Potentials of Open Source in Student-centered Digital University Teaching

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Abstract

University teaching has encountered significant challenges in recent years, particularly with the need for students to master digital tools and environments. The digital transformation of education necessitates a focus on students as users of digital learning platforms, which can facilitate flexible and personalized teaching. Incorporating Open Source (OS) technologies into university curricula not only enhances digital skills but also promotes the collaborative ethos central to OS communities, allowing students actively participating in the development and adaptation of digital tools. A digital learning management system (LMS) should not only serve as a teaching tool but also as a mediator for developing essential skills through customizable content, promoting student-centered learning. This shift enhances student motivation through individualized incentives and increased autonomy. Furthermore, the integration of OS encourages students to engage with open, accessible software, fostering deeper digital literacy by enabling them to contribute to digital ecosystems and reflect on the societal impact of free access to information and technologies. The constructive alignment model links teaching activities, examinations, and learning outcomes, all centered on students' needs. It emphasizes the acquisition of competencies through well-designed assessments and learning activities. Digital competencies can be mapped using the European DigComp Framework, ensuring that both learning outcomes and assessment methods align with these competencies.

1. Introduction

Teacher training should be increasingly digitalized in order to enable teachers to acquire digital skills independently and pass them on to students. The Standing Conference of the Ministers of Education and Cultural Affairs of Germany emphasizes this in its strategy paper "Education in the digital world" [1]. University lecturers have a responsibility to impart these skills to future teachers. The accreditation of teacher training courses should therefore take digital skills into account and systematically adapt the courses [2].

The need for such a restructuring arises from the rapid change in job profiles due to the digital transformation, which poses major challenges for in-service schools. There is a demand for teachers to develop diagnostic, analytical and monitoring skills in order to be able to use them effectively in vocational education [2]. In addition, future teachers must impart media pedagogical, technical and social skills to students in an outcome-oriented manner [3].

However, there is still a lack of compulsory courses in these areas of competence in the higher education sector. Only 6% of the respective modules offered for vocational teacher training are anchored as mandatory in the curriculum [4]. It is therefore necessary to expand these courses in order to ensure media didactic skills and the correct use of media [5]. Additional content should not be integrated into courses that contain already sufficient content, as this does not allow for an in-depth examination of digital topics. Instead, stand-alone courses on digital skills and working environment concepts should be developed [6].

2. The Concept of Digital Literacy

In order to do justice to the above-described status quo, university modules in vocational teacher training should be developed cooperatively, taking into account the requirements of vocational schools, educational institutions, companies and universities [2]. An integrative development promotes cooperation between the parties involved and identifies three guiding principles for digital course and module development:

Integration of media didactic and technical content: It is important that teachers are not only able to use media didactic tools, but also understand and teach operational digital processes. This requires suitable curricular and didactic formats [2].

Dynamic adaptation of teacher training: Teacher trainers should promote methodological skills so that future teachers can recognize operational changes and process them pedagogically in order to develop a professional attitude [2].

Cooperative teacher training: The digital transformation offers new opportunities for collaboration between schools and companies. Teachers must develop cooperative attitudes during

their studies in order to engage other (educational) stakeholders [2].

In addition to integrative, dynamic and collaborative training, skills development is of central importance. Future teachers need skills to cope with the digital transformation [7]. A competence framework such as the European Union's "Digital Competence Framework for Citizens" (DigComp) provides a good basis for module design by dividing digital competences into five main areas: information and data literacy, communication and collaboration, digital content creation, (data) security and problem-solving skills [8].

The TPACK model, which integrates technological knowledge (TK) into subject-specific didactics [9], serves to combine the requirements of university teacher training with digital competence requirements. It comprises subject-specific content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK) and emphasizes the need to integrate these types of knowledge to promote digital skills [9]. A modified curriculum for vocational and business education should take account of professional and social change and include the teaching of digital skills as an integral component [10]. Models such as those by Bonnes and Schumann [11] and Seufert et al. [12] offer concrete approaches for integrating digital skills into teacher training and emphasize the importance of media skills and IT knowledge. DigComp covers the development of basic digital skills and basic knowledge, while the TPACK model enables the integration of technological knowledge (TK) into existing curricular frameworks. Seufert's model supplements existing subject areas with digital aspects. However, for vocational teacher training it is necessary to define specific professional competencies that teachers need to understand and teach operational processes and systems.

Digital literacy acts as an interface between specialist knowledge and technology, taking into account economic requirements such as digital business processes and value chains [13]. The competence areas are similar to those of DigComp and include "Information and Data", "Digital Content Creation", "Functional and Technical Basic Knowledge", "Digital Communication" and "Strategic Knowledge". Particularly noteworthy is the operational focus of digital literacy, which has a clear business process orientation, e.g. the importance of digital channels for business start-ups or the selection of suitable tools for professional tasks [13].

The "strategic knowledge" differs in its business context and focuses on metacognitive knowledge and critical thinking about technological change [13].

The models show a connectedness and offer several points of connection between business management issues and generalized digital competencies that are useful for designing modules and courses in business education with a digital focus [13]. The "Business Digital Literacy Model", which builds on digital literacy, integrates business knowledge and digital literacy in an area of action and requirements, and serves as a basis for the further development and application of study programs in business and business education [13].

Incorporating digital literacy into a student-centered approach ensures that future educators are equipped with the necessary digital competences to create dynamic, individualized learning experiences that promote self-directed learning and adaptability in rapidly evolving educational environments.

3. Open Source – Learning Medium and Topic

The topic of the module concept is Open Source (OS) or Open Source Technologies (OST) in vocational education and training. Before explaining why this makes sense for a course with a digital orientation and a focus on teaching digital skills, the subject itself should be defined.

3.1. Open Source paradigm and understanding

The Open Source Initiative (OSI), a non-profit organization committed to the dissemination and promotion of OS software [52], provides a basic explanation for OS and developed ten criteria that must be met for software to count as OS [53]. An OS license makes it possible to pass it on to third parties or sell it as part of a distribution (software package or software bundle) without charging license fees. The source code of the software must be available in a clearly legible form. The license must permit modifications and derivative works and allow publication under the same conditions as the original software. The distribution of software with modified source code must also be permitted. The license must not discriminate against any person or group and must not restrict the use of the software for certain purposes or areas of activity. This must also apply to everyone to whom the software is distributed; no additional licenses may be required. The license must not be dependent on a software package and must be valid if the program is used as a stand-alone program or if it is distributed together with other software. Finally, the license must not restrict the distribution of the software to a specific technology, device or interface [53]. In summary, OS want to grant everyone equal and free access to software. OS may be freely distributed and used by schools and universities. The collaborative idea and independent, free access to software and its program code (also known as source code) is also a reason why OS are interesting for vocational training and companies [54]. In surveys on

the use and importance of OS software in companies, the main reasons for using such products are the simple adaptation to company requirements, community support, quality and flexibility [55]. The advantages of OS software are further enhanced by the low-cost or free use of this software, in contrast to proprietary software, and counterarguments, such as inconsistent support or a lack of long-term support, are offset by a combination of core developers together with OS software communities [56]. It is therefore not surprising that 82% of corporate IT managers surveyed prefer vendors and suppliers that contribute to OS communities. At the same time, almost 90% of respondents are convinced that enterprise OS solutions are more secure than closed software products. As a result, only 45% of the companies interviewed still rely on proprietary software and the trend continues to develop in the direction of OS software [57].

3.2. Using Open Source for the development of digital competencies in higher education

In order to be able to reflect this development in schools, prospective teachers should master the basics of new digital technologies, such as OS and build up a basic knowledge and understanding of them in order to be able to act as facilitators of these technologies themselves [11]. It should be noted that the availability of digital media is not the same as their use, as Persike and Friedrich 2016 explain, which is shown below [46]. Students tend to be conservative with regard to digital media and rarely look for alternative learning sources. Hence, the integration of digital media into courses should be actively encouraged by lecturers in order to achieve regular use by students. A push offer can help to compensate for the discrepancy between the availability of digital learning formats and their use and at the same time inform students about the possible advantages and functionalities of new digital media [46].

With the introduction of digital teaching methods at universities, a process is therefore also necessary that teaches students the tools to deal with these new technologies. This is also, where the topic of OS comes in, as it encompasses the previously discussed digital skills as a concrete medium, the OS software, but also as a computer science approach of the OS community. As a concrete software product, OS can thus train the ability to generate data independently and extract databases from proprietary software environments, to adapt parts of the software to one's own needs and actively design it, and to analyze and subsequently evaluate digital information [58]. OS as a community is aligned with the competencies of DigComp [8]. OS promotes digital collaboration and exchange by sharing digital content and building collaborative expertise [8]. Furthermore, the area of content creation is addressed by creating own content, thinking about its possible copyright and use and finally integrating or programming it into a digital system [8]. Connections can also be made between digital literacy and OS. For example, the OS principle of open data can be used to present database entries in a machine-readable and generally usable format, which gives a supplier ("production and logistics") the opportunity to feed data directly into the customer's system without further human interaction, as it is available in the same format ("information and data") [58] [13].

The knowledge required by students, as well as the corresponding skills to enable such data management, should be covered in a module on the use of OS in vocational education and training. Ultimately, OS begins with integrative, dynamic and cooperative teacher education and combines this with the domain reference of digital literacy, the knowledge transfer of the TPACK model and the digital competencies of DigComp.

4. Embracing Student-Centered Learning and Constructive Alignment

The course idea focuses on a student-centered approach, which uses a constructivist perspective and emphasizes individual teaching-learning arrangements [14]. Mayrberger defines this approach as a (media) didactic perspective for designing the teaching and learning process [15]. This orientation is supported by the use of a learning management system (LMS), which enables flexible learning situations tailored to the students [16]. This promotes a shift from teaching to learning, which is called for as part of the Bologna Process [17] [18]. Launched in 1999, the latter is a collaborative initiative among European countries to create a more coherent and compatible higher education system through the standardization of degree structures, enhancement of quality assurance, and promotion of mobility for students and staff.

Self-directed learning is another central element of the course, where learners monitor, evaluate and reflect on their own learning process. This is particularly relevant for future teachers as it allows them to adapt flexibly to rapidly changing content [19]. In line with the DigComp digital competencies, learners develop cognitive, metacognitive and resource-oriented strategies [19].

To achieve this, the course incorporates Constructive Alignment (CA) principles. CA is the coherence between learning activities, outcomes and assessments, which must be aligned with student learning to ensure an intrinsic connection between the elements [21] [18]. This approach requires a shift in perspective from teaching to learning to enable customization to learners and learning content [18]. Active encouragement of learners improves learning

success and competence growth, and supports lifelong learning, especially through case-based and problem-based learning (PBL) [21].

PBL helps students to acquire skills and knowledge independently, to solve problems and apply their problem-solving strategies to real-world examples. Students who are taught according to PBL principles demonstrate greater self-efficacy and self-direction. This learning model supports the development of competencies as required by the Bologna Process [18].

In the context of examinations, Biggs and Tang distinguish between formative assessments, which provide feedback during learning, and summative assessments, which measure learning success at the end of a module [21]. Traditional assessment systems can be detrimental as they are often seen as unavoidable and lead to superficial learning strategies. Assessment focused on LOs, on the other hand, reinforces learning and is an essential factor in the teaching and learning process [21]. Assessment performance should reflect LOs and be practical for teachers and learners [21].

Digital competencies and innovative teaching methods must be taken into account in the design process. LOs should be formulated from the students' perspective with active verbs and indicate the desired level of understanding. Learning activities support the achievement of LOs and they should be chosen independently. Assessment tasks should relate to the LOs and complement the chosen activities to check acquired competences [21] [18]. The "backwards design" first determines the LOs and then the content and methods based on them [22].

5. Aligning Learning Outcomes with Digital Education Needs

The development of learning outcomes (LOs) is essential for the conceptual and structural planning of modules, as they define the desired LOs [23]. LOs aim to cause sustainable behavioral changes in learners. They are also often referred to as learning objectives [23] and are intended to promote comprehensive action competencies, especially in higher education didactics and vocational teacher training [24]. Digital elements and topics must be integrated into new teaching arrangements in order to meet the requirements of digitalization [20].

LOs are important in various areas of VET, including understanding digital technology, using it to participate in society and gain knowledge, and interpreting its implications [25]. The teaching of digital literacy is also central, including the creation of digital content, basic functional and technical knowledge and digital communication [13]. Digital skills must be critically reflected upon and continuously developed in order to be able to react to technological changes [13].

LOs should ensure that future teachers are able to use and teach digital media and technologies effectively [11].

5.1. Theoretical Design

The conception of LOs requires a theoretical and didactic foundation based on learning objective taxonomies and theories. Möller [26] describes LOs as statements about the competences to be acquired, the framework conditions and success criteria of the learning process. The level of abstraction of LOs is divided into indicative learning objectives, broad learning objectives and detailed learning objectives, with detailed learning objectives defining specific competences after a limited number of learning units [27].

Bloom's taxonomy and its revision by Anderson and Krathwohl offers a model for classifying LOs into cognitive processes and types of knowledge [28]. This model helps to define general LOs, but lacks a reference to higher education didactics. The TAMAS matrix integrates LOs with learning activities and performance assessment and enables adjustments in the revision process [29].

An exemplary LO according to TAMAS could be the following: "Students can structure, analyze and select suitable Open Source programs for their problem." This LO is observable, measurable and formulated in a resource-adequate way.

In summary, theoretically based LOs should contain concrete and measurable active verbs, address thematically categorized content and be assigned to a knowledge dimension and requirement level [17].

5.2. Main topics and content design of learning outcomes

In this module, the theoretical foundation can now be used to define specific learning objectives. However, the topic of OS as such is too comprehensive to cover every aspect adequately in a single module, which is why it is necessary to reduce the material or topic and select core content that matches the interests of the target group, their prior knowledge and learning context [15].

Despite the reduction of the subject area, OS should not be reduced to a purely didactic teaching-learning tool, but should be kept at the center of the module [39]. Due to the small selection of literature that deals with OS as a central teaching subject in university teaching, this reduction attempts to select subject areas based on their own weighting and link to digital skills.

In order to gain an initial overview of the specific LOs and target options, a subject map is used. In this, the aspects of the topic are clustered, and connections are shown [51].
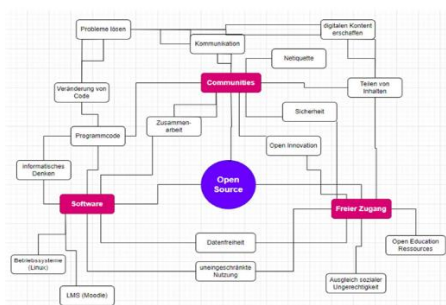
Figure 1. Unorganized Subject Map
(Own illustration)

It should be noted that this map is not a complete coverage of the subject. Asking students for all knowledge about a subject area does not serve as a common thread that should run through a module and completeness with regard to the current level of knowledge is always characterized by the subjective perception of the teacher [59]. If the subject area is covered too extensively, individual aspects are implemented with lower quality and the essential points disappear among the non-essentials [60].

Three important topic categories can be identified from the map and the number of lines: "Communities", "Software" and "Free access" (see Fig. 4). An indicative learning objective at course level would be "The competence to understand OS as software, innovative working methods and philosophical approaches and to be able to apply them in school or company-based vocational training". For the broad learning objectives, the overarching indicative learning objective is broken down into its components and the action objects and active verbs are assigned to each aspect [21]. This results in the following general learning objectives for this module:

i. Students should be able to describe OS software and determine programs for specific problem situations.

ii. Students should be able to reflect on and evaluate the collaborative idea of OS communities.

iii. Students should create their own freely accessible content and examine its benefit for society.

The broad learning objectives are based on the students' prior knowledge in order to supplement existing knowledge and not overburden the learner with excessive leaps in knowledge and skills [61]. Nevertheless, the LOs must be sufficiently in-depth in order to understand the functions of the technology, the use of the media and the knowledge about it [5]. By balancing these two aspects, the overall goal of deepening learners' digital skills and enabling them to use OS should be achieved [40]. The first broad learning objective deals with the aspect of "software" from the subject map, which, with the

terms now sorted, serves as a basis for consideration for these objectives (see Fig. 5). The following explanation of the classification of results is derived from Anderson and Krathwohl and the TAMAS model [28] [29]. As business education students come from different degree programs and have different levels of prior knowledge depending on their second subject, the software component is at the lower end of the levels [62] [63]. Students should be able to describe programs (action object) for a problem situation (level 2 - understand) and then adapt the appropriate software (level 3 - apply), for which they need factual and procedural knowledge. In order to be able to evaluate and reflect on the collaborative idea of the OS communities and at the same time create their own contributions for the communities, competences of level 5 - assess and level 6 - create are required. At this point, learners need procedural knowledge in order to be able to evaluate the processes appropriately and metacognitive knowledge in order to integrate their information contributions into a social framework adapted to the group.

The final broad objective, assessing freely accessible content and checking the benefit of this, also requires level 5 - assess, and procedural knowledge is required for this assessment process [28] [29]. However, it is not possible to categorize the levels precisely, as knowledge and skills from related areas are required for some aspects and subsequent detailed objectives. This smallest result unit is closely interwoven with the structure and the teaching format in the following chapter and is mentioned here with the respective competence, the structural arrangement follows afterwards.
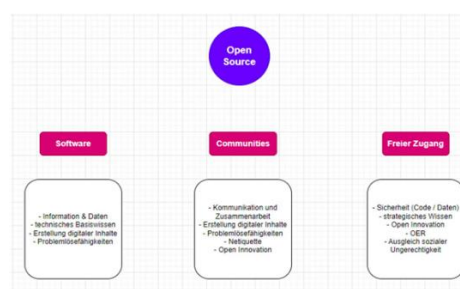

Figure 2. Organized Subject Map
(Own illustration)

Through the choices offered to students in this course concept, a subcategory, in Software, for example, Development Environment, Self-Hosting and Open Applications, covers a detailed learning objective. The path to the respective competence is then chosen by selecting one of the activities or problems in the respective category, which activates self-directed learning according to Biggs and Tang.

In the "Software development" category, the detailed learning objective is "Students understand the computer science principles used in open software

environments". This means that at the level of "understanding", the competence "basic functional and technical knowledge" of the Digital Literacy Model and the "information and data competence" of DigComp are covered with the object of action of the development environments. In the "Self-hosting" category, the detailed learning objective is "Students can explain, use and make limited adjustments to the programs they have set up themselves". This means that at the level of "understanding" and "applying", the competence "basic functional and technical knowledge" of the Digital Literacy Model and the "problem-solving ability" of DigComp are covered with the action object of the self-hosted programs. By adapting content at the lowest level, the "creation of digital content" of both models is also addressed in outline. Application programs are also available in the last area of "Open applications", this time the learning objective is "Students know examples of open applications and can identify other open software based on criteria". This means that at the level of "remembering" and "understanding", the "information and data" competence of the digital literacy model and again the "information and data competence" of DigComp are covered with the action object of the open source software. In the digital literacy model, this category is more closely aligned with the area of "information" than with "basic technical knowledge", as the ability to select the appropriate information and programs from those available is required here instead of worrying about hosting and installation, as in the previous area. The two fields of "communities" and free access are aimed at higher levels and are therefore provided with fewer options, but with greater elaboration of the individual areas. Free access in connection with OS includes the topic sections "Free Beer", "Open Source Business Model" and "OER - Open Education Resources". The "Free Beer" item deals with the hidden costs of proprietary software. The detailed learning objective here is "Students can point out the differences between free and free software and thus evaluate the type of software". This means that at the level of "analyzing" and "evaluating", the competence "basic functional and technical knowledge" of the Digital Literacy Model and the "information and data competence" of DigComp are covered with the object of action of free and open source software. In the "Open source business model" field, the students should "compare existing business models based on OS projects or code with classic business concepts and evaluate their success model" through the detailed learning objective. Thus, at the level of "analyzing" and "evaluating", with the action object of OS business models, the action skills of "communicating and collaborating" and "problem solving" through changed company profiles of DigComp are included. The last topic in the area of free access is "OER - Open Education Resources". Here, students should "assess

and argue why open educational resources are an integral part of research and design their own educational content for the corporate sector". This means that the competence "Creating digital content" of the Digital Literacy Model and also "Creating digital content" and "Problem-solving skills" of the DigComp are covered by "Assessing" and "Creating" with the action object of the OS educational resource. The higher requirement level, in contrast to the two previous items, must therefore be taken into account in the assessment and procedural knowledge, which is required in all three subject areas. The last topic area of "Communities" deals with the items: "communication strategy", "open knowledge management" and "open innovation". In the area of "communication strategy", students should "design a strategy or guide on how to communicate with each other in online project groups and determine netiquette, i.e. online communication rules". Thus, at the level of "creation", with the action object of the communication guide, the action skills of "communicating and collaborating" of DigComp and the "creation of digital content", as well as "communicating digitally" of digital literacy are dealt with. In the area of "open knowledge management", learners should "evaluate motivating and hindering factors for sharing knowledge in the company and create a template for knowledge sharing". This covers the level of "creating" with the action object of the knowledge template and the level of "assessing" with the object of the motivational factors. The competencies "Creation of digital content" of the DigComp and Digital Literacy, as well as the "Problem-solving strategy" of the DigComp are thus taught. Finally, the "Open Innovation" item is covered. In "Open Innovation", the otherwise closed innovation process is opened up to stakeholders, allowing parties such as universities, research institutes or individuals to participate in the process [64]. Students should "understand open innovation processes and be able to create their own process flow chart for an open innovation". This addresses the level of "creation" with the action object of the process flowchart and the level of "understanding" with the object of open innovation. Procedural and factual knowledge is required. The competencies can be assigned to the DigComp categories of "information and data literacy", "creation of digital content" and "problem-solving strategy", as well as the two categories "creation of digital content" and "information and data" of digital literacy. Due to the complexity of this subject area, metacognitive knowledge is also partially tested in addition to the focus on percentage knowledge. This raises the question which digital skills should be prioritized [2]. The LOs mentioned above focus primarily on the direct competencies that are appropriate to the topic and only selectively deal with meta-competencies or competencies unrelated to the topic.

6. Elements of an Innovative Digital Learning and Assessment Environment

In curriculum design according to TAMAS, activities and performance assessments are developed to adapt and modify learning objectives [29]. In the context of teacher education, future teachers must develop skills for independent, lifelong learning and promote such learning processes in their students [30]. Teaching staff have the task of providing the necessary structure, as well as support the effective achievement of the learning objectives [31].

6.1. Learning methods

A mixed concept of digital and analog elements is the aim. Blended learning (BL), which combines face-to-face and online elements, offers a suitable form of learning for this [32]. The duality enables students to shape their educational processes in a self-directed manner, supported by the flexibility of online teaching and social exchange in face-to-face events [33]. BL promotes the development of digital and practical skills, while at the same time using face-to-face teaching as a safeguarding component [34]. The flipped classroom, a sub-form of the BL, reverses the traditional teaching structure by providing learning materials in advance for self- study and using the attendance time for active learning activities [35] [36]. This encourages self- directed learning and interaction in the face-to-face phases through discussions and practical exercises [37]. In modern approaches, the absence phases are supported by projects and e-portfolios [36]. In this course idea, Moodle as an e-learning platform that integrates both face-to-face and online phases meets this requirements [38]. Moodle, as an open source LMS, enables adaptation to specific teaching needs and supports learner-centered teaching through interactive tools such as quizzes, wikis and forums [39] [40].

6.2. Moodle as platform for digital teaching

The BL or flipped classroom format requires a platform that can be used for both face-to-face and self-study phases. For this course concept, it is the e-learning platform Moodle, an Open Source LMS. A LMS is a software application for the administration, documentation, tracking, reporting, automation and delivery of educational courses, training programs or learning and development programs [38]. Moodle is freely available as an OS platform, can be used in your own server environment and can be adapted and modified for your own purposes [66]. This flexibility means that the LMS can be used both on-site in classroom courses and off-site for research and learning activities. In this way, the software does

justice to the dual concept of the BL approach and enables situational and spontaneous engagement with the learning material, which is possible between teachers and learners as well as between students [39]. In such learning systems, a variety of tools is available for integrative and learner-centered teaching. These include, for example, quizzes for testing what has been learned, wikis for writing texts together, forums to support communication and blogs to promote structured thinking among students [40]. However, simply inserting these tools into the course would not offer learners any benefit through the LMS. For this reason, it is important to consider a number of success factors when modeling the course later on, which Di Serio, among others, established in 2022 [34]. Thorough planning through the assessment of LOs, clear definition of competences and revision of classroom material for digital use. The workload and work packages must be adapted to the needs of the audience and aligned with the appropriate teaching method. Problem- oriented and high-quality content that reflects future challenges should be created. Lecturers must learn how to use online tools and be open to changes in everyday teaching so that new content can be created and old content can be moderated and modified. As mentioned in the chapter on learner-centeredness, students are the focus and the content, videos and interactive activities should be built around them. New assessment methods, such as the e-portfolio or peer assessment, should be integrated thoughtfully and with continuous revision. Peer assessments should also be used to introduce social learning into the LMS with the help of chats and forums and promote learner exchange and interaction. As a tool, the technology should complement and support the teaching and learning process in a meaningful way. All of this leads to an active and positive teaching environment in which students are motivated to achieve their own competence goals [34]. Moodle therefore offers the opportunity to promote constructivist knowledge acquisition by designing the learning environment in such a way that skills and knowledge can be constructed, the teacher can provide impulses in the learning process through face-to-face events and learners have the opportunity to monitor their learning status and build up a skills profile [65].

Another advantage of the digital teaching environment is that content can be adaptively adjusted to learners, depending on how far along they are in the process of completing activities [65]. This is made possible in Moodle by interactive content based on H5P. This framework allows both complex tasks and interactive learning games to be created with an editor and reused very easily using HTML and iFrame elements and embedded elsewhere or in other courses. There is also very good documentation for H5P, which teachers can use to acquire new skills themselves [66]. Due to the easy customizability and

flexible design of the learning content, the acquisition of knowledge and skills can also be designed as a MOOC, e.g. for external or cross-course participants. MOOCs, i.e. Massive Open Online Courses, are online courses for a large number of participants that can be accessed by any course member from any location as long as an internet connection is available and offer a complete online course experience without additional structural costs [67]. The MOOC principle serves as an additional offer in this course, as it would stand in the way of its primary use as a BL approach due to the number of participants and the resulting lack of support for individual learners [16].

The combination of the competencies and models mentioned in the framework, the learning objectives and the activity and examination modalities from the CA approach results in an initial structure that is filled with content. Based on the idea of Downes and Siemens from 2008, the MOOC at course level can be described as a cMOOC, a "constructive" MOOC [68]. The focus here is on collaboration and exchange between students, while at an external level the course can be practiced as a pure MOOC [68]. As a result, peer assessment is integrated into the course at module level. In line with the principle of self-directed and self-organized learning, students can choose from the three main categories "Software", "Communities" and "Free Access". The topic of OS is approached from a technical perspective (software) and a pedagogical or educational perspective (free access, communities) [45]. These categories contain the detailed learning objectives with activities to build skills in the respective areas. If the required assessment hurdle is met and students and lecturers provide feedback on performance, the acquired competence can be included in the student's own portfolio. The competencies are aligned with the DigComp and digital literacy frameworks. They provide prospective teachers with the technological, pedagogical and content-related knowledge to pass on the competencies and the module topic of the OST to future students.

6.3. Learning activities

To develop fitting learning activities, the AVIVA model can be effectively applied to this course idea. The AVIVA model for activity design integrates didactic concepts and learning methods with the Moodle platform in a course format. AVIVA in Germany stands for "Ankommen (Arrive)", "Vorwissen aktivieren (Activate prior knowledge)", "Informieren (Inform)", "Vertiefen (Process)", and "Auswerten (Evaluate)" [41] [42] [43]. The model is based on the didactic three-step approach: "introduction", "work phase", and "conclusion," whereby learners are supported and guided through structured activities. The AVIVA model aligns closely with the learning objectives (LOs) outlined in the OS module by promoting active and self-directed learning, crucial for developing digital skills like problem-solving and collaboration.

In the "arrival and attunement" phase, the focus is on introducing key concepts of OS, such as the differences between proprietary and open-source software. At this stage, a Notepad could allow students to submit their own OS-related terms, clarifying their prior understanding and personalizing the course experience. This also resonates with the goal of reducing the OS subject matter to match student knowledge and learning context, as highlighted earlier [41].

The second phase, "Activate prior knowledge," can leverage mind maps to document and restructure students' existing knowledge of open-source communities, software, and collaborative methodologies. This phase mirrors the focus on connecting new content with prior knowledge to avoid overwhelming students, as emphasized in the module's design [41].

In the "Informing" phase, knowledge bases are created using multimedia resources like videos and text documentation, a method particularly suited to explaining complex topics such as GitHub functionalities, OS business models, or free software. The sandwich method alternates between theoretical content and hands-on activities, which corresponds to the learning objective of applying OS concepts in real-world contexts, such as understanding development environments or contributing to OS communities [41] [44].

The "processing" phase is where students engage in practical applications of their acquired knowledge, working on independent and complex tasks such as coding projects or setting up self-hosted programs like Nextcloud or Docker. This phase takes up most of the course time and encourages self-paced, problem-solving activities, closely aligned with the module's focus on digital competencies like evaluating OS communities and creating digital content [41] [2].

Finally, in the AVIVA model, the learning activities are evaluated through a portfolio. This reflective tool helps students document their progress and assess their growth in competencies such as collaborating in OS communities, creating freely accessible content, and analyzing business models. The use of portfolios fits well with the broad learning objectives, allowing students to demonstrate their ability to apply OS knowledge in practical, real-world scenarios, ultimately fostering the deepening of digital skills. This structured approach provides a learner-centered and self-determined learning path that is tailored to the needs of the students, integrating theoretical foundations, practical applications, and digital literacy enhancement, thus ensuring comprehensive competency development in line with the Digital Literacy Model and DigComp frameworks [45].

6.4. Examination and Performance Assessment

The examination performance in the module is based on various elements, with the focus on a course portfolio that serves as a summative assessment. This portfolio assesses the students' level of competence through self-completed subtasks [46]. Formative assessments are carried out through digital tests after each activity, which are used as peer feedback to support learning progress without exam pressure [46]. Students should work cooperatively and exchange solutions. The examination format is Moodle-compatible and avoids disadvantages due to group work. The tasks are aligned with the LOs and are designed to capture complex thinking and problem-solving processes, with attention paid to clear formulations in order to avoid misunderstandings [47].

All participants are assessed according to the same criteria, regardless of the selected sub-activities. The conceptual assessment framework (CAF) supports assessment development by combining the following different models: The "student model" defines the competencies to be measured. The "evidence model" explains how these competencies are measured.

The "task model" specifies where the competencies are measured. The "assembly model" coordinates the various components and the "presentation model" details the form in which the assessments are presented [48] [49]. In the course, the "student model" is covered by specified LOs, the "evidence model" by action products and final tests, the "task model" by practical tasks, and the "assembly model" by a mix of examination tasks [8]. The presentation takes place digitally and in writing via Moodle and GitHub, which both serve as a "delivery model". The tasks range from setting up the software, issue tracking and documentation to troubleshooting in the synchronization chain. This corresponds to the competence descriptions of DigComp and represents the "evidence model" [48] [49].

7. Implications and Future Opportunities in Digital Course Development

The process of creating digital modern courses offers numerous opportunities that can be further developed in future modules, research and yet to be implemented courses. One key opportunity is to promote digital transformation using Moodle, which is a strategy to utilize technologies such as cloud computing, Internet of Things, data analytics, virtual and augmented reality, and artificial intelligence to impart knowledge [14]. These technologies improve the learning process through new teaching formats and increased student participation. Learning management platforms such as Moodle support this development, as content is cloud-based and accessible at any time. Open source code enables the integration of additional applications and pedagogical concepts [14].

A further potential lies in the structural flexibilization of university teaching in order to do justice to dynamic career paths and the need for lifelong learning [50]. Digital modules and open educational resources enable "virtual mobility", whereby students can combine courses and certificates from different institutions [10] [14]. Competent and digitally trained teaching staff are essential for the development of such innovative teaching content. The module teaches digital skills and integrates didactic concepts with structural concepts to create a sustainable teaching-learning concept. This module structure can be implemented at degree program and university level to ensure the education of integrative, dynamic and collaborative teachers for various formats and topics [14].

In conclusion, it can be emphasized that the opportunities for the development of future digital, innovative and modern teaching content require teaching staff who are equally trained and equipped with digital skills. The module addresses this need and teaches students digital skills in the area of OS, the building block of current and future software and technology solutions such as Linux, Docker or GitHub.

8. References

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