas can be generated in a very short time.

The advantage of this activation method is that all group members are included and obliged to participate. Furthermore, by structuring the sheets, teachers receive a progress log of the brainstorming process and can still assign the outputs to individual students.

As mentioned in the previous methods, this method can also be used at the beginning of the semester to initiate group processes. Getting to know the method at the beginning of the semester also creates a tool for students to fall back on in case of difficulties in the group work.



### Project-based learning

Project-based learning is an active pedagogical method that enables students to learn through the realisation of concrete projects (Perrenoud, 1999). These projects involve challenging and authentic tasks that are related to real work situations (Kokotsaki et al., 2016/ Solomon, 2003) and extend over a longer period of time (Gary, 2015).

"When students understand that their work is ultimately valuable as a real problem that needs solving, or a project that will impact others, they're motivated to work hard." (Solomon, 2003)

Project-based learning is a format in which the focus is on the learning process of the students themselves and in which course objectives must be achieved through collaboration (Kokotsaki et al., 2016).

Projects can be individual or collective: Students have to solve problems in a specific situation and context. While working on projects, students build up the expected knowledge and skills, which are linked by the project and its different phases and tasks. Through this type of work, students can gain greater autonomy, self-confidence and trust in their abilities, feel less judged than in the presence of teachers, learn to negotiate and be at the centre of the learning process.

Teachers become learning guides for groups or individual students in the work process to guide them in their work and research. In doing so, they must support, motivate, encourage and guide students (Kokotsaki et al., 2016) to ensure the success of the method.

Excursus Project-based learning in the lecture *System Level Rapid Development in Mechatronics*:

The following presentation was given to the students in a material accompanying the lecture. This presentation was then followed by seven topic blocks that the students had to work on over the course of the semester.

#### Introduction:

"This companion material is designed to guide you through the Mechatronics Masters Module 'System Level Rapid Development in Mechatronics'.

After mastering this module, you should have gained experience in relation to the following areas:

- System simulation with Matlab/Simulink.
- Comparison of simulation and real system behaviour (self-balancing two-wheeled robot).
- Code export (control algorithms) from Matlab/Simulink.
- Gathering information from different sources to solve problems.

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- Improve your time and project management.

To help you understand the structure and intention of this module, imagine the following "realistic" hypothetical situation:

- You are a young engineer; you have just graduated with a master's degree in mechatronics.
- Fortunately, you have found a job in a company that makes different types of robots.
- You start work today.
- Your supervisor tells you that your first few weeks at the company will be different than planned because another engineer left the company unexpectedly last week and his work has to be made up somehow.
- The engineer was working on a project for a two-wheeled robot. His task was to prepare a presentation for a customer in about three months, showing some basic functions.
- So, the engineer has already managed to get a prototype roughly working (simulation and real hardware), but that's it. No optimisations, no features and unfortunately - as usual in real life - a massive lack of documentation.
- As this is an important project and presentation for the company, your manager has decided on the following approach:
  - You will be part of a new project group with two or three other young engineers as teammates, who also started work today.
  - The reason for choosing a group is that you are all not experienced engineers and you still have a lot to learn, you face many challenges and within a group it is less likely that progress will get stuck at some point.
  - This way you can help, teach and support each other within your group, and you can distribute subtasks to speed up development.
  - You will receive a hardware prototype and the simulation models, as well as a rough timetable with three milestones to report to your supervisor for overall progress.
- Your task (or better: the group's task) is to finish the project. You can plead lack of information, that you never did this or that, that your teammates have no idea, that your predecessor made mistakes and so on. But assertions don't help you when it comes to progress, and your supervisor expects results. You cannot wait for lectures to give you the knowledge you need, gathering the necessary information is solely up to you and/or your teammates; as it is in most real-life situations. "

(Further information in the chapter *Practical implementation and recommendations for action (example 1)*)

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### Digital platforms

Learning Management Systems (LMS) and other digital platforms can be used to facilitate peer-to-peer activities in a course. For this purpose, teachers can create collaborative tasks and use the platforms as communication tools.

*Wang and Kinuthia (2004) identify four components that should be used to construct technology-enhanced learning environments. These are "Using Technology to Evaluate", "Using Technology to Enrich", "Using Technology to Motivate", "Using Technology to implement" (Wang & Kinuthia, 2004).*

The following illustrations present examples of the use of two platforms that were used by teachers in the XP2P project for the purpose of peer-to-peer activities. Transferability to other platforms is also possible.

### OLAT (LMS)

The Learning Management System (LMS) OLAT, for example, can be used to promote peer-to-peer activities. In addition to the typical functions of an LMS, such as the provision of learning materials or the organisation of the flow of information outside the classroom (contact with the teachers, e-mails to all course participants), OLAT also offers a special feature - the design of a learning path course.

Such a learning path course was used in a transfer course of the XP2P project and adapted to the needs of the students.

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Figure 1: Learning path course (lightweight design)

The special feature of this learning path course is that students are introduced to new tasks step by step. These are unlocked for them level by level according to the principles of games. This means that students can only advance to the next "level" after successfully completing a level. The tasks become progressively more difficult and complex over the course of the semester. The percentage progress is graphically displayed to the students so that they can clearly see what level they have reached in the corresponding course.

This kind of gamification of the lecture content favours peer-to-peer learning: while the completion of the tasks would still be feasible for the students individually at the beginning, the increasing difficulty and complexity forces the peers to cooperate with each other: division of labour and mental exchange become increasingly essential for completing the tasks. At the same time, elements such as progress bars and the gradual activation of levels motivate students to continue the course.

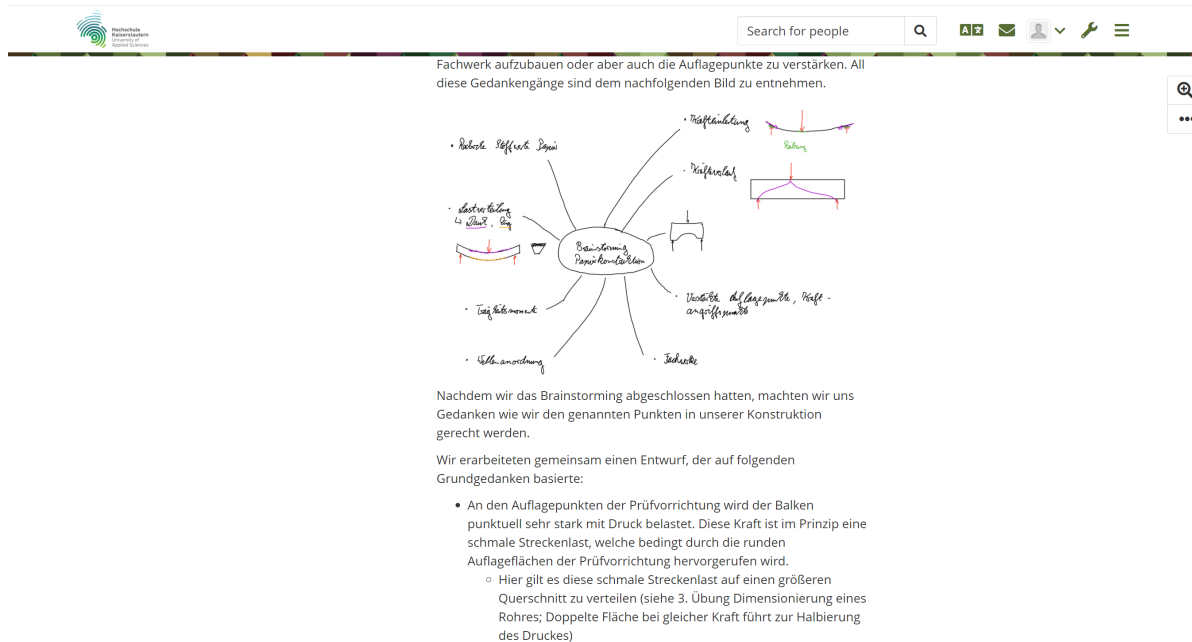
### Mahara (portfolio platform or replacement for an LMS)

*Reciprocal peer learning:* Mahara can also be used in the sense of a learning management system and ensure the provision of learning materials as well as the organisation of the flow of information outside the classroom.

However, the e-portfolio platform can also be used for collaborative work in the sense of peer-to-peer learning by formulating work assignments for the e-portfolios and the portfolio tasks they contain in such a way that group work becomes necessary.

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Peer-to-peer tasks in the XP2P project were designed to be oriented towards the portfolio structure and to favour collaboration. Here too, group work was forced in such a way that exchange and division of labour became increasingly necessary as a progressive increase in the level of difficulty and complexity took place.



Fachwerk aufzubauen oder aber auch die Auflagepunkte zu verstärken. All diese Gedankengänge sind dem nachfolgenden Bild zu entnehmen.

Brainstorming Prüfvorrichtung

- Belastung Effekt Spani
- Lastverteilung in Druck, Zug
- Tragknotenpunkt
- Verankerung
- Prüfkörper
- Prüfkörper
- Prüfkörper
- Verstärkte Auflagepunkte, Kraft angreifbar
- Injektion

Nachdem wir das Brainstorming abgeschlossen hatten, machten wir uns Gedanken wie wir den genannten Punkten in unserer Konstruktion gerecht werden.

Wir erarbeiteten gemeinsam einen Entwurf, der auf folgenden Grundgedanken basiert:

- An den Auflagepunkten der Prüfvorrichtung wird der Balken punktuell sehr stark mit Druck belastet. Diese Kraft ist im Prinzip eine schmale Streckenlast, welche bedingt durch die runden Auflageflächen der Prüfvorrichtung hervorgerufen wird.
  - Hier gilt es diese schmale Streckenlast auf einen größeren Querschnitt zu verteilen (siehe 3. Übung Dimensionierung eines Rohres; Doppelte Fläche bei gleicher Kraft führt zur Halbierung des Druckes)

Figure 2: Extract from Janis Lanzer's e-portfolio (lightweight design)

**Peer assessment:** The e-portfolio can be used as a tool to promote peer assessment. It is important to create an external motivation for students to actually assess each other, because it is an additional workload and it can be hard to criticise the work of others. There are several ways to create productive peer feedback related to the portfolio. One possibility would be to set up learning tandems (Sporer et al., 2009), in which students with different levels of knowledge help each other. This would result in the same constellations of people continuously assessing each other over the course of the e-portfolio. Another approach would be to promote students' intrinsic motivation by highlighting the benefits of such mutual assessments. Once students engage with each other's portfolios, with their creative and personal approaches to implementing the given assessment criteria and achieving the competences, they also learn to better understand the assessment criteria and identify their own difficulties (Sporer et al., 2009). This requires a high level of persuasion by the teacher. Since such motivation is voluntary, even motivated students may neglect feedback in favour of time-consuming commitments in other seminars, projects and lectures. A third possibility is to make a certain number of peer

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feedback units compulsory for students and thus include constructive assessment as a competence goal. In this case, however, there is a risk that students do not continuously write these assessments over the course of the semester, but rather "work through" this requirement at a time that is convenient for them.

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## Exchange

In peer-to-peer education, different types of exchanges can be used to facilitate group activities. The exchange can take place between teachers and students as well as between students themselves.

Within the XP2P project, the following exchange possibilities could be applied or favoured.

- Synchronous vs. asynchronous  
Synchronous exchange possibilities can be both formal meetings specified by the teachers in the (online) lectures and informal group meetings that are arranged individually by the students for working on the group projects. Asynchronous exchange opportunities are primarily the communication channels of the LMS and e-portfolio platforms that are specified and used for the purpose of project work: in particular, this means the comment function of the e-portfolios and the group forums that are made available to the students in Moodle and Mahara to ask questions outside of their own peer group and to discuss problems.
- Face-to-face vs. online  
Face-to-face here refers to the exchange in presence (lectures/ office hours/ group work). Due to the pandemic, that dominated the XP2P project, face-to-face exchanges had to be significantly reduced, especially in the first half of the project. As an alternative, online video conference formats were implemented for the purpose of exchange: online lectures, online consultation hours and online group meetings. In addition, students could also communicate via the group forums, chat and comment functions of the LMS and e-portfolio platforms.
- Planned vs. spontaneous  
Scheduled exchanges can be set by teachers or planned by students themselves. Teachers can give students periods of time for exchange in their courses. Teachers can leave the organisation of the exchange to the students themselves or provide them with impulse questions/assignments for discussion that promote group work. In addition, students can plan the joint exchange in order to be able to work on the group tasks on a regular basis. Spontaneous exchange between students can take place in presence: e.g. in lecture-free periods or interruptions between lectures. However, spontaneous exchange can also take place online as soon as discussion points arise, for example in LMS forums or the comment functions of e-portfolios.
- Formal vs. informal  
Formal exchange opportunities are provided by teachers within the courses. This includes the exchange during the application of creativity techniques, given group work, the exchange with the teachers on lecture content and, if applicable, given communication tasks, such as the obligatory submission of feedback on the e-portfolios. Informal exchange opportunities describe learning environments that are selected by the students themselves. These are group work on the project tasks, digital communication platforms (possibly selected by the students themselves) and voluntary feedback.

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## Support services for students

The following chapter describes support services that teachers can provide to their students in peer-to-peer education to initiate, monitor and ensure the continuation of peer activities.

### Evaluation scheme

When introducing a new teaching and learning method, it is essential to make the method as transparent as possible for the students at the beginning of the semester. An assessment grid can be used for this purpose. This assessment scheme must be as detailed and comprehensible as possible for the students and clearly map and define the competences to be achieved. The individual competences should be divided into different achievable levels so that students have the opportunity to reflect on and assess their learning status. In this way, students develop an understanding of what is expected of them in the course and lose their "fear" of the new, unfamiliar approach. Teachers can thus steer students in the appropriate direction they are trying to go with the method.

In addition, this provides an opportunity for the formative assessment method: contents can be discussed with the students directly at the beginning of the semester. In the case of strong deviations from the actual status of the students and the achievable goals, any necessary changes can be made in consultation with the students or expectations/goals/procedures can be adjusted.

Vorlesung: Leichtbaukonstruktion

Gruppe/Studierende:

Formales & Sprache	Einwandfreie Rechtschreibung und Grammatik	Rechtschreibung und Grammatik sind überwiegend einwandfrei.	Rechtschreibung und Grammatik weisen kleinere Fehler auf.	Rechtschreibung und Grammatik weisen grobe Fehler auf.	Mangelhafte Rechtschreibung und Grammatik.
	Einheitliche & korrekte Anwendung vorgegebener Zitierlinien. Das Literaturverzeichnis enthält genau die im Text verwendete Literatur.	Zitate sind kenntlich gemacht, Quellen vollständig angegeben. Das Literaturverzeichnis enthält genau die im Text verwendete Literatur.	Zitate sind nicht immer eindeutig kenntlich gemacht, Quellenangaben teilweise unvollständig. Das Literaturverzeichnis enthält nicht alle Titel und/oder Titel, die nicht im Text erwähnt wurden.	Zitate sind unzureichend kenntlich gemacht, einige Quellenangaben fehlen. Das Literaturverzeichnis hat nennenswerte Lücken.	Zitate sind nicht kenntlich gemacht, Quellenangaben fehlen überwiegend oder vollständig (Plagiatsverdacht). Die Zuordnung der verwendeten Literatur ist erschwert oder unmöglich.
	Präzise Wortwahl, angemessener Ausdruck.	Wortwahl ist zum Großteil präzise, Ausdruck ist der Arbeit angemessen.	Wortwahl ist teilweise ungenau, Ausdruck ist der Arbeit nicht immer angemessen.	Häufig ungenaue Wortwahl, Ausdruck ist insgesamt schwach.	Wortwahl und Ausdruck sind der Aufgabenstellung nicht angemessen.
erreichte Punkte:	4	3	2	1	0
Struktur, Aufbau & Berechnungen	Gesamtaufbau der Arbeit ist logisch und im Detail nachvollziehbar. Die Artefakte werden präzise betitelt.	Gesamtaufbau der Arbeit ist logisch und nachvollziehbar. Die Artefakte werden angemessen betitelt	Logischer Gesamtaufbau ist erkennbar, im Detail jedoch nicht immer nachvollziehbar. Die Artefakte werden nicht immer nachvollziehbar betitelt.	Wesentliche Teile des E-Portfolios sind vorhanden, Gesamtaufbau weist logische Mängel auf. Die Betitelung der Artefakte ist häufig nicht nachvollziehbar.	Die Logik des Aufbaus der Arbeit ist nicht ersichtlich. Die Betitelungen der Artefakte sind nicht nachvollziehbar.
	Annahmen werden vollständig gekennzeichnet und begründet	Annahmen werden gekennzeichnet und begründet	Annahmen werden teilweise gekennzeichnet und/oder teilweise begründet	Annahmen werden schwach gekennzeichnet und/oder begründet	Annahmen werden nicht gekennzeichnet und/oder begründet
erreichte Punkte:	4	3	2	1	0

Figure 3: Excerpt from evaluation scheme (lightweight design)

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### Training/ Tutorials

When introducing a new teaching and learning method, it is essential to prepare students as comprehensively as possible for the new method and to take away their fear of the new right at the beginning. This can increase the willingness of all students to engage with the new format. It is therefore necessary to discuss the method of peer-to-peer learning with the students at the beginning of the course and to provide them with tools for working with it.

In terms of formative evaluation, it is essential to discuss peer-to-peer learning with the students and to work out the expectations, principles and approaches together. In this way, the students not only develop an understanding of the format, but the teachers can also gain insights into possible scenarios for the further development of the course and, if necessary, make adjustments to the curriculum.

In addition, through appropriate training, teachers can provide students with tools that they can use during the course. This enables students to solve challenges and problems independently in the first instance, thus improving group dynamics.

### Pedagogical scenario

Supporting learners in a peer-to-peer scenario is crucial to the success of each individual. This support must be close, regular and individual. It must be face-to-face, but also digital.

The teachers must then accept to change their attitude and no longer take on the role of imparting knowledge, but be facilitators, coaches, mediators for students and student groups. This requires a lot of work that is different from that of imparting pedagogy.

The course syllabus and timetable are part of a clear pedagogical scenario (programme) that is explained to students at the beginning of the semester and then shared in a learning management system.

By explaining to students how the different pedagogical activities are structured in the different courses of the (Master's) degree programme, they can identify the stages of their progress in acquiring the competences of the (Master's) degree programme and thus understand and integrate them according to their personal path and goals.

*"Thus, only by formally acknowledging peer learning within the study curriculum can appropriate recognition for the process and its outcomes be achieved (Saunders, 1992). Once students have been introduced to peer learning through planned activities, they usually realise that they have more to gain than to lose. We therefore need to provide opportunities for different types of peer learning by building relevant activities into the course of study"*

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*itself. This means more than just planning a few small group discussions to fill the gaps between lectures. By managing peer learning we are formalising what would be a highly unpredictable and selective process if left to students and their casual conversations outside the classroom, and also making the process more inclusive". (Boud, 2001)*

### *(Peer) Assistant*

In the XP2P project, the use of an assistant proved to be a good way of carrying out peer tutoring. At the time of the XP2P lecture, this assistant was also a student from a higher semester and had already successfully completed the corresponding course. Due to his parallel roles as a student and an employee of the university, he was able to act as an optimal interface between the lecturers and the students.

The students could accept him as an equal contact person. This lowered the threshold to turn to the assistant with questions and challenges and to engage in subject-related discussions, as there was less fear of making mistakes or embarrassing oneself. In this way, the assistant was able to set important impulses for the students without unsettling them through a hierarchical imbalance. This was also facilitated by the faster reaction time of the student assistant and the possibility of informal contact (e.g. via social networks).

### *Interim reports or interim presentations*

The inclusion of interim reports or interim presentations can be useful for three reasons: first of all, regular reporting encourages the cooperation of the group members. If the semester tasks are complex and extensive, this can also promote intensive cooperation.

In addition, this creates an opportunity to monitor group progress: regular appointments and interim reports give the teachers an insight into the group dynamics and the learning progress of the group. Especially in peer-to-peer learning, where students are largely left to their own devices, such monitoring by the teachers is important. The teachers can intervene and support in case of problems in the group: for example, free-riding behaviour of individual group members, lack of progress, misconceptions, etc.. This results in an additional feeling of security for the teachers and for the students, that the objectives of the course will be achieved.

Finally, regular reporting can also make the individual performance of students visible. This makes sense especially when the curriculum prescribes individual grading of students. But it also gives students the necessary incentive to rise above themselves and excel in group work, as there is less danger of individual group members lowering their performance.

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Excursus Lecture "System level rapid development in mechatronics":

Nº	Topic	Duration [weeks]	milestone date
1	Setting up the S/W environment	2	26.10.2020
2	Multi body simulation		
3	Control design	1	02.11.2020
	buffer	1	<b>M1: 9.11.2020</b>
4	State machines	1	16.11.2020
5	Code export	1	23.11.2020
6	Setting up and testing the two-wheel robot	1	30.11.2020
	buffer	1	<b>M2: 7.12.2020</b>
7	The tasks to master	5	<b>M3: 18.01.2021</b>
		13	

Figure 4: Project timetable lecture System level rapid development in mechatronics

The previous picture shows the timetable of the first XP2P semester of the lecture "System level rapid development in mechatronics". M1, M2, M3 mark the three milestones that had to be fulfilled in the lecture. For this, the students were to present their interim e-portfolio statuses on the corresponding dates. Since a large part of the work in the lecture had to be completed in group work or in self-study, the teachers nevertheless received regular insights into the students' learning progress through the obligatory interim reports. The students were thus assured that the teachers did not leave them alone with the complete responsibility for the learning process and the teachers, on the other hand, could continue to monitor whether the students' learning development was progressing in the right direction.

(Further information in the chapter *Practical implementation and recommendations for action (example 1)*)

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## Analysis

To evaluate peer-to-peer education as a teaching and learning method, the concept of SWOT analysis (Strengths/ Weaknesses/ Opportunities/ Threats) is used in the following chapter. In this context, the SWOT analysis enables the evaluation of a current status and also offers the elaboration of future options for action (Wollny & Paul, 2015).

The table is followed by a discussion of the content of the individual evaluation points.

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Table 1: SWOT analysis peer-to-peer learning

<b>(Internal) strengths</b>	<b>(Internal) weaknesses</b>
<ul style="list-style-type: none"> <li>• Sustainable teaching method: "competent students".</li> <li>• Implementation of a feedback culture that promotes (learning)</li> <li>• Promoting communication skills (among students)</li> <li>• Promotion of team skills (for students)</li> <li>• Strengthening self-confidence (among students)</li> <li>• Encourage/include groups that tend to withdraw in competitive environments (e.g. women).</li> <li>• Taking responsibility for one's own learning</li> <li>• "Practical experience": Linking to real work practice</li> <li>• Enabling assessment of authentic student performance</li> <li>• Avoidance of "free riders"</li> <li>• Student success depends on group formation</li> </ul>	<ul style="list-style-type: none"> <li>• Danger of "free riders"</li> <li>• Student success depends on group formation</li> <li>• (So far) Lack of experience(s) of teachers and staff to apply the method in an optimal way</li> <li>• Little exchange of experience with teachers</li> </ul>
<b>(External) opportunities</b>	<b>(External) risks</b>
<ul style="list-style-type: none"> <li>• New requirements for students</li> <li>• Promoting lifelong learning</li> <li>• Enable individualised educational content</li> <li>• Stronger competence orientation (Bologna)</li> </ul>	<ul style="list-style-type: none"> <li>• Legal requirements (examination regulations)</li> <li>• Expectations of the students</li> <li>• Designing an optimal learning environment</li> </ul>

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(Internal) strengths

*Sustainable teaching method: "competent students".*

Peer-to-peer education is a particularly sustainable teaching and learning method due to the independent way of working. Students can discover the topics of the respective course at their own pace and from a personal perspective and the focus is on group work. The autonomy that students are given can promote a positive attitude towards learning, which in turn increases the intrinsic motivation of the students to participate in the course and the development of the content.

In addition, students have to discuss the content they have learned with their peers and, if necessary, explain the knowledge they have acquired to each other. Through constant discourse, students have to link and reflect on what they have already learned with the input of their peers. This exchange enables students to deal with the topics of the courses in a personal way.

*Implementation of a feedback culture that promotes (learning)*

In the XP2P project, peer-to-peer education in connection with the e-portfolio requires a change of role from the teachers involved: they are supposed to continuously accompany the students in their learning processes and give them feedback on their progress. Instead of taking on the classic teaching role, they become learning facilitators. This changed perception of teachers promotes an equal communication with students that is detached from the established hierarchical relationships in university teaching. Feedback is implemented as an integral part of teaching (Dossier Unididaktik, 2006), students experience an appreciation of their own points of view and dare to act outside their own comfort zone and to think innovatively. This can lead to the development of a feedback culture that makes students more self-confident and improves teaching through authentic feedback.

*Promoting communication skills (among students)*

Peer-to-peer education, as defined in the XP2P project, places a large focus on students' communication skills. In this method, students learn by explaining and discussing what they have learned. They need to be able to communicate their own ideas and points of view in a way that other students with different backgrounds and specialisations can understand (Boud, 2001/ Keppell et al, 2006). This can be a challenge for students, especially at the beginning of the course, because in classical lectures they are used to receiving knowledge rather than developing and communicating knowledge independently. In the course of the lecture, students are forced to develop their own communication skills in order to ensure productive group work.

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### *Encourage/include groups that tend to withdraw in competitive environments.*

Peer-to-peer education, through its collective mode of operation, can be beneficial for student groups that tend to withdraw in competitive and individualised learning methods, such as women or certain cultural groups/minorities (Boud, 2001). Collaborative learning, as well as the inclusion and appreciation of different experiences and knowledge that comes with it, can motivate these groups to participate more (Boud, 2001).

Unlike teaching methods that aim at the passive absorption of knowledge by students and thus demand subordination of the students, peer-to-peer education tries to strengthen the autonomy of the students. They get the feeling that diverse points of view are desired and can thus confidently put forward their own ideas/approaches to solutions. They do not have to fear being judged negatively, which is essential for groups with experiences of discrimination.

### *Taking responsibility for one's own learning*

Through the freedoms that peer-to-peer education provides for students, they are encouraged to take responsibility for their own learning.

Since the teachers remain largely in the background of the course and do not give the students any detailed guidelines on the content to be learned - except for rough milestones to structure the lecture, if necessary - the students have to manage their group work independently, organise schedules and distribute tasks sensibly. Students must differentiate between tasks that are to be completed independently and tasks that should be worked on in groups. In doing so, they have to choose a learning and working pace that is in their own interest but also in the interest of the whole group. Students learn to be able to agree on a way of working in the group that is beneficial and feasible for all participants.

Peer-to-peer education is not a method that actively teaches content to students; instead, students are expected to develop this content independently and to discuss it with other students. Success always depends on the effort and intrinsic motivation of the students.

### *"Practical experience": Linking to real work practice*

In peer-to-peer learning, students have to implement tasks in practical assignments, communicate appropriately with other students and group members, and ultimately take responsibility for learned content. Instead of relying on teachers to provide them with appropriate knowledge and all the necessary information materials, lecture notes and exam-relevant information, students have to autonomously develop the necessary knowledge in cooperation with group members. The teachers, on the other hand, remain in the background of the activities and only intervene when it is urgently necessary.

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This way of working puts students in real work situations that are common for engineers in the private sector. They are thus already trained during their studies to master difficult situations in teams, to take responsibility for work assignments and to adapt to new work environments.

### *Enabling assessment of authentic student performance*

From the students' and teachers' point of view, one advantage of peer-to-peer education is that student performance can be authentically assessed through the teaching and learning method. Teachers continuously follow the students' learning processes as learning guides throughout the course and thus gain an insight/overview of the students' individual development.

Students are thus assured that the final grade from the course is not determined by a selective knowledge test, but that further development and special achievements in the course are honoured and included in the grade.

At the same time, the teachers gain an insight into the different forms of student learning and can thus improve their own teaching: they can use these collected insights to adapt the design of the courses to the needs of the students.

### *Avoidance of "free riders"*

Free riders in education are students who benefit from the group's performance and results without making any relevant contributions themselves - they allow themselves to be pulled along by the group through the course.

The development and avoidance of these free riders in peer-to-peer education (but also in other teaching methods) depends essentially on the design of the tasks. As soon as tasks are simple, small and limited in scope, there is a danger that individual students can pull out of the group work and, on the other hand, individual students are able to solve these tasks independently.

Complex, open tasks that require the cooperation and contributions of the entire group, on the other hand, can limit free-rider behaviour. On the one hand, it is made difficult for the students to master the tasks independently. On the other hand, the students are made aware that all contributions are important and valued. This also creates a positive incentive to promote cooperation.

### *Student success depends on group formation*

Grouping in peer-to-peer education can be both an advantage and a disadvantage for student success.

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In homogeneous groups, the positive effects of peer-to-peer learning for students are limited. It may be that the groups can work together particularly productively and dynamically, since the students have a lot in common with each other and may already know each other well. However, the consequence of this can be that the students do not exceed a certain level in the course of the lecture and cannot rise above themselves. In this case, there is a lack of impulses and discussions that result precisely from the diversity in the students' personalities and previous knowledge.

With heterogeneous groups, on the other hand, the opposite case can occur: While there is the potential of purposeful student differences, these differences can inhibit fruitful collaboration.

Teachers must recognise such problems in their role as learning facilitators and develop methods to eliminate them. For example, peer tutors (see chapter on peer tutoring) can be used specifically to set impulses in largely homogeneous groups and thus repeatedly stimulate the exchange of ideas.

To avoid poor group dynamics, it is advisable to stimulate cooperation in the group right at the beginning. For example, creativity techniques (see chapter on creativity techniques) can be used at the beginning of a course to get to know each other and to loosen up the group.

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(External) opportunities

*New demands on students (due to labour market, globalisation, technical development)*

The continuous development of new technologies and globalisation have a significant impact on the labour market. Students who learn only to reproduce knowledge risk preparing for jobs that disappear from the labour market (OECD, 2006). Instead, they are expected to be able to solve multi-faceted tasks and problems for which there are no clearly regulated approaches (McWhorter et al., 2013). They must be able to communicate complex scientific ideas clearly and convincingly (McWhorter et al., 2013). Higher education institutions face the challenge of creating a curriculum that prepares students for such obstacles in the labour market. They do not need to prepare students for specific work situations. Instead, they need to develop competences that enable students to apply theoretical principles in such a way that they can solve complex practical problems (Salzburg Research Forschungsgesellschaft, 2007).

Peer-to-peer education can play a supporting role here. In this teaching and learning method, students have to implement tasks in practical assignments, communicate appropriately with fellow students and group members, and ultimately take responsibility for learned content. Instead of relying on teachers to provide them with appropriate knowledge and all the necessary information material, lecture notes and exam-relevant details, students must autonomously develop the necessary knowledge in cooperation with group members. The teachers, on the other hand, remain in the background of the activities and only intervene when it is urgently necessary.

This way of working puts students in real work situations that are common for engineers in the private sector. They are thus already trained during their studies to master difficult situations in teams, to take responsibility for work assignments and to adapt to new work environments.

*Promoting lifelong learning*

The concept of lifelong learning assumes that learning is "a biographical project" (Arnold et al., 2000). This means that, contrary to common perception, learning does not only take place at certain times and in certain learning situations, but inevitably accompanies people throughout their biography.

From the authors' point of view, peer-to-peer education has the potential to implement this concept in a promising way. In order for adults to successfully target and steer lifelong learning processes, they are dependent on "learning spaces" that provide them with flexible access to learning. This means being able to learn productively regardless of time, place, financial means and according to their own needs. Peer-to-peer education offers this possibility through its flexible and self-determined character.

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In addition, peer-to-peer learning requires students to regularly question their own learning in discussions with their fellow students and can thus optimise their learning processes in the long term.

### *Enable individualised educational content*

Constructivist learning theory assumes that knowledge is not simply transferred to learners, but is constructed by learners in an active process. Accordingly, knowledge acquisition is individual and dependent on each learner's respective view of reality (Reich, 2017).

In peer-to-peer education, students' individual learning processes can be taken into account and rewarded. Learners are given as much freedom as possible in how and in what environment relevant subject content is learned. Even if it is specified that students must work together in small groups, they can organise this group work according to their own needs and personalities. They can determine the type of exchange and their learning environments themselves.

Teachers benefit from engaging with individual approaches: they can improve their own teaching by observing students learning. By focusing on student learning, individualised educational content can be facilitated.

### *Stronger competence orientation (Bologna)*

The Bologna reforms require higher education to focus studies and teaching more on the acquisition of competences (Stratmann et al., 2009). However, everyday university life often continues to be oriented towards standardised knowledge assessments whose grades do not allow conclusions to be drawn about the transfer of learning and the competences actually acquired by students (Stratmann et al., 2009).

The character of peer-to-peer education requires the processing of open and complex questions and tasks, which are processed over the course of a semester/project. Through the constant exchange between the students and the accompanying discussion of learned content, students have to reflect on themselves and their learning strategies. Here they can look at problems from a personal perspective and apply the theoretical foundations.

The change from "input orientation to outcome orientation in teaching" (Salzburg Research Forschungsgesellschaft, 2007) can thus be advanced by applying peer-to-peer education. With this method, teachers must not only assess the acquired knowledge at the end of the course, but also accompany and involve the students' learning process.

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## (Internal) weaknesses

### *Danger of "free riders"*

Free riders in education are students who benefit from the group's performance and results without making any relevant contributions themselves - they allow themselves to be pulled along by the group through the course.

The development and avoidance of these free riders in peer-to-peer education (but also in other teaching methods) depend essentially on the design of the tasks. As soon as tasks are simple, small and limited in scope, there is a danger that individual students can pull out of the group work and, on the other hand, individual students are able to solve these tasks independently.

Complex, open tasks that require the cooperation and contributions of the entire group, on the other hand, can limit free-rider behaviour. On the one hand, it is made difficult for the students to master the tasks independently. On the other hand, the students are made aware that all contributions are important and valued. This also creates a positive incentive to promote co-operation.

### *Student success depends on group formation*

Grouping in peer-to-peer education can be both an advantage and a disadvantage for student success.

In homogeneous groups, the positive effects of peer-to-peer learning for students are severely limited. It may be that the group can work together particularly productively and dynamically, since the students have a lot in common among themselves and may already know each other well. However, the consequence of this can be that the students do not exceed a certain level in the course of the lecture and cannot rise above themselves. There is then a lack of impulses and discussions that result precisely from the diversity in student personalities and previous knowledge.

With heterogeneous groups, on the other hand, the opposite case can occur: While there is the potential of purposeful student differences, these differences can inhibit fruitful collaboration.

Teachers must recognise such problems in their role as learning facilitators and develop methods to eliminate them. For example, peer tutors (see chapter on peer tutoring) can be used specifically to set impulses in largely homogeneous groups and thus repeatedly stimulate the exchange of ideas.

To avoid poor group dynamics, it is advisable to stimulate cooperation in the group right at the beginning. For example, creativity techniques (see chapter on creativity techniques) can be used at the beginning of a course to get to know each other and to loosen up the group.

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*(So far) Lack of experience(s) of teachers and staff to apply the method in an optimal way*

Peer-to-peer education demands specialised skills from teachers that other testing methods do not require: Teachers have to completely rethink their role and become tutors and learning guides. Changing one's own role requires didactic knowledge on the one hand and on the other hand also the ability to hold back and hand over the creative role of the course to the students. Such modifications of the previous way of working must first be learned by teachers and may not be equally feasible for every teacher.

*Little exchange of experience with teachers*

As peer-to-peer education focuses on students working together and teachers monitoring the learning, the exchange between teachers and students is largely relegated to the background. Although this promotes cooperation between students, it prevents students from benefiting from the experience of teachers, which far exceeds the students' horizons of experience. But teachers also benefit from such an exchange, as they get to know their students better and receive impulses for their own teaching through their contributions and questions.

Therefore, it makes sense to also create discussion spaces in peer-to-peer education that enable the exchange between teachers and students. In the XP2P project, e-portfolios were chosen as a tool for this. Teachers followed the written work of the students and gave their feedback, which in turn could be used by the students as a basis for discussion.

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(External) risks

### *Legal requirements (examination regulations)*

Examination regulations provide universities with a legal framework that regulates the standards and procedures of examinations for individual degree programmes. Depending on how specific these examination regulations are, they can restrict or even exclude the use of new teaching and learning methods in the curriculum from the outset.

For teachers who want to integrate new methods into the curriculum, it is therefore necessary to first clarify the legal framework and then either a) adapt the teaching/learning method to the examination regulations or b) make an effort to have the examination regulations amended accordingly.

It is relevant for the success of peer-to-peer education that it is also anchored in the examination regulations, since for students, in addition to intrinsic motivation, the rewarding of their own achievements through appropriate grading is essential.

### *Expectations of the students*

When implementing a new teaching and learning concept, it is essential that the new method is accepted and embraced by students. Through classical teaching concepts, students are used to teachers presenting and conveying relevant content to them. This is accompanied by a certain expectation that teachers have to fulfil from the students' point of view. If teachers cannot credibly convey the new approach to students when introducing concepts, there is a risk that the corresponding course or module will a) not be chosen/attended by students in the case of elective modules or b) not be implemented productively in the case of compulsory modules. Especially with a concept such as peer-to-peer education, where intrinsic motivation plays a central role in successful implementation, a "boycott" of the course would be disastrous.

It is therefore advisable that teachers explain the new method to students in detail and clearly highlight the positive aspects for students. Students must perceive that peer-to-peer education does not have a negative influence on grading. Instead, teachers must authentically convey that the learning concept honours the individuality of the students; gives them the opportunity to develop within the course and to grow beyond their own horizons. Especially when introducing the method, students should know that they will not experience any disadvantages compared to traditional courses.

### *Designing an optimal learning environment*

Higher education institutions must actively approach the development of learning spaces and thus be able to support students in achieving their goals and learning successes. This is how the "paradigm shift from teaching to learning" (Ninnemann et al., 2020) can be enabled. Such

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learning spaces must incorporate the diverse needs of learners and provide them with resources that enable learners to "integrate academically and socially" (Dingfeld et al., 2020).

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### What conclusions can be drawn from the SWOT analysis?

The previous explanations were able to show that peer-to-peer education as a teaching and learning method can have numerous advantages for students. It supports students in expanding competences relevant to the future or the profession and can promote group dynamics towards greater productivity than is the case in classic teaching and learning formats. The success of this method depends in particular on the design of the format by the teachers. They need to be trained in the planning and implementation of peer-to-peer education (if this format is new to them) and include different scenarios. This includes actively involving all group members and planning the formation of the group. In the latter, it is particularly important to think through what to do if a) the group is too homogeneous and progress may stall or b) the group is too heterogeneous and productive group work may not happen.

This also means that the role of the teacher in this format should not be misunderstood. Even if lecture units can be largely dispensed with and replaced by short inputs on new knowledge, it does not mean that the teacher should withdraw from the course. Instead, teachers should be constantly involved in the group work (observing) and maintain an overview of it. They must intervene and guide where problems arise and act as contact persons when students need new impulses.

The opportunities analysed show that peer-to-peer education is a future-oriented format. It focuses on competence development, prepares students for new challenges of the labour market and promotes lifelong learning. On the other hand, the risks related to difficulties resulting from the past can be minimised through active and frequent use of the peer-to-peer format. Specifically, legal requirements can be adapted to the needs of the method if necessary, students' expectations can be changed by getting to know the format, and the design of the learning environments can be improved through experience and exchange of experiences.

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## E-portfolio as an examination method

### Theory

The following chapter examines, on a higher level, the key aspects associated with the e-portfolio method elaborated in the XP2P project.

#### What is a (scientific) e-portfolio?

For the purpose of the XP2P project, the following definition was established: The e-portfolio is a digital collection created to assess learning progress and contains multimedia evidence of students' efforts and competences. Reflections take on a special role in this collection, supporting a critical examination of individual learning behaviour and promoting exchange with the portfolio's viewers. The creator of the e-portfolio shares the content out of an intrinsic motivation. As the owner of the portfolio, he or she can thus reflexively and continuously improve learning.

#### What are the goals/benefits associated with this?

The e-portfolio not only checks the extent to which knowledge has been absorbed, but also shows in particular how this knowledge is handled. Students are thus given the opportunity to deal intensively with their own learning and to apply what they have learned in an individual way. By creating reflections, students learn to assess and guide their own learning. This can create a special motivation to actively participate in the processing of the e-portfolio (Roberts, et al., 2016). Important aspects associated with this are summarised by Chau and Cheng under the terms "personalised learning" and "learner responsibility". "Personalised learning" describes a strengthening of the students' commitment and motivation to explore topics from a personal perspective (Chau & Cheng, 2010). "Learner responsibility", on the other hand, is the inference that independent learners accept responsibility for their own learning. That is, they see a personal benefit in learning the necessary content. This fosters a positive attitude towards learning itself and develops the ability to consciously reflect on content (Chau & Cheng, 2010). Together with the inclusion of feedback, peer review and discussion on e-portfolio platforms, digital collections have the potential to positively influence lifelong learning processes through continuous sharing and editing of content (Bhattacharya & Hartnett, 2007/ Deneen, 2013). E-portfolios support students in taking responsibility for their own learning by exploring study content from a personal perspective and discussing it with other students in (online) discourses. Students can thereby gain a higher degree of independence and self-confidence and are thus prepared for lifelong learning processes in a promising way. Furthermore, the digital collections are a tool to connect to the reality of students' lives. Reese and Levy argue that current students are familiar with communicating via digital media and sharing their experiences online. E-portfolios are then a way to combine these aspects in an academic context:

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students can set their own goals and document and share their work on them online, while reflectively engaging with their own learning (Reese & Levy, 2009 /Chau & Cheng, 2010).

The e-portfolio is also described as an authentic form of assessment, as it makes visible the students' self-set goals, critical thinking, approaches to solving complex problems and reflections on the individual learning process (Bhattacharya & Hartnett, 2007/ Reese & Levy, 2009). This gives teachers the advantage of recognising students' weaknesses and problems and providing individual support (Gomes, 2008).

## What are the central elements of the e-portfolio?

### *Learning outcomes*

For students, portfolio work begins with the collection of artefacts. Such artefacts can be products such as videos, podcasts or photos, as well as elaborations that arise in the learning process, such as reflections (Stratmann et al., 2009). The e-portfolio serves as a digital repository in which artefacts are collected in a structured way (Hampshire & O'Connor, 2012), although this structure is not imposed from the outside, but is founded by the creators themselves. Therefore, the portfolio can be understood as a creative process that reflects the personal approaches of the creators and demonstrates their ability to present systematically and authentically (Panyukova, 2019).

This conscious selection of relevant artefacts represents students' first dimension of reflection (Bräuer, 2016), which is then continued in the actual reflective contributions.

### *Reflective writing*

An important didactic tool of the e-portfolio is the use of reflections. The personal character of the e-portfolio and a comprehensible connection between the accumulated artifacts can be made visible in the reflections (Jarvinen & Kohonen, 1995).

The complexity of reflections becomes clear in Bräuer, who describes seven levels of reflexive practice that portfolio creators can go through in the contributions: Describing - Documenting - Analysing - Interpreting - Evaluating - Assessing and Planning (Bräuer, 2016).

In general, the reflective contributions can be described as "reflective self-assessment" (Jarvinen & Kohonen, 1995), i.e. a critical examination of one's own learning takes place. The focus shifts from a teacher-centred format that imparts knowledge to be finally tested in an examination to a format that maps the students and their learning processes. A kind of paradigm shift is taking place, where students are no longer concerned with "satisfying" the teacher, but with improving the quality of their own learning (Lawson & Thompson, 2012). This enables the exit from the role of passive recipients of knowledge (Strasser & Knecht, 2012). Instead,

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students must actively engage with information, question it and internalise it in the context of individual prior knowledge, different everyday experiences and personal objectives.

### *Feedback*

Feedback is a central element in portfolio work and is only helpful if those who evaluate an e-portfolio also understand its structure. Feedback is optimally useful when it is individually adapted to the creators of the portfolio. In particular, the focus of the assessment by the teacher should be on the acquisition of competences (Sporer et al., 2009). Due to the time-consuming nature of such assessment, it is helpful to share the responsibility of feedback and to delegate the task to the students as well.

For this reason, three types of feedback can be implemented within the e-portfolio and used for the final overall assessment. This includes feedback from the creators of the portfolio - here, the respective creators evaluate themselves and their learning processes in reflection contributions provided for this purpose. In addition, peer feedback and feedback from an authority, i.e. the teacher, are also included (Sporer et al., 2009). In the case of feedback from fellow students, it is important to create an external or intrinsic motivation for students to evaluate each other, because on the one hand it is an additional workload and on the other hand it can be associated with an overcoming to express criticism of the work of others. An external motivation would be the explicit inclusion of peer feedback in grading, which is also represented and defined accordingly in a grading scheme. An intrinsic motivation would be to highlight the benefits for the feedback providers, such as gaining new insights/approaches or the opportunity to exchange with peers.

However, feedback should not be limited to constructive criticism of fellow students; instead, students must also be encouraged to demonstrate that they have addressed feedback from teachers and fellow students on their own portfolio. This is referred to as a feedback loop that needs to be closed. In concrete terms, this consists of the following steps:

1. Give or collect feedback
2. Evaluate and analyse feedback
3. Implement suggestions/ draw consequences.

Through such an approach, a feedback culture can be implemented in the course of the semester. It is important to emphasise that proof is not necessarily provided by obedient acceptance of the feedback; instead, a conclusive justification for non-acceptance can also be provided. The prerequisite for this is a demonstration of how the criticism has been dealt with and a comprehensible justification for a different course of action than that suggested by the teacher or fellow students. In this way, the students' personal development can be advanced, since the feeling of being subordinate to the teachers is not conveyed, but the impression of being entitled to vote is strengthened. This then also promotes the learners' self-confidence.

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## Method

E-portfolio implementation flowchart: The following chapter provided guidance for the implementation of the e-portfolio method. The process is based on the experiences in the XP2P project and gives an insight into the practice of this method. The aim is to show which steps should be considered when implementing the e-portfolio. The authors do not claim the general validity of the description - individual framework conditions of institutions, courses or teachers may make further steps necessary or the steps mentioned may then be irrelevant.

Table 2: E-portfolio method flowchart

Preparation	
<ul style="list-style-type: none"> <li><input type="checkbox"/> Set goals and purposes</li> <li><input type="checkbox"/> Research</li> <li><input type="checkbox"/> Define the e-portfolio</li> <li><input type="checkbox"/> Create an assessment scheme</li> <li><input type="checkbox"/> Select and set up a platform</li> <li><input type="checkbox"/> Prepare sample portfolios/ tutorials</li> <li><input type="checkbox"/> Train teaching staff (and staff members, if applicable)</li> </ul>	
Implementation	
Lecturer	Students
<ul style="list-style-type: none"> <li><input type="checkbox"/> Present and discuss the event concept</li> <li><input type="checkbox"/> Introduce portfolio work</li> <li><input type="checkbox"/> Accompany portfolios</li> <li><input type="checkbox"/> Support services                             <ul style="list-style-type: none"> <li><input type="checkbox"/> Office hours</li> <li><input type="checkbox"/> Regular feedback</li> <li><input type="checkbox"/> Final discussion/ colloquium</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Create and select artefacts</li> <li><input type="checkbox"/> Reflections</li> <li><input type="checkbox"/> Feedback</li> </ul>
Follow-up	
<ul style="list-style-type: none"> <li><input type="checkbox"/> Assess e-portfolios</li> <li><input type="checkbox"/> Back-Ups</li> <li><input type="checkbox"/> Evaluate</li> </ul>	

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## Preparation

The following chapter explains the necessary steps highlighted by the writers to prepare the e-portfolio method in Table 2.

### *Determination of goals and purposes*

Before using the portfolio, it is first important to deal with the basic aspects of portfolio work. For this purpose, possible goals and purposes of e-portfolio use should first be analysed and weighed up. It is therefore necessary to answer the following questions at the beginning:

- Which competences should be promoted by the e-portfolio? How should the e-portfolio support me and the students?
- What purpose should the e-portfolio serve?
- What goals do I want to achieve with it?
- Does the method fit the target group?
- How much time do I want to/can I invest in the method?
- How would I like to integrate the e-portfolio into the lecture/seminar/project?

### *Select portfolio types*

When researching the portfolio method, it is first important to consider the different types of e-portfolios and which portfolio method is best suited to the particular course and the target group it addresses.

When distinguishing e-portfolios, three main categories can be found, which can be found in Barrett and Carney, among others:

1. Product-oriented portfolios represent achievements that are designed to demonstrate externally specified skills and competences (Barrett & Carney, 2005). It is therefore a summative assessment where the final result is scored, similar to an exam for example. This type of portfolio can be used as an examination format.
2. Process-oriented portfolios, on the other hand, document the learning process of students and invite them to reflect on their own skills and learning processes (Barrett & Carney, 2005). Such a portfolio aims at formative assessment, as it constantly reviews the learning status and serves as an orientation for the learners in the learning process. These interim results can also be used by the teacher to adjust course planning.
3. In addition, the authors name a third purpose of the portfolio that includes aspects of both categories and cannot basically be assigned to one of the two categories. They call this purpose "marketing". They refer to portfolios that are presented to potential employers. The creators of such portfolios present their best work, which they consider to be particularly interesting and meaningful for the application process. This can be

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evidence of certain skills and competences, but also their own contributions to reflection (Barrett & Carney, 2005). However, since a conscious selection of suitable artefacts takes place here, aspects of both product and process orientation can be found in such collections.

The term (e-)portfolio is used in different contexts and leads to different understandings of representations and goals of the portfolio method in these different contexts. Therefore, it is important to establish an adequate definition of the portfolio based on the self-imposed goals and the results of the research. This definition should cover the chosen focus as accurately as possible.

The definition should then be presented to the students at the beginning of the lecture so that a common understanding of the applied concept can emerge and misunderstandings can be avoided.

### *Creation of an evaluation grid*

Since the e-portfolio is an unknown working and learning element for most students, it is important to create as much transparency as possible. This means that learning goals and outcomes to be achieved through the portfolio tasks, as well as criteria that will be included in the assessment, should be agreed with the students at the beginning (Kilian-Yasin & Müller, 2012/ Chan & Yan, 2013).

An assessment grid can be used for this purpose. This assessment scheme must be as transparent and comprehensible as possible for students and clearly map and define the competences to be achieved. The individual competences should be divided into different achievable levels so that students have the opportunity to reflect on and assess their learning status. This has two advantages: a) on the one hand, students develop an understanding of the expectations placed on them in the course and b) on the other hand, the assessment scheme is an aid for the reflections that students have to write in the context of the portfolio work, as it gives them a focus for tracking their own learning development.

The following table shows examples of competences that were specifically addressed in the context of the portfolio work of the XP2P project. These generic competences are not acquired exclusively through the work on the e-portfolio, but they are favoured. For example, the ability to give constructive feedback and to deal with feedback can be acquired both through communication in the portfolio platform (in the case of the XP2P project, the platform Mahara was used for this) and through group work in the context of the lecture. Therefore, an area for "Evidence in the portfolio" was added to the table, which refers to the work on the digital col-

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lection, but does not exclude that the competences are also acquired elsewhere. Specific contents of the lectures are left to the teachers themselves, therefore there are no competences in the table that are based on specific knowledge.

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Table 3: Competences e-portfolio

Competence	Essential components	Main expectations	Evidence in the e-portfolio
<b>Learning</b>	Learn how to learn new things & apply them in different situations	<ul style="list-style-type: none"> <li>• Develop learning strategies</li> <li>• Filter necessary knowledge</li> <li>• Transfer knowledge to new situations</li> <li>• Development of alternative solutions to problems</li> </ul>	<ul style="list-style-type: none"> <li>• Transfer of the learned contents to the e-portfolio &amp; its design</li> <li>• Reflections on own learning strategies</li> </ul>
<b>Self-reflection</b>	Critical examination of one's own learning	<ul style="list-style-type: none"> <li>• Critical examination of own learning &amp; own approaches to solutions</li> <li>• Consideration of alternative solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Honest reflections, questioning one's own learning behaviour, admitting difficulties &amp; striving to optimise one's own learning.</li> </ul>
<b>Analytical thinking</b>	Application of knowledge to solve complex problems	<ul style="list-style-type: none"> <li>• Critical examination of different approaches to solutions</li> <li>• Development of innovative solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Documentation of the solution approaches in the artefacts (graphs, analyses, calculations...)</li> <li>• Reflection on one's own strategies in problem solving</li> </ul>
<b>Digital skills</b>	Ability to use media for communication & action purposes	<ul style="list-style-type: none"> <li>• Adaptability to work with new, evolving media</li> <li>• Responsible handling</li> <li>• Clear &amp; appropriate communication with teachers/ fellow students</li> </ul>	<ul style="list-style-type: none"> <li>• Confident handling of Mahara &amp; its functions</li> <li>• Exploiting the extensive functions of the software</li> <li>• Communication via comment &amp; group functions</li> </ul>
<b>Feedback</b>	Constructive engagement with other people's work & analytical approach to feedback on own work	<ul style="list-style-type: none"> <li>• Critical examination of other work, constructive assistance for optimisation</li> <li>• Differentiated handling of feedback on own work</li> </ul>	<ul style="list-style-type: none"> <li>• Thoughtful &amp; constructive feedback in other students' comment sections.</li> <li>• Addressing the comments in one's own portfolio → Presentation of acceptance of the feedback or reasoned rejection</li> </ul>

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<p><b>Communication</b></p>	<p>Effective written communication of own work &amp; own engagement with other work</p>	<ul style="list-style-type: none"> <li>• Understanding of good scientific documents (in engineering)</li> </ul>	<ul style="list-style-type: none"> <li>• Analysis of scientific documents</li> <li>• Collection of own scientific papers</li> <li>• Feedback on other e-portfolios</li> </ul>
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### *Platform selection and set-up*

Before implementing the e-portfolio, it is necessary to select a suitable platform. As things stand, there is a wealth of different platforms that are explicitly designed for the creation of e-portfolios. In addition, there is also the possibility of presenting portfolios in weblogs, which are intended for the use of diary-like blog posts and do not exist only for the explicit design of e-portfolios.

From this set of platforms, it is important to choose one that fits the goals of the corresponding course and that takes into account the institutional requirements (in terms of server administration, acquisition costs, etc.).

When selecting a platform, it should also be considered whether it has to be used in conjunction with a learning management system (e.g. Moodle, OLAT, etc.) or whether it can be used instead of an LMS. If a portfolio platform is used as the only system within a course, it must be checked in advance whether, for example, there are options for managing digital course content (lecture notes, presentations, etc.), for networking course participants (group functions, chat functions, etc.) or for submitting interim results. If, on the other hand, an LMS is already provided by the university, it must be checked to what extent a connection (e.g. via LTI) can or should be established between the two platforms.

For the purpose of the XP2P project, different e-portfolio platforms were considered. The project participants finally decided to use the New Zealand open-source software Mahara. The table below provides an overview of the programmes considered, including the main features and some notes from the writers. In the following table, only those programmes are examined that contain explicit possibilities of use for e-portfolios. A claim to completeness cannot be made.

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Table 4: Portfolio platforms

Platform	Functions	Notes
<b>Mahara</b>	<ul style="list-style-type: none"> <li>• Comprehensive privacy settings: Creators decide what is seen, when and by whom</li> <li>• Special artefact types: Blogs, planning tools, notes</li> <li>• Comment functions (but not for all artefacts)</li> <li>• Share URL: Visibility of the portfolio for viewers without an account</li> <li>• Export of portfolios: permanent storage and use of the portfolio possible (even after expiry of the account)</li> <li>• Group function for networking</li> <li>• Linking with other programmes such as Moodle or OLAT possible</li> <li>• Numerous extensions through plug-ins, e.g. SmartEvidence.</li> <li>• Artefacts exist independently of the portfolio: an artefact can be used as often as desired in different portfolios/collections, changes in the artefact are simultaneously adopted everywhere</li> <li>• Numerous digital formats are available: Texts, images, videos, sound recordings, external media, open badges, etc.</li> <li>• Use via mobile devices possible</li> </ul>	<ul style="list-style-type: none"> <li>• Open Source</li> <li>• Active online community: online help in case of difficulties/ constantly updated manual/ many multilingual tutorials on YouTube or other platforms</li> <li>• Ease of use (intuitive)</li> </ul>
<b>Karuta</b>	<ul style="list-style-type: none"> <li>• Extensive assessment options</li> <li>• Numerous design options</li> <li>• Possibilities to make assessment criteria and objectives transparent: students can then track which aspects have been sufficiently addressed and how close they are to their objectives; learners can submit artefacts directly to specific assignments</li> <li>• Numerous digital formats are available: Texts, images, videos, sound recordings, external media, etc.</li> <li>• Portfolios can be shared by e-mail</li> </ul>	<ul style="list-style-type: none"> <li>• Open Source</li> <li>• Training time necessary (not intuitive)</li> <li>• Active community, but mostly in the French-speaking area</li> <li>• Helpful templates for portfolios and evaluation schemes can be installed: good knowledge of French is advantageous</li> </ul>

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Platform	Functions	Notes
<b>PebblePad ePortfolio</b>	<ul style="list-style-type: none"> <li>• Comprehensive privacy settings: Creator decides what is seen, when and by whom</li> <li>• Can be connected to external programmes such as Dropbox, OneDrive, Google Drive, Moodle</li> <li>• For teachers: PebblePad can identify learners who need special help by monitoring their interactions.</li> <li>• Extensive feedback options</li> <li>• Numerous digital formats are available: Texts, images, videos, sound recordings, external media, etc.</li> <li>• Use via mobile devices possible</li> <li>• Free design options/ personalisability: design can be creatively shaped by the user</li> </ul>	<ul style="list-style-type: none"> <li>• Ease of use (intuitive)</li> <li>• Chargeable</li> </ul>
<b>Open OLAT E-Portfolio</b> (Learning Management System)	<ul style="list-style-type: none"> <li>• Comprehensive privacy settings: Creators decide what is seen, when and by whom</li> <li>• special artefact types: Forum, self-created wiki entry, performance record (a certificate issued in and through OLAT about tests taken or tasks handed in and graded), file, texts, learning diary, blog</li> <li>• No embedding of e.g. YouTube videos possible</li> <li>• Comment and star rating function</li> </ul>	<ul style="list-style-type: none"> <li>• Training time necessary (not intuitive)</li> <li>• OLAT access via university necessary: cannot be used further without an account. If individual artefacts are to continue to be used after the end of studies, they must be saved separately.</li> </ul>

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Platform	Functions	Notes
<b>Word-Press</b> (Webblog Software)	<ul style="list-style-type: none"> <li>• Creative design possibilities</li> <li>• Large collection of extensions, add-ons and plug-ins</li> <li>• Prefabricated portfolio designs can be used: facilitate familiarisation with unfamiliar formats such as e-portfolios (in some cases subject to a fee)</li> <li>• Can be connected to external programmes such as Dropbox and numerous social networks</li> <li>• Numerous digital formats are available: Texts, images, videos, sound recordings, external media, etc.</li> <li>• Use via mobile devices possible</li> </ul>	<ul style="list-style-type: none"> <li>• Open source: download free of charge, but use may be associated with costs</li> <li>• WordPress is one of the most widely used content management systems: Target for cybercriminals</li> <li>• Some functions require knowledge of web design: in case of problems, you have to rely on the help of the community.</li> <li>• Responsibility for your own website, means being responsible for security, back-ups and updates yourself</li> <li>• Frequent updates</li> <li>• Training time necessary (not intuitive; but a lot of help can be found online)</li> <li>• Basics in HTML and CSS advantageous</li> </ul>
<b>Elgg</b> (Social Networking System)	<ul style="list-style-type: none"> <li>• Comprehensive privacy settings: Creators decide what is seen, when and by whom</li> <li>• Numerous extensions through plug-ins</li> <li>• Special artefact types: Tags, wikis, podcasts, blogs</li> <li>• Comment functions</li> <li>• Numerous digital formats are available: Texts, images, videos, sound recordings, external media, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Open Source</li> <li>• Active online community: online assistance in case of difficulties</li> <li>• Training time necessary (not intuitive)</li> </ul>

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### *Preparation of sample portfolios and tutorials*

It is also beneficial if teachers create an example portfolio. This makes the portfolio use authentic (Strasser & Knecht, 2012) and the students get a better impression of what a collection can look like or what ideas are pursued with it in the context of the lecture unit.

In connection with the portfolio definition, the example portfolio can then be called up by the students as needed, so that misunderstandings in the application of the (new) method are prevented.

Within the XP2P project, among other things, the following sample portfolio was created, which incorporated the needs of the respective courses:

[Example portfolio](#) (for detailed explanation see *Practical implementation and recommendations for action (example 1)*)

### *Training of teaching staff and employees*

If other teachers/staff members are involved in the lecture, an introduction of these persons to the portfolio work is necessary. This is because the attitude of the teachers and the students plays a weighty role in the success of a portfolio. This therefore also implies that all teachers involved must give the students the impression that they are interested in the format as a whole and have dealt with it in detail. Only if teachers consider the portfolio method to be coherent for the learning process, they can also credibly convey to the students that they stand behind the method. They also need knowledge about the method and its purpose.

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## Implementation Teachers

### *Presentation and discussion of the event concept*

At the beginning of the course, it is advisable to present the planned new method to the students as openly and transparently as possible and to discuss the concept. In doing so, it should become clear what expectations are placed on the students through the portfolio work. The assessment scheme should be a central focus. In this way, the students can understand the central learning objectives and deal with the competences to be achieved in discussions with the teachers and the other students: in particular, the understanding of competences should be addressed here, as these are of central importance for the e-portfolio. This concept is often too diffuse for students and therefore tends to be equated with knowledge acquisition or justified by knowledge acquisition. A distinction between content and competences is particularly important here.

In terms of a formative assessment format, such a discourse with students provides the first opportunity for teachers to adjust the assessment scheme and/or semester planning, if necessary.

### *Introduction to portfolio work*

Introducing students to portfolio work is a crucial success factor and should be firmly planned at the beginning. On the one hand, the students should be taught about the technical possibilities of the selected platform. An active demonstration during which a collection of different artefacts is created is suitable for this.

On the other hand, the example portfolio should be presented in this context and with it the didactic requirements, which are thereby made transparent for the students. An example of this can be found in chapter *Practical implementation and recommendations for action (Example 1)*.

Students should then be given the opportunity to try out the platform for themselves and ask their questions.

A confident use of the platform and a basic understanding of the portfolio method are essential for a targeted approach during the semester.

### *Accompanying the portfolios*

In order to support peer learning in the XP2P project in particular, but also the acquisition of skills by the students, the teachers act as coaches and moderate the individual learning process.

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To ensure continuous work on the e-portfolio, it is advisable to set several milestones throughout the semester. These can then be used as points of contact for interim presentations and evaluations.

It is advisable to set concrete tasks for the respective milestones. It is important to note that the corresponding tasks are oriented towards the learning objectives or the addressed competences and "test" them. Furthermore, the tasks should neither be too prescriptive nor too open-ended. The former challenges the students too little and limits creative approaches to solving problems, as it severely restricts the approach. An overly open formulation, on the other hand, is perceived as daunting due to its lack of clarity (Hao Yang & Wu, 2013). Thus, a middle ground must be created in which students are granted as much self-direction as possible (Quellmelz & Ruschin, 2013) without overburdening them with too much freedom. The acceptance of portfolio work can be increased if the tasks are formulated according to the realities of the students' lives. It therefore makes sense to involve student assistants in the design of the tasks. In this way, a language style familiar to the students can be used (Kilian-Yasin & Müller, 2012) and their perspectives can be taken into account.

Setting binding milestones can cover three important aspects for successful portfolio work:

- Ensuring regular integration of the portfolio in classroom teaching: Here it can be avoided that the e-portfolio is regarded merely as an additional task and is thus neglected in the course of the semester.
- Ensuring regular reflections: The linking of milestones and reflection contributions ensures that these reflections are written continuously throughout the semester and thus represent an individual overview of the students' learning development.
- Adjustment of semester planning: The e-portfolio, as applied in the project, is assessed in the sense of a formative examination. Such an assessment is linked to a continuous review of individual learning levels and the adjustment of course planning based on intermediate results. In terms of this assessment format, milestones can be used by the teachers to evaluate the portfolio work and, if necessary, to make adjustments to further semester planning.

### *Support services*

There are different support services that can be offered to students throughout the semester. A selection of offers that have emerged as beneficial in the course of the XP2P project is presented in this sub-chapter.

- Consultation hours on the e-portfolio: Regular, synchronous office hours that students can use exclusively for questions and discussions about the e-portfolio. These appointments should be voluntary and designed according to the students' interests. The ex-

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periences in the XP2P project have shown that questions and focal points of such consultation hours can differ significantly depending on the composition of the corresponding groups.

- **Regular feedback:** Teachers should continuously monitor and comment on students' portfolio work throughout the semester: asynchronous feedback in the comment sections of the digital portfolio platforms is best suited here. In terms of content, feedback from teachers should contain stimulating and constructive feedback. Concrete answers should be avoided: only in the case of gross errors and serious challenges can the feedback then become more concrete. Such handling gives students the security that they will not be left alone with their progress during the semester and run the risk of learning completely wrong content. In formats that are new to students and largely based on independent work, this sense of direction is essential.
- **Final discussion/ colloquium:** After completion of the portfolio work, a discussion about the learning and competence development during the semester is recommended. A presentation of the e-portfolios is suitable for this: this can take place in small groups or in the form of individual discussions. Students can receive feedback on their competence development and helpful advice. Teachers, on the other hand, can review the individual portfolios in detail and receive feedback on the (new) format.

## Implementation Students

### *Artefact selection*

For students, portfolio work begins with collecting and selecting artefacts.

"The conscious selection of relevant excerpts as artefacts for the ePortfolio represents a first reflection dimension". (Bräuer, 2016)

Such artefacts can be products such as videos, podcasts or photos, as well as executions that emerge in the learning process, such as reflections (Stratmann et al., 2009).

Artefacts should be assembled in the e-portfolio in a meaningful way so that they can be presented and disseminated. It is therefore necessary that the readers can recognise a structure in the digital collection. A common thread in the presentation can be mapped visually or, for example, through sequentially numbered headings of the artefacts. In addition, the creators of the e-portfolio have the possibility to justify connections in the reflection contributions and/or to use text/video/sound artefacts to explain their own structuring.

In higher education, it is mostly the teachers and fellow students who can view and comment on the digital collections (Stratmann et al., 2009). However, the creators of the portfolio can in principle decide which audience they want to make the portfolio available to, so it is necessary to gear the presentation of the e-portfolio to the audience and to question the extent to which

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one's own presentation is comprehensible to the viewers. For example, a non-specialist audience will find it more difficult to understand visual connections, so additional explanatory elements may be helpful.

### *Reflections*

An important didactic tool of the e-portfolio is the use of reflections. The personal character of the e-portfolio and a comprehensible connection between the accumulated artifacts can be made visible in the reflections (Jarvinen & Kohonen, 1995). In general, the reflections can be described as "reflective self-assessment" (Jarvinen & Kohonen, 1995), which means that there is a critical examination of one's own learning. The focus shifts from a teacher-centred format that imparts knowledge to be finally tested in an examination to a format that maps the students and their learning processes. A kind of paradigm shift is taking place, where students are no longer concerned with "satisfying" teachers, but with improving the quality of their own learning (Lawson & Thompson, 2012). This enables the exit from the role of passive recipients of knowledge (Strasser & Knecht, 2012). Instead, students must actively engage with information, question it and internalise it in the context of individual prior knowledge, different everyday experiences and personal objectives.

"Self-assessment is a process of formative assessment during which students reflect on and evaluate the quality of their work and their learning, judge the degree to which they reflect explicitly stated goals or criteria, identify strengths and weaknesses in their work, and revise accordingly" (Lawson & Thompson, 2012).

Since the portfolio aims at a formative assessment, such an assessment is associated with a constant review of the individual learning status and the adjustment of course planning based on intermediate results. Reflections are particularly suitable for such a review, as they require the students to honestly examine their learning progress; what has been learned must be placed in an overall context and critically considered. The students must question to what extent they are getting closer to their self-imposed learning goals and what difficulties may be holding them back from these goals. It can be helpful to give the students specific questions on which they can write their reflections. Uniform questions then make it easier for students to exchange ideas and give each other constructive feedback (Strasser & Knecht, 2012). Merminod associates three learning objectives with the reflection units: to identify competences, to formulate them and to communicate them (Merminod, 2012). In the first step, the reflections should encourage students to set their learning goals not in terms of knowledge acquisition, but to consider which competences they would like to acquire in the lecture/seminar/project (Merminod, 2012). In the second step, students formulate and explain these competences for themselves in their reflections (Merminod, 2012), so that they can understand for themselves what is involved in these competences and how they can achieve them. In the final step, students communicate the competences externally and present them to an audience (Merminod, 2012). This means that they have to make a connection between the multimedia artefacts and

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the reflective contributions in order to present to the outside world the extent to which the self-imposed goals and competences have been achieved.

Since the aim of the e-portfolio is to be able to optimally track the students' growth in competence throughout the semester, it makes sense to check the level of knowledge and existing competences at the beginning and end of the seminar/lecture/project. This can take place, for example, through questionnaires (Quellmelz & Ruschin, 2013) or the reflection contributions of the e-portfolio can be used. For this purpose, initial and final reflections can be introduced. The initial reflection should then link knowledge and competences already acquired from previous lectures, projects and seminars on related topics. This can show which aspects have been neglected in one's own learning so far, which goals have been set for the semester in question, where individual strengths and weaknesses can be found in the respective topic. Pre-prepared forms can be helpful here, which contain open questions that the students can respond to.

For example, the following questions can be used for an initial reflection independent of the topics of the course:

- Which focus do I choose for my portfolio? Why?
- What knowledge do I already have on the subject?
- How do I want to approach the portfolio strategically?
- At which points do I possibly need assistance?

Finally, a final reflection should evaluate one's own learning process, take up the most important findings of the course, formulate questions that are still open and provide an outlook on the further learning process.

The following questions can serve as a guide for the final reflection:

- What benefits do I generate for myself and for others through the portfolio?
- In what other context can the portfolio be helpful (e.g. work/other lectures/seminars/projects)?
- What strengths and weaknesses have I identified in myself?
- Which topics were not sufficiently considered in the lecture and/or the portfolio?

### Feedback

In the case of the XP2P project, two concepts, peer-to-peer learning and the e-portfolio, are to be combined. Both concepts aim at self-directed learning that offers students the possibility to set their own learning and competence goals according to the realities of their lives and to develop them further in cooperation with fellow students. Therefore, one purpose of the e-

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portfolio is to create an optimal tool for the peer-to-peer concept on the basis of which students can receive feedback.

Within the e-portfolio, three types of feedback can be implemented and used for the final overall assessment. This includes feedback from the creators of the portfolio: here, the creators evaluate themselves and their learning process in designated reflection posts. Furthermore, feedback from an authority, i.e. the teacher, and peer feedback are added (Sporer et al., 2009). The promotion of peer feedback is particularly interesting in connection with the peer-to-peer idea of the XP2P project. Here it is important to create incentives for students to evaluate each other, because on the one hand it is an additional workload and on the other hand it can be associated with an overcoming to express criticism of the work of others. There are several ways to create productive peer feedback related to the portfolio. One possibility would be to set up learning tandems (Sporer et al., 2009), in which students with different levels of knowledge help each other. This would result in the same constellations of people continuously assessing each other over the course of the e-portfolio. Another approach would be to promote students' intrinsic motivation by highlighting the benefits of such mutual assessments. Once students engage with each other's portfolios, with their creative and personal approaches to implementing the given assessment criteria and achieving the competences, they also come to better understand the assessment criteria and identify their own difficulties (Sporer et al., 2009). This requires a high level of persuasion by the teacher. Since such motivation is voluntary, even motivated students may neglect feedback in favour of time-consuming commitments in other seminars, projects and lectures. A third possibility is to make a certain number of peer feedback units compulsory for students and thus include constructive assessment as a competence goal. In this case, however, there is a risk that students do not write these assessments continuously throughout the semester, but "work off" this requirement at a time that is convenient for them.

Evidence is not necessarily provided by obedient acceptance of the feedback; instead, a conclusive justification for non-acceptance can also be provided. The prerequisite for this is a demonstration of engagement with the criticism and a comprehensible justification for a different approach to that suggested by the teaching staff or fellow students. In this way, the students' personal development can be advanced, since the feeling of being subordinate to the teachers is not conveyed, but the impression of being entitled to vote is strengthened. This then also promotes the learners' self-confidence.

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## Post-processing

The following chapter explains the necessary steps that have been highlighted by the writers for the follow-up of the e-portfolio method in Table 2.

### *Assessment of the e-portfolio*

Finally, an e-portfolio can also be assessed similarly to an exam (Stratmann et al., 2009). The assessment must clearly refer to the assessment scheme that was presented at the beginning of the course. The individual learning progress of the students should be honoured without putting them in direct comparison to the other students.

Independent of the subject-related assessment criteria, the following aspects can be assessed in an e-portfolio: Appropriate scope, completeness, comprehensible and systematic structure, sound and factual accuracy, content and coherence (red thread, individual parts form a whole), originality, authentic and constructive reflection sections, formal criteria (artefacts have appropriate titling and source references, bibliography, uniform font type and size, chosen layout, etc.), linguistic formulations (grammar, spelling).

### *Back-ups of all e-portfolios*

If the e-portfolio is used as an examination method, it is also necessary to observe the applicable legal requirements for examination documents. If a legal minimum retention requirement applies, appropriate back-ups of all e-portfolios must be created and kept.

In addition, it can be helpful for future students to be able to view "best practice" examples of previous courses. In this case, written permission for presentation purposes must be obtained from the respective portfolio creators.

### *Evaluation of the portfolio method*

The following questions can help to evaluate the success of the portfolio method:

- Did the e-portfolio help in achieving the goals you set yourself?
- What was good/ bad?
- Do I want to use the portfolio again as a method? Why? Why not?
- What should be done differently/ better?
- Does the target group fit the method?

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## Analysis

In order to evaluate the e-portfolio as a development and testing tool, the concept of SWOT analysis (*Strengths/ Weaknesses/ Opportunities/ Threats*) is used in the following chapter. In this context, the SWOT analysis enables the evaluation of a current status and also offers the elaboration of future options for action (Wollny & Paul, 2015).

The aim of this analysis is a holistic examination of the portfolio concept that includes both teacher and student perspectives. For better visual comprehensibility, the two central perspectives are distinguished by coloured markings: **development** and **assessment tool**; aspects that are included beyond this but cannot be **assigned to any category** are also shown. The table is followed by a discussion of the content of the individual evaluation points.

Table 5: SWOT analysis on the e-portfolio

<p><b>(Internal) strengths</b></p> <ul style="list-style-type: none"> <li>• Individual, authentic test instrument</li> <li>• Sustainable learning tool: "competent students".</li> <li>• Implementation of a feedback culture that promotes (learning)</li> <li>• Promotion of technological skills</li> <li>• Promotion of reflexive skills</li> <li>• Promoting structuring</li> <li>• Stimulation of creative processes</li> <li>• Linking to digital realities of life</li> <li>• Implementation of new technologies</li> </ul>	<p><b>(Internal) weaknesses</b></p> <ul style="list-style-type: none"> <li>• High time expenditure</li> <li>• Subjective test instrument</li> <li>• Challenges for students</li> <li>• Lack of special skills of the teachers</li> <li>• Dependence on digital platforms</li> <li>• Costs</li> </ul>
<p><b>(External) opportunities</b></p> <ul style="list-style-type: none"> <li>• Stronger competence orientation (Bologna)</li> <li>• New requirements for students</li> <li>• Promoting lifelong learning</li> <li>• Enable individualised educational content</li> </ul>	<p><b>(External) risks</b></p> <ul style="list-style-type: none"> <li>• Legal requirements: Freedom of content vs. equal opportunities</li> <li>• Access/ availability of the e-portfolios</li> </ul>

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## (Internal) strengths

### *Individual, authentic test instrument*

From both a teacher and learner perspective, a key strength of the portfolio is its function as an individually focused and authentic assessment tool (Reese & Levy, 2009/ Bhattacharya & Hartnett, 2007). Instead of focusing on knowledge queries, as is the case with traditional examinations, the assessment of the e-portfolio is designed around the students and their different learning developments.

The open design of the portfolio requires teachers to set complex tasks that demand transfer performances from students and are aimed at their competence expansion (Reese & Levy, 2009). Students are given the opportunity to set their own goals within the e-portfolio and thus give the e-portfolio an individual character.

Through the interplay of complex problem solving, collaborative learning and reflective practice, teachers gain a holistic picture of student development. This gives them the opportunity to authentically assess students and their progress.

### *Sustainable learning tool: "competent" students*

The e-portfolio is a particularly sustainable learning tool due to its open form. Topics of the respective courses are discovered from a personal perspective and thus activate the learners' intrinsic motivation (Chau & Cheng, 2010). Instead of passively receiving knowledge, students actively take responsibility for their own learning and control of their own learning processes (Bräuer, 2016). This promotes a positive attitude towards learning, as students can consciously experience and appreciate their role in it (Chau & Cheng, 2010).

### *Implementation of a feedback culture that promotes (learning)*

The e-portfolio, as used in the XP2P project, requires teachers to change roles: they are supposed to continuously accompany students in their learning processes and give them feedback on their progress. Instead of taking on the classic teaching role, they become learning companions, tutors who provide new impulses through regular feedback (Chau & Cheng, 2010/ Buhl et al., 2019/ Hornung-Prähauser et al., 2007). This changed perception of teachers promotes equal communication with students, which is detached from the established hierarchical relationships in university teaching. Feedback is implemented as an integral part of teaching (Dossier Unididaktik, 2006), students experience an appreciation of their own points of view and dare to act outside their own comfort zone and to think innovatively. This can lead to the development of a feedback culture that makes students more self-confident and improves teaching through authentic feedback.

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### *Promotion of technological skills*

The efficient familiarisation with new platforms and programmes is of great importance in the current times. Students (especially engineering students) need to be able to familiarise themselves quickly with new digital formats in order to be able to use them optimally for their work and communication. Experimental formats, such as the e-portfolio, present students with new challenges, but they are in a "safe" environment where they can receive support with their problems. This gives them the opportunity to practice their own technological adaptability and prepares them for real-life challenges in the workplace (Lorenzo & Ittelson, 2005; Chau & Cheng, 2010).

In addition, through the digital portfolio, students have a record of their multimedia skills that they can use as a presentation to potential employers even after they have finished their studies (Lorenzo & Ittelson, 2005).

However, the strengthening of technological skills cannot only be related to the students themselves. Teachers also benefit from familiarising themselves with new programmes and using them.

### *Promotion of reflexive skills (self-reflection, reflexive writing)*

The personal character of the e-portfolio and a comprehensible connection between the accumulated artifacts can be made visible in the reflections (Jarvinen & Kohonen, 1995). Within the reflections, a critical examination of one's own learning takes place (Jarvinen & Kohonen, 1995). The focus shifts from a teacher-centred format that imparts knowledge to be finally tested in an examination to a format that maps the students and their learning processes. A kind of paradigm shift is taking place, where students are no longer concerned with "satisfying" teachers, but with improving the quality of their own learning (Lawson & Thompson, 2012). This enables the exit from the role of passive recipients of knowledge (Strasser & Knecht, 2012). Instead, students must actively engage with information, question it and internalise it in the context of individual prior knowledge, different everyday experiences and personal objectives.

### *Promoting structuring*

The e-portfolio is a very open and freely designable format. Even though students are given learning and competence objectives at the beginning of the lecture/seminar/project, they are largely free in their learning paths and in the design of the e-portfolio. Students must set the focus of their portfolio themselves; they must carry out the design of the portfolio according to their own considerations and must consciously select relevant artefacts for their academic achievements (Bräuer, 2016). In addition, the e-portfolio must be formulated in a way that is appropriate for the target group. All this demands a high degree of self-organisation and self-structuring from the students.

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### *Stimulation of creative processes/introduction to creative processes*

"Filling your web portfolio is a creative process that reflects the author's personality, their ability to systematise information, present it clearly and authentically. " (Panyukova, 2019)

### *Linking to digital realities of life*

The e-portfolio ties in with the digital realities of students' lives. Younger generations grow up with a variety of media and for them it is normal to be able to access information and knowledge anytime and anywhere (McWhorter et al., 2013; Bräuer, 2016). This normality also includes sharing experiences and ideas in social networks (Reese & Levy, 2009; Schmidt et al., 2009). It is therefore only logical that higher education also includes formats that tie in with this very normality.

E-portfolios can be accessed and edited by students at any time via laptops, computers, tablets or mobile phones. This gives them the opportunity to upload ideas and solutions spontaneously, to incorporate multimedia formats into their presentations and to communicate asynchronously with fellow students and teachers. This links the worlds of experience inside and outside the university, which increases accessibility to the e-portfolio and its acceptance among students.

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(External) opportunities

### *Stronger competence orientation (Bologna)*

The Bologna reforms require higher education to focus studies and teaching more on the acquisition of competences (Stratmann et al., 2009). However, everyday university life often continues to be oriented towards standardised knowledge assessments whose grades do not allow conclusions to be drawn about the transfer of learning and the competences actually acquired by students (Stratmann et al., 2009).

The character of the e-portfolio requires the processing of open and complex questions and tasks, which are processed over the course of a semester/project. Within the continuous self-reflections, students must be able to look at the problems from a personal perspective and apply the theoretical foundations for this.

The change from "input orientation to outcome orientation in teaching" (Salzburg Research Forschungsgesellschaft, 2007) can thus be advanced through the use of e-portfolios: instead of only checking selectively to what extent knowledge content has been absorbed (Reich, 2017), the entire learning process is tracked and commented on up to the achievement of objectives. In this way, individual performance can be rewarded without assessing it in direct comparison with other students (Panyukova, 2019).

### *New demands on students due to new technologies, globalisation and an ever-changing labour market*

The constant development of new technologies and globalisation have a significant impact on the labour market. Students who learn only to reproduce knowledge risk preparing for jobs that disappear from the labour market (OECD, 2006). Instead, they are expected to be able to solve multi-faceted tasks and problems for which there are no clearly defined approaches (McWhorter et al., 2013). They must be able to communicate complex scientific ideas clearly and convincingly (McWhorter et al., 2013). Universities and colleges face the challenge of creating a curriculum that prepares students for such obstacles in the labour market. They do not have to prepare students for concrete work situations, but instead they have to develop competences that enable students to apply theoretical principles in such a way that they can solve complex practical problems (Salzburg Research Forschungsgesellschaft, 2007).

E-portfolios can play a supporting role in this. The collected artefacts within a portfolio demonstrate a concrete acquisition of competences using the example of specific problems. In reflection articles, students must analyse their learning process and be able to communicate and argue in a scientifically correct manner. The e-portfolio can thus be used as evidence of acquired competences, making important work-relevant skills visible (McWhorter et al., 2013).

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### *Promoting lifelong learning*

The concept of lifelong learning assumes that learning is "a biographical project" (Arnold et al., 2000). This means that, contrary to common perception, learning does not only take place at certain times and in certain learning situations, but inevitably accompanies people throughout their biography.

From the point of view of the writers, the e-portfolio has the potential to implement this concept in a promising way. In order for adults to successfully target and manage lifelong learning processes, they are dependent on "learning spaces" that provide them with flexible access to learning. This means being able to learn productively regardless of time, place, financial means and according to their own needs. The e-portfolio offers this possibility through its flexible and adaptable character. In addition, those who create an e-portfolio must regularly question their own learning by means of reflection tasks and can thus optimise their learning processes in the long term. The portfolio is rounded off by its continuous support from teachers and other learners, who provide feedback on content and set impulses.

### *Enable individualised educational content*

Constructivist learning theory assumes that knowledge is not simply transferred to learners, but is constructed by learners in an active process. Accordingly, knowledge acquisition is individual and dependent on each learner's respective view of reality (Reich, 2017).

Through the e-portfolio, the different learning processes and the different conceptions of reality can be made visible (Reich, 2017). The creation of a portfolio is a creative process that reflects the personalities and abilities of each author (Panyukova, 2019).

Teachers benefit from dealing with the individual approaches, can better understand different learning processes with the students in an active exchange on the portfolios and thus design their own teaching more effectively (Salzburg Research Forschungsgesellschaft, 2007). By focusing on student learning, individualised educational content can be made possible.

The European Union is also oriented towards this concept and demands that all European people be given the opportunity to adapt to social and economic changes (Memorandum on Lifelong Learning, 2000), without, however, being able to name concrete implementations of the concept.

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### (Internal) weaknesses

#### *High time expenditure*

Even though the e-portfolio is not a novelty as a testing and learning tool, it has not been used equally in all fields of study so far. According to current research, the concept is little established in engineering in particular. This results in a high time commitment for those who want to implement this concept in their fields. They have to turn away from already established methods and take (unknown) risks. New or little researched methods require extensive training and a high level of personal effort.

In addition, the e-portfolio as an assessment tool requires a change in the previous assessment scheme: The focus here is on the learning development of the students and must therefore include the overall performance of the students throughout the semester. For transparency, this must already be completed at the beginning of the semester and made accessible to the students.

As this is often a formative assessment tool, a certain flexibility is required: based on the performance and development of the students, the possibility must remain to make adjustments to the assessment scheme. Teachers are therefore expected to continuously accompany students individually, give feedback and adapt the teaching concept and the assessment scheme based on these individual insights.

Finally, the teachers must then assess the e-portfolio in such a way that the individual learning development of the entire semester is included in the grade.

#### *Lack of special skills of the teachers:*

Knowledge examinations are already established; new methods, on the other hand, require training time and willingness on the part of the teachers.

The e-portfolio demands various special skills from teachers that other assessment methods do not require: Teachers must have the appropriate digital skills. Before introducing students to an e-portfolio, they must themselves be able to operate the platform(s) through which the e-portfolios are created and act as a point of contact for that very platform(s). Even if universities usually have technical staff managing digital platforms, both technical and didactic aspects must be equally known when using the e-portfolio; a complete separation of these areas is not possible in a digital assessment tool.

In this case, however, digital competences do not only include the use of the platform, but also expect corresponding digital communication skills from the teachers. They must be willing to communicate asynchronously with students and leave them pointed and constructive feedback in the comment columns of the e-portfolios. While such a communication method is linked to the realities of students' lives, this is not equally true for teachers. Especially for older generations, this can become a challenge.

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Teachers also need to completely rethink their role in portfolio work. Instead of maintaining the role of teacher, they have to become tutors, learning guides. Changing their own role requires didactic knowledge on the one hand and on the other hand also the ability to hold back and hand over the creative role of the course to the students. Such modifications of the previous way of working must first be learned by teachers and may not be equally feasible for every teacher.

### *Challenges for students*

One problem with the e-portfolio is the time required to create it, which is also the main hurdle in getting students interested in this instrument. Even if they can recognise and appreciate the advantages of the e-portfolio - be it the individual learning support, the focus on competence development or the portfolio as proof of one's own achievements - the time required will always have an influence on the students' decision to choose a module/project. The portfolio then competes with established examinations: Because even though these may not be as sustainable as the e-portfolio, this is not comprehensible to outsiders (i.e. potential supervisors, for example) on the basis of the grades in the degree. Therefore, when choosing their modules/projects, students have to weigh up personal development against the time required. If, for example, students also have to finance their studies themselves through part-time jobs, it may not be possible to make a "free" decision here.

### *Dependence on digital platforms*

One weakness of the e-portfolio, in contrast to established examinations such as written examinations or term papers, is the associated dependence on digital platforms.

On the one hand, new platforms have to be created and on the other hand, there is the need to maintain these platforms. Since it is often not possible to fall back on existing staff, the appropriate personnel must be available.

Courses that use the e-portfolio as a learning and assessment tool continuously through the semester (or beyond) depend on the technologies being appropriately functional and secure at all times. In the event of platform malfunctions, delays in portfolio work occur and participants rely on responsible staff to quickly provide solutions to existing problems.

### *Costs*

The establishment of the e-portfolio is also a cost issue. Thus, the acquisition and maintenance of e-portfolio platforms cause new costs. Maintenance, in particular, requires additional costs throughout, as technical staff must be permanently available.

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Furthermore, it should be considered that possibly didactic staff should be employed for implementation and monitoring. Especially at the beginning of the introduction of a new concept, expertise is important. This can consist of training teachers on the e-portfolio (be it didactically or technologically), but also training students on the concept can be helpful. Especially when teachers are not yet fully familiar with the e-portfolio method and still want to provide students with optimal access to the e-portfolio.

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## (External) risks

### *Legal requirements: Freedom of content vs. equal opportunities*

General principles of equality apply in the context of examination procedures. Thus, higher education institutions must establish identical examination conditions and evaluate examination performance according to comparable assessment principles: both aspects entail risks in the case of the e-portfolio.

Identical examination conditions include, for example, that comparable technical equipment is available to all students, disadvantage due to poorer working conditions and serious disruptions can be ruled out, and opportunities for attempted cheating must also be eliminated.

When using the e-portfolio as a learning and examination tool, these comparable working conditions are difficult to understand, since the advantages here lie precisely in the open working environment and the possibility of asynchronous and location-independent learning. Students whose technical devices are not suitable for optimal work (if such devices are available at all) must be able to fall back on computers in the university facilities. However, this means that the advantages of location-independent and thus self-determined learning and working are not available on an equal footing with other students.

In addition, attempts at cheating within an e-portfolio (the same applies to other examination formats such as assignments) are difficult to detect; whether and to what extent the presented achievements were worked out independently is difficult to recognise in retrospect. This risk can be prevented by teachers communicating continuously with students synchronously and asynchronously about the portfolios, by formulating assignments in such a way that an individual character can become clear, and also by additional interim and final presentations of the e-portfolios or colloquia on these.

Finally, the assessment principles must also be comparable. As mentioned at several points in this paper, the e-portfolio is characterised by its subjective nature, as it incorporates the individual learning progress of the students. When reviewing e-portfolios, teachers have to meet the challenge of translating these subjective aspects into objective assessment principles. If this challenge cannot be met in certain environments, the e-portfolio should preferably be used as a learning tool without final assessment.

### *Access/ Permanent availability*

From a higher education perspective, the following basic idea of the e-portfolio carries a risk:

"The creator of the e-portfolio is its owner, sharing content out of intrinsic motivation to improve learning."

E-portfolio platforms are designed in such a way that they allow the portfolio creators as much self-determination as possible. This applies to the design of the portfolio on the one hand, but also to the visibility of the presentations on the other. This means that students are given the

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opportunity to share portfolios with target groups (e.g. teachers, students or potential employers) and to withdraw their access if necessary. This becomes a problem when a minimum legal retention period applies to an examination performance. Therefore, in consultation with the students, precautions must be taken to ensure this retention requirement. This can be made possible, for example, through exports of the e-portfolios or back-ups of the platform(s). In any case, this goal of retention must be communicated to the students at an early stage, as otherwise there is a risk that portfolios or individual elements/areas of the e-portfolios will be deleted or modified and the higher education institution or the respective teacher will thereby make themselves legally vulnerable.

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## What conclusions can be drawn from the SWOT analysis?

The previous SWOT analysis of the e-portfolio looked at the e-portfolio primarily from two different perspectives: Firstly, as an assessment method (here the focus is on the teacher perspective) and secondly, as a learning tool (here the focus is on the learner perspective). For this reason, the résumé from the two different perspectives is described below.

### *The e-portfolio as an examination method*

The opportunities and strengths of the e-portfolio as an assessment tool can be summarised as a shift from "input orientation to outcome orientation in teaching" (Salzburg Research Forschungsgesellschaft, 2007). This means that teachers turn their focus away from pure knowledge transfer and look at the individual learning and competence development of students without evaluating and comparing them as a group. Since students have to perform transfers within their e-portfolios, teachers get a holistic picture of student performance and are thus able to assess students more authentically.

The risks and weaknesses of the e-portfolio in this assessment method result largely from the lack of establishment of the e-portfolio to date and the associated uncertainties. Be it in terms of the time required, the lack of specialised skills on the part of the teachers or the legal risks that the portfolio can harbour. Although these risks and weaknesses must be considered and analysed before using the e-portfolio, they can be significantly mitigated through experience in its use.

The motivation of the teachers is therefore crucial for the successful use of the e-portfolio as an examination performance: Initially, they have to invest a lot of work and time in designing and establishing the method. However, if they are willing to do so, they have the potential to optimise student learning in the long term and also to improve their own teaching, as they can develop a better understanding of the learning development of their own students.

### *The e-portfolio as a learning tool*

The SWOT analysis of the e-portfolio as a learning tool shows that, from a student's point of view, it is primarily caught between personal benefit and time investment. The opportunities and strengths are manifold: e-portfolios enable students to achieve sustainable learning successes, grant them individual support and assessment, promote a wealth of important soft skills, especially so-called future skills<sup>1</sup>, and tie in with the digital realities of students' lives. This offers clear advantages and opportunities for the students' professional future. This is countered in particular by the time expenditure associated with the creation of the e-portfolio,

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<sup>1</sup> <https://nextskills.org/future-skills-finder/>



without the time-consuming work behind it becoming clear. Therefore, it is above all the intrinsic motivation that determines whether the e-portfolio is used profitably.

It is important to mention, however, that the lack of special skills (e.g. digital skills) of teachers can have a negative impact on the portfolio work as a whole. If teachers are not able to motivate students and/or cannot credibly integrate the portfolio into the seminar/lecture/project, then it cannot have the positive effects described above.

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## Competence-oriented teaching

### Theory

The concept of competence has already been mentioned several times in the previous chapters without specifying it in more detail for higher education teaching. Schaper defines "academic competence" as the ability to deal constructively with complex, novel and demanding tasks (Schaper et al., 2012). In the academic context, these abilities include the following elements: scientific concepts, analyses, reflections, innovative concepts and problem-solving skills, communication of scientific knowledge accumulations (Schaper et al., 2012), as well as

"Self-regulation and reflection of one's own problem-solving and cognition-guided actions" (Schaper et al., 2012).

Competences should be learner-centred, as they cannot be transferred but have to be developed by the respective learners themselves (Hericks & Rieckmann, 2018). Therefore, it is necessary that the respective learning objectives are communicated transparently to students and that they are involved in the design of the learning processes (Schaper et al., 2012).

A focus on the application relevance of competences is of central importance (Hericks & Rieckmann, 2018). Through the acquisition of competences, students must be enabled to find their way in open and challenging (both private and professional) work areas (Schaper et al., 2012/ Hericks & Rieckmann, 2018), in which they use professional knowledge for their own ability to act (Frank & Iller, 2013). Knowledge is thus a necessary prerequisite for competence development (Weyer et al., 2017); competences, on the other hand, are necessary prerequisites for successfully coping with complex requirements in a self-organised manner (Frank & Iller, 2013/ Rhein, 2010).

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## Method

### How can necessary competences be identified?

"The process of competence-oriented degree programme development begins with an understanding of the educational goals of the degree programmes by reconstructing science as an object of learning and education." (Rhein, 2010)

In order to implement competence-oriented teaching and to identify the corresponding competences for a course or a degree programme, it is first necessary to clearly and comprehensibly disclose the learning objectives of the course(s) (Schaper et al., 2012). It is advisable to involve students in the development process right from the start and to let them become active participants in their own learning process (Schaper et al., 2012).

Various considerations can be included in the identification of competences:

- Aimed competences must enable a "combination of (subject-related) knowledge and (subject-related) ability to act" (Frank & Iller, 2013).
- Students must be encouraged to actively engage with the topic themselves (Weyer et al., 2017/ Schaper et al. 2012).
- Possible future areas of application (Weyer et al., 2017), of the competences to be acquired should be highlighted in advance.
- New competences should build on existing competences (Frank & Iller, 2013) and on existing knowledge.

#### Identify necessary competences

Our new students usually bring little awareness of competence orientation with them. They have been educated too much in the acquisition of knowledge in everyday school life. When changing to a university, it is therefore a good idea to promote a stronger attitude towards competence orientation among the students. It is important that the transition from school to university is used in the lectures of the first weeks of the first semester to bring about this change. When accrediting the study programme, special attention must be paid to ensuring that teaching and examination forms are actually oriented towards competence orientation, as otherwise the existing learning patterns, which are oriented towards the acquisition of knowledge, will become perpetuated.

Introducing students to a competence orientation includes the knowledge that competences require new (subject) knowledge that is to be developed through practical applications in different contexts.

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While the subject-specific competence goals are already defined in detail in the module descriptions, reflections offer the opportunity to define and pursue the non-subject-specific competence goals independently and individually. In the semesters completed in the XP2P project, students mentioned self and time management as examples in their self-reflections, as well as cooperation skills, conflict management, technical drawing, presentation skills and specific skills in the area of 3D-printing, which had not been the focus of the curriculum until then. In consultation with the teachers, the individual students then set corresponding goals, the pursuit of which was recorded individually in the e-portfolio. The corresponding teacher feedback at the end of the semester reinforced the students' view that a university is a place for competence development that can take individual strengths and goals into account.

### How can competences be "taught" in a sustainable way?

The title of this chapter is deliberately placed in inverted commas because, unlike knowledge, competences cannot be taught and transferred, but must be actively acquired by students based on the knowledge they have learned. In this context, teachers can only adapt their teaching to the extent that students are supported in acquiring competences. The following text explains what needs to be taken into account.

For teachers, competence-oriented teaching often means adapting their way of working. Therefore, they must be willing to deal intensively with this view of teaching and learning and, if necessary, acquire the necessary qualifications for this (Schaper et al., 2012/ Weyer et al., 2017). This profound change in the teaching-learning culture, which began many years ago through the study reform in the course of the Bologna process, is still ongoing. In order to consistently implement this so-called "shift from teaching to learning", it is necessary to rethink and redesign studies and teaching from the perspective of student learning (Wildt 2006).

To this end, it is advisable to implement exchange opportunities for teachers among themselves, but also teachers and students, so that teachers can be accompanied in a competence-oriented manner, experiences with competence-oriented teaching can be discussed and the methodology can be continuously improved (Schaper et al., 2012/ Weyer et al., 2017).

Competency-based teaching must always be oriented towards the learning outcome, which combines knowledge and application (Frank & Iller, 2013).

This type of teaching must therefore be geared towards the learners and their path to achieving the learning outcomes of the course. On the one hand, this can mean that students are involved in the concrete design of the course, but also that learning processes and learning outcomes are adapted to the individual needs of the students (Frank & Iller, 2013). Accordingly, it is necessary to

"To design learning situations in such a way that existing competences can be linked to and plans for individual further development can be developed". (Frank & Iller, 2013)

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Since competence-oriented teaching places high demands on students and their learning competences, comprehensive supervision and support of learners is necessary for the success of the concept (Schaper et al., 2012). Formats that continuously accompany students throughout the semester are suitable for this; an example of this is the e-portfolio.

The tasks embedded in such a teaching format should contain concrete application references and relate to the competences formulated for the corresponding course in the curriculum (Schaper et al., 2012). The tasks must be formulated in such a way that they promote active engagement with the learning content (Schaper et al., 2012) and relate to future areas of application that are as realistic as possible (Weyer et al., 2017). In terms of constructive teaching theory, the teacher remains in the background as much as possible in this format, accompanying the students in their work and providing support to the learners in the form of feedback (Schaper et al., 2012/ Weyer et al., 2017). Instead, students must be encouraged to engage with the learning objects independently and thus advance the acquisition of competences (Weyer et al., 2017).

In the module "Lightweight Design", mechanical engineering students of the 5th semester are asked to determine the deflection of a specific aircraft fuselage in the exercise "Reasoned Estimation of Deformations". The solution involves independently collecting information about this aircraft on the Internet (take-off weight, empty weight, dimensions as well as the position and individual weights of heavy individual components such as landing gear and engines). After a self-determined check of the position and weight distribution of the most important components, an estimate of the deflection is calculated, taking into account assumptions from technical mechanics and materials science. The solution paths of the individual groups are documented, distributed and discussed together. Students initially think the task is unsolvable, but in the end are often amazed at how similar the groups' answers are. The feedback from the students indicates an intensive experience of competence. This strengthens their self-confidence and helps them not to be deterred by "unsolvable" tasks, but to consistently and purposefully apply what they have learned so far.

A non-subject-specific example can be the student mention of conflict competence as a learning objective in the initial reflection. In many module descriptions, the development of non-subject-specific competences is mentioned as a module objective, without going into more detail on how the objective is to be achieved or evaluated. In this case, the e-portfolio provides a concrete entry point into competence development. In one concrete case, it was individually agreed to identify and describe potential conflict situations in teamwork, to develop possible procedural strategies and to subsequently reflect on the result. The support provided by the teacher (as an engineer with life experience, but without specific qualifications for dealing with conflict situations) mainly consists of supporting the student interest in

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the topic, promoting the students' self-competence and increasing the commitment of the procedure by having a (planned/expected) exchange on the topic at the end of the semester.

### How can competences be presented?

From the student's point of view, the question arises within a course how the acquisition of competences can be credibly presented: both to the teacher and in future work situations.

There are various possibilities for presenting the development of competences within courses. These include the continuous and regular writing of self-reflections (e.g. in e-portfolios or as written submissions). This gives students the opportunity to examine and analyse their own competence acquisition from their individual perspective. They can constantly document their further development and compare it to their initial status. In doing so, they can bring in corresponding evidence for the acquisition of competences.

For the teachers, this has the advantage of giving them a deep insight into the students' learning. They can track whether the competences were actually acquired, how they were acquired and what difficulties arose or may still exist.

The writing of self-reflections should be supported by assessment grids that enable standardised self-assessment. This means that students should be given a scheme of competences to be achieved, which includes explanations of the respective competences and their different gradations. This allows students to focus on relevant competences in their self-reflections without having to spend time looking for or defining suitable competences for themselves. Instead, they gain an insight into the expectations of the teachers and can orient themselves to concrete contents.

For teachers, this provides a good overview of competence development: on the one hand, a standardised assessment of the students and, on the other hand, an explanation of this assessment. Through this multidimensional insight, the teacher can then check whether the self-assessment corresponds to reality and can give the students accurate feedback on their (previous) competence development.

#### Reflections:

In general, reflective contributions can be described as "reflective self-assessment" (Jarvinen & Kohonen, 1995), i.e. a critical examination of one's own learning takes place. The focus shifts from a teacher-centred format that imparts knowledge to be finally tested in an examination to a format that maps the students and their learning processes. A kind of paradigm shift is taking place, where students are no longer concerned with "satisfying" teachers, but with improving the quality of their own learning (Lawson & Thompson, 2012). This enables the exit from the role of passive recipients of knowledge (Strasser & Knecht, 2012). Instead, students must actively engage with information, question it and internalise it

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in the context of individual prior knowledge, different everyday experiences and personal objectives.

"Self-assessment is a process of formative assessment during which students reflect on and evaluate the quality of their work and their learning, judge the degree to which they reflect explicitly stated goals or criteria, identify strengths and weaknesses in their work, and revise accordingly" (Lawson & Thompson, 2012).

The students must question to what extent they are getting closer to their self-imposed learning goals and what difficulties may be holding them back from these goals. It can be helpful to give the students specific questions on which they can write their reflections. Uniform questions then make it easier for students to exchange ideas and give each other constructive feedback (Strasser & Knecht, 2012). Merminod associates three learning objectives with the reflection units: identifying competences, formulating them and communicating them (Merminod, 2012).

Another way of tracking and promoting students' competence acquisition at the same time is peer feedback. Students can evaluate each other's work and give each other feedback on their competence acquisition. In the course of this, they enter into discussions about definitions of competences and about the extent to which competences already acquired have been or can be demonstrated. In formulating feedback and dealing with feedback received, students also acquire social skills.

#### Peer feedback:

There are several ways to create productive peer feedback. One possibility would be to set up learning tandems (Sporer et al., 2009), in which students with different levels of knowledge help each other. This would result in the same constellations of people continuously assessing each other over the course of the semester. Another approach would be to promote students' intrinsic motivation by highlighting the benefits of such mutual assessment. Once students engage with each other's work and ideas, their creative and personal approaches to implementing the given assessment criteria and achieving the competences, they also come to understand the assessment criteria better and identify their own difficulties (Sporer et al., 2009). This requires a high level of persuasion by the teacher. Since such motivation is voluntary, even motivated students may neglect feedback in favour of time-consuming commitments in other seminars, projects and lectures. Evidence is not necessarily provided by obedient acceptance of feedback; instead, a conclusive justification for non-acceptance can also be provided. The prerequisite for this is a demonstration of engagement with the criticism and a comprehensible justification for a different approach to

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that suggested by the teachers or fellow students. In this way, the students' personal development can be advanced, since the feeling of being subordinate to the teachers is not conveyed, but the impression of being entitled to vote is strengthened. This then also promotes the learners' self-confidence.

At the end of the course, it is recommended to hold a colloquium. Here the students can present their personal competence development. In this way, they can once again defend the previous self-reflections and additionally draw a final summary of the competence development. The teachers can enter into an exchange with the students about their competence development. Based on the students' self-assessments, the teachers can then also ask targeted questions to get the students to transfer their knowledge and to check whether the written explanations correspond to reality. Unlike in (oral) examinations, the focus here is explicitly not on acquired knowledge, but on competences and, if applicable, the application of these competences.

#### Final interview/ colloquium:

At the end of the course, a discussion about the learning and competence development during the semester is recommended. A presentation of the overall results (e.g. by means of an e-portfolio or a project work) is suitable for this. This can take place in small groups or in the form of individual discussions. Students can receive feedback on their competence development and helpful advice for the future. Teachers, on the other hand, can review individual developments and term papers in detail and at the same time receive feedback on the new teaching format.

### How can competences be assessed?

Examinations have a considerable influence on students' learning processes. They orient learning primarily towards passing examinations and the accompanying feedback (Schaper et al., 2012). In the sense of constructive alignment, it is important in competence-oriented teaching that examination forms are aligned in such a way that they "correspond to the contents and requirement levels of the learning outcomes" (Schaper et al., 2012). Examination tasks should be formulated in such a way that the focus is not on the reproduction of knowledge content, but rather on transfer tasks and critical discussions (Brendel et al., 2019).

Suitable assessment methods for competence-oriented teaching are the following:

- A multidimensional assessment: several types of assessments are proposed to learners to test their competences:

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- Formative self-assessment through the creation of an e-portfolio
- Self-corrected formative assessments (quizzes) that allow learners to see their progress and adjust their goals as needed
- Formative assessments validated and corrected by a teacher (different exercises, worksheets, homework, in-class written exams, oral exams, documentation research, wikis, forums...)
- Diagnostic and formative assessment by peers and teachers: in the form of oral exchanges, comments, notes validated by teachers. This can only be formative as it is not possible to ask one student to evaluate another.
- Summative assessment through report writing, oral presentations and supervised tasks.

Peer assessment is very enriching for learners. It allows them to step back from their own practice, which encourages reflective analysis. The relevance of the feedback given to other students is also one of the criteria for assessing the module.

During their student project work, the interim feedback of the teachers allows the students to refocus and/or enrich their work in order to better achieve the goals reflected in the final project.

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## Analysis

In the following chapter, the concept of SWOT analysis (Strengths/ Weaknesses/ Opportunities/ Threats) is used to evaluate competence orientation in teaching. In this context, the SWOT analysis enables the evaluation of a current status and also offers the elaboration of future options for action (Wollny & Paul, 2015). The aim of this analysis is a holistic examination of competence-oriented teaching that includes both teacher and student perspectives. Following on from the table, the content of the individual evaluation points is then discussed.

Table 6: SWOT analysis for competence-oriented teaching

<b>(Internal) strengths</b>	<b>(Internal) weaknesses</b>
<ul style="list-style-type: none"> <li>• Sustainable teaching method</li> <li>• Learner-centred format</li> <li>• Promotion of independence/ autonomy</li> <li>• Practical orientation/ application reference</li> <li>• Promotion of self-reflection</li> <li>• When acquiring subject-specific competences, interdisciplinary competences can also be acquired</li> </ul>	<ul style="list-style-type: none"> <li>• (So far) Lack of experience(s) of teachers and staff to apply the method in an optimal way</li> <li>• Acquisition of competences requires knowledge: without sustainable knowledge transfer, competences cannot be acquired</li> <li>• Competences cannot be transferred: intrinsic motivation of students must be emphasised</li> <li>• More time required</li> </ul>
<b>(External) opportunities</b>	<b>(External) risks</b>
<ul style="list-style-type: none"> <li>• New requirements for students</li> <li>• Promoting lifelong learning</li> <li>• Stronger competence orientation prescribed by Bologna</li> <li>• Enable individualised educational content</li> </ul>	<ul style="list-style-type: none"> <li>• Subjectivity: no uniform definition/ no uniform (cross-institutional) understanding of competences</li> <li>• Structures and learning spaces must be created in which students can acquire competences in a self-directed manner</li> </ul>

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## (Internal) strengths

### *Sustainable teaching method*

Competency-based teaching is a particularly sustainable teaching/learning method due to the independent way of working. Students have to develop the topics of the respective course from a personal perspective, since competences, unlike knowledge, cannot be transferred from teachers to students (Hericks & Rieckmann, 2018). The autonomy that students are given can promote a positive attitude towards learning, which in turn increases the intrinsic motivation of the students to participate in the course and the development of the content.

Furthermore, teaching that is geared towards competences must enable students to find their way later in the professional environment and enable them to work on complex tasks (Schaper et al., 2012). For the students, this makes the meaningfulness of higher education clear: instead of learning for a degree, they learn in this structure for a concrete goal: the ability to act in the later professional field. The concrete objective promotes the sustainability of the teaching method and encourages students to engage more deeply with the subject matter of the course.

### *Learner-centred format*

Competency-based teaching is oriented towards the learners in a special way. On the one hand, competence-oriented teaching must be arranged in such a way that the students take centre stage in the design of the course. This means that instead of the course being primarily geared towards imparting certain knowledge content, competence-oriented teaching must first and foremost include how students can be enabled to acquire the required competences. This form of teaching must not only constantly consider the students' perspectives, but ideally involve the students themselves in the planning and design of the course (Schaper et al., 2012/ Hericks & Rieckmann, 2018). On the other hand, the decisive goal of this type of education is to prepare students for professional life by enabling them to relate acquired knowledge to their ability to act and thus to master complex and novel tasks (Hericks & Rieckmann, 2018). The intrinsic motivation of students must therefore be considered and promoted.

### *Promoting independence/ autonomy:*

As competence-based teaching is a learner-centred format and is oriented towards the individual learning processes and needs of students, students must also take responsibility for their own learning. Teachers can still impart the knowledge content to the students, but they can only support or accompany the learners in the acquisition of competences. Students must find their own way to acquire competences.

A focus on the application relevance of competences is of central importance (Hericks & Rieckmann, 2018). Through the acquisition of competences, students must be enabled to find their way in open and challenging (both private and professional) work areas (Schaper et al.,

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2012/ Hericks & Rieckmann, 2018), in which they use professional knowledge for their own ability to act (Frank & Iller, 2013). It is therefore important to target the intrinsic motivation of the students and to make it clear to the students what benefits they can derive from the acquisition of competences. As soon as an understanding of the applicability of the competences and their importance for the students becomes clear, the willingness to take responsibility for their own learning can also arise.

### *Practical orientation/ application reference*

Competency-based teaching aims to prepare students for future complex tasks and problems in the world of work by enabling students to analyse, reflect and apply knowledge (Schaper et al., 2012/ Hericks & Rieckmann, 2018).

To achieve this goal, practical tasks must be developed in this format: Students should be encouraged to communicate with other students about the content and discuss different perspectives. Instead of relying on the teachers to provide them with the relevant knowledge and all the necessary information material, lecture notes and exam-relevant data, the students have to develop the necessary knowledge themselves or acquire it in cooperation with their fellow students. The teachers, on the other hand, remain in the background of the activities and only intervene when it is urgently necessary. They have more of a guiding/instructive function here. Through the design and planning of the course, they provide a direction in which the students should develop. In addition, the teachers intervene if the students are not able to meet most of the challenges on their own or if the development is going in the wrong or unfavourable direction.

This way of working puts students in real work situations that are common for engineers in particular. This trains them to master difficult situations, to take responsibility for work assignments and to adapt to new work environments already during their studies.

### *Promotion of self-reflection*

The focus shifts from a teacher-centred format that imparts knowledge to be tested in an examination to a format that is oriented towards students and their learning processes (Lawson & Thompson, 2012). Students themselves focus on improving the quality of their own learning. They acquire competences by actively engaging with information, questioning it and internalising it in the context of individual prior knowledge, different everyday experiences and personal objectives, and by relating it to concrete work situations.

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*When acquiring subject-specific competences, interdisciplinary competences can also be acquired*

Competences enable students

"to act specifically and successfully in a self-directed way in situations of previously not sufficiently determinable concrete requirements" (Rhein, 2010).

This means that competences are not geared to concrete work situations and problems, but have a more general character. Competences taught to students in a single subject have the potential to be helpful in numerous other subjects and life situations (Hericks & Rieckmann, 2018). The conversion of individual subjects to competence-oriented teaching can therefore have positive side effects for the other subjects at the same time. Students are then able to find their way in new complex situations, as they can more easily transfer what they have learned to new situations.

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(External) opportunities

*New demands on students (through the labour market, globalisation, technical development)*

The constant development of new technologies and globalisation have a significant impact on the labour market. Students who learn only to reproduce knowledge risk preparing for jobs that disappear from the labour market (OECD, 2006). Instead, they are expected to be able to solve multi-faceted tasks and problems for which there are no clearly defined approaches (McWhorter et al., 2013). They must be able to communicate complex scientific ideas clearly and convincingly (McWhorter et al., 2013). Higher education institutions face the challenge of creating a curriculum that prepares students for such obstacles in the labour market. They do not have to prepare students for concrete work situations, but instead they have to develop competences that enable students to apply theoretical principles in such a way that they can solve complex practical problems (Salzburg Research Forschungsgesellschaft, 2007).

Competency-based teaching requires students to implement tasks in practical assignments and to take responsibility for learned content. Instead of relying on teachers to provide them with the relevant knowledge and all the necessary information material, lecture notes and exam-relevant information, students have to develop the necessary knowledge and competences autonomously (if necessary, also in cooperation with other students). The teachers, on the other hand, remain in the background of the activities, accompany the learning and only intervene if the students are unable to meet most of the challenges independently or if the elaboration develops in a wrong or unfavourable direction.

*Promoting lifelong learning*

The concept of lifelong learning assumes that learning is "a biographical project" (Arnold et al., 2000). This means that, contrary to common perception, learning does not only take place at certain times and in certain learning situations, but inevitably accompanies people throughout their biography.

In order for adults to successfully target and manage lifelong learning processes, they depend on "learning spaces" that provide them with flexible access to learning. This means that you can learn productively regardless of time, place, financial means and according to your own needs. Competency-based teaching offers this possibility through its focus on students' learning processes. In this teaching format, teachers ideally involve students in the planning and design of the course and discuss with them the optimal learning conditions for the whole course unit.

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### *Stronger competence orientation prescribed by Bologna ("shift from teaching to learning")*

The Bologna reforms require higher education to focus study and teaching more on the acquisition of competences (Stratmann et al., 2009). However, everyday university life often continues to be oriented towards standardised knowledge assessments whose grades do not allow conclusions to be drawn about the transfer of learning and the competences actually acquired by students (Stratmann et al., 2009).

The change from "input orientation to outcome orientation in teaching" (Salzburg Research Forschungsgesellschaft, 2007) can be advanced by applying competence-oriented teaching. In this method, teachers must not only assess the acquired knowledge at the end of the course, but also accompany and include the students' learning process.

### *Enable individualised educational content (in the sense of constructivist learning theory)*

Constructivist learning theory assumes that knowledge is not simply transferred to learners, but is constructed by learners in an active process. Accordingly, knowledge acquisition is individual and dependent on each learner's respective view of reality (Reich, 2017).

Competence-oriented teaching also defines learning in terms of constructivist learning theory. Here, learning is understood from a practical perspective and requires teachers to design the learning processes in such a way that they can be approached by students in a self-directed and active way (Schaper et al., 2012). Students have to construct knowledge themselves and build competences on it.

Teachers benefit from engaging with individual approaches: they can improve their own teaching by observing students learning. By focusing on student learning, individualised educational content can be facilitated.

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(Internal) weaknesses

*(So far) Lack of experience(s) of teachers and staff to apply the method in an optimal way*

Knowledge examinations are already established; new methods, on the other hand, require training time and willingness on the part of the teachers.

Competency-based teaching demands special skills from teachers, which they may first have to acquire: Teachers must rethink their role here. Instead of maintaining the role of teacher, they must become tutors, learning guides (Boud, 2001). Changing one's own role requires didactic knowledge on the one hand and on the other hand also the ability to hold back and hand over the creative role of the course to the students. Such modifications of the previous way of working must first be learned by teachers and may not be equally feasible for every teacher.

*Acquisition of competences requires knowledge: without sustainable knowledge transfer, competences cannot be acquired*

Through the acquisition of competences, students must be enabled to find their way in open and challenging (both private and professional) work areas (Schaper et al., 2012/ Hericks & Rieckmann, 2018), in which they use professional knowledge for their own ability to act (Frank & Iller, 2013). Knowledge is thus a necessary prerequisite for competence development (Weyer et al., 2017); competences, on the other hand, are necessary prerequisites for successfully coping with complex requirements in a self-organised manner (Frank & Iller, 2013/ Rhein, 2010).

Knowledge transfer and competence acquisition are therefore inextricably linked. The successful transfer of knowledge is a necessary prerequisite for the acquisition of competences and thus requires teachers to plan theory and practice units in a way that fits perfectly. Here, the inclusion of the learners in the planning of the course is particularly advantageous. If the teachers can gain an insight into the students' learning, they can plan their teaching to suit the target group and thus optimise the transfer of knowledge.

*Competences cannot be transferred: intrinsic motivation of students must be emphasised*

"However, competences cannot be taught by teachers, but must be developed by the learners themselves". (Hericks & Rieckmann, 2018)

Competency-based teaching requires teachers to have a clear focus or orientation on students and their needs. Teaching must therefore be designed in such a way that teachers and stu-

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dents work together. Students must be encouraged and motivated to want to acquire the necessary competences and to invest themselves accordingly in the course; the fear of bad grades cannot be a driver in the acquisition of competences. In this way, students only learn for individual exams; however, the long-term advantages of competence orientation for professional life (and possibly also for private life) cannot be acquired in this way. Instead, students must be able to understand the long-term benefits of competence-oriented teaching. For this, it is necessary to accompany the students through the course, to enter into discourse with them and to encourage them to grow beyond themselves through motivating feedback. As soon as students can perceive learning as a positive experience - and not merely as a necessary evil to achieve a good grade - the long-term goals of learning can also be attained.

### *More time required (especially in the introductory phase)*

Even though competence-oriented teaching is not a novelty and even though the Bologna reforms have called for an expansion of this very form of teaching, it has not yet been used equally in all fields of study. This results in a high time commitment for those who want to implement this concept in their fields. They may have to abandon already established methods and take (unknown) risks. New or little-researched methods require extensive training and a high level of personal effort.

In addition, competence-oriented teaching requires a change in the previous assessment scheme: The focus here is on the learning development of the students and must therefore include the overall performance of the students throughout the semester. For transparency, this should already be completed at the beginning of the semester and made available to the students.

Teachers are therefore expected to continuously accompany students individually, give them feedback and adapt the teaching concept and the assessment scheme based on these individual insights. The individual learning development of the entire semester flows into the grading.

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(External) risks

*Subjectivity: no uniform definition/ no uniform (cross-institutional) understanding of competences*

For outsiders and potential employers, competence-based teaching raises the problem of the subjectivity of acquired competences. The assignment of individual competences can vary quite a lot from country to country, institution to institution, teacher to teacher and be defined more or less strictly. There is a danger here that competences become nothing more than empty terms and that individual institutions create certificates of competences carelessly because this makes them look good to the outside world. For students, this can then lead to the achievement of as many competences as possible developing in the same direction as the attainment of as good grades as possible: Students then no longer learn because it has a long-term benefit for them, but in order to obtain an official certificate that looks good on paper, but ultimately says little about the student's ability.

To avoid subjectivity, common national (at best international) definitions of competences are necessary, for example in a catalogue of competences. This creates clarity for people outside the courses and there is no danger of competences degenerating into content-less badges on paper. Instead, teachers must enable students to develop cross-institutional competences that prepare them for the labour market.

*Structures and learning spaces must be created in which students can acquire competences in a self-directed manner*

Since competence-oriented teaching requires students to acquire competences independently and according to individual learning processes, learners must also be provided with learning spaces to acquire these competences (Dingfeld et al., 2020). This means that students must have the opportunity to work outside of the courses, to exchange ideas with other students and to try things out. Especially for the intrinsic motivation of students, such enabling of shared learning spaces is central. Educational institutions are often unable to meet this need for self-determination and students must either limit collaborative work to predetermined event times or withdraw into private environments. The first option restricts students' creativity and freedoms, which is detrimental to competence acquisition. The second aspect potentially pushes motivated students into suboptimal working environments. Especially in science and engineering, access to laboratories and specialised hardware or to powerful computers can be important tools for optimal understanding and elaboration of content. Lack of access can then cause frustration and slow down students' eagerness.

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### What conclusions can be drawn from the SWOT analysis?

The preceding SWOT analysis clearly shows that the benefits of competence-based teaching for students are considerable. Teaching is adapted to the learners and involves them in planning; instead of prescribing content to students, they are empowered to acquire competences independently. This type of teaching has the potential to be particularly sustainable and to prepare students more strongly for later professional life.

The risks and weaknesses of the method, on the other hand, are mainly to be found with the teachers and the educational institutions. The main issues here are the time required, the high costs, the lack of uniformity between the educational institutions or the insufficient provision of individualised learning spaces. In addition, competence-oriented teaching demands a lot from teachers: they must be able to motivate students to learn and to convey basic knowledge to them to such an extent that this can be used as a basis for acquiring competences.

It can therefore be seen that in order to achieve the benefits of competence-oriented teaching, the students in particular must be given greater focus. Teachers have to be aware of the extra effort and the resulting challenges in order to support students. Ultimately, this means that the intrinsic motivation of teachers is particularly important in this concept.

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## Practical implementation and recommendations for action (Example 1)

### Assignments in the lectures (plan)

#### What were the tasks?

#### Lecture System level rapid development in mechatronics (WS 20/21)

Goal: Develop and improve competences in the field of systems engineering/development.

Idea: The students were given an only roughly functioning system (two-wheeled self-balancing robot) as ready-to-use hardware and the corresponding simulation model. The system behaviour had to be improved by using and adapting the simulation model and the results had to be verified by operating the hardware.

#### Hardware:

Ready-to-use, self-balancing two-wheeled robot (developed and built at Kaiserslautern University of Applied Sciences) with two brushless gimbal motors, an inertial measurement unit and an Arduino board (MKR WiFi 1010) as main components.

#### Software:

Mathworks Simulink with intensive use of the following toolboxes: Simscape Multibody, Stateflow, Control Design, Design Optimisation and Code Export.

Finally, in order to compare the improvements more easily, the robot (real and in simulation) had to perform some predefined tasks:

- Drive as fast as possible
- Fast driving with 360 degree turns after every metre
- Adjustment to change the centre of gravity by adding an unbalanced extra weight
- Driving a precise figure eight

Setup: The students worked in small groups of 3 to 4 students (each student got his/her own robot to work with). In the lecture, experience showed that 4-5 groups could be formed. Some tasks were developed as a group, but all students were also expected to focus on a topic of their own choice.

A written accompanying programme led through the entire semester, which was divided into two halves:

- First half: Acquiring the necessary skills to understand and work with the simulation model and transfer algorithms from the simulation to the robot. This included e.g. multi-body simulation, control design, state diagrams and code export. This was necessary

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because the students had different backgrounds in terms of their skills in one, some or all of the topics covered in this module.

- Second half: Improving the behaviour and capabilities of the robot in the simulation as well as on the real object.

The students were given a timetable (Figure 5) for working on the different topics. This served as an orientation to ensure continuous work on the tasks and the e-portfolio (see "Use of e-portfolios/Mahara"). Three obligatory milestones (M1, M2, M3) each completed a thematic focus. For this, the students had to submit reflections by the deadlines mentioned.

Nº	Topic	Duration [weeks]	milestone date
1	Setting up the S/W environment	2	26.10.2020
2	Multi body simulation		
3	Control design	1	02.11.2020
	buffer	1	<b>M1: 9.11.2020</b>
4	State machines	1	16.11.2020
5	Code export	1	23.11.2020
6	Setting up and testing the two-wheel robot	1	30.11.2020
	buffer	1	<b>M2: 7.12.2020</b>
7	The tasks to master	5	<b>M3: 18.01.2021</b>
		13	

Figure 5: Project timetable 1st XP2P semester (System level rapid development in mechatronics)

Support: An assistant offered students first-level help with technical questions. For this, students could use the assistant's regular (every 2 weeks) online counselling appointments or contact him by mail. The professor kept track of the students' performance as the assistant reported to him. In addition, the assistant also passed on tips and hints from the professor to

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the students, if necessary. However, it was not apparent to the students that the professor was involved in this process.

Students could ask Ms Zingraf about possible problems with the Mahara platform or the portfolio in general during the regular online consultation hours and by email.

Feedback: Feedback was given in the form of comments in the e-portfolio in Mahara at predefined milestones (three milestones spread over the semester, see Figure 5).

At the end of the semester, after submitting all mandatory milestones, students were given access to three randomly selected portfolios of their fellow students. They had to read through the corresponding work and write constructive feedback in the comment section of Mahara.

### *Use of e-portfolios/Mahara*

In order to be able to present the e-portfolio method authentically, a [sample e-portfolio](#) was created that reflected the didactic concept. This type of presentation has a number of advantages: First and foremost, it serves as an example for students of how an e-portfolio can be designed and makes the requirements and expectations for the design of the e-portfolio transparent. However, it also shows that the teachers have dealt with Mahara in depth. The comment function of the sample portfolio also offers the possibility to ask direct questions about individual aspects of the concept. A lively exchange about the proposed concept can thus lead to its optimisation.

The following illustrations show the didactic concept for creating the e-portfolio in the XP2P project. Like a classical scientific paper, it is divided into an introduction, a main part and a conclusion.

The introduction should be an occasion for the students to deal with the portfolio work as a whole. At the beginning of the semester, they should develop first ideas on how they want to approach their e-portfolio strategically and which aspects they have to consider. Furthermore, this introduction initiated the students to work with reflections. To do this, they should relate what they have learned so far to the respective lecture and their expectations of it. In this context, the students were already able to set initial focal points for their digital collections and thus name competences that they wanted to acquire in the course of the semester. In this way, the students dealt in detail with the further course of the semester right at the beginning and reflected on what they had learned in their studies so far. This gave them the opportunity to refresh their existing knowledge and put the current lecture into an overall context. The open structure enabled the students to set their personal priorities, which can be beneficial for life-long learning processes.

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Entry Reflection

Posted by Marina Zingraf on 17 April 2020, 10:33 AM  
Last updated 03 August 2020, 11:25 AM

**Introduction/ exposé: Presentation, delimitation & justification of the choice of topic. Forecast of the portfolio.**

Reflection of the own learning process is a requirement for a successful portfolio. In doing so, it looks back at what has been worked out so far: What has been learnt should be placed in an overall context and viewed critically.

The reflections should be scientifically sound and combine knowledge and competences already acquired in other lectures and seminar units as well as in the Bachelor's programme. Or show which aspects have been neglected in learning so far and are taken up by the respective lecture. Assistance can be provided by means of pre-fabricated forms containing open questions that the students can address.

- Which focus do I choose for my portfolio? Why?
- What knowledge do I already have on the subject?
- How do I want to approach the portfolio strategically?
- At which points do I possibly need assistance?

**Important!** Use blog entries for reflection. Allow comments. This allows the exchange to take place explicitly at the artifact.

Comments (1) Add comment Details

Figure 6: Introduction (e-portfolio)

The comment functions of Mahara were intended for communication with students and teachers. Communication could take place directly on individual artefacts or at the end of the e-portfolio in the final comment field. The former had the advantage that the particularly important reflections could be commented on and addressed directly and discussions could take place about very specific aspects. This avoided the final comments going into too much detail and the discussions becoming confusing.

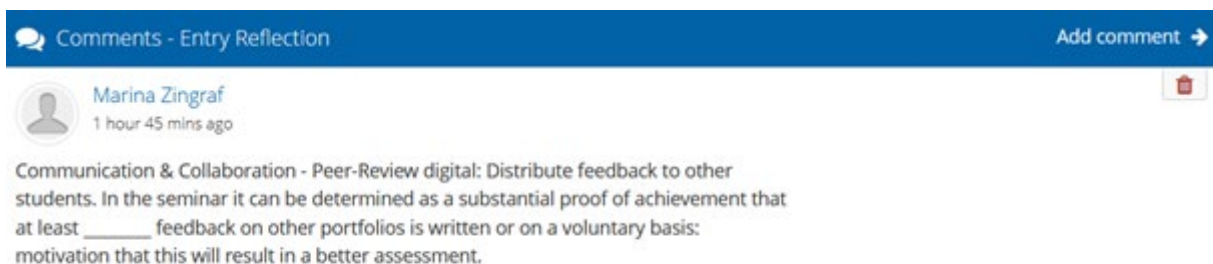


Figure 7: Comments on artefacts (e-portfolio)

The main section was the most important part of the digital collections. It served to present the collected artefacts. Here, the students were supposed to compile their own media, but they

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could also insert research materials and substantiate their arguments with these materials. As with any academic work, it was important to cite sources.

Since in the case of the XP2P project the students' learning progress was checked, continuous work on the e-portfolio was expected. Therefore, the reflection units had to be written at regular intervals.

For clarity, it was recommended that students number their artefacts in the title. This also facilitated communication about artefacts in the final comment field.

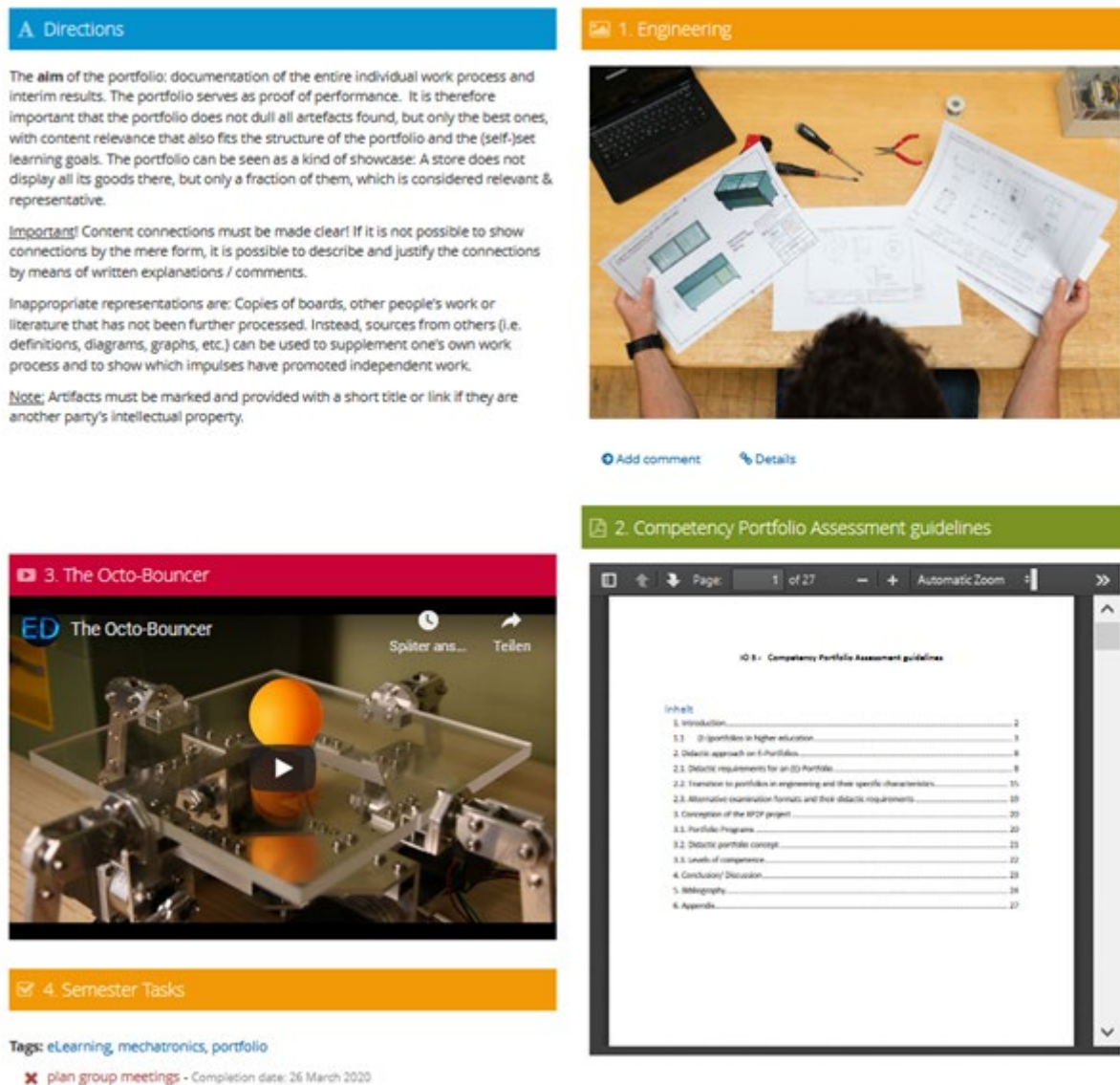


Figure 8: Main part (e-portfolio)

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Since the reflections were written at regular intervals, the students had to use the blog function in Mahara for this. A special feature of the blog entries are the time notes "Posted on..." and "Last updated...", which made it possible to see whether the reflections were submitted on time and whether work was still being done on them after the official deadline. It was a control mechanism that ensured continuous work on the e-portfolio. In terms of content, the reflection units related to the learning progress in the course. The design of the reflections was left up to the students: They could justify the common thread and thus the strategic approach of the portfolio; explain problems in lectures and point out their possible solutions; analyse important models, graphs, diagrams, etc. with the help of the acquired knowledge; place lecture units in the overall context of the study programme or relate them to professional goals; or answer specific questions from the teachers. If one wants to steer the students' reflection units in a certain direction from the outset, it is advisable to tell the students important goals of the reflections at the beginning of the lecture and to formulate the expectations clearly. Since engineering students often have little experience with reflective writing, clear and transparent communication with students is of particular importance.

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## Reflections

Posted by Marina Zingraf on 17 April 2020, 3:01 PM  
Last updated 03 August 2020, 11:24 AM

Reflection on your own learning process is a requirement for a successful portfolio. For this purpose, reflective blog entries have to be written for the individual sections of the lecture. In doing so, the students look back at what has been worked out so far: What has been learned should be put into an overall context and viewed critically. The reflections should be scientifically based and combine knowledge and skills already acquired in other lectures and seminar units and in the Bachelor's programme. Or show which aspects have been neglected in learning so far and are taken up by the respective lecture.

Reflections can make visible the connection between product and process, i.e. between learning products and processes. Continuous identification and reflection of learning progress causes and promotes conscious acquisition of learning and professional competence. Students also learn to give constructive feedback, to accept it and if necessary to reject it, thus promoting the examination of their own work & self-confident acting becomes a basic requirement if one "dares" to contradict lecturers/colleagues with good reason.

Important! Plan fixed dates for interim results so that students are required to write reflections continuously.

[Add comment](#)

[Details](#)

Figure 9: Reflections (e-portfolio)

In the last section, the students had to formulate concluding reflections. Here they were to write a summary of their portfolio work during the semester. The students were to describe how they felt about working with the e-portfolio and whether they would describe it as a helpful tool overall. They should also reflect on the contents of the lecture and relate these to the competences they have acquired. The following figure shows sample questions that can serve as an aid in writing the final reflection. In addition, a bibliography had to be included in the final section if third-party intellectual property was used.

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Closing Reflection

Posted by Marina Zingraf on 17 April 2020, 11:34 AM  
Last updated 03 August 2020, 11:24 AM

**Conclusion: detailed portfolio closing, review & outlook**

Evaluation of the lecture and the own learning process - most important findings - new questions - outlook. The following questions can serve as a guideline for the final reflection:

- What benefits do I generate through the portfolio for myself and for others?
- In what other context can the portfolio be helpful (e.g. work/ other lectures/seminars)?
- What strengths and weaknesses have I identified in myself?
- Which topics were not sufficiently considered in the lecture and/ or in the portfolio?

[Add comment](#) [Details](#)

Bibliography



[Details](#)

Figure 10: Final part (e-portfolio)

Teachers and students could use the comments section at the end of the e-portfolio for communication purposes. If individual comments were considered too personal, they could be submitted so that only the creators of the portfolio could see them. However, as communication among students was an important aspect in the assessment of overall performance, it was recommended that private comments only be written by teachers if they felt that students might feel uncomfortable with certain statements. Comments should not be understood by students as "orders", but should encourage them to look more intensively at areas where they have difficulties or where a change of perspective would be necessary. Teachers were therefore recommended to refrain from statements that describe what would be right. Instead, comments should give impulses/ food for thought and only intervene in case of serious mistakes and misunderstandings.

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Marina Zingraf  
1 hour 44 mins ago

The commentary function should be used by the teacher to give feedback on the portfolio. In return, students are obliged to prove that they have dealt with the feedback of the lecturer. The aim is to implement a feedback culture. Proof can be provided by commenting on the lecturer's comments and/ or by linking them to the group presentations.

**important!** Proof is not necessarily provided by obedient acceptance of the lecturer's criticism; instead, a conclusive justification for non-acceptance can be provided. The requirement for this is a demonstration of the examination of the criticism and a comprehensible justification for a different procedure than that suggested by the lecturer. In this way, the personality development of the students can be promoted, since the feeling of being subordinate to the lecturer is not conveyed, but the impression of being independent is strengthened and self-confidence is promoted.

---

Marina Zingraf  
1 hour 44 mins ago

**Important evaluation criteria are:** Appropriate volume, completeness, comprehensible & systematic structure, reasonable & factual correctness, content & coherence (common thread, individual parts form a whole), originality, reflection sections, formal criteria (artifacts have appropriate titles & references, bibliography, uniform font and font size, chosen layout etc.), linguistic formulations (grammar, spelling), affidavit (sworn statement)

4 comments

Add comment

Paragraph B I [List Icons] [Link Icon] [Image Icon] [Undo Icon] [Redo Icon]

Words: 0

Figure 11: Comment area (e-portfolio)

## Lecture System level rapid development in mechatronics (WS 21/22)

*Only the changes to the first XP2P semester are mentioned here.*

**Support:** Change from regular online consultations to office hours one week before each milestone and one-to-one meetings on request.

**Feedback:** Students had to present their portfolios in a short presentation (approx. 10 minutes) one week after each milestone. This facilitated the assessment for the teachers, as it made the individual performances of the students visible and the teachers could better understand how well the students were actually familiar with the contents of the portfolios. For example, students had to provide spontaneous transfer performances in response to direct questions.

### What framework conditions were set?

Due to the pandemic, it was not possible to offer the lectures in attendance.

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(WS 20/21): In the first XP2P semester, traditional lectures were largely dispensed with. At the beginning of the semester, an introductory event was offered via Zoom, in which the teachers introduced themselves and the concept of the XP2P lecture. Here, all components of the structure - peer-to-peer learning and the e-portfolio - were explained in detail. The aim was to make the expectations as transparent as possible for the students. In addition, the students were able to get to know each other and make initial contacts to form groups. Students who were not interested in the particular structure of the course, could switch to other courses at the beginning of the semester.

After the introductory lecture, no further joint appointments were planned in the large lecture group. The students were to work out the contents of the lecture independently in their groups with the help of the materials available. The group constellations could be chosen by the students themselves; the teachers only supported the students in finding groups if they asked for help.

The students were largely free in their work planning. They only had to follow the given milestones (see Figure 5) and hand in their portfolios by the given deadlines. The aforementioned introductory and concluding reflections were voluntary and only served as support for the students. They could be used to get to know the Mahara platform, get feedback from the teachers and share their own opinion about the concept of the XP2P lecture.

Regular office hours were introduced to support the students. For technical questions and problems, students could make use of the office hours of the assistant Mr Mäurer. For questions about the e-portfolio and the Mahara platform, the XP2P project staff member Ms Zingraf provided advice.

Due to the pandemic, the counselling appointments were offered online via Zoom. Students were able to attend the announced appointments, ask questions and interact with staff and fellow students without prior registration.

Groups were set up for the lectures on the portfolio platform Mahara. Here, students could network and exchange information, access lecture materials and submit e-portfolios to the lecturers.

To help students understand the portfolio method, a [sample portfolio](#) was created to transparently present explanations and expectations to students (see chapter "Using e-portfolios/Mahara" for more information)

After completing the last compulsory milestone, students were assigned three random e-portfolios. Students had to work through these portfolios and formulate constructive feedback on them. They could choose their own focus; they just had to show that they had engaged with the work of their fellow students. Students could post their critique either anonymously or with plain names in the comments on the portfolios. This was to take away their fear of getting into conflicts with other students or being dishonest for fear of the same.

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(WS 21/22): In the following semester, the concept was largely retained. However, additional presentation dates were introduced where the entire lecture group met digitally to review the portfolios of the individual students. In their presentations, the students were able to present their own progress and approaches and address challenges and problems. They were also able to gain an insight into the approach of all students and thus gain new impulses for their own work.

### What competences should be acquired?

A general aim of the lecture is to introduce the students to the engineering way of working. Concrete learning objectives resulting from the lectures are the following.

At the end of the module, students will be able to analyse the advantages and disadvantages of using specific software to support and accelerate a development process at system level. This includes e.g. multi-body simulation, control design, state machines, code export and visualisation.

Students have to balance between cost/efficiency/time/safety and the use of more or less complicated software-based tool chains.

They must also be able to use Matlab/Simulink to create and optimise a model of a self-balancing robot:

- The multibody simulation model
- The control structure for stabilisation
- Visualisation

Based on the model, the control parameters have to be optimised and finally the code generated, including the hardware driver, which has to be generated and exported to a physical controller that controls a real two-wheeled robot.

Toolboxes used are e.g. SimMechanics, Control Design, Simulink 3D Animation, Simulink Coder, Embedded Coder, Simulink Control Design, Stateflow.

In addition, students will be enabled to create a project plan by combining theoretical and practical knowledge with the aim of a rapid development process.

Through the use of peer-to-peer learning, the competence objectives also included, in particular, collaboration skills, communication skills, reporting skills and conflict management.

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In connection with the e-portfolio, the following competences in particular are promoted (see Table 5). Detailed explanations of the table can be found in the chapter "E-portfolios as an assessment method".

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Table 7: Competences e-portfolio

Competence	Essential components	Main expectations	Evidence in the e-portfolio
<b>Learning</b>	Learn how to learn new things & apply them in different situations	<ul style="list-style-type: none"> <li>• Develop learning strategies</li> <li>• Filter necessary knowledge</li> <li>• Transfer knowledge to new situations</li> <li>• Development of alternative solutions to problems</li> </ul>	<ul style="list-style-type: none"> <li>• Transfer of the learned contents to the e-portfolio &amp; its design</li> <li>• Reflections on own learning strategies</li> </ul>
<b>Self-reflection</b>	Critical examination of one's own learning	<ul style="list-style-type: none"> <li>• Critical examination of own learning &amp; own approaches to solutions</li> <li>• Consideration of alternative solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Honest reflections, questioning one's own learning behaviour, admitting difficulties &amp; striving to optimise one's own learning.</li> </ul>
<b>Analytical thinking</b>	Application of knowledge to solve complex problems	<ul style="list-style-type: none"> <li>• Critical examination of different approaches to solutions</li> <li>• Development of innovative solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Documentation of the solution approaches in the artefacts (graphs, analyses, calculations...)</li> <li>• Reflection on one's own strategies in problem solving</li> </ul>
<b>Digital skills</b>	Ability to use media for communication & action purposes	<ul style="list-style-type: none"> <li>• Adaptability to work with new, evolving media</li> <li>• Responsible handling</li> <li>• Clear &amp; appropriate communication with teachers/ fellow students</li> </ul>	<ul style="list-style-type: none"> <li>• Confident handling of Mahara &amp; its functions</li> <li>• Exploiting the extensive functions of the software</li> <li>• Communication via comment &amp; group functions</li> </ul>
<b>Feedback</b>	Constructive engagement with other people's work & analytical approach to feedback on own work	<ul style="list-style-type: none"> <li>• Critical examination of other work, constructive assistance for optimisation</li> <li>• Differentiated handling of feedback on own work</li> </ul>	<ul style="list-style-type: none"> <li>• Thoughtful &amp; constructive feedback in other students' comment sections.</li> <li>• Addressing the comments in one's own portfolio → Presentation of acceptance of the feedback or reasoned rejection</li> </ul>

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<p><b>Communication</b></p>	<p>Effective written communication of own work &amp; own engagement with other work</p>	<ul style="list-style-type: none"> <li>• Understanding of good scientific documents (in engineering)</li> </ul>	<ul style="list-style-type: none"> <li>• Analysis of scientific documents</li> <li>• Collection of own scientific papers</li> <li>• Feedback on other e-portfolios</li> </ul>
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## Implementation (do)

### What is the composition of the teams?

At the beginning of the semester, the students had to get together in groups consisting of a maximum of four students. The students were largely left to choose their own group members. They could get together privately or search for team members via the group forum in Mahara. In case of problems with finding a group, the teachers finally stepped in and divided the remaining students into groups with open capacities.

Since there were no lecture units in the first XP2P semester and the students had few insights into the work of their fellow students beyond their own groups, selected portfolios were made accessible to them. The teachers assigned three randomly selected e-portfolios to each student via a "secret URL" (see grey box for explanation). The students were then able to view these portfolios; they had to engage with the content of the portfolios and formulate constructive criticism based on this. The students could do this either anonymously or with their real names.

#### Secret URLs:

This is a feature in Mahara that allows links to be created to e-portfolios. People who receive this link are then able to view the corresponding portfolio without necessarily having a Mahara account. The respective authors of the portfolio will then no longer be able to track who is viewing the portfolio, as the link can be distributed as often as desired. However, it is possible to delete the link at any time and thus prevent access. Those who access a portfolio via a Secret URL can comment on the portfolios and must decide whether they want to do this by stating their account, their name or completely anonymously.

Students can use this feature of Mahara to share their work with potential employers, giving them authentic insights into their past achievements.

### What was the peer-to-peer exchange like?

In particular, project-based learning has been used to promote mutual learning among peers: Project-based learning is an active pedagogical method that enables students to learn by carrying out concrete projects (Perrenoud, 1999). These projects involve challenging and authentic tasks that relate to real work situations (Kokotsaki et al., 2016 / Solomon, 2003) and take place over an extended period of time (Gary, 2015). Through this type of work, students can gain more autonomy, confidence and trust in their abilities, felt less judged than in the presence of teachers, learn to negotiate and be at the centre of the learning process (for more information see chapter "Project-based learning").

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In addition, the portfolio platform Mahara was used to promote and facilitate mutual peer learning (see chapter "[Reciprocal Peer Learning](#)") and peer assessment (see chapter "[Peer Assessment](#)") in the lectures.

For peer tutoring (see chapter "[Peer tutoring](#)"), an assistant was also used who was both a project staff member and a student. Due to his parallel roles, he was able to act as an optimal link between the teachers and the students, as the students could accept him as an equal contact person.

### What did exemplary good e-portfolios look like?

Good portfolios were characterised by detailed and self-critical initial reflection, thus paving the way for self-directed competence development. Another aspect was the presented competence development besides the pure subject reporting. A third aspect was the interaction with peers: some participants obviously encouraged their fellow students to read and comment on their portfolio.

### How was the assessment carried out?

The lecture was assessed in the first XP2P semester with the help of the e-portfolio. In the second XP2P semester, the milestone presentations were included in the assessment in addition to the e-portfolio. In the first XP2P semester, the criteria of the engineering way of working and the presentation of the learning process and progress were primarily decisive for the assessment of the portfolios. It was transparently explained to the students that the concept was new for the teachers and would not have a negative influence on the grading. Based on the results of the 1st XP2P semester, an assessment scheme was then developed for the 2nd XP2P semester (see Table 8). This was presented to the students at the beginning of the lecture and discussed with them. During the lecture, the students could access the assessment scheme at any time.

### What challenges were encountered?

The biggest challenge - and to the surprise of those involved in the project, also a great promoter of the learning concept - was the Covid19 pandemic. The planned project could be adapted to the new situation at the university with only a few changes and offer the students a good teaching experience, despite contact restrictions and mandatory isolation. Even international students could be integrated into the lecture from their home countries.

Although the teaching/learning concept of the XP2P project proved to be adaptable, several challenges arose. The international students involved in the course from abroad had to face some difficulties. For example, the group work had to be planned taking into account the different time zones. In addition, it was not possible to send the hardware that was made available

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to the students in Germany beyond the European countries. So here the students had to get creative and organise the group work in a division of labour without disadvantages for individual students.

Another difficulty that arose due to the pandemic (and which was a general problem of the pandemic) was the lack of social contact among the students. Course appointments that were actually scheduled for exchange and group finding among students had to be changed to online formats (lecture events and office hours). However, these were characterised by a clear distance and were not accepted very enthusiastically by the students. As a result, students (especially in the first XP2P semester) were only able to gain a few insights into the work of their fellow students during the course and peer-to-peer learning was limited to the group determined at the beginning of the semester. The relationship with the technical assistant was also more distant due to the online formats, although he had great potential as a fellow student.

The reason why the pandemic was nevertheless described at the beginning of this chapter as a great promoter of the learning concept was due to the students' attitude. Since the XP2P set-up could be adapted to the circumstances of the pandemic without major restrictions, it gave students the impression that it had been developed specifically for this situation. Other teachers, on the other hand, had greater problems adapting their usual concepts in their courses, which had a negative impact on some parts of the teaching. The students, on the other hand, did not have to fear that they would be involved in a provisionally planned lecture whose concept might have to be changed and adapted in the course of the semester.

Moreover, the students were oriented towards online teaching. It was not a challenge to require them to do extensive digital work in Mahara. The concept was not in competition with face-to-face courses at that time.

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## Evaluation of the results (check)

Qualitative data collection methods were introduced for teacher and student feedback. Students were asked to write their feedback on the courses in the final reflections of the e-portfolios and could choose their own focus. Questionnaires with open questions were prepared for teachers and staff to answer in (group) interviews. As the format was new for the project team involved, this type of questioning was deliberately chosen in order not to steer or distort the answers in certain directions. In this way, the multi-layered subjective views of the students and teachers could be elaborated and new perspectives and impulses for the project could be revealed.

## How do the teachers reflect on the implementation?

- Mandatory sessions in P2P courses can be greatly reduced.
  - An optimal working method is achieved when students remain mostly in group work and there are only sessions of the whole lecture group for intermediate presentations and short content inputs.
- If students can choose their own group constellations, this tends to lead to very homogeneous groups that find it difficult to grow beyond their personal limits.
  - The teachers must either determine the group constellations
  - or create better opportunities so that students get more input from outside their own group to be successful even in homogeneous groups.
- There was a lack of shared physical working/learning spaces due to the pandemic.
  - This has slowed down P2P efforts and prevented sharing beyond one's own group.
  - Problems and backlogs were only noticed through regular exchange with the assistant, who had better contact with the students due to his position.
- The chosen concept must take greater account of intercultural differences and leave open choices that can be adapted to the individual groups (e.g. more or less structuring of the lecture).

## How do the students reflect on the implementation?

- The intensive group work was positively highlighted by almost all students in the reflections.
- The students had the feeling of acquiring practice-oriented skills.
- The flexibility to respond to the individual situation of the students was appreciated.
- Particularly positive in view of the pandemic: the students were also able to collaborate digitally.
  - International students who had to stay in their home countries due to the pandemic were happy to be able to participate digitally in the course, but had to cope with various challenges (e.g. time difference).

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- Continuous feedback from teachers was particularly appreciated.
- The peer assessment was positively received as new perspectives could be brought in.
- The division of the lecture into milestones was helpful for the students to organise themselves.
- The regular office hours of the staff were found to be helpful.
- The high time requirement was criticised, as a large part of the content had to be worked out by the students themselves and the creation of the e-portfolio also proved to be time-consuming.

### Summary

Overall, the format was well received by the students. In particular, the possibility of peer-to-peer learning in connection with the project-based work was very much appreciated by the students. This gave them the impression of being in a real work situation and they could take responsibility for their own learning. Difficulties arose for the students especially with the portfolio work: the concept was new to them and they were partly overwhelmed with having to write reflexively and use a new platform.

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Practical implementation and recommendations for action (transfer to another discipline)

Assignments in the lectures (plan)

What were the tasks?

### Lecture Lightweight Design (WS 21/22)

The course "Lightweight Design" has been offered by the same teacher for the last ten years, but for the XP2P project it was specially redesigned as a so-called "learning path" course in the Learning Management System "OLAT". This means that the individual tasks within the course had to be worked on one after the other, after the previous ones had been successfully completed. Roughly, the assignments consisted of the following elements: 1) input reflection, 2) determination of shear force and moment distribution (refresher and extension of a previous course), 3) estimation of the deformation of a given aircraft fuselage (students had to make assumptions and apply their knowledge of engineering mechanics, 4) buckling (design of the lightest solution of a compression strut considering a compressive load, local and overall buckling), 5) design, construction and test of a paper beam loaded in 3-point bending. 6) Intermediate reflection, followed by 7) a "semester project" to design, build and test a lightweight C-frame. Finally, the semester ended with 8) a reflection.

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**Meij: LBK (Lernpfad)**

- Einschreibung
- Kontakt
- Unterlagen
- Einführung
- Lernportfolio
- Eingangsreflexion
- Q- und M-Verläufe
- Schätzen
- Knicken
- Papierkonstruktion
- Zwischenreflexion
- Projekt C-Bügel
- Abschlussreflexion
- Entwicklungsgespräch

**Meij: Leichtbaukonstruktion (Lernpfad)**

- Einschreibung**  
⌚ Bearbeitungszeit: 5 Minuten
- Kontakt**  
⌚ Bearbeitungszeit: 1 Minuten
- Unterlagen**
- Einführung**  
⌚ Freigabedatum: 29.09.2021, 00:00 | Bearbeitungszeit: 60 Minuten
- Lernportfolio**  
⌚ Bearbeitungszeit: 60 Minuten

Bitte loggen Sie sich in Mahara mit Ihren Hochschulzugangsdaten (gleiches Prinzip wie bei OLAT) ein. Sobald Sie entsprechende Gruppe eingeladen, wo Ihnen alle wichtigen Informationsmaterialien zum E-Portfolio und zur Pla

Nutzen Sie bitte die Plattform Mahara für die Kommunikation Rund um das E-Portfolio/ Mahara- bei allgemeiner Vorlesungsgruppe zur Verfügung. Gerne können Sie sich bei konkreteren Fragen zum E-Portfolio oder bei Schw (marina.zingraf@hs-kl.de).

Figure 12: Screenshot of the OLAT course on lightweight design

### What framework conditions were set?

The above steps had to be completed by predetermined dates during the semester. For each step, there were rules for the size of the group, ranging from individual work (1, 2, 6, 8) to groups of three (3, 4, 5, 7). The students submitted a short report via the learning management system OLAT (as the platform is good at handling the deadlines as well as the overall overview of the completion of the tasks). Subsequently, the students had to include these exercises in their e-portfolio and thus describe the learning process.

### What competences should be acquired?

The intended competences of the course focused technically on solving lightweight design tasks, which typically involve unknown problems (knowledge transfer), parallel handling of contradictory requirements (optimisation), unusual force curves (engineering mechanics), material selection (materials science), building a component (experiencing the difference between "ideal" designs and reality) and testing the component (feedback on different principle solutions, the role of often overlooked load types, such as instability).

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In addition, and particularly relevant in the case of peer-to-peer learning combined with e-portfolios, the competence objectives included collaboration skills, project management, communication skills, giving and receiving appreciative feedback to/from peers, reporting skills, conflict management.

### Which evaluation methods should be introduced?

The assessment in the form of a grade was done by the teaching staff: during the semester on the basis of the students' participation and the interaction shown in the group work and at the end of the semester on the basis of the content stored in OLAT and the description of the learning process in the e-portfolio in Mahara.

There was informal assessment between students in the form of peer-to-peer feedback.

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## Implementation (do)

### What is the composition of the teams?

For the group tasks, students were free to choose their partners according to personal preferences. For the peer-to-peer feedback, all students were divided into four groups of four students each. Within each group, students had to share the contents of their portfolios with peers. One reason for this was to avoid all students having to share their e-portfolio with all other students. Since reflections contain personal views and background information, and given today's understanding of privacy and restrained data sharing, a compromise had to be found to ensure that students could still share their e-portfolios and thus get feedback from their peers.

### What was the peer-to-peer exchange like?

A main form of peer-to-peer exchange remained (compared to previous years) teamwork. However, in the XP2P setting, considerable additional peer-to-peer feedback was generated by allowing students to share their e-portfolio. As writing the e-portfolio was new to all students and associated with considerable uncertainty, there was active 'peering' into fellow students' e-portfolios. During the lessons, it was repeatedly emphasised that giving constructive feedback to fellow students is one of the assessment criteria. As a result, some students made extensive use of this opportunity to comment on their peers' work. In all cases, these comments were positive and constructive according to the assessment of the teaching staff. This may be due to the fact that the students know each other personally and the communication thus took place in a much more personal environment than is the case with comments in the various social media. Other students, on the other hand, did not use this option at all or only sparingly. Perhaps it was a question of laziness or even fear of criticising peers.

### What did exemplary good e-portfolios look like?

Good portfolios were characterised by a detailed and self-critical initial reflection and thus paved the way for self-directed competence development. Another aspect was the competence development presented besides the pure subject reporting. A third aspect was the interaction with peers: Some participants obviously encouraged their fellow students to read and comment on their portfolio.

### How was the assessment carried out?

Assessment (grading) was mainly based on the technical content of the reports and portfolio contributions. The reflective contributions in the e-portfolio were not directly used for assessment, but were considered to support the overall quality of the work delivered.

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### What challenges were encountered?

The main concerns related to the attitude expected of students, firstly to write reflections and secondly to share them with peers. In both cases, students were open to the new teaching/learning style and no changes were required. It was important to discuss the expected benefits with students in advance and to create an atmosphere of mutual trust.

The biggest challenge was the workload. For the students, reporting and reflection turned out to be a huge workload. In future semesters, reporting on the technical details of the intermediate steps will have to be much less. With sixteen students participating, the workload of the teachers (assessors) also exceeded an acceptable level. The difficulty lay in the continuous monitoring of the creation of the e-portfolio. As the process was new, it was important to provide corrective and confirmatory feedback to the students during the semester. At the end of the semester, many texts in the portfolio had been changed in the meantime (it was advised to improve the e-portfolio based on the peer and teacher feedback), so it was necessary for the assessment to go through everything again in order to achieve a fair comparison and grading of the participants. In total, everything was read about three times. For future semesters, it is suggested to change the assessment from classical grading to "pass/fail". The reflexive character of the teaching/learning style gives good arguments for this. In addition, individual feedback can be given in the final colloquium, so that the students' desire to know how well they have done in comparison to others can be met. Furthermore, the lowered reporting requirements will also be beneficial for the assessment of the work.

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## Evaluation of the results (check)

### How do the teachers reflect on the implementation?

Peer-to-peer learning in combination with the use of an e-portfolio will remain the didactic concept of the module "Lightweight Design". It proved to be very motivating and enabled students to experience themselves as learners and experts in a variety of relevant situations. The same concept will also be implemented in a new module "Introduction to Plastics Technology" for 5th semester students (from winter semester 22/23 onwards). The method seems to be suitable for students who are already familiar with normal university life. It is even more beneficial when students see it as a welcome alternative to the rather passive learning in some other lectures.

### How do the students reflect on the implementation?

The following sentences are taken from the various e-portfolios, with permission of the students named.

#### *Initial reflection*

*"For me, this is a successful seminar if I can still remember the content of this event in 30 years and still use the knowledge imparted here in everyday life. (...) So that I can also measure my learning progress, I set down my strengths and weaknesses here and define measurable goals on the basis of this:"* (Janis Lanzer; followed by concrete strengths, weaknesses and goals)

*"My direct experience with lightweight design currently comes from 3D-printing (...) I find the "exchange" between nature and technology interesting, i.e. where can we take other things / "constructions" from nature as a model for more efficient constructions."* (Simon Bühler)

Simon Bühler's contribution exemplifies that several students have extensive and valuable experience with the topic of "lightweight design" in a broader sense.

#### *Estimation of the deflection of an aircraft fuselage*

*"When I first skimmed the assignment, it seemed almost impossible to solve it and at first I did not know how to approach the task. (...) The 'guideline' given in the assignment on how to approach this problem then helped me a lot and step by step I got the feeling that I could finally arrive at a result, even if it was certainly falsified by many assumptions."* (Fabian Theel)

This post in Fabian Theel's e-portfolio was answered by a fellow student who was amazed that their two groups followed a similar strategy and came to surprisingly similar results. This exercise at the beginning of the semester gives students confidence and helps to create a mentality of "never giving up" during the upcoming exercises.

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### Design of a light compression strut reflecting several failure modes

*"The task of dimensioning a strut helped me personally to get a feeling for the values. When playing with numerical values, it was good to see what happens, for example, when I change the radius or the wall thickness, what effect this then has on the safety factor of compression, local and overall buckling. "(Tim Wollersheim)*

*"I was a bit surprised how easy it was to solve the optimisation task in the end. (...) By doing simple thought experiments (...) and looking more closely at the formula for determining the critical stress (...), I gained a good understanding of the relationships between pressure load on a strut and the resulting failure modes. "(Fabian Theel)*

Developing effective optimisation strategies is a hurdle for many students. Peer-to-peer learning offers an effective way to help students improve their communication and optimisation skills without the frustration that individual learning can bring in this regard. The use of the derived strategy of this exercise in subsequent exercises demonstrates the sustainable nature of the learning process.

### Design of a paper beam for 3-point bending

*"The design principles listed in the script could be wonderfully transferred to the construction task with paper. (...) All the groups tried to optimise the thin walls, which are undoubtedly present in a paper construction, by stiffening it with a sandwich construction or other stiffening arts by gluing or folding. Almost all of them made do with the supporting effect of bending (or folding) the paper. "(Fabian Theel)*

*"In hindsight, I would say that we approached the beam in the wrong way. We would have been better off planning the beam on edge from the beginning, as is often seen in textbooks, and then changing our construction in the beam." (Tim Wollersheim)*

Tim Wollersheim's comment shows one aspect of the mental integration of theory and practice. Although the group members knew that it would be advantageous to put the beam on edge, they initially decided to go another way. For the teaching staff, this opens up a dilemma as to how quickly the students should be corrected. In an atmosphere where "we learn from mistakes", it was deemed better to let them experience this, and the early failure of the beam came as expected. Nevertheless, what made the students' work so valuable was their detailed evaluation of the beam and its (poor) performance combined with well thought-out design recommendations.

### Design of a C-shaped beam

*"(...) and precisely this subconsciously picked up knowledge are probably the ones that I will also "instinctively" use in upcoming tasks in my studies or later profession. I think that is one*

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*of the biggest advantages of this type of study/examination performance, which was very unfamiliar to me at first." (Fabian Theel)*

In fact, this quote refers almost verbatim to the "staircase of competence", in which the highest level is described as "I act correctly without consciously retrieving the source".

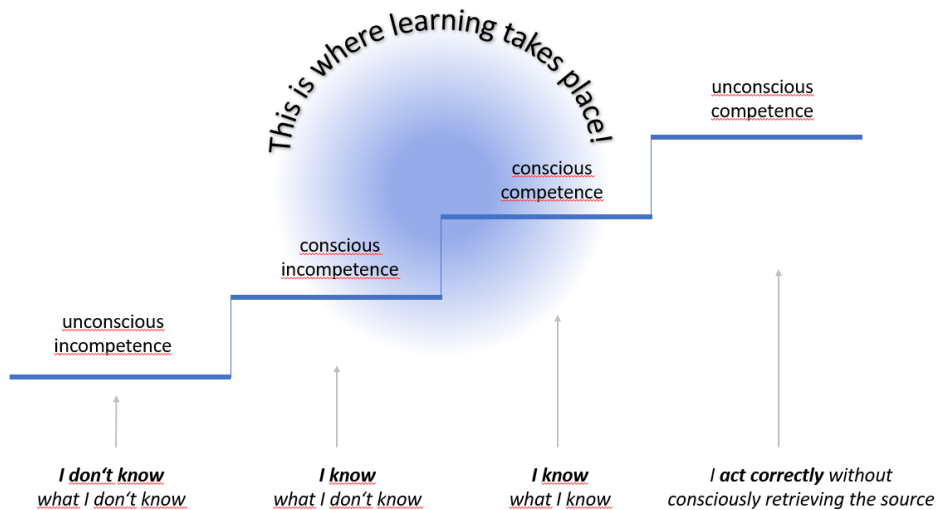


Figure 13: Competence staircase according to Seidl (2021)

*"Writing the portfolio also helped to consolidate the content. You delve deeper into it and formulating it again in your own words helps much more than just reading about it or being told about it. In a way, you also learn to look critically at something that you have built or calculated yourself and to find possible mistakes yourself and to think about suggestions for improvement." (Sophie Geminn)*

### Comparison of competence development with previous training

The way the course was conducted differed considerably from previous years, so that a balanced comparison is only possible to a limited extent. Main differences were the introduction of a completely new "learning path" course, which gave an additional structure to the different assignments. Secondly, students were introduced to the concept of P2P learning at the beginning of the semester and made aware that they share responsibility for the learning outcomes of their fellow students. This concept is unusual: both for the students and for the teachers involved. Thirdly, the assessment criteria were announced at the beginning of the semester, which clearly helped to "bring" the students along for the teaching experiment.

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## Proposals for implementation (act)

The following indications can be derived from the two XP2P semesters:

- It is important to explain the concept of peer-to-peer learning to students at the beginning of the semester. The explanation must include both the role of the students and the role of the teaching staff. It is important for the teaching staff to remain "visible", either face-to-face or virtually, so that students realise that this didactic method is about ownership of the learning process, but without the teaching staff giving up the coaching role. But: Peer-to-peer learning should not be replaced by too intensive coaching.
- Short inputs on new knowledge are more time-saving than leaving the students to work out all the content.
- At the beginning of the course, an introduction to the portfolio concept is recommended so that students can get to know the method. It is particularly important to present examples of the e-portfolio, because students need support to be able to imagine what a portfolio looks like and what expectations go along with it. But: At the same time, the e-portfolio should not be filled with too many specifications. This limits the creativity of the students and thus prevents new perspectives (both from the learner's and the teacher's perspective) from being created.
- Engineering students are usually not familiar with writing self-reflective texts. Orientation questions are therefore a good tool for learners' reflections.
- The assessment scheme must be specific to the lecture and discussed with the students at the beginning of the course. Students should have constant access to the scheme throughout the course.
- As lectures are reduced as much as possible in this format, learning spaces should be created instead where students can meet and exchange outside their own group(s). These learning spaces enable students to learn in a self-directed way according to their own possibilities/needs.
- Feedback on the learning process is a good motivator for the students and at the same time gives them a feeling of security in the self-directed learning.

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## Appendix

Table 8: Evaluation scheme "System level rapid development"

<b>Formalities &amp; Language</b>	Perfect spelling and grammar	Spelling and grammar are mostly faultless.	Spelling and grammar have minor mistakes.	Spelling and grammar show major mistakes.	Poor spelling and grammar.
	Consistent & correct application of specified citation guidelines. The bibliography contains exactly the literature used in the articles.	Quotations are clearly marked, sources are given in their entirety. The bibliography contains exactly the literature used in the text.	Citations are not always clearly marked, references are sometimes incomplete. The bibliography does not contain all titles and/or titles that are not mentioned in the text.	Citations are insufficiently marked, some sources are missing. The bibliography has notable gaps.	Quotations are not clearly marked, sources are mostly or completely missing (suspicion of plagiarism). The attribution of the literature used is difficult or impossible.
	Precise choice of words, appropriate expression.	Choice of words is precise for the most part, expression is appropriate to the subject matter.	Choice of words is sometimes imprecise, expression is not always appropriate to the subject of the work.	Often inaccurate choice of words, expression is weak overall.	The choice of words and expression are not appropriate to the task.
<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
<b>Structure, Design &amp; Calculations</b>	Overall structure of the work is logical and comprehensible in detail. The artefacts in the e-portfolio are precisely titled.	Overall structure of the work is logical and comprehensible. The artefacts in the e-portfolio are appropriately titled.	Logical overall structure is recognisable, but not always comprehensible in detail. The artefacts are not always comprehensibly titled.	Essential parts of the e-portfolio are available, overall structure has logical deficiencies. The titling of the artefacts is often not comprehensible.	The logic of the structure of the work is not apparent. The titles of the artefacts in the e-portfolio are not comprehensible.

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	Assumptions in modelling/calculation are fully identified and justified.	Assumptions in the modelling/calculation are identified and justified.	Assumptions in modelling/calculation are partly marked and/or partly justified.	Assumptions in modelling/calculation are weakly labelled and/or justified.	Assumptions in modelling/calculation are not marked and/or justified.
<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
<b>Content</b>	The topic and objective of the work is precisely described and specified. The topic is placed in a broader context.	The topic and objective of the work are described and specified. The broader context is mentioned.	The topic and objective of the work is described in general terms.	The topic and objective of the work remain vague. No placement in a broader context.	The topic and objective of the work is not described.
	Sources used (e.g. practical examples, literature, empirical data) underline the argumentation and serve to answer the question.	Sources used (e.g. practical examples, literature, empirical data) underline the majority of the argumentation and serve to answer the question.	Reference of the sources included (e.g. practical examples, literature, empirical data) to the argumentation is not evident in some cases, relevance for answering the question remains vague.	The sources used (e.g. practical examples, literature, empirical data) are hardly related to the argumentation; their relevance for answering the question is only hinted at.	Sources included (e.g. practical examples, literature, empirical data) are not related to the argumentation and to answering the question, incorrect sources are included.
	The submitted e-portfolio is complete in terms of content and includes evidence for all 3 milestones, as well as the entry and closing reflections.	The submitted e-portfolio is as complete as possible in terms of content and contains evidence for all 3 milestones.	The submitted e-portfolio is not complete in terms of content; evidence of a milestone is missing.	The submitted e-portfolio is not complete in terms of content; evidence for two milestones is missing.	The submitted e-portfolio is not complete in terms of content; adequate evidence for all milestones is missing.

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	The e-portfolio has a logical chain of reasoning, based on the expected level of knowledge. The results are presented and discussed in a complete, detailed and differentiated manner. The work deals with the problem comprehensively (within the scope of possibilities).	Based on the expected level of knowledge, the e-portfolio has a largely logical chain of reasoning. The results are presented explicitly and comprehensibly. The work deals with the objectives.	The portfolio shows in parts erroneous conclusions in the argumentation process. The results are not always presented explicitly and comprehensibly, and there may be gaps with regard to individual aspects.	The argumentation process shows clear errors that can be attributed to many areas of error. The results are not presented in a comprehensible way or hardly relate to the problems.	The argumentation process shows serious errors. The results are not presented or do not relate to the problem. It is obvious that the student has clear knowledge gaps in relation to the lecture.
<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
<b>Reflection &amp; critical examination</b>	The student's own contribution is clearly evident.	The student's own contribution is evident.	The student's own contribution is evident in parts of the work.	Student is largely guided by the performance of others.	No individual contribution on the part of the student.
	The student's own approach and answer to the question are comprehensively reflected upon.	The participants reflect on their own approach and their answers to the questions.	Reflection on one's own approach and answering the question is present in rudimentary form.	Reflection on one's own approach and answering the question is hardly evident.	Reflection on one's own approach and answering the question is missing.
	Alternative solutions are included and critically discussed.	Alternative solutions are included and critically discussed in approaches.	Alternative solutions and perspectives on the topic are included, no or hardly any critical discussion.	Alternative solutions are hardly included, critical reflection is missing.	Alternative solutions are not recognised.

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<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
<b>Collaboration &amp; Cooperation</b>	There is regular and problem-based communication between the group members. (Forum, feedback in the comments).	There is mostly problem-based communication between the group members.	Problem-based communication takes place in parts between the group members.	There is hardly any communication between the group members.	The student does not communicate with his/her own team or with fellow students in general.
	The student communicates appropriately with fellow students and own group members. (written, oral)	The student communicates appropriately with fellow students and own group members as far as possible.	The student does not always communicate appropriately with fellow students and own group members.	The student does not communicate appropriately with fellow students and own group members.	
	The student comprehensively deals with his/her own strengths and weaknesses in relation to the team tasks (reflection on own performance in the team).	The student deals in detail with his/her own strengths and weaknesses in relation to the team tasks.	The student deals with his/her own strengths and weaknesses in relation to the team tasks.	The student hardly deals with his/her own strengths and weaknesses in relation to the team tasks.	The student is not able to reflect on his/her own strengths and weaknesses in relation to the team tasks.
<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>

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<b>Feedback</b>	The student deals productively with feedback from the lecturer/staff/fellow students. He/she demonstrates differentiated engagement with feedback in the e-portfolio or comments section.	The student engages with feedback from the lecturer/staff/fellow students and demonstrates comprehensible engagement with feedback in the e-portfolio or comments section.	The student engages with feedback from the lecturer/staff/fellow students in parts. Evidence of engagement with feedback in the e-portfolio or comments section is incomplete.	The student hardly engages with feedback from the lecturer/staff/fellow students. Evidence of engagement with feedback in the e-portfolio or comments section is marginal.	The student does not demonstrate engagement with feedback from the lecturer/staff/fellow students.
	The student is able to formulate constructive feedback on the work of fellow students. In doing so, he/she refers to the guidelines and expectations of the lecture. <sup>2</sup>	The student is able to formulate helpful feedback on the work of fellow students. He/she refers to the requirements and expectations of the lecture.	The student is partially able to formulate constructive feedback on fellow students' work. Specifications and expectations of the lecture are slightly included.	The student finds it difficult to formulate constructive feedback on fellow students' work. Specifications and expectations of the lecture are hardly included.	The student is unable to formulate constructive feedback on fellow students' work.
<i>points scored:</i>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
<i>Total score:</i>					
<b>Commentary:</b>	Individual learning growth as a bonus in assessment. Goal: Demonstration of an engineering approach to work				

<sup>2</sup> Note: It must be recognisable that a critical examination of the portfolios of the fellow students takes place - even if one's own level of knowledge is not on the same level as that of the fellow students. In this case, there should be an evasion of the visual design, individual areas, one's own learning gains through the portfolio at hand, etc. The students' own weaknesses should be acknowledged. In this context, admitting one's own weaknesses should not necessarily be seen as negative.

<sup>2</sup> Basis of the evaluation scheme: [https://www.wu.ac.at/fileadmin/wu/d/i/bildungswissenschaft/Lehre/Bewertung\\_SE-Arbeiten.pdf](https://www.wu.ac.at/fileadmin/wu/d/i/bildungswissenschaft/Lehre/Bewertung_SE-Arbeiten.pdf)

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