

# Digital literacy and artificial intelligence literacy in teacher training

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**Abstract:** The research titled “digital and AI literacy in teacher training” seeks to bolster the professional training of future educators in all phases of teacher education within Germany, with a particular emphasis on integrating digital and artificial intelligence (AI) literacy into contemporary educational practices. Recognizing the escalating importance of digital competencies—an urgency that the COVID-19 pandemic underscored globally—this initiative establishes a cohesive framework connecting universities, seminar leaders, and schools. Its core objective is to enable student teachers to adopt and implement digital methodologies in the classroom while providing continuous, contextually relevant training for in-service educators. Through this interconnected structure, the research aims to bridge educational theory and practice. **Methods:** The research applies a Design-Based Research (DBR) methodology, facilitating a dynamic process in which educational tools and approaches are developed, tested, and refined in real-world settings. To assess efficacy, the research utilizes online questionnaires aligned with established digital competence frameworks, such as the European DigCompEdu model, enabling educators at all stages of teacher training to self-assess their digital and AI literacy skills. The geographical context of Bavaria in southern Germany is specifically referenced, where the research pilot takes place to set a scalable example for broader implementation. **Findings:** Preliminary evaluations reveal that the module-based structure effectively enhances participants’ digital competencies. Teacher candidates report a higher degree of readiness to implement digital teaching tools, collaborate effectively online, and navigate AI-related resources in classroom contexts. This reflects an overall improvement in digital confidence and capability, particularly in areas like content creation and pedagogical communication. **Conclusions:** The research’s structured approach, fostering institutional collaboration and phased integration of digital competencies, highlights an effective model for embedding AI and digital literacy in teacher education. Continuous assessments and feedback loops ensure its relevance across training stages, enabling educators to remain adaptive and responsive to new educational technologies. Ultimately, this model may serve as a blueprint for other regions and countries aiming to update and enhance their teacher training frameworks in response to digital transformation demands.

**Keywords:** digital literacy; AI literacy; professional development; curriculum development

## 1. Concept overview of the research “digital and AI literacy in teacher training”

### 1.1. Actual status

The topic of “digitalization” or “digital and AI literacy in teacher training” and the associated professional preparation of future teachers for teaching with digital media has played a central role in all phases of teacher training for several years [1]. As early as 2016, the federal states agreed on a binding framework for the socially significant “education in the digital world” [2]. However, with the outbreak of the

coronavirus pandemic in 2020 and the necessary switch to purely online teaching, the topic of “digitalization” and “digital and AI literacy in teacher training” has become even more important. In 2020, for example, the federal and state governments added the funding priority “digitalization in teacher training” to the “teacher training quality campaign” introduced in 2018. The federal and state governments are thus specifically funding researches that research the challenges and opportunities of digitalization and test approaches to how teachers can support children and young people in using media competently, purposefully and responsibly through targeted use in the classroom [3]. It is also clear from the further and continuing education programs within the second and third phases of teacher training that the topic of “digitalization” is increasingly becoming the focus of teacher training.

For more than two years now, the “Digital Education Consultancy in Bavaria (Germany)” has provided teachers in every district in Bavaria with specially trained teachers on the topic of “digital and AI literacy in teacher training”, who advise and support schools on media education and information technology. The media pedagogical advisors for digital education (mBdB) focus their activities on media pedagogical counselling and further training, while the activities of the information technology advisors for digital education (iBdB) focus on information technology counselling and further training. Additional contact persons are available in the district regions for special support programs in the field of digital education for teachers [4]. Universities, as training centers for the first phase of teacher training, have also been offering courses with a specific focus on digital education for students, and not just since the coronavirus pandemic. Although innovative digital teaching/learning concepts are presented in theory and practice in these courses, the specific framework conditions of the school locations cannot be taken into account and a certain, unrealistic optimum is usually assumed [5]. This emphasizes the need for increased exchange and networking between the first and second phases of teacher training.

## **1.2. Description of the research**

### **1.2.1. Overarching objective and measures**

The aim of this research is to professionally prepare student teachers in the first and second phases of teacher training for teaching with digital media and to provide teachers in the third phase of teacher training with further education and training in the field of digital education. To this end, it is necessary for all stakeholders in the three-phase teacher training program to be appropriately trained in the field of digital education on the one hand, and to work closely together and network with each other on the other. It is precisely this institutionalized cooperation between the universities with a focus on research and teacher training, the seminar rectors and schools that makes it possible to teach students innovative digital teaching/learning concepts in the courses. On the one hand, these concepts must be theoretically sound; on the other hand, students must be able to experience how these concepts can be applied in practice. This practical application could be demonstrated by means of school excursions, experiences of deputy teachers and internships, but should be reflected upon and critically categorized in accompanying seminar formats.

In order for an institutionalized cooperation between universities, seminar rectors and schools to take place, the secondment of suitable teachers as pedagogical staff is necessary, which is approved by the State Ministry of Education and Cultural Affairs [6]. In order to achieve the above-mentioned research objectives, the seconded teachers should be trained advisors in the field of “digital literacy in teacher education” on the one hand, and on the other hand they should be part-time seconded teachers, i.e. 50% of the seconded teachers should work at the university and 50% should continue to work at their schools. This division in particular allows theory and practice to be optimally combined and harmonized.

The detailed list of specific detailed objectives and the measures required to achieve them are listed in detail in a later section, where they are also explained in more detail.

### **1.2.2. Added value in relation to the actors**

All stakeholders in the three-phase teacher training program benefit from the implementation of the research. The institutionalized cooperation between universities, seminar rectors and schools ensure mutual insights into the training content and training methods of student teachers and trainee teachers and guarantees curricular coordination of the individual training phases. This cooperation also enables the latest findings from educational research to be incorporated into the network, while the feedback from practice is a valuable factor for research. For student teachers in the first phase of teacher training, the main advantage is that by attending the relevant courses, they become familiar with innovative and applicable digital teaching/learning concepts in a complexity-reduced form, which they can implement directly as trainee teachers in the second phase of teacher training. The added value for teachers already working in the teaching profession is that they receive targeted further and advanced training in the field of digital education that is tailored to the current educational situation and the associated needs of schools.

### **1.3. Realization of the research in three stages**

With regard to the overarching goal and the measures of the research and the associated added value for all stakeholders, the focus of the research implementation is on the one hand on strengthening the theory-practice link through close cooperation and networking between the stakeholders of the first and second phase of teacher training (university, seminar rectors, partially seconded teachers), and on the other hand on the targeted further education and training of teachers already working in the teaching profession in the field of digital education at schools (third phase of teacher training). The detailed objectives required for this, the measure(s) and resources required for realization and the resulting added value, divided into three stages, are presented below.

*In research stage 1*, the partially seconded teachers (digital education advisors) are familiarized with the university didactic offerings and the media infrastructure at the University of Passau, which should serve as a basis for their further professional work. This stage will focus primarily on teacher training phase I. The partially seconded teachers (digital education advisors) are to develop and implement course concepts that serve to impart skills related to the planning and implementation of

digitally supported teaching. The aim is, among other things, product-orientated courses in which students can practice and reflect on the use of digital media in complexity-reduced settings and create and publish digital teaching/learning materials (e.g. digital worksheets, H5P modules, course layouts, etc.). In addition, networking structures will be established and joint meetings with representatives of all teacher training phases will be organized. The aim of these networking structures is also to identify the need for support on the part of the participating schools. In research stage 1, the partially seconded teachers (digital education advisors) will also develop and pilot a module program for those involved in teacher training phase II (seminar leaders and trainee teachers).

**In research stage 2**, the partially seconded teachers (digital education advisors) will further develop and expand this module program, which for the first time will also include stakeholders from teacher training phase III. This module program will be piloted in research stage 2.

Finally, **research stage 3** extends the measures for (regional) teacher training and further education. Both stages build on the course formats designed in research stage 1 and should also be designed to be action- and product-orientated.

### **1.3.1. Detailed objective 1: Networking of all stakeholders involved in teacher training (research stages 1 to 3)**

**Detailed objective 1:** Institutionalized cooperation between the seminar rectors trained in the field of “digital and AI literacy in teacher training” and the partially seconded teachers (digital education advisors) with representatives of the University of Passau.

**Measure(s):** To realize the first detailed objective, starting with research stage 1, intensive and regular communication and exchange meetings will be held between the representatives of the University of Passau as well as the seminar rectors and the partially seconded teachers (digital education advisors). These meetings also serve to identify training needs and establish a cooperation network in which students can carry out and reflect on digitally supported teaching. This measure will be continued and intensified in research stages 2 and 3 in order to achieve continuity.

**Resource(s) required:** Regular time slots and communication opportunities must be found to establish a culture of communication. The DiLab innovation rooms presented above are available for these meetings.

**Added value:** The institutionalized cooperation between the representatives of the University of Passau, the seminar rectors and the partially seconded teachers (digital education advisors) ensures mutual insights into the training content and training methods of student teachers and trainee teachers and guarantees curricular coordination of the individual training phases. In addition, this cooperation enables the latest results from educational research to be incorporated into the network on the one hand, and on the other hand, the feedback from practice is a valuable factor for research.

### **1.3.2. Detailed objective 2: Further qualification of partially seconded teachers (digital education advisors) (research stage 1)**

**Detailed objective 2:** Regular organization of specific workshops for the further qualification of teachers on secondment (digital education advisors) in the area of “digital and AI literacy in teacher training”.

**Measure(s):** Development and organization of workshops for the further qualification of deputy teachers (digital education advisors) in the field of “digital and AI literacy in teacher training” by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces of middle childhood.

**Required resource(s):** Provision of spatial, technical and personnel resources for the implementation of the workshops by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces in middle childhood. This measure will focus on research stage 1, but will be continued in research stages 2 and 3 depending on the topic and occasion.

**Added value:** Through the further qualification of the partially seconded teachers (digital education advisors), the interlinking of theory and practice at the university can be accompanied and quality-assured so that students can introduce the corresponding teaching formats as part of their teacher training program. In addition, the partially seconded teachers (digital education advisors) can draw on the specialist resources of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces of middle childhood as multipliers in the development of further and continuing education programs for teacher training phases II and III.

### **1.3.3. Specific objective 3: Courses focusing on “digital and AI literacy in teacher training” (research stages 1 to 3)**

**Specific objective 3:** Development, further development and publication of courses focusing on “digital and AI literacy in teacher training” at the University of Passau.

**Measure(s):** Support for part-time teachers (digital Education advisors) in the design of relevant courses by representatives of the DiLab and the Chair of Educational Science specializing in diversity research and educational spaces in middle childhood.

**Required resource(s):** Provision of expertise as well as courses already held as a “template” by representatives of the DiLab and the Chair of Educational Science specializing in diversity research and educational spaces in middle childhood as well as access to the technical and spatial infrastructure of the DiLab innovation spaces. This measure will be continued and expanded in research stages 2 and 3.

**Added value:** For student teachers in the first phase of teacher training, the main advantage is that by attending the relevant courses, they can familiarize themselves with innovative digital teaching/learning concepts that have already been successfully applied in practice and benefit from the experience of partially seconded teachers (digital education advisors).

#### **1.3.4. Specific objective 4: Teaching/learning materials on the topic of “digital and AI literacy in teacher training” (research stages 1 to 3)**

**Detailed objective 4:** Development and publication of teaching/learning materials on the topic of “digital and AI literacy in teacher training” by the teachers (digital education advisors).

**Measure(s):** Development and publication of teaching/learning materials on the topic of “digital and AI literacy in teacher training” with student teachers as part of the courses held at the university since research stage 1. The materials will be published via the university’s OER platform (blog system).

**Required resource(s):** Provision of spatial, technical and, if necessary, personnel resources as well as know-how and already developed digital teaching/learning offers by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces of middle childhood as well as research results of SKILL.de.

**Added value:** For student teachers in the first phase of teacher training, the main advantage is that they can develop digital teaching/learning concepts together with the experienced part-time teachers (digital education advisors), which they can implement directly in their internships at selected model schools and as teacher candidates in the second phase of teacher training.

#### **1.3.5. Specific objective 5: School excursions and internships (levels 1 to 3)**

**Detailed objective 5:** Organization of excursions and internships to selected model schools, in particular schools of partially seconded teachers (digital education advisors).

**Measure(s):** Support and accompaniment of partially seconded teachers (digital education advisors) on excursions and internships to selected model schools, especially schools of partially seconded teachers (digital education advisors), by representatives of the Chair of Educational Science specializing in diversity research and educational spaces in middle childhood. This measure will be continued and further expanded and intensified in research stages 2 and 3.

**Resource(s) required:** Provision of expertise by the partially seconded teachers (Digital Education advisors), by representatives of the Chair of Educational Science specializing in diversity research and educational spaces in middle childhood and the schools of the partially seconded teachers.

**Added value:** For student teachers in the first phase of teacher training, the main advantage is that they get to know the theoretical content taught in the courses they attend in practice at the schools of the partially seconded teachers (digital education advisors) directly on site.

#### **1.3.6. Specific objective 6: Workshop programs for trainee teachers (levels 1 to 3)**

**Specific objective 6:** Development, further development and publication of specific workshop programs with a focus on “digital and AI literacy in teacher training”, including at the University of Passau for teacher trainees.

**Measure(s):** Development and organization of specific workshops for the further education and training of teacher trainees in the field of “digital and AI literacy in teacher training” by the partially seconded teachers (digital education consultants) and

representatives of the Chair of Educational Science with a focus on diversity research and educational spaces of middle childhood.

**Resource(s) required:** Provision of spatial, technical and, in some cases, personnel resources for the realization of the workshops by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces in middle childhood. This measure will be intensified in research stages 2 and 3 in order to achieve continuity.

**Added value:** The added value for trainee teachers lies in the fact that they receive further and advanced training in the field of digital education that is specifically tailored to the current educational situation and the associated needs of their schools.

### **1.3.7. Specific objective 7: Further education and training of seminar rectors (level 2 to 3)**

**Specific objective 7:** Regular organization of specific workshops for the further education and training of seminar rectors in the area of “digital and AI literacy in teacher training”.

**Measure(s):** Development and organization of specific workshops for the further education and training of seminar rectors in the field of “digital and AI literacy in teacher training” by the partially seconded teachers (digital education consultants) and representatives of the Chair of Educational Science with a focus on diversity research and educational spaces of middle childhood.

**Resource(s) required:** Provision of spatial, technical and, in some cases, personnel resources for the realization of the workshops by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces in middle childhood. This measure will be intensified in research stage 3 in order to achieve continuity.

**Added value:** The added value for headteachers lies in the fact that they receive further and advanced training in the field of digital education that is specifically tailored to the current educational situation and the associated needs of schools.

### **1.3.8. Specific objective 8: Digital teacher training (level 2 to 3)**

**Specific objective 8:** Digital teacher training in the form of hybrid further and continuing education programs with workshops at the University of Passau and e-learning programs in the area of “digital and AI literacy in teacher training” for teachers at schools as part of the third phase of teacher training.

**Measure(s):** Development and organization of hybrid further and continuing education offers with workshops and e-learning offers by the partially seconded teachers (digital education consultants). The workshops can take up, “remix” and further develop the teaching and learning materials developed in detailed objective 4 in order to be adapted to the needs of the respective schools.

**Resource(s) required:** Provision of spatial, technical and, in some cases, personnel resources as well as expertise for the implementation of workshops at the University of Passau; provision of existing online resources (e.g. OER platforms, mebis, learning platforms on the topic of media education in primary and secondary schools) by representatives of the DiLab and the Chair of Educational Science with a focus on diversity research and educational spaces in middle childhood.

**Added value:** The added value for teachers already working in the teaching profession is that they receive further and advanced training in the field of digital education that is specifically tailored to the current educational situation and the associated needs of schools.

### **1.3.9. Detailed objective 9: Evaluation measures (level 1 to 3)**

**Detailed objective 9:** Optimization, adaptation and further development of the research

**Measure(s):** Development and implementation of in-process evaluation measures starting with the first stage of research implementation. This measure will also be continued in research stages 2 and 3.

**Required resource(s):** Provision of expertise and human resources by representatives of the Chair of Educational Science specializing in diversity research and educational spaces in middle childhood.

**Added value:** The in-process evaluation ensures that deficits can be identified at an early stage and optimizations and adjustments can be carried out continuously and during ongoing development.

## **2. Research approach and methodological procedure**

The aim of the digital and AI literacy in teacher training” research is not only to develop and improve digital and media-related (teaching) skills among all stakeholders in the three phases of teacher training, but also to implement and consolidate the research measures in the long term.

The following research question and the sub-research questions derived from it are central to the evaluative accompanying research for the research “digital and AI literacy in teacher training”, which can relate to all actors in the three phases of teacher training.

### **Central research question:**

What are the characteristics of a cross-phase training program that aims to promote digital and AI literacy skills?

### **Partial research questions:**

- What is digital and AI literacy?
- What does digital and AI literacy mean in the different phases of teacher training?
- What structures are in place to promote digital and AI literacy in the various phases of teacher training?

### **2.1. Evaluation objects**

The research “digital and AI literacy in teacher training” is the object of the evaluation. This research is to be further developed and improved by incorporating the evaluation results. Another focus is on building and developing the skills of the intended users of the research.

### **2.2. Evaluation purpose**

With its partly summative and partly formative orientation, the present evaluation study has an insight, optimization, decision-making and legitimation function [7]. The



results are intended to ensure considerations on the further direction of the research process and findings on the continuation of the research and the measures developed.

### 2.3. Research process

The three-stage research process with the empirical methods and times used in each case is visualized in detail below.

#### **Preliminary study:**

- Development of a conceptual framework for understanding digital competence and its development opportunities for educational professionals.
- Literature research and document analysis.

#### **Design and development phase:**

Cycles of development, testing and evaluation of the didactic design:

- Trial cycle 1: Winter semester 2021/22 and summer semester 2022.
  - Written survey.
- Trial cycle 2: Winter semester 2022/23 and summer semester 2023.
  - Written survey.
- Trial cycle 3: Winter semester 2023/24.
  - Written survey.

#### **Evaluation phase:**

- Derivation of design principles for the promotion of digital competence among educational professionals.
- Consolidation of the results.

### 2.4. Design Based Research (DBR) as a research approach [4]

In order to best achieve the research objectives and answer the research questions satisfactorily, the research approach used was Design-Based Research, or DBR for short, according to [8] was chosen. This approach makes it possible to conceptualize the research theoretically, to test it in reality through testing, modification and evaluation, and to feed the findings back into the development process and, if necessary, to go through this cycle several times in an iterative process.

### 2.5. The evaluation instrument used

As can already be seen from the research process, data is collected at repeated points in time from different evaluation target groups. Online questionnaires tailored to the respective target group(s) are used as an evaluation tool. These are intended to record the situation of all actors in the three phases of teacher training (lecturers, deputies, digital education advisors, students, head teachers, seminar leaders, trainee teachers, teachers) before and after the digitalization measure. To this end, the questionnaire items are used to determine how the digitalization measure, in this case a multi-part module program on digital literacy, affects the further development of the participants' digital and media-related (teaching) skills.

The online questionnaire contains items for self-assessment with regard to the participants' already developed digital and media-related (teaching) competences with a 7-level response format (*strongly disagree* to *strongly agree*). To develop the questionnaire, the "digital competences" competence grid was used as a basis, which

analyzed various international framework and competence models for describing digital competences:

- the TPCK “Technological Pedagogical Content Knowledge”.
- the Norwegian “digital education” model.
- the Austrian digi.kompP model.
- the DIGCOMP framework of the EU Commission.
- the digital literacy model of the Joint Information Systems Committee (JISC).

The DIGCOMP framework and the digital literacy model of the Joint Information Systems Committee (JISC) were used as the basis for the development of the “digital competences” competence grid. For this reason, both are explained in more detail below.

The DIGCOMP framework distinguishes between the following six digital competences, which take into account the various aspects of teachers’ professional activities.

- 1) **Area 1: Professional engagement:** Use of digital media for communication, collaboration and professional development.
- 2) **Area 2: Digital resources:** Selection, creation and publication of digital resources.
- 3) **Area 3: Teaching and learning:** Planning and designing the use of digital media in teaching and learning.
- 4) **Area 4: Evaluation:** Use of digital technologies and strategies to improve performance assessment.
- 5) **Area 5: Learner orientation:** Use of digital media for differentiation and individualization as well as for the active involvement of learners.
- 6) **Area 6: Promoting learners’ digital competence:** Enable learners to use digital media creatively and responsibly for information, communication, content creation, wellbeing and problem solving.

The digital literacy model of the Joint Information Systems Committee (JISC) distinguishes the following seven digital skills:

- 1) **Media literacy:** Critically read and creatively produce academic and professional communications in a range of media.
- 2) **Communications and collaboration:** Participate in digital networks for learning and research.
- 3) **Career and identity management:** Manage digital reputation and online identity.
- 4) **ICT literacy:** Adopt, adapt and use digital devices, applications and services.
- 5) **Learning skills:** Study and learn effectively in technology rich environments, formal and informal.
- 6) **Digital scholarship:** Participate in emerging academic, professional and research practices that depend on digital systems.
- 7) **Information literacy:** Find, interpret, evaluate, manage and share information.

The dimension of media literacy, which covers both the area of media production and distribution as well as the critical, reflective use of digital media, was divided into two competences: Media literacy and media production. The competency grid

therefore comprises a total of eight dimensions or competency statements, which are reflected in the questionnaire and its items:

- 1) Information literacy.
- 2) Analyzing, reflecting (media literacy).
- 3) Digital production (media production).
- 4) Communication, collaboration.
- 5) Digital identity, career planning.
- 6) IT competence (ICT literacy).
- 7) Digital teaching (learning skills).
- 8) Digital scholarship.

In addition to the socio-demographic dimensions, the entire questionnaire is made up of the following eight dimensions (**Table 1**):

**Table 1.** Dimensions and items of the questionnaire.

<b>Dimension (= competence areas)</b>	<b>Items (= competence statements)</b>
Information literacy	6
Analysing, reflecting (media literacy)	6
Digital production (media production)	4
Communication, collaboration	5
Digital identity, career planning	6
IT competence (ICT literacy)	9
Digital teaching (learning skills)	7
Digital scholarship	7

In the following four tables, one item (= competence statement) per dimension (= competence area) per teacher training phase with the exemplary activities and indicators was selected as an example. [9,10] serves as the theoretical frame of reference in each case.

**All statements that were included in the final online questionnaire are listed below.**

***Dimension (1) Information literacy***

- I can name digital sources for obtaining specialized information (I).
- I can obtain digital information to prepare my teaching (II).
- I can assess the quality of the source of digital information (e.g., reliability, scientific quality, topicality, etc.) (II).
- I can comply with legal provisions when passing on information (e.g., copyright, right of use, licence terms) (II).
- I feel able to support others (colleagues, learners) in researching information online (III).
- I can support others (colleagues, learners) in complying with legal regulations when using digital information (III).

***Dimension (2) Analyzing, reflecting (media literacy)***

- I critically reflect on my own digital media usage behavior (media content, duration of use, locations, types of media, etc.) (I).

- I critically analyze information from digital media (e.g., who is providing this information, for what reason, with what aim) (I).
- I can critically scrutinize and reflect on the use of digital media in my own teaching on the basis of certain criteria (suitability of media, methods, content, teaching/learning objectives) (II).
- I can select suitable digital tools (e.g., ePortfolios, blogs etc.) for reflection (II).
- I feel able to guide and accompany others (colleagues, learners) in analyzing and reflecting on their media use (III).
- I am confident that I can guide and accompany others (colleagues, learners) in analyzing and reflecting on their learning process (e.g., learning objects, learning actions) (III).

**All statements that were included in the final online questionnaire are listed below.**

***Dimension (3) Digital production (media production)***

- I can describe different types of digital teaching and learning materials (e.g., WBTs, screencasts, podcasts, explanatory videos, simulations) (I).
- I can consciously use different design elements in the production of digital teaching/learning materials (e.g., color, font, images, music) (II).
- I can guide others (colleagues, learners) in the design of digital materials (III).
- I have the confidence to support others in the production of digital materials (III).

***Dimension (4) Communication, collaboration***

- I can identify potential problems and opportunities of online communication (I).
- I can communicate digitally with others (colleagues, learners) (II).
- I can react to problems with digitally mediated communication (II).
- I can guide others (colleagues, learners) to organize their digital communication with others (colleagues, learners) (III).
- I feel able to teach others (colleagues, learners) how to deal with problems of digital communication (III).

**All statements that were included in the final online questionnaire are listed below.**

***Dimension (5) Digital identity, career planning***

- I can describe how websites/blogs can be used to present one's own scientific activities (I).
- I know the possibilities of alternative, digital proof of competence (e.g., badges, certificates) (I).
- I can appropriately present my own identity as a scientist in social networks (II).
- I can operate my own website/blog to present my scientific activities (II).
- I acquire digital proof of competence (e.g., badges, certificates) to establish my digital identity (II).
- I trust myself to guide others (colleagues, learners) in implementing suitable measures to protect my digital self (III).

***Dimension (6) IT competence (ICT literacy)***

- I can describe several functions of a learning platform (I).

- I can describe several functions of typical Web 2.0 tools (e.g., social networks, blogs, wikis, forums) (I).
- I can use various Web 2.0 tools (e.g., social networks, blogs, wikis, forums) (II).
- I can use the tools of a learning platform from the learner's perspective (e.g., forum, e-mail, uploading and downloading files) (II).
- I can use learning platforms to support my courses (e.g., create a course structure, set up a forum, upload files, contact students, create groups, create online tests) (II).
- I have the confidence to instruct others (colleagues, learners) in the use of Web 2.0 tools (using blogs, wikis, forums, social networks) (III).
- I feel able to instruct others (colleagues, learners) in the use of learning platforms (III).
- I feel able to guide others (colleagues, learners) in the use of authoring tools for the production of digital materials (III).
- I can instruct others (colleagues, learners) to take measures to protect their digital data (III).

**All statements that were included in the final online questionnaire are listed below.**

***Dimension (7) Digital teaching (learning skills)***

- I can explain terms and abbreviations relating to eLearning (I).
- I can describe different media and their characteristics (e.g., chat as a synchronous medium) (I).
- I can design and implement online or blended learning scenarios (content, methods, social forms, media) (II).
- I can practically apply my knowledge of eLearning scenarios and their added value in my teaching/studies (II).
- I can consider important planning aspects for the conception of eLearning scenarios (target group analysis, framework conditions) (II).
- I have the confidence to guide the conception of media-supported teaching-learning settings (III).
- I feel able to advise others (colleagues, learners) in the implementation of media-supported teaching-learning settings (III).

***Dimension (8) Digital scholarship***

- I can name the added value of digital tools for data collection (I).
- I can name the added value of digital tools for analyzing research data (I).
- I can describe the benefits of digital publishing options (e.g., open access) (I).
- I use digital tools to collect and analyze research data (e.g., online questionnaires, statistics programs, visualization software) (II).
- I use digital media to publish my research results (e.g., open access, e-journals, working papers) (II).
- I use digital tools to document my research process (e.g., science blog) (II).
- I can guide others (colleagues, learners) in the use of digital tools for data collection and data analysis (III).

### **3. Development of a four-part module series for the research “digital and AI literacy in teacher training”**

The four-part module series consists of four thematic blocks with specific focal points. The aim of the module series is to develop or improve participants’ digital and media-related (teaching) skills based on the six competence areas of DigCompEdu Bavaria. The individual modules are implemented in self-study format (Module 1) and in inverted or flipped classroom format (Modules 2, 3 and 4). For the participants, inverted or flipped classroom means that they are each given a preparatory task that they work on in self-study using the scripts, video tutorials, websites, specialist literature, etc. provided. The corresponding attendance days are used for joint in-depth study. The inverted or flipped classroom variant has the advantage that the participants have the same prior knowledge on the attendance day and can begin with the in-depth study. To secure the results, a separate online course was created on the mebis learning platform, on which the blog posts and the teaching material developed (teaching concepts, learning videos, e-books, etc.) as well as the reflections and peer feedback from the modules are collected.

At the end of the third year of the research, the switch was made to a mebis teach SHARE course so that it could be made available to all interested seminar leaders in the long term.

A total of four modules were developed, which are explained in more detail below and build on each other. Modules 1 and 2 are the theoretical foundation modules, while Modules 3 and 4 are the advanced specialization modules. These serve the targeted transfer of theoretical knowledge into practice.

#### **3.1. Module 1: Basics: Constructive alignment—teaching, learning and assessment from a single source**

This module provides an introduction to the framework model of testing, constructive alignment and an introduction to digital literacy-based teaching. Participants will also learn about various examples of digital literacy-based teaching in the sense of constructive alignment that have already been used in practice for different teaching topics and will critically and reflectively justify the suitability for their own type of school with advantages and disadvantages and implementation options. In addition, the participants are given the task of designing their own example of digital literacy-based teaching in the sense of constructive alignment for a specific teaching example based on the CurriculumPLUS, either alone or in a group, and giving each other feedback.

**Tasks:** The participants’ first task is to familiarize themselves with the framework model of testing, constructive alignment and the model of media competence or “digital literacy”. For this purpose, they are provided with specific materials in the form of literature, websites, vodcasts, podcasts, etc. on the accompanying platform, which they should use to describe constructive alignment and digital literacy in their own words and critically and reflectively justify the fit for their own type of school with advantages and disadvantages and implementation options. The participants

record their results in the form of a short audio contribution or a learning video on the online platform and give themselves constructive feedback.

Participants will then familiarize themselves with various examples of digital literacy-based teaching in the sense of constructive alignment on different teaching topics that have already been used in practice and will evaluate these critically and reflectively on the basis of defined criteria with regard to motivating and active use from the learner's perspective. Participants will then discuss the implementation of constructive alignment and digital literacy in the classroom as a group. The participants record their results in the form of a forum entry on the online platform and give each other constructive feedback.

### **3.2. Module 2: Digital learning culture or learning culture(s) of digitality: Digital and AI literacy means utilizing the potential of digital technologies didactically**

In this module, participants learn about various digital tools in the areas of communication, collaboration, interaction, presentation and AI (including WBTs, blogs, websites, apps, screencasts, podcasts, explanatory videos, simulations) for designing digital and AI literacy-based lessons in the sense of constructive alignment with the respective advantages and disadvantages and evaluate these digital tools critically and reflectively on the basis of defined criteria with regard to motivating and active use from the learner's perspective. Participants select a digital tool and create a short explanatory video on the use of their chosen digital tool based on a specific application in the classroom and give themselves constructive peer feedback.

**Tasks:** On the accompanying platform, participants receive a list of links to digital tools with detailed descriptions and explanations of how they can be used in the classroom.

The task of the participants is to try out the various tools and to critically and reflectively justify the suitability for their own type of school with advantages and disadvantages and implementation options. To this end, the participants create a short explanatory video on the use of their chosen digital tool based on a specific application in the classroom. Participants record their results on the online platform and receive constructive feedback.

The participants are then given a second task: To watch a video created by a primary school pupil to present the book "Keiner gruselt sich vor Gustav" using the green screen method and then to discuss the appropriate didactic implementation with regard to constructive alignment and digital literacy. The participants record their results in the form of a forum entry on the online platform and give each other constructive feedback.

### **3.3. Module 3: Digital learning culture in the classroom or transformations of digital learning culture(s): Using constructive alignment, digital and AI literacy and digital media in specialized teaching**

In this module, participants learn how to use constructive alignment, digital and AI literacy and digital media in subject lessons and how to use them in their own lessons.

*Tasks:* Participants are first given the task of creating a digital learning environment with a tool of their choice for a specific teaching subject and for a specific teaching topic that they are currently dealing with in their traineeship. This digital learning environment must be based on constructive alignment (see Module 1) and must also include various digital tools for communication, collaboration, interaction, presentation, AI, etc. (see Module 2). The participants should actively use this learning environment they have created in their lessons and present their experiences (= teaching results) to their colleagues by creating a short presentation video. The participants record their results in the form of a forum entry on the online platform and give each other constructive feedback.

The participants are then given a second task: To discuss the learning environments they use in their lessons. The participants record their results in the form of a forum entry on the online platform and give each other constructive feedback.

### **3.4. Module 4: Reflection or future skills and learning spaces: Facing the changes brought about by digital transformation didactically**

This module not only shows participants how technical subjects are changing as a result of digital transformation, but also how they can respond to these changes didactically. To this end, participants learn which future skills and which new digital professional competence requirements they will need in the future and how they can acquire them by reflecting specifically on their experiences in Modules 1 to 3.

As a central task, the participants should reflect once again on their experiences in the creation and practical use of their digital learning environment (Module 3) and present their thoughts/findings to their colleagues by creating a podcast. The participants record these results in the form of a forum entry on the online platform and give each other constructive feedback.

### **3.5. Competence expectations after attending the multi-part module program**

After the entire four-part module program, participants will have the following skills based on the skills grid according to [9] and the DigCompEdu Bavaria (Table 2).



**Table 2.** Competence grid “digital competences” with references to the individual competence areas and the sub-competences in “DigCompEdu Bavaria”.

<b>“Digital skills” competence grid</b>		
<b>Items = competence statements</b>	<b>Measures implemented</b>	<b>Indicators for the achievement of competences</b>
<b>Dimension = competence area (1) Information literacy</b>		
<b>Dimension = competence areas with the associated sub-competences in DigCompEdu Bavaria</b>		
2. digital resources with the sub-competences		
2.1 Selecting digital resources and		
2.3 Organizing, protecting and sharing digital resources		
5. learner orientation		
5.1 Digital participation		
5.2 Differentiation and individualization		
Active involvement of learners		
6. promoting the digital competence of learners with the sub-competences		
6.1 Information and media skills		
6.4 Responsible use of digital media		
6.5 Digital problem solving		
<b>Teacher training phase</b>	<b>Activities</b>	<b>Indicators</b>
<b>Teacher training phase I</b>	Learners familiarize themselves with digital sources (online search engines, online portals, digital libraries, etc.) and formulate suitable search strategies.	Learners search for predefined terms using suitable search strategies and record their results in a blog post
I can name digital sources for obtaining specialized information.		
<b>Teacher training phase II</b>	Learners evaluate the credibility and reliability of digital sources and resources and consider possible limitations in their use.	Learners receive digital sources and resources and have to evaluate them in terms of credibility, reliability and possible restrictions on use in a blog post.
I can assess the source of digital information in terms of its quality (e.g. reliability, scientific nature, topicality, etc.).		
<b>Dimension = competence area (2) Analyzing, reflecting (data literacy)</b>		
<b>Dimension = competence areas with the associated sub-competences in DigCompEdu Bavaria</b>		
1. professional commitment		
1.1 Professional communication		
1.2 Professional co-operation		
1.3 Reflective practice		
2. digital resources		
2.1 Selecting digital resources		
2.3 Organizing, protecting and sharing digital resources		
3. teaching and learning		
3.1 Gauges		
3.2 Learning support		
3.3 Collaborative learning		
Self-directed learning		
4. evaluation		
4.1 Assessing the learning status		
4.2 Analyzing learning evidence		
4.3 Feedback and planning		
5. learner orientation		
5.1 Digital participation		
5.2 Differentiation and individualization		
5.3 Active involvement of learners		
6. promoting the digital competences of learners		
6.1 Information and media skills		
6.2 Digital communication and collaboration		
6.4 Responsible use of digital media		
6.5 Digital problem solving		

**Table 2. (Continued).**

<b>“Digital skills” competence grid</b>		
<b>Items = competence statements</b>	<b>Measures implemented</b>	<b>Indicators for the achievement of competences</b>
<b>Teacher training phase</b>		
<b>Teacher training phase I</b>		
I critically reflect on my own digital media usage behaviour (media content, duration of use, locations, types of media, etc.).	<b>Activities</b> Learners carry out critical reflections on their own digitally supported pedagogical activities. Learners become familiar with digital tools for developing digital literacy-based teaching,	<b>Indicators</b> Learners receive specific work assignments for critical self-reflection, which they record in the form of a blog post on the online platform.
<b>Teacher training phase II</b>		
I can critically scrutinize and reflect on the use of digital tools in my own teaching on the basis of certain criteria (suitability of media, methods, content, teaching/learning objectives).	including their advantages and disadvantages, and evaluate these digital tools critically and reflectively on the basis of defined criteria.	Learners present their results in groups, give each other written peer feedback on the presentations based on predefined feedback rules and also record them on the online platform.
<b>Competence grid “digital competences” (Theoretical reference: DigCompEdu Bavaria)</b>		
<b>Items = competence statements</b>	<b>Measures implemented</b>	<b>Indicators for the achievement of competences</b>
<b>Dimension = competence area (3) Digital production (media production)</b>		
<b>Dimension = competence areas with the associated sub-competences in DigCompEdu Bavaria)</b>		
1. professional commitment		
1.1 Professional communication		
1.2 Professional co-operation		
1.3 Reflective practice		
2. digital resources		
2.1 Selecting digital resources		
2.2 Creating and customizing digital resources		
2.3 Organizing, protecting and sharing digital resources		
3. teaching and learning		
3.1 Gauges		
3.2 Learning support		
3.3 Collaborative learning		
3.4 Self-directed learning		
4. evaluation		
4.1 Assessing the learning status		
4.2 Analyzing learning evidence		
4.3 Feedback and planning		
6. promoting the digital competences of learners		
6.1 Information and media skills		
6.2 Digital communication and collaboration		
6.3 Creation of digital content		
6.4 Responsible use of digital media		
6.5 Digital problem solving		
<b>Teacher training phase</b>		
<b>Teacher training phase I</b>		
I can describe different types of digital teaching/learning materials (e.g. WBTs, blogs, websites, apps, screencasts, podcasts, explanatory videos, simulations).	<b>Activities</b> Learners get to know digital tools for developing digital teaching/learning materials with their respective advantages and disadvantages.	<b>Indicators</b> Learners evaluate these digital tools on the basis of defined criteria with regard to motivating and active use from the learner’s perspective, which they record in the form of a blog post on the online platform.
<b>Teacher training phase II</b>		
I can consciously use different design elements (e.g. colour, font, images, music) in the production of digital teaching/learning materials.	Students create digital teaching/learning materials for the design of digital literacy-based lessons, taking into account formal and aesthetic design principles and intended effects in group work.	Learners use digital tools to create digital teaching/learning materials for the design of digital literacy-based lessons, taking into account formal and aesthetic design principles and intended effects for a specific lesson example based on the LehrplanPLUS and record the results in a blog post.
<b>Teacher training phase III</b>		
I can guide others (colleagues, learners) in the design of digital materials.	Learners give each other peer feedback on the teaching/learning materials created.	Learners then give each other written peer feedback on the teaching/learning materials created on the online platform.

**Table 2. (Continued).**

<b>“Digital skills” competence grid</b>		
<b>Items = competence statements</b>	<b>Measures implemented</b>	<b>Indicators for the achievement of competences</b>
<b>Competence grid “digital competences” (Theoretical reference: DigCompEdu Bavaria)</b>		
<b>Items = competence statements</b>	<b>Measures implemented</b>	<b>Indicators for the achievement of competences</b>
<b>Dimension = competence area (4) Communication, collaboration</b>		
<b>Dimension = competence areas with the associated sub-competences in DigCompEdu Bavaria</b>		
1. professional commitment		
1.1 Professional communication		
1.2 Professional co-operation		
1.3 Reflective practice		
2. digital resources		
2.1 Selecting digital resources		
2.2 Creating and customizing digital resources		
2.3 Organizing, protecting and sharing digital resources		
3. teaching and learning		
3.1 Gauges		
3.2 Learning support		
3.3 Collaborative learning		
3.4 Self-directed learning		
4. evaluation		
4.1 Assessing the learning status		
4.2 Analyzing learning evidence		
4.3 Feedback and planning		
6. promoting the digital competences of learners		
6.1 Information and media skills		
6.2 Digital communication and collaboration		
6.3 Creation of digital content		
6.4 Responsible use of digital media		
6.5 Digital problem solving		
<b>Teacher training phase</b>	<b>Activities</b>	<b>Indicators</b>
<b>Teacher training phase I</b> I can identify potential problems and opportunities in online communication.	Learners learn about the various options for online communication (chat, email, forum, video conferencing, etc.) and their advantages and disadvantages.	Learners evaluate these digital communication tools on the basis of defined criteria with regard to motivating and active use from the learner’s perspective, which they record in the form of a blog post on the online platform.
<b>Teacher training phase II</b> I can communicate digitally with others (colleagues, learners)	Learners select suitable digital communication tools for designing digital literacy-based lessons in the sense of constructive alignment	Learners design a concrete teaching example and teaching materials for the design of a digital literacy-based lesson in the sense of constructive alignment based on the CurriculumPLUS, in which various possibilities of online communication are specifically used in the classroom and record the results in a blog post.
<b>Teacher training phase III</b> I can guide others (colleagues, learners) to organize their digital communication with others (colleagues, learners)	Learners give peer feedback on the selected means of communication	Learners give each other written peer feedback on the results presented to each other

#### 4. Research implementation and results in the individual test cycles

The online survey was conducted in the form of a before/after survey as part of the module program offered. The reason for the before/after survey was to evaluate how corresponding seminar/module programs in teacher training affect the development of digital and media-related (teaching) skills and thus to be able to adapt and further develop seminar/module programs accordingly.

In order to be able to compare the changes in the individual competence areas resulting from participation in the module program, the competence scales are analyzed graphically using box plots. The X-axis of the graphs contains all variables assigned to the scale, the Y-axis the values (Likert scale) from 1 to 7 (1 = not at all true, 2 = not true, 3 = somewhat not true, 4 = neither true, 5 = somewhat true, 6 = somewhat true, 7 = completely true). The median (center of the distribution) is marked with a line within a box (covers the area in which 50 % of the data lies); the symmetry

of the distribution can be seen here. The whiskers (“whiskers”, i.e., the lines on the box) represent the values outside the box (limited to 1.5 times the interquartile range), all values outside the box are marked as points (outliers).

When analyzing the before/after survey, the area within the box (50%) and the median are considered in each case by comparing the results of the two surveys by comparing the respective box plots.

#### 4.1. Trial cycle 1—winter semester 2021/22 to summer semester 2022

##### 4.1.1. Methodological documentation and evaluation of the results of the first trial cycle

At the first survey date and therefore before the four-part module series, 19 trainee teachers took part. Only one questionnaire was cancelled. All other questionnaires were completed to the end. After review, the questions appeared to have been answered “seriously”, i.e. there were no missing or inappropriate answers, e.g. in the year of birth.

If not already done by the questionnaire program, the variables were first given an appropriate label according to the codebook (Appendix).

All new variable names (content-matching variable names instead of numerically consecutive designations) of the codebook were applied (Appendix).

The variables for browser and processing time have been deleted as they do not appear in the codebook (Appendix).

##### **Presentation of the evaluation of the results of the first trial cycle of the before/after survey in the period from the winter semester 2021/22 to the summer semester 2022**

At the first survey date and therefore before the four-part module program, 19 trainee teachers took part. Of the 19 participants, 13 were female and six were male. At the second survey point, and thus after the four-part module program, only eleven of the 19 trainee teachers were still taking part. Of the eleven participants, six were female and five were male (see **Table 3** and **Table 4**).

**Table 3.** Mother’s highest school-leaving qualification.

	Frequency	Percent	Valid percentages	Cumulative percentages
Valid				
Secondary school leaving certificate	5	16.7	16.7	16.7
Secondary school leaving certificate	7	23.3	23.3	40.0
High school diploma/Abitur/Matura	3	10.0	10.0	50.0
Apprenticeship/skilled worker qualification	5	16.7	16.7	66.7
Master craftsman qualification/master craftsman examination	2	6.7	6.7	73.3
Technical college/technical school/trade academy	4	13.3	13.3	86.7
University	4	13.3	13.3	100.0
Total	30	100.0	100.0	

**Table 4.** Father’s highest school-leaving qualification.

	Frequency	Percent	Valid percentages	Cumulative percentages
Secondary school leaving certificate	5	16.7	16.7	16.7
Secondary school leaving certificate	7	23.3	23.3	40.0
Apprenticeship/skilled worker qualification	2	6.7	6.7	46.7
Master craftsman qualification/master craftsman examination	3	10.0	10.0	56.7
Valid Technical college/technical school/commercial academy	3	10.0	10.0	66.7
University	6	20.0	20.0	86.7
Technical University (TH)	2	6.7	6.7	93.3
Promotion	2	6.7	6.7	100.0
Total	30	100.0	100.0	

All eight areas of competence are analyzed individually below. The mean values, standard deviations and standard errors of the mean value before and after the four-part module series are listed in tabular form.

**Category I: Information literacy (IK)** (see **Table 5**)

**Table 5.** Mean values before and after the four-part module series for the trainee teachers on information literacy (IK). The differences in this area are not significant for the LAAs.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
IK01	before	5.47	1.219	0.289
	to	5.09	1.868	0.563
IK02	before	5.79	1.084	0.249
	to	5.64	1.689	0.509
IK03	before	5.58	1.071	0.246
	to	5.09	1.578	0.476
IK04	before	4.53	1.504	0.345
	to	5.18	1.834	0.553
IK05	before	5.11	1.595	0.366
	to	4.73	1.618	0.488
IK06	before	3.89	1.595	0.366
	to	4.73	1.737	0.524

**Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series**

Overall, it can be said for this competence area that the increase in competence is heterogeneous depending on the category surveyed. There is a one-off change (increase by one level IK 06), but in some cases the competence is assessed as unchanged. In some cases, self-assessments are also lower than before the module visits (IK 01 and IK 03). Overall, however, the self-assessed information literacy before the module visits is for the most part at the same level as before the module

visits (IK 02, IK 04 and IK 05). However, this result can be attributed to the fact that scientific work was not part of the module content. It was assumed that the participants had already been extensively confronted with scientific work during their studies and had acquired the relevant skills there. However, the result shows that it is necessary to offer corresponding content in the individual modules in order to specifically promote this area of expertise.

**Category II: Analyzing, reflecting (media literacy) (ML)** (see Table 6)

**Table 6.** Mean values before and after the survey for the teacher trainees on Analyzing, Reflecting (Media Literacy) (ML). The differences in this area are only significant in one category (ML05); differences in the other areas of competence are not significant.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
ML01	before	4.95	0.911	0.209
	to	5.27	1.489	0.449
ML02	before	5.42	1.427	0.327
	to	5.36	1.690	0.509
ML03	before	5.32	0.885	0.203
	to	5.18	1.601	0.483
ML04	before	4.11	1.150	0.264
	to	4.27	1.849	0.557
ML05*	before	0.368	1.336	0.306
	to	5.00	1.549	0.467
ML06	before	3.54	1.467	0.337
	to	4.64	1.629	0.491

\*  $p < 0.005$ .

**Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series**

Increases can be seen in more categories here, the picture is somewhat more homogeneous than in the previous competence area of information literacy. For item “Analyzing, reflecting” ML02, there is a drop in the self-assessed competence of trainee teachers (although not significant) for item ML02. For item ML01, the self-assessed competence remains the same. Increases were recorded for all other items (ML03 to ML 06).

**Category III: Digital production (Media production) (MP)** (see Table 7)

**Table 7.** Mean values before and after the survey for trainee teachers on digital production (media production) (MP). The differences in this area are not significant.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
MP01	before	4.53	1.429	0.328
	to	5.00	2.145	0.647
MP02	before	5.37	1.383	0.317
	to	5.55	1.635	0.493
MP03	before	4.32	1.416	0.325
	to	4.36	2.014	0.607
MP04	before	3.89	1.729	0.397
	to	4.36	1.963	0.592

***Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series***

The trainee teachers do not rate the increase as high; only for item MP04 do the trainee teachers now rate their competence higher. However, this increase is not significant. However, there is also no deterioration as in the previous categories.

**Category IV: Communication, Collaboration (KK)** (see **Table 8**)

**Table 8.** Mean values before and after the survey for trainee teachers on communication, collaboration (KK). The differences in this area are not significant except for the K02 category.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
KK01	before	5.32	0.946	0.217
	to	4.55	2.115	0.638
KK02*	before	6.63	0.597	0.137
	to	5.64	1.690	0.509
KK03	before	5.32	1.108	0.254
	to	5.00	1.549	0.467
KK04	before	5.42	1.261	0.289
	to	4.27	2.054	0.619
KK05	before	4.79	1.398	0.321
	to	4.73	1.679	0.506

\* =  $p < 0.005$ .

***Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series***

The teacher trainees assess their competence before and after the modules in the same way; only for item KK02 does the self-assessed competence drop by one level (significant change).

**Category V: Digital identity, career planning** (see **Table 9**)

**Table 9.** Mean values before and after the survey for trainee teachers on digital identity, career planning (DIK). The differences in this area are not significant except for the DIK03 category.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DIK01	before	3.79	1.512	0.347
	to	3.73	1.794	0.541
DIK02	before	3.42	1.805	0.414
	to	3.45	1.753	0.529
DIK03+	before	3.16	1.302	0.299
	to	4.73	1.849	0.557
DIK04	before	2.68	1.668	0.383
	to	3.45	1.809	0.545
DIK05	before	2.95	1.433	0.329
	to	3.09	1.814	0.547
DIK06	before	2.95	1.311	0.301
	to	3.36	1.963	0.592

+ =  $p < 0.05$ .

***Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series***

The greatest changes observed to date are in this category (in some cases more than 2 levels difference). No deteriorations are estimated, only the trainee teachers remain at the same level as before the four-part module series for the items DIK06 and DIK01. However, it should be specifically noted here that this competence category is not included as a focus or specifically promoted in any of the modules, but is merely addressed.

**Category VI: IT competence (ICT literacy) (ICT) (see Table 10)**

**Table 10.** Mean values before and after the survey for trainee teachers on IT competence (ICT literacy) (ICT). The differences in this area are not significant for the trainee teachers.

Category	Time of survey	Mean value	Standard deviation	Standard error of the mean
ICT01	before	4.89	1.729	0.397
	to	5.09	2.166	0.653
ICT02	before	5.11	1.595	0.366
	to	4.91	1.868	0.563
ICT03	before	5.21	1.548	0.355
	to	4.91	1.868	0.563
ICT04	before	5.68	1.493	0.342
	to	4.73	2.005	0.604
ICT05	before	5.21	1.548	0.355
	to	4.73	2.195	0.662



**Table 10.** (Continued).

Category	Time of survey	Mean value	Standard deviation	Standard error of the mean
ICT06	before	4.53	1.541	0.353
	to	3.91	1.973	0.595
ICT07	before	4.58	1.677	0.385
	to	3.91	1.921	0.579
ICT08	before	3.63	1.802	0.413
	to	3.55	1.753	0.529
ICT09	before	3.95	1.545	0.354
	to	3.91	1.921	0.579

**Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series**

In this competence area, the trainee teachers only rate themselves as one level more competent than before in one category (ICT01). The trainee teachers did not perceive any change in their competence in five items (ICT 09, 06, 05, 03 and 02). For three items, they even rated themselves as less competent after participating in the module than before participating in the module (ICT08, 07, 04). However, none of the differences in the group of trainee teachers are significant. However, the four modules specifically promoted the ICT competence area for this competence area in particular. This makes it all the more important to continue to specifically address and promote this area of competence in the modules.

**Category VII: Digital teaching (learning skills) (LS)** (see Table 11)

**Table 11.** Mean values before and after the survey for trainee teachers on digital teaching (learning skills) (LS). The differences in this area are not significant for the trainee teachers.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
LS01	before	3.89	1.370	0.314
	to	3.91	1.640	0.495
LS02	before	4.26	1.759	0.404
	to	4.09	1.446	0.436
LS03	before	3.79	1.584	0.363
	to	3.91	1.814	0.547
LS04	before	3.74	1.821	0.418
	to	3.91	1.578	0.476
LS05	before	3.58	1.610	0.369
	to	3.64	1.629	0.491
LS06	before	3.21	1.751	0.402
	to	3.09	1.446	0.436
LS07	before	3.11	1.629	0.374
	to	3.00	1.483	0.447

***Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series***

Trainee teachers show a more heterogeneous picture of self-assessment in this category: For three items (LS01, LS05, LS07) they perceive no change, for items LS04 and LS03 the trainee teachers perceive an increase and for items LS06 and LS02 even a decrease by one level. However, none of the differences for the trainee teachers are significant.

**Category VIII: Digital scholarship (DS) (see Table 12)**

**Table 12.** Mean values before and after the survey for trainee teachers on digital scholarship (DS). The differences in this area are not significant except for the DS05 category.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DS01	before	3.89	1.560	0.358
	to	4.18	1.537	0.464
DS02	before	3.68	1.493	0.342
	to	4.18	1.537	0.464
DS03	before	3.53	1.611	0.370
	to	3.64	1.629	0.491
DS04	before	2.58	1.774	0.407
	to	3.45	1.968	0.593
DS05+	before	1.84	1.259	0.289
	to	3.64	2.063	0.622
DS06	before	1.84	1.259	0.289
	to	2.82	1.991	0.600
DS07	Before	2.16	1.708	0.392
	to	3.09	1.868	0.563

***Summary and interpretation of the evaluation results, including the reflection round at the end of the four-part module series***

In this competence area, the teacher trainees report greater increases in competence (e.g. category DS07). For four items, the trainee teachers feel more competent after participating in the module than before (DS04, DS05, DS06, DS07). However, the difference is only significant for DS05. No item was perceived to be less competent than before and no increase in competence was perceived for three items (DS01, DS02, DS03). Competence level 1 was retained for two items (DS05 and DS06). It should again be noted here that this result can be attributed to the fact that the modules did not originally include any involvement with scientific work. The result thus shows once again that it is necessary to include appropriate content in which this area of competence is specifically promoted.

**4.1.2. Summary and conclusions for test cycle 2**

In the first trial cycle, the analyses of the self-assessments from the online questionnaires show a very heterogeneous picture overall. For example, the self-

assessed competence in Category I: Information literacy (IK) among the teacher trainees before the module series is largely at the same level as before participating in the four-part module series. In Category II: Analyzing, reflecting (media literacy) (ML), more items show increases, the picture is somewhat more homogeneous than in the previous competence area of information literacy. In Category III: Producing digitally (Media production) (MP), the growth is also not rated very highly by the teacher trainees. Only in one item (MP04) do the trainee teachers rate their competence higher. In Category IV: Communication, Collaboration (KK), the teacher trainees also rate their competence before and after participating in the module in the same way; only in one item does the self-assessed competence drop by one level (KK02). In category V: Digital identity, career planning (DIK), the biggest changes observed to date (in some cases a difference of more than two levels). No deteriorations are estimated, only two items of the trainee teachers remain at the same level as before the four-part module series. However, it should be specifically noted here that this competence category is not included as a focus or specifically promoted in any of the modules, but is merely addressed. In category VI: IT competence (ICT literacy) (ICT), the trainee teachers perceive no change in their competences for five items (ICT 09, 06, 05, 03 and 02). For three items, they even rated themselves as less competent after participating in the module than before participating in the module (ICT08, 07, 04). However, none of the differences in the group of trainee teachers are significant. However, the four modules specifically promoted the ICT competence area for this competence area. This makes it all the more important to continue to specifically address this area of competence in the modules and to promote it even more intensively. In category VII: Digital teaching (learning skills) (LS), the teacher trainees again show a more heterogeneous picture of their self-assessment: For three items (LS01, LS05, LS07) they perceive no change, for two items (LS04 and LS03) there is an increase and for a further two items (LS06 and LS02) there is even a decrease of one level. In the competence area of category VIII: Digital scholarship (DS), the trainee teachers report greater increases in competence (e.g. item DS07). For four items, the trainee teachers feel more competent after participating in the module than before (DS04, DS05, DS06, DS07). However, the difference is only significant for DS05. No item was perceived to be less competent than before and no increase in competence was perceived for three items (DS01, DS02, DS03). Competence level 1 was retained for two items (DS05 and DS06).

The analyses of the self-assessments from the online surveys suggest that it is important to specifically integrate scientific work into the modules in test cycle 2 in order to specifically promote this area of competence.

#### **4.2. Trial cycle 2—winter semester 2022/23 to summer semester 2023**

In the second year of the research, trainee teachers from primary and secondary schools took part in the module program. The face-to-face seminar days always took place on Tuesdays and Fridays with the primary school trainee teachers and the trainee teachers alternately. Starting in winter semester 2022/23, primary school education students from the Chair of Educational Science with a focus on diversity research and educational spaces in middle childhood as well as teachers already working in practice

from the “digital education advisor” network also took part as part of mixed matching. The aim is to ensure that the participants support each other with their different expertise and learn/benefit from each other.

The wishes of the seminar leaders for competence area 1 Information literacy, which corresponds to sub-competence area 6.2 Searching and processing in DigCompEdu Bavaria, as well as the results of the self-assessments from the online questionnaires of the participating teacher trainees were also taken into account and the module series was adapted or expanded accordingly. This is because it has been shown, particularly in competence area 1 information literacy, that a targeted inclusion of this content is necessary in order to specifically build and expand competences here. Due to the new composition of the group of participants (student teachers, trainee teachers and teachers already working in the field), adjustments have been made to the content, particularly with regard to the group tasks. The aim is for all three groups to be able to contribute their specific expertise.

#### 4.2.1. Methodological documentation and evaluation of the results of the second test cycle

Ten trainee teachers took part in the first survey and thus before the four-part module program. Of the ten participants, five were female and five were male. At the second survey point, after the four-part module program, seven more trainee teachers suddenly took part, making a total of 17 trainee teachers. Of the 17 participants, twelve were female, three were male and two were diverse.

Due to the quality of the data, it is not entirely clear how serious the answers were. The fact that all competences deteriorated after participating in the module cannot be explained by a heightened perception and improved awareness of the problem. This was clarified through a targeted debriefing with the implementers and is summarized in chapter 4.2.3 Summary and conclusions for test cycle 3.

All eight areas of competence are analyzed individually below. The mean values, standard deviations and standard errors of the mean value before and after the four-part module series are listed in tabular form.

##### Category I: Information literacy (IK) (see Table 13)

**Table 13.** The mean values before and after for the trainee teachers are shown below. The differences in this area are non-significant for IK01 and IK03 and significant for IK02, IK04, IK05 and IK06.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
IK01	before	6.10	0.568	0.189
	to	5.35	1.412	0.342
IK02*	before	6.50	0.527	0.395
	to	5.18	1.629	0.149
IK03	before	6.00	0.471	0.149
	to	5.29	1.649	0.400
IK04*	before	5.90	1.101	0.348
	to	4.12	1.691	0.410

**Table 13.** (Continued).

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
IK05*	before	6.30	0.675	0.213
	to	4.59	1.622	0.394
IK06*	before	5.40	1.265	0.400
	to	3.53	1.700	0.412

\* =  $p < 0.05$ .

**Summary of the evaluation results**

Overall, the mean values for trainee teachers have fallen in all areas, and these mean value changes are significant for four categories.

**Category II: Analyzing, reflecting (media literacy) (ML)** (see Table 14)

**Table 14.** Mean values before and after the survey for the trainee teachers on analyzing and reflecting (media literacy) (ML). The differences in this area are significant for the LAAs in two categories (ML03 and ML06); differences in the competence areas ML01, ML02, ML04, ML05 are not significant.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
ML01	before	5.70	1.494	0.473
	to	4.59	1.698	0.412
ML02	before	6.00	1.155	0.365
	to	4.82	1.629	0.395
ML03*	before	6.10	0.568	0.180
	to	4.71	1.532	0.371
ML04	before	5.50	1.179	0.373
	to	4.35	1.835	0.445
ML05	before	5.40	1.265	0.400
	to	4.35	1.618	0.392
ML06*	before	5.50	0.972	0.307
	to	4.00	1.696	0.411

\* =  $p < 0.05$ .

**Summary of the evaluation results**

Overall, the mean values for trainee teachers have fallen in all areas; these mean value changes are significant for two categories.

**Category III: Digital production (Media production) (MP)** (see Table 15)

**Table 15.** Mean values before and after the survey for trainee teachers on digital production (media production) (MP). The differences in this area are all significant for the LAAs.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
MP01*	before	5.90	0.738	0.233
	to	4.53	1.875	0.455
MP02*	before	6.30	0.675	0.213
	to	4.76	1.786	0.433
MP03*	before	6.10	0.568	0.180
	to	4.65	1.730	0.420
MP04*	before	6.10	0.738	0.233
	to	4.41	1.661	0.403

\* =  $p < 0.05$ .

**Summary of the evaluation results**

Candidate teachers reported significant self-perceived deteriorations in competence in all categories.

**Category IV: Communication, Collaboration (KK)** (see Table 16)

**Table 16.** Mean values before and after the survey for the trainee teachers on communication, collaboration (KK). The differences in this area are significant for the LAAs except for the categories K02 and KK05.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
KK01*	before	5.70	0.483	0.153
	to	4.41	1.734	0.421
KK02	before	6.60	0.516	0.163
	to	5.47	1.807	0.438
KK03*	before	6.10	0.516	0.163
	to	4.35	1.730	0.420
KK04*	before	6.10	0.568	0.180
	to	4.65	1.618	0.392
KK05	before	5.70	0.675	0.213
	to	4.59	1.622	0.394

\* =  $p < 0.05$ .

**Summary of the evaluation results**

In the self-assessment, the trainee teachers report a perceived weakening of competences in each category; with the exception of two categories (KK02 and KK05), these changes are significant.

**Category V: Digital identity, career planning** (see Table 17)

**Table 17.** Mean values before and after the survey for trainee teachers on digital identity, career planning (DIK). The differences in this area are significant for the LAAs with the exception of the DIK01 category.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DIK01	before	4.10	1.524	0.482
	to	3.41	1.906	0.462
DIK02*	before	4.50	1.716	0.543
	to	2.88	1.764	0.428
DIK03*	before	4.70	1.337	0.423
	to	3.24	1.715	0.416
DIK04*	before	4.60	1.506	0.476
	to	2.76	1.640	0.398
DIK05*	before	4.60	1.430	0.452
	to	2.82	1.667	0.404
DIK06*	before	5.00	1.563	0.494
	to	3.12	1.867	0.453

\* =  $p < 0.05$ .

**Summary of the evaluation results**

In this category, too, only deteriorations were estimated; with the exception of the DIK01 category, all differences are significant.

**Category VI: IT competence (ICT literacy) (ICT) (see Table 18)**

**Table 18.** Mean values before and after the survey for the trainee teachers on IT competence (ICT literacy) (ICT). The differences in this area are significant for the LAAs for the ICT 07–09 categories.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
ICT01	before	6.10	0.738	0.233
	to	5.06	1.819	0.441
ICT02	before	5.70	0.675	0.213
	to	4.88	1.833	0.445
ICT03	before	5.40	0.966	0.306
	to	4.88	1.764	0.428
ICT04	before	6.20	0.632	0.200
	to	5.12	1.764	0.428
ICT05	before	5.70	0.949	0.300
	to	4.76	1.954	0.474
ICT06	before	5.40	1.075	0.340
	to	4.35	1.998	0.485
ICT07*	before	5.60	1.075	0.340
	to	3.94	1.886	0.458

**Table 18.** (Continued).

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
ICT08*	before	5.30	1.494	0.473
	to	3.82	1.912	0.464
ICT09*	before	5.30	1.160	0.367
	to	3.71	2.024	0.491

\* =  $p < 0.05$ .**Summary of the evaluation results**

In this competence area, too, only deteriorations in competence are reported, even if significant differences are only recorded for the categories ICT07–09.

**Category VII: Digital teaching (learning skills) (LS)** (see Table 19)

**Table 19.** Mean values before and after the survey for trainee teachers on digital teaching (learning skills) (LS). The differences in this area for the LAAs are only non-significant for the competences LS05 and LS07.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
LS01*	before	5.20	0.632	0.200
	to	3.82	1.741	0.422
LS02***	before	5.70	0.675	0.213
	to	3.71	1.611	0.391
LS03*	before	5.30	0.823	0.260
	to	4.06	1.638	0.397
LS04*	before	5.30	0.823	0.260
	to	4.00	1.732	0.420
LS05	before	4.90	0.738	0.233
	to	4.24	1.640	0.398
LS06**	before	5.00	0.816	0.258
	to	3.59	1.661	0.403
LS07	before	4.90	1.101	0.348
	to	3.76	1.602	0.389

\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ ; \*\*\* =  $p < 0.001$ .**Summary of the evaluation results**

In this area, too, only worsened mean values were reported at the second time point, only non-significant for the areas LS05 and 07.

**Category VIII: Digital scholarship (DS)** (see Table 20)



**Table 20.** Mean values before and after the survey for trainee teachers on digital scholarship (DS). The differences in this area are not significant for the LAAs except for the categories DS01 and DS02.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DS01**	before	4.70	1.059	0.335
	to	3.35	1.730	0.420
DS02*	before	4.20	1.135	0.359
	to	2.76	1.522	0.369
DS03	before	4.20	1.476	0.467
	to	3.00	1.620	0.393
DS04	before	3.90	1.912	0.605
	to	2.59	1.770	0.429
DS05	before	2.70	1.767	0.559
	to	2.53	1.772	0.430
DS06	before	2.70	1.767	0.559
	to	2.41	1.698	0.412
DS07	Before	3.70	1.703	0.539
	to	2.41	1.622	0.394

\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ .

### *Summary of the evaluation results*

In this competence area, the trainee teachers also only report perceived deteriorations in competence. However, these mean value changes are only significant in two categories (DS01 and DS02).

### **4.2.2. Summary and conclusions for test cycle 3**

As already noted at the beginning of chapter 4.2, a sharpened perception and an improved awareness of the problem cannot explain why all competences deteriorated after participation in the four-part module program. In order to be able to understand how serious the responses really were, a targeted debriefing was carried out with the group of people carrying out the program and an attempt was made to clarify the situation/mood in which the questionnaire was completed, particularly in the follow-up survey.

It turned out that the “mood” of the participating LAAs was generally “unfavorable” in all modules. On the one hand, the LAAs were not particularly “thrilled” that they were not among themselves, but had to work together with both student teachers and teachers already working in practice in the modules and were thus no longer among themselves in their usual seminar group. In addition, the second-year LAAs were already under exam stress and criticized the unfavorable time slot of the fourth module.

In response to these unfavorable evaluation results, the four-part module program will be scheduled to be more exam-friendly for the two-year LAAs, and only trainee teachers and their seminar leaders will take part in trial cycle 3. In addition, the targeted debriefing with the group of people carrying out the program in trial cycle 3 will always take place after each individual module and not only after completion of

the four-part module program, in order to be able to react and intervene in a more targeted manner or during the module program.

### 4.3. Trial cycle 3—winter semester 2023/24 to summer semester 2024

#### 4.3.1. Methodological documentation and evaluation of the results of the third test cycle

At the first survey point (before the workshops), 35 trainee teachers (hereinafter referred to as LAAS) took part, and 16 at the second. At time 1, 29 participants were female and 6 male. At the second time point, there were 13 female and 3 male participants. The mean age was 25.2 years (sd = 3.2), the median was 25 years.

All eight areas of competence are analyzed individually below. The mean values, standard deviations and standard errors of the mean value before and after the four-part module series are listed in tabular form.

#### Category I: Information literacy (IK) (see Table 21)

**Table 21.** The mean values before and after for the trainee teachers are shown below. The differences in this area are significant for IK04 (I can comply with legal regulations when passing on information) and IK06 (I can support others in complying with legal regulations when using digital information). Increases in competence are assessed in each case.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
IK01	before	5.74	1.010	0.171
	to	5.81	1.109	0.277
IK02	before	5.97	0.822	0.139
	to	5.94	0.998	0.249
IK03	before	5.60	0.946	0.160
	to	5.50	1.366	0.342
IK04**	before	4.60	1.397	0.236
	to	5.56	0.964	0.241
IK05	before	5.37	1.190	0.201
	to	5.63	0.806	0.202
IK06**	before	4.54	1.400	0.237
	to	5.50	0.894	0.224

\*  $p < 0.05$ ; \*\*  $p < 0.01$ .

#### Category II: Analyzing, reflecting (media literacy) (ML) (see Table 22)

**Table 22.** The differences in this area are significant for the LAAs in three categories (ML01: I critically reflect on my own use of digital media, ML02: I critically analyze information from digital media and ML06: I trust myself to guide others in analyzing and reflecting on their learning process), with higher competences being assessed at the second point in time in each case.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
ML01*	before	5.20	0.964	0.163
	to	5.81	0.750	0.187
ML02**	before	4.97	1.200	0.203
	to	5.81	0.750	0.187
ML03	before	5.37	0.973	0.164
	to	5.69	1.078	0.270
ML04	before	4.74	1.462	0.247
	to	5.44	1.031	0.258
ML05	before	4.40	1.594	0.269
	to	5.00	0.894	0.224
ML06*	before	4.29	1.564	0.264
	to	5.25	1.183	0.296

\*  $p < 0.05$ ; \*\*  $p < 0.01$ .

### *Summary of the evaluation results*

Overall, the mean values for trainee teachers have fallen in all areas; these mean value changes are significant for two categories.

### **Category III: Digital production (Media production)** (see Table 23)

**Table 23.** The differences in this area are only significant for MP01 (I can describe different types of digital teaching and learning materials). Here, the competence was assessed almost one point higher at the second point in time.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
MP01**	before	5.00	1.260	0.213
	to	5.94	0.854	0.213
MP02	before	5.69	1.231	0.208
	to	5.94	0.772	0.193
MP03	before	4.74	1.482	0.251
	to	5.31	1.302	0.326
MP04	before	4.63	1.682	0.284
	to	5.31	1.401	0.350

\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ .

### **Category IV: Communication, Collaboration** (see Table 24)

**Table 24.** No significant differences can be reported between the two points in time for the area of communication and collaboration.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
KK01	before	5.37	1.165	0.197
	to	5.44	0.964	0.241
KK02	before	6.23	0.731	0.124
	to	6.06	0.929	0.232
KK03	before	5.09	1.269	0.214
	to	5.50	1.033	0.258
KK04	before	5.14	1.240	0.210
	to	5.44	1.031	0.258
KK05	before	5.00	1.328	0.225
	to	5.31	1.250	0.313

\*  $p < 0.05$ ; \*\*  $p < 0.01$ .

**Category V: Digital identity, career planning** (see Table 25)

**Table 25.** The differences in this area are significant for the LAAs in the categories DIK01 (I can describe how websites/blogs can be used to present my own academic work), DIK02 (I know the possibilities of alternative, digital proof of competence) and DIK05 (I acquire digital proof of competence to establish my digital identity). The assessed competences are higher at the second point in time.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DIK01*	before	3.74	1.462	0.247
	to	4.81	1.471	0.368
DIK02*	before	3.43	1.441	0.244
	to	4.56	1.788	0.447
DIK03	before	3.97	1.599	0.270
	to	4.56	1.413	0.353
DIK04	before	3.51	1.616	0.273
	to	4.44	1.896	0.474
DIK05*	before	3.31	1.795	0.303
	to	4.44	1.504	0.376
DIK06	before	3.43	1.852	0.313
	to	4.38	1.784	0.446

\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ .

**Category VI: IT competence (ICT literacy)** (see Table 26)

**Table 26.** The differences in this area are significant for the LAAs for the categories ICT 1 (I can describe several functions of a learning platform), ICT02 (I can describe several functions of typical Web2.0 tools), ICT06 (I am confident that I can instruct others in the use of Web2.0 tools) and ICT09 (I can instruct others to take measures

to protect their digital data). In each case, the self-assessments of the group are higher after the workshop.

Category	Time of survey	Mean value	Standard deviation	Standard error of the mean
ICT01**	before	4.97	1.248	0.211
	to	6.13	0.806	0.202
ICT02**	before	4.77	1.330	0.225
	to	5.75	1.065	0.266
ICT03	before	5.23	1.308	0.221
	to	5.75	1.342	0.335
ICT04	before	5.29	1.341	0.227
	to	5.69	1.493	0.373
ICT05	before	4.89	1.530	0.259
	to	5.19	1.424	0.356
ICT06*	before	4.20	1.389	0.235
	to	5.19	1.424	0.356
ICT07	before	4.20	1.549	0.262
	to	4.69	1.815	0.454
ICT08	before	3.86	1.332	0.225
	to	4.75	1.693	0.423
ICT09*	before	3.89	1.510	0.255
	to	4.94	1.526	0.382

\* =  $p < 0.05$  \*\* =  $p < 0.01$ .

### Category VII: Digital teaching (learning skills) (see Table 27)

**Table 27.** The differences (all assessed competences are higher at the second point in time) in this area for the LAAs are for the competences LS01 (I can explain terms relating to elearning), LS02 (I can describe different media and their characteristics), LS04 (I can apply my knowledge of elearning scenarios in my teaching), LS05 (I can consider important planning aspects for the conception of elearning scenarios), LS06 (I am confident that I can guide the conception of media-supported teaching-learning settings) and LS07 (I feel able to advise others on the implementation of media-supported teaching-learning settings).

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
LS01**	before	4.06	1.349	0.228
	to	5.13	1.258	0.315
LS02*	before	4.23	1.592	0.269
	to	5.19	1.377	0.344
LS03	before	4.03	1.599	0.270
	to	4.81	1.377	0.344
LS04*	before	3.80	1.491	0.252
	to	4.94	1.340	0.335

**Table 27.** (Continued).

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
LS05*	before	3.97	1.543	0.261
	to	4.94	1.340	0.335
LS06*	before	3.69	1.451	0.245
	to	5.00	1.366	0.342
LS07**	before	3.57	1.577	0.267
	to	4.88	1.258	0.315

\* =  $p < 0.05$  \*\* =  $p < 0.01$ .

**Categories VIII: Digital scholarship** (see Table 28)

**Table 28.** The differences in this area are significant for the LAAs for the categories DS04 (I use digital tools to collect and analyze research data), DS05 (I use digital media to publish my research results), DS06 (I use digital tools to document my research process) and DS07 (I can guide others in the use of digital tools for data collection and data analysis) and are each rated as more pronounced for the time after the workshop.

Category	Time of the survey	Mean value	Standard deviation	Standard error of the mean
DS01	before	3.94	1.533	0.259
	to	4.56	1.504	0.376
DS02	before	3.71	1.582	0.267
	to	4.56	1.548	0.387
DS03	before	3.57	1.632	0.276
	to	4.56	1.632	0.408
DS04*	before	3.49	1.483	0.251
	to	4.63	1.628	0.407
DS05*	before	3.26	1.669	0.282
	to	4.44	1.825	0.456
DS06*	before	3.11	1.605	0.271
	to	4.31	1.815	0.454
DS07*	Before	3.23	1.629	0.275
	to	4.31	1.662	0.416

\* =  $p < 0.05$  \*\* =  $p < 0.01$ .

**4.3.2. Summary and conclusions**

The desired adjustments resulting from the evaluations from trial cycle 2 (more examination-friendly scheduling of the four-part workshop, exclusive participation of teacher trainees with their seminar leaders and thus the second phase of teacher training, targeted debriefing with the group of people carrying out the workshop always following each individual module) have had a positive effect, as the evaluations clearly show.

In the next step, the four-part workshop program will be “rolled out” and evaluated throughout Bavaria in the form of a “teach and share” Mebis course with corresponding training sessions in order to be able to achieve continuity in the second phase of teacher training.

## **5. Review and outlook**

At a time when digital transformation is permeating all areas of life, it is crucial that prospective teachers have the necessary digital skills to best prepare their students for the challenges of the future. The research “digital literacy and artificial intelligence literacy in teacher education” aims to impart precisely these skills and accompany future educators on their journey into the digital world.

As part of this research, workshops were offered to give trainee teachers (LAAs) an initial insight into the world of digital media and its use in the classroom. Based on the evaluation and consultation with the seminar leaders involved, the program was converted to an accompanying mebis course.

This decision has several advantages. Firstly, the online course is more compatible with the seminar planning and schedule, as the seminar leaders and LAAs can access the content flexibly and from any location. The mebis course also offers the option of integrating it into the seminar planning for the year.

### **5.1. Previous and extended research objectives**

#### **Focus on all phases of teacher training:**

The research covers all three phases of teacher training and ensures that student teachers, trainee teachers and teachers already working in the teaching profession benefit equally from the measures. The secondment center at the university makes it possible to continue and improve this comprehensive approach.

#### **Strengthening the link between theory and practice:**

The research places a strong focus on linking theory and practice through close collaboration and networking between those involved in the first and second phases of teacher training. The secondment position at the university strengthens this link and ensures that the (future) teachers are familiar with both the latest theoretical concepts and practical applications.

The further qualification of the secondment position at the university supports and quality-assures the interlinking of theory and practice at the university.

#### **Further education and training of seminar rectors as part of the research:**

The regular organization of specific workshops for the further education and training of seminar rectors is an important aspect of the research. The secondment office at the university makes it possible to effectively coordinate these further education and training measures and ensure that they are tailored to the needs of seminar rectors.

#### **Training of digital education counsellors as part of the accompanying Mebis course:**

The content and process-orientated training of the BdBs by the secondment office ensures that the seminar leaders receive on-site support in the implementation of the

respective modules. Innovations and changes can be effectively multiplied and communicated through the network

**Optimization, adaptation and further development of the research:**

The development and implementation of process-accompanying evaluation measures is an important aspect of the research. The secondment office makes it possible to effectively coordinate these university evaluation measures and to ensure that deficits are identified at an early stage and that optimizations and adjustments can be carried out continuously and in the course of ongoing development.

**Networking and institutionalized cooperation:**

The research aims to build networking structures and establish joint meetings with representatives of all teacher training phases. Intensive and regular communication and exchange between the representatives of the University of Passau, the seminar rectors and the secondment office are a central aspect of the research. The secondment center at the university promotes and strengthens this networking and cooperation, which leads to improved curricular coordination of the individual training phases.

**Up-to-dateness of the modules:**

The topicality of content is an important aspect in the learning cultures of digitality. Current research results, technical applications, methods, examples and content of the Mebis course are constantly updated and updated. This ensures a smooth and up-to-date theory-practice connection. On the basis of this, the seminars can be guaranteed to run smoothly.

**5.2. Action planning for the 2024/25 school year**

- Roll-out of the modules to all primary and secondary school seminars in Lower Bavaria.
- Implementation of the mebis course in all seminars.
- Develop a series of training courses in cooperation with the university for all digital education consultants (BdBs).
- Develop a training program in cooperation with the university for all seminar leaders.
- Develop further training series in cooperation with the university for the speaker network.
- Organization of several hours of further training for seminar leaders by seconded teachers.
- Organization of several hours of further training for digital education advisors by seconded teachers.
- Organization of training courses lasting several hours for the speaker network by seconded teachers.
- Support of the seminars in the realization of the individual modules, also through appointments in the seminars.
- Supporting the seminar organizers with technical issues.
- Ensure content updates and further development of the modules.
- Development of a module with contemporary examination formats for the existing modules.



- Further develop the content and scientific basis in the seminars at the university.
- Develop and implement suitable training programs for LAA support teachers.
- Organize and ensure cooperation and reflection with seminar leaders, university and BdBs.

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## Appendix: Codebook for the research “digital and AI literacy in teacher training”

**Table A1.** Socio-demographic variables.

Variable name	New variable name (for merge)	Question	Label in the data record	Characteristics/coding
V_1 (personal code)	Code	<p>Please enter your code in the first field and generate it as follows:            What is the first letter of the first name of your mother or a person who comes closest to a mother for you (e.g. MARIA = M)?            What is the first letter of the first name of your father or a person who comes closest to a father for you (e.g. JOHANN = J)?            What is the first letter of your first name? (e.g. PETER = P)            What is the first letter of your place of birth? (e.g. LONDON = L)            What is the first digit of the day of your birthday? (27.05.1999 = 2)</p>		XXXX11 (combination of four letters and two numbers)
V_2 (gender)	Sex	Enter your gender.	Gender	1 = female 2 = male 3 = diverse
V_3 (year of birth)	Age_year_of_birth	Enter your year of birth.	Year of birth	1111 (four-digit numerical code)
V_5 ((occupational) job group)	job	Indicate which group you belong to.	(Professional) group	1 = Teaching degree students in seminar 41226 with Peter Freudenstein 2 = Teaching degree students in seminar 41231 with Johannes Graup 3 = Teaching degree students in seminar 40602 with Doris Cihlars 4 = trainee teachers 5 = Seminar rectors/seminar leaders 6 = Digital education counsellors 7 = (Deputy) teachers 1 = no school-leaving qualification 2 = Secondary school leaving certificate 3 = secondary school leaving certificate 4 = Grammar school leaving certificate/Abitur/Matura 5 = Apprenticeship/skilled labour qualification 6 = Master’s degree/ Master craftsman examination 7 = Vocational school/technical school/commercial academy 8 = University of Applied Sciences 9 = University 10 = Technical University (TH) 11 = University of Teacher Education (PH) 12 = Promotion 13 = Habilitation
V_10 (mother’s education)	Educational_achievement_mother	Indicate your mother’s highest level of education.		

**Table A1. (Continued).**

Variable name	New variable name (for merge)	Question	Label in the data record	Characteristics/coding
V_11 (father's education)	Educational_achievement_father	Indicate your father's highest educational qualification.		1 = no school-leaving qualification 2 = Secondary school leaving certificate 3 = secondary school leaving certificate 4 = Grammar school leaving certificate/Abitur/Matura 5 = Apprenticeship/skilled labour qualification 6 = Master's degree/ Master craftsman examination 7 = Vocational school/technical school/commercial academy 8 = University of Applied Sciences 9 = University 10 = Technical University (TH) 11 = University of Teacher Education (PH) 12 = Promotion 13 = Habilitation

**Table A2. Information literacy.**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_23	IK_01	I can name digital sources for obtaining specialised information	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_24	IK_02	I can obtain digital information to prepare my teaching	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_25	IK_03	I can assess the source of digital information in terms of its quality (e.g. reliability, scientific nature, topicality, etc.).	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_27	IK_04	I can be involved in the transfer of Information Comply with legal provisions (e.g. copyright, right of use, licence terms)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A2. (Continued).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_28	IK_05	I feel able to support others (colleagues, learners) in researching information online	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_29	IK_06	I can support others (colleagues, learners) in complying with legal regulations when using digital information	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A3. Analysing, reflecting (media literacy).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_31	ML_01	I critically reflect on my own digital media usage behaviour (media content, duration of use, locations, types of media, etc.)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_32	ML_02	I critically analyse information from digital media (e.g. who is providing this information, for what reason, for what purpose)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_33	ML_03	I can critically scrutinise and reflect on the use of digital media in my own teaching on the basis of certain criteria (suitability of media, methods, content, teaching/learning objectives)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_34	ML_04	I can select suitable digital tools for reflection (e.g. ePortfolios, blogs, etc.)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_35	ML_05	I feel able to guide and accompany others (colleagues, learners) in analysing and reflecting on their media use	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A3. (Continued).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_36	ML_06	I have the confidence to guide and accompany others (colleagues, learners) in analysing and reflecting on their learning process (e.g. learning objects, learning actions)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A4. Digital production (media production).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_68	MP_01	I can describe different types of digital teaching and learning materials (e.g. WBTs, screencasts, podcasts, explanatory videos, simulations)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_69	MP_02	I can consciously use different design elements in the production of digital teaching/learning materials (e.g. colour, font, images, music)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_70	MP_03	I can guide others (colleagues, learners) in the design of digital materials	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_71	MP_04	I have the confidence to support others in the production of digital materials	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A5. Communication, collaboration.**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_118	KK_01	I can identify potential problems and opportunities of online communication	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A5. (Continued).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_119	KK_02	I can communicate digitally with others (colleagues, learners)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_120	KK_03	I can react to problems with digitally mediated communication	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_121	KK_04	I can guide others (colleagues, learners) to organise their digital communication with others (colleagues, learners)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_122	KK_05	I feel able to teach others (colleagues, learners) how to deal with problems of digital communication	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A6. Digital identity, career planning.**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_123	DIK_01	I can describe how you can use websites/blogs to present your own scientific activities	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_124	DIK_02	I know the possibilities of alternative, digital proof of competence (e.g. badges, certificates)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_125	DIK_03	I can appropriately present my own identity as a scientist in social networks	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A6. (Continued).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_126	DIK_04	I can run my own website/blog to present my scientific activities	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_127	DIK_05	I acquire digital proof of competence (e.g. badges, certificates) to establish my digital identity	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_128	DIK_06	I have the confidence to guide others (colleagues, learners) in implementing suitable measures to protect my digital self	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A7. IT competence (ICT literacy).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_129	ICT_01	I can describe several functions of a learning platform	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_130	ICT_02	I can describe several functions of typical Web 2.0 tools (e.g. social networks, blogs, wikis, forums)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_131	ICT_03	I can use various Web 2.0 tools (e.g. social networks, blogs, wikis, forums)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_132	ICT_04	I can use the tools of a learning platform from the learner's perspective (e.g. forum, e-mail, uploading and downloading files)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A7. (Continued).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_133	ICT_05	I can use learning platforms to support my courses (e.g. create a course structure, set up a forum, upload files, contact students, create groups, create online tests)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_134	ICT_06	I have the confidence to instruct others (colleagues, learners) in the use of Web 2.0 tools (blogs, wikis, forums, social networks)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_135	ICT_07	I feel able to instruct others (colleagues, learners) in the use of learning platforms	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_136	ICT_08	I feel able to instruct others (colleagues, learners) in the use of authoring tools for the production of digital materials	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_159	ICT_09	I can instruct others (colleagues, learners) to take measures to protect their digital data	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely

**Table A8. Digital teaching (learning skills).**

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_152	DS_01	I can name the added value of digital tools for data collection	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely



**Table A8.** (Continued).

Variable name	New variable name for merge	Question	Label in the data record	Characteristics/coding
V_153	DS_02	I can name the added value of digital tools for analysing research data	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_154	DS_03	I can describe the benefits of digital publishing options (e.g. open access)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_155	DS_04	I use digital tools to collect and analyse research data (e.g. online questionnaires, statistics programs, visualisation software)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_156	DS_05	I use digital media to publish my research results (e.g. open access, e-journals, working papers)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_160	DS_06	I use digital tools to document my research process (e.g. science blog)	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely
V_161	DS_07	I can guide others (colleagues, students) in the use of digital tools for data collection and data analysis	s. Question	1 = does not apply at all 2 3 4 5 6 7 = applies completely