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PAPER

Research in Online Teacher Professional Development: A Systematic Mapping Review

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ABSTRACT

This systematic mapping study examines 115 studies on online teacher professional development (OTPD) programs, including online-only and blended learning (BL) formats. Findings reveal that most programs combine synchronous and asynchronous phases, emphasizing collaborative, action-oriented, and reflective learning approaches. Frequently used technologies include discussion forums, videos, and learning management systems (LMS), while innovative tools such as virtual reality (VR) and artificial intelligence (AI) are less commonly implemented. Approximately half of the programs involve instructor guidance. These findings offer valuable insights into the design and implementation of OTPD and underline the need for further research into content-specific strategies and the effective use of emerging technologies.

KEYWORDS

online teacher professional development (OTPD), in-service teacher learning, educational technologies, systematic review

1 INTRODUCTION

In an educational system constituted by complex structures of causes, conditions, and effects, the professional competence of teachers is considered a central factor influencing the quality of teaching. Adopting an agile and competent approach to societal challenges and changes, characterized by numerous transformation processes, is crucial for contemporary teaching-learning processes [33], [81]. In line with the demand for high-quality education, numerous training programs for the professional development (PD) of in-service teachers have been implemented so far. However, many of these–mostly designed as short-term courses according to the 'one-size-fits-all' principle–prove to be unsuitable for ensuring an ongoing professionalization process [25]. Critiques frequently cite issues such as a lack of practical relevance, superficial content, insufficient support for implementing learned material, neglect of student learning, and the isolated nature of the interventions [28], [31], [88].

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The need for PD courses that meet the daily demands and challenges as well as the everyday professional lives of teachers and that consider their needs and wants is flexible, providing in-service support that has catalyzed the development of online teacher professional development (OTPD) [25], [42], [57]. Numerous concepts now exist, and new initiatives are constantly being taken to advance the integration of digital technologies into PD courses for teachers [11], [25]. New technologies, social networks, and platforms provide teachers with quick and easy access to diverse PD opportunities, most of which can be delivered anywhere and at any time [25]. OTPD can be used to reach a larger number of teachers who share similar interests and have congruent PD needs [109]. Furthermore, OTPD efforts can succeed in addressing teachers' individual interests and abilities in more concrete terms, thereby achieving a high degree of personalization [31], [75], [76], [107].

In addition to formats that are conducted entirely online, blended learning (BL) concepts have become established [6], [14]. Involving a combination of online and face-to-face (f2f) sessions, the extent to which they are BL depends on the weighting, as identified in the relevant literature. Given its high reputation in research, this systematic mapping study follows the systematization of the Sloan Consortium (now Online Learning Consortium), according to which the online portion of training must be at least 30% and at most 79% to be defined as a BL concept. Accordingly, any instead of all is considered an online-only format [2].[1]

2 NEED FOR CURRENT STUDY AND RESEARCH QUESTION

The research field of OTPD is receiving augmented attention, with a large number of research papers, especially from the field of higher education [16], [82]. The development and importance of learning communities for PD of teachers are also increasingly the focus of research (e.g., [55], [94], [98]). Nonetheless, few reviews exist to date that have addressed the formal delivery landscape of OTPD courses for practicing teachers [3], [11], [30], [92], [100]. Existing research provides valuable guidance for the conceptualization, development, and design of OTPD courses but underscores the need for further in-depth investigation: "The more understanding there is of the characteristics of OTPD, the more online platforms and learning support tools can be based on research-informed practices" ([3], p. 19).

In the context of the highest relevance being attributed to teacher PD in general terms for the quality of education together with the ever-growing number of OTPD provisions on offer, an understanding of evidence-based design elements, instructional methods, and support measures of those OTPD formats that have been successfully implemented seems to be important [11], [26]. Since the development of high-quality (online) PD formats opposed to being associated with numerous challenges, including issues of scalability, adaptability, sustainability, inclusivity, and accessibility [27], evidence on current practices is even more important. Therefore, the goal of this study is to draw conclusions about the design of current OTPD courses for practicing teachers. In addition to the formats, the underlying methodological-didactic approaches as well as the educational technologies used are of interest. The central research question to be answered is thus:

[1] Given their high popularity and outstanding potential [70], BL concepts will also be included in this analysis alongside online-only formats. Thus, OTPD in this study includes both online-only formats and BL formats according to the described systematization.

How are digital courses for the further training and development of in-service teachers designed with regard to their formats delivered as well as their media-didactic and media-technical design?

3 METHOD

This study employs a systematic mapping review to describe the research field and identify relevant topics. Mapping reviews offer the potential to provide a general overview of the research field as well as of the way previous research has been conducted by categorizing existing literature according to certain bibliographic characteristics, theoretical concepts or specific settings. This makes it possible to identify research gaps and formulate recommendations for further research [32], [79], [83].

The search strategy to identify relevant studies was developed iteratively with support from the university research librarian. In the context of this study, the following databases were searched for relevant, peer-reviewed literature:[2] Scopus, Web of Science, and EBSCO Education Source.[3] The original search string consisted of the following terms and was adapted according to the functional logics and the special requirements of the databases (refer to Table 1): teacher, train, develop, professional, learning, open, distance, mobile, digital, distribute, blended, and hybrid. Initially, 5923 records were identified, and the search was completed in June 2022.

Table 1. Search strings for databases (Scopus, Web of Science, EBSCO Education Source)

Scopus	Last Search: 05.06.2022	(TITLE-ABS-KEY ((teacher W/3 (train* OR develop* OR professional))) AND TITLE-ABS-KEY ((learning W/3 (open OR distance OR mobile OR digital* OR distribute* OR blended OR hybrid)))) AND PUBYEAR > 2011 AND (LIMIT-TO (LANGUAGE, "English"))
Web of Science	Last Search: 08.06.2022	TOP (teacher Near/3 (train* OR develop* OR professional)) AND TOP (learning Near/3 (open OR distance OR mobile OR digital* OR distribute* OR blended OR hybrid)) AND PUBYEAR 2012-01-01 to 2022-06-08
EBSCO Education Source	Last Search: 10.06.2022	((teacher N3 (train* OR develop* OR professional))) AND ((learning N3 (open OR distance OR mobile OR digital* OR distribute* OR blended OR hybrid))))

The next step consisted of the selection and compilation of studies. The articles chosen had to satisfy specific criteria shown in Table 2. The first search found a total of 5923 studies across the three databases. After setting the time frame to the years 2012 to 2022 and reducing the search to English-language results, a total of 3708 studies remained that were eligible for screening by title and abstract. This was done by the author.

[2] Although the peer review process is controversial in the scientific community, only articles published in peer-reviewed journals will be considered in this review. Not least, these are generally considered to be highly trustworthy and of exceptional quality, as they are subject to a rigorous review process [21], [50].

[3] Since the study was conducted by only one researcher and research was highly complex, the search was limited to three central databases.

Table 2. Selection criteria

Inclusion Criteria	Exclusion Criteria
English Language	Not English
Peer reviewed	Not published in a peer-reviewed journal
Empirical study	Not empirical or primary research
Published between 2012 and 2022	Published before 2012
Author(s) mentioned and full text available	No author(s) mentioned and full text not available
Target audience: in-service teachers	Other target audience
Formal OTPD setting	Other setting

To manage the citations throughout the research project, different tools were used in combination. The citation export from the databases was done in such a way that it was compatible with Citavi. In this way, all citations could be systematically compiled. At the same time, 23 duplicates could already be removed with the help of the Citavi function. The title and abstract screening resulted in the exclusion of all articles that did not meet the selection criteria. If these did not provide sufficient information, the article was moved to the next stage. Meanwhile, the screening process revealed that 832 articles did not constitute empirical studies, and 2575 articles did not meet the selection criteria. With this in mind, a total of 278 potentially relevant articles were transferred to EPPI Reviewer Web, a web-based system for managing and analyzing systematic reviews. After transferring the data to the EPPI software, two duplicates were found and further removed. This was followed by the retrieval of the full texts of the selected articles using document search by Citavi, EPPI, and hand search. If some articles were not available in this way, the authors were asked personally to make the article available. Although a number of articles were obtained in this way, a total of six articles were not available and had to be excluded from the analysis. The full-text versions of the preliminarily included articles were obtained and screened for eligibility based on the same selection criteria. Thus, another 155 articles could be removed so that a total of 115 articles were used for the final analysis.[4] The selection process for identifying suitable studies is shown in detail in the PRISMA[5] diagram (see Figure 1) [74]. The type of information to be extracted from the data material was determined based on the research question formulated at the beginning. A qualitative content analysis was performed, and Bonds' [5] coding system was used as a resource in combination with Bowers' [10] tech typology to extract data using EPPI Reviewer Web. Due to limited resources, it was not possible to have the coding carried out by at least two independent authors. Nevertheless, in case of uncertainties regarding certain codes (e.g., problems with the allocation of data material), these were marked and discussed together with the supervisor. This procedure also resulted in trustworthy codes [20].

[4] An overview of all included studies can be found in the support files.
[5] Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

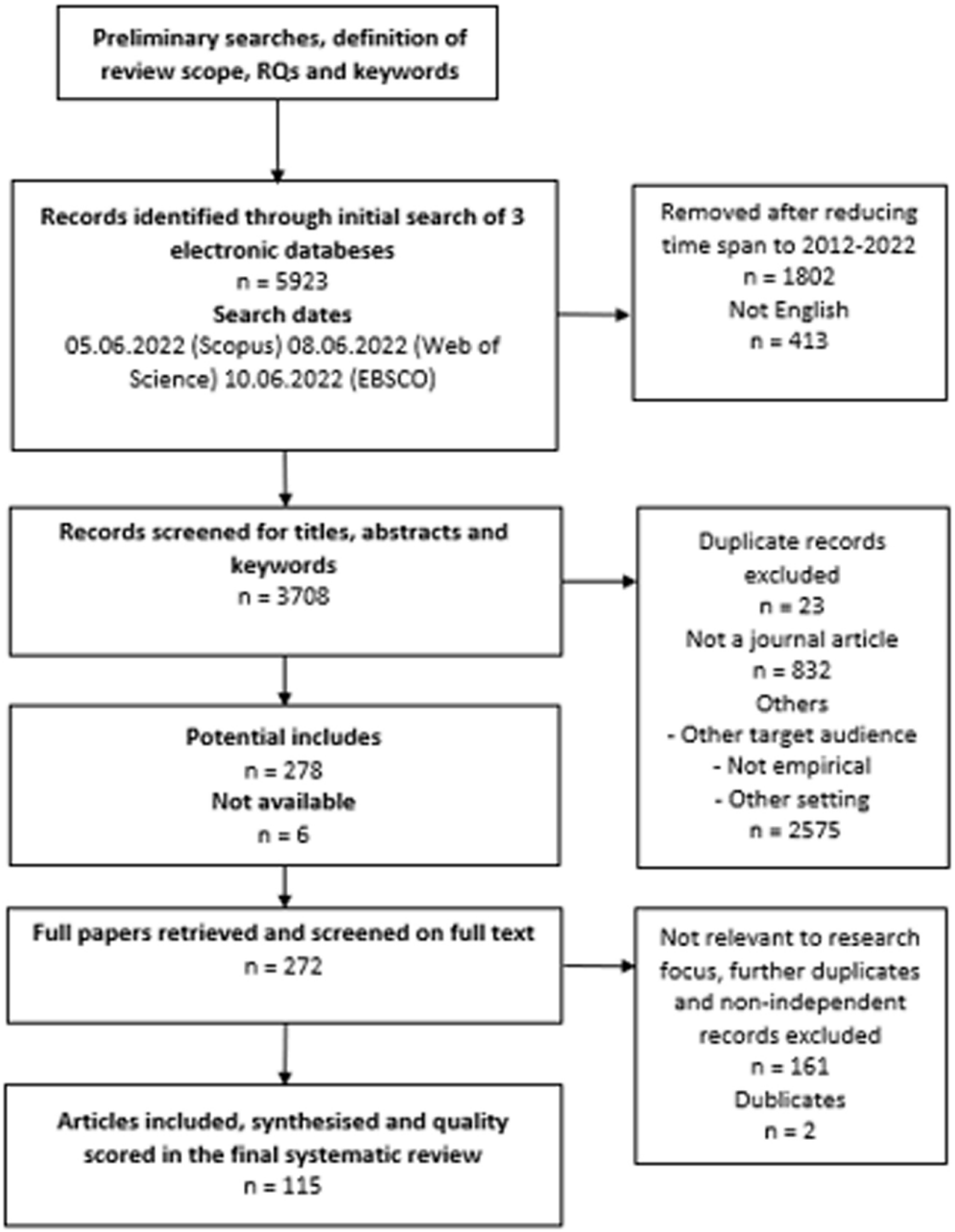

Fig. 1. PRISMA diagram

4 RESULTS

Given the limited capacity of this study, the presentation of results is limited to particularly striking results and is based on a selection of exemplary studies. If serious differences between BL and online-only formats could be identified, these will be explained in a differentiated manner at the appropriate point. Otherwise, the results for both formats are presented in summarized form.[6]

[6] A detailed overview of the course characteristics is provided in the supplementary files of this review.

4.1 Format and structure of OTPD courses

In total, n = 66 OTPD courses were identified as online-only, while n = 47 was categorized as BL formats.[7] Both types predominantly combined asynchronous and synchronous phases, with exclusively synchronous or asynchronous courses being rarely presented (e.g., [41], [91], [104]). Online-only formats were typically designed to span several months or weeks (e.g., [7], [60]), although there were occasional instances where courses extended over several years (e.g., [100]). A similar trend towards longer durations was observed in BL formats (e.g., [18]). However, there were a few rare examples where the courses lasted only a few weeks (a maximum of four weeks), such as described by Michos and Hernández-Leo [71]. Short-term courses, typically lasting only a few days, were primarily developed in response to the COVID-19 pandemic (e.g., [4], [45]), with all of these courses focusing on PD related to distance learning. Ulmane-Ozolina et al. [99] was the only study that explicitly determined the course duration based on the prior knowledge of the participating teachers. Overall, the flexible duration of in-service training or individual training phases was rarely reported, with only n = 3 instances mentioned.

4.2 Teaching and learning methods

In nearly all OTPD courses, various forms of collaborative learning were employed (n = 92), ranging from group work and the establishment of learning communities (e.g., [4], [29]) to the exchange of experiences, activities, and ideas through forums, discussions, and peer teaching (e.g., [62], [95]). In particular, discursive exchange among participants played a significant role in numerous courses, regardless of the format (e.g., [47], [77], [108], [110]). While collaborative activities were the dominant mode of engagement in some courses, such as those by Al-Balushi and Al-Abdali [1] and Gynther [3], group work or collective exchange is used more as supplementary elements in other training programs (e.g., [9], [43]).

A substantial proportion of OTPD programs emphasized active engagement with the course content (n = 90). Hands-on tasks, research activities, problem-based learning, and project-based learning were commonly utilized to encourage participants to acquire knowledge and skills inductively. These activities often involved the development of lesson plans, learning activities, or teaching materials, some of which became the final product of the training (e.g., [12], [101]) and were occasionally used as the basis for assessment (e.g., [40]). The application or testing of learned content was also a key feature in several training courses, typically enacted through the participants' own lessons or via role plays and scenarios (e.g., [66], [101]). With one exception, role-playing was exclusively used in online-only training formats. Some programs incorporated creative learning methods, such as storytelling ([79]) or learning games (e.g., [53], [58]).

Cognitive teaching-learning models were referenced in n = 86 instances. Notable approaches included learning through examples, discovery learning via active experimentation, and testing of content. For example, in the BL programs of Krasnova

[7] Number related to the total number of programs in Bl and online format (N = 113). The difference between the number of training programs and the total number of included studies is due to the fact that in some studies the comparison of several formats was planned. For comparative studies, each measure analyzed was designed as an individual program.

and Shurygin [54] and Knie et al. [53], participants conducted practical experiments designed to foster authentic engagement with the subject matter.

Activities aimed at encouraging critical thinking and reflection were predominant in the OTPD courses analyzed. These activities often focused on various aspects, such as teachers' own learning processes (e.g., [59], [65]), teaching practices (e.g., [84]), training content (e.g., [73]), the training process itself (e.g., [49]), or the learning experiences of other participants (e.g., [62]). While group reflections, which were less common in online-only formats, were used in BL courses to evaluate collectively implemented projects (e.g., [93]), individual online-only formats placed greater emphasis on reflection. In these cases, reflection was structurally integrated into the course through mechanisms such as 'reflective logs' (e.g., [36]), which promoted ongoing self-reflection throughout the training process.

Evidence of transmissive instructional strategies was found in n = 33 cases, although these strategies rarely dominated the course design (e.g., [87]). Specifically, in BL formats, transmissive strategies were more prevalent at the beginning of the course, particularly during f2f sessions, where foundational knowledge was typically transferred (e.g., [46], [67]). In online-only courses, introductory instructional videos were primarily used to convey basic knowledge (e.g., [45]) but were rarely employed as the course progressed (e.g., [60], [47]).

A small number of courses (n = 5) incorporated adaptive learning strategies. For example, the online-only training in the MOOC format described by Gynther [39] was based on an adaptive learning system, which offered a personalized curriculum that tailored instructional interventions to the specific needs and characteristics of the participants. This approach aimed to create optimal learning conditions for each individual. Similarly, Gunawan et al. [37] employed an adaptive learning system in their BL course, where participants first completed a digital test. The results of this test were automatically evaluated, and the system generated recommendations for the subsequent course content, activities, and forums. However, unlike the previously mentioned examples, participants had the autonomy to choose whether to follow the system's suggestions or pursue a more individualized learning path. In an effort to address the diverse needs, learning speeds, and strategies of teachers, Chaipidech et al. [17] implemented a personalized learning system supported by AI in their OTPD course. This AI-driven approach was designed to foster self-directed learning and more specifically cater to individual learner needs.

4.3 Instruction

Evidence of guidance by at least one instructor[8] was available for around half of all digital training courses analyzed (n = 61). The major roles of the instructor are presented in Table 3 and included diagnosis (n = 40), support (n = 36), organization (n = 28), and knowledge transfer (n = 20), as well as active participation (n = 6) and motivation (n = 11), with the motivational role being described primarily for online-only training.

[8] For reasons of better readability, only the singular will be used in the following, and the term "instructor" will be used.

Table 3. Role of the instructor in OTPD programs analyzed (N = 113)

Function and Tasks	n
Diagnostic • Feedback • Performance assessment • Observation and analysis of learning processes • Observation and analysis of practice phases • Identification of learning difficulties	40
Support and advice • Scaffolding • Coaching/Mentoring • Answering questions	36
Organization and management • Planning and implementation • Instructions • Task coordination • Organization of learning processes	28
Knowledge transfer • Lectures	20
Motivation • Participation in the course • Working on tasks • Practical application • Formulating learning objectives	11
Active participatory role • Discussions • Working phases • Co-teaching	6

In Chaipidech et al. [17], OTPD was exclusively technology-driven, whereas in a few other cases, technological tools were used at least partially for course delivery. For example, in Gynther [39] and Gunawan et al. [37], an adaptive system was employed in combination with an instructor, with participants granted certain freedoms in course design (e.g., choice of assignment format). In a few online-only programs, the use of an instructor was completely omitted (n = 6). Although in Laurillard [56], Terrazas-Arellanes et al. [96], Boltz et al. [4], and Şenel et al. [90], participants also worked independently without direct instructor guidance and were able to proceed at their own pace, these programs nonetheless provided a structured framework for action. The freedom to make decisions and the autonomy to act do not necessarily preclude the presence and/or support of an instructor. For instance, in Gamrat et al. [35] and Weinhandl et al. [105], participants were given choices regarding course content, assessment formats, and/or assignments, but the instructor continued to monitor the activities of the teachers and intervened in a supportive capacity as needed. Similarly, in the courses of Lynch et al. [63] and Jocius et al. [47], teachers were able to engage with OTPD at their own pace, but with guidance from an instructor.

A combination of instructor-led and self-directed learning was also present in some BL courses (n = 13). Commonly, these formats combined guided f2f meetings with independent online learning (e.g., [46], [80]). The mention of participants being granted autonomy in selecting course content and/or tasks was rare, and in most cases, this referred primarily to the content of the online sessions (e.g., [37], [43], [53]).

A distinctive feature was reported in the OTPD programs of Dahri et al. [23] and Dahri et al. [24], where one teacher from the participating school districts was first trained as a "guide teacher" and subsequently led the training and assisted other teachers. Other experts were only available in the background and could be contacted exclusively through the guide teachers.

4.4 Educational technology

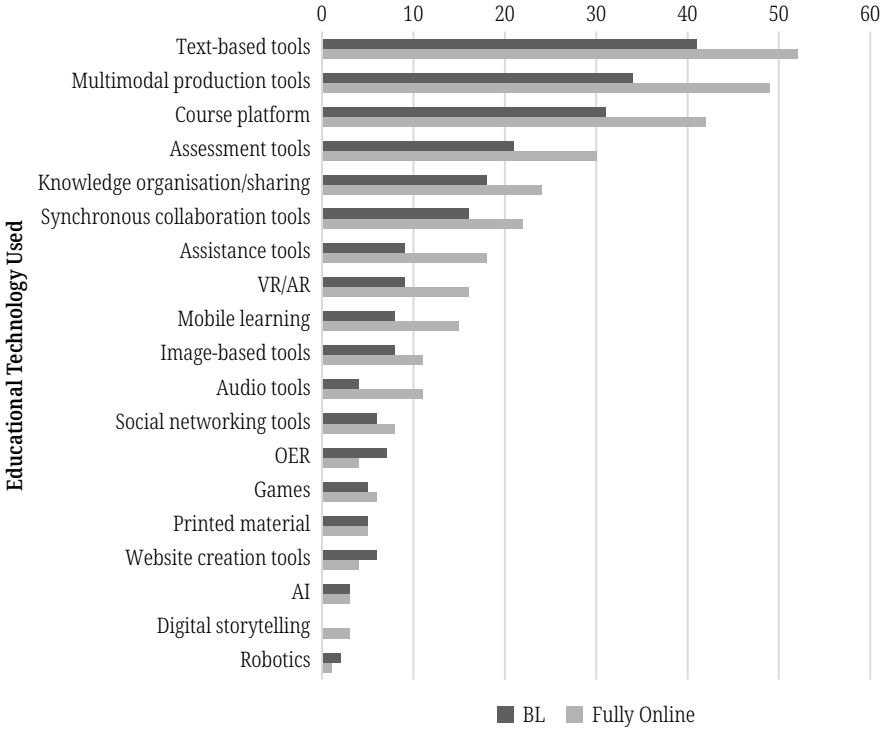

Fig. 2. Educational technology used across programs in online-only and BL formats (N = 113)

The types of technology used in the OTPD programs analyzed are presented in Figure 2. It should be noted that many programs integrated multiple technologies. Given the scope of the study, it is not feasible to discuss each technology separately. Therefore, this section will focus on the most predominant or innovative tools, as well as noteworthy findings in the context of online teacher professional development.

Discussion forums were among the most frequently mentioned tools (n = 60). In some programs, multiple forums were utilized. For example, Joubert et al. [48] distinguished between a general forum and group-specific forums. Discussion forums were employed to stimulate collective exchange (e.g., [4]), facilitate communication with the instructor (e.g., [86], [91]), or address issues in larger group settings (e.g., [12], [58]). In some cases, discussion forums served as a space for individual or collaborative task completion. In a few instances, participation in these forums was explicitly required and considered mandatory for successful course completion (e.g., [89]).

Digital texts were used almost as frequently as discussion forums (n = 61). These included task-oriented texts (e.g., case studies, as in [8]), sample lesson plans, articles (e.g., [103]), and theoretical texts (e.g., [89]). In online-only formats, digital texts also served an additional function: conveying course-related information such as guides, course plans, FAQs, and activity overviews (e.g., [13], [19]). In rare cases, participants were provided with a digital version of the course materials or recorded presentations (e.g., [22]).

Videos played a central role in the technologies utilized across the reviewed programs (n = 71), encompassing lectures, tutorials, demonstration videos, theoretical videos, video presentations, and video podcasts. In some instances, teachers were asked to record their lessons and demonstrate the application of the learning content, making these recordings available online (e.g., [22], [69]). In Schreiber and Jansz [89], participants were required to submit an introductory video at the beginning of the OTPD program. Aside from videos created by teachers, BL formats typically used videos as supplementary materials (e.g., [40]). Recorded lectures were found to be less common, especially in BL formats, and were typically only used in situations where it was not possible for a teacher to attend a f2f session ([108]).

The majority of the training courses (n = 73) integrated a digital platform to coordinate, organize, and/or conduct OTPD as part of their design. Commonly used learning management systems (LMS) included Blackboard, Moodle, Desire2Learn, Canvas, Brightspace, Edmodo, Coursera, Spada Indonesia, Fronter, Neo LMS, and Schoology. In some cases, LMS platforms were created specifically for the course (e.g., [46]) or relied on the LMS platforms provided by universities participating in the program. University-based LMS platforms were exclusively integrated into online-only formats [13], [56], [102]. Two LMS platforms (Blackboard and a local platform) were used solely by Huilcapi-Collantes et al. [44].

Various and often multiple assessment tools were utilized as part of the OTPD courses analyzed (n = 51). In online-only formats, digital questionnaires and quizzes were the most prevalent, while digital tests were less common and more frequently found in BL formats. For example, in Kaul et al. [49] and in the BL course by Situmorang et al. [101], the completion of a digital questionnaire at the beginning of the training was a prerequisite for continued participation. A distinctive feature of OTPD in the BL format was the use of digital questionnaires for course evaluation. In these cases, completing a digital evaluation form was mandatory for successful course completion, with the evaluation process being considered equivalent to an exam. In some instances, digital questionnaires and quizzes were employed for teachers' self-assessment.

eAssessment was mentioned in several studies and was often associated with tests, exams, and/or quizzes. In certain instances, an online testing system was used for computerized assessments (e.g., [56], [63]), with several programs relying on platform-integrated tools. In some courses, automated assessments conducted at the beginning or during the training served as the basis for further recommendations regarding course progression (e.g., [17], [37]). In rare cases, eAssessment was not primarily linked to exam performance but rather to the provision of automated feedback during OTPD. This feedback was designed to support teacher self-assessment, as seen in Gynther [39]. Similarly, in Sompong et al. [93], evaluation buttons allowed both teachers and instructors to activate feedback for evaluation purposes.

A particularly uncommon form of assessing digital performance was digital badging, which involves online certificates verified through blockchain technology and containing metadata regarding participants' performance [52]. Only two online-only formats [35], [47] employed a digital badging system. In these cases, participants were awarded badges for completing assignments and were provided with opportunities to track their learning progress. In the BL format course by Xie et al. [106], badges were used as rewards for task completion, though these were supplemented by quizzes.

Overall, assistance tools for course navigation and structure were rarely integrated into the training design (n = 27) and were primarily employed in online-only courses. These tools included not only guidance on course delivery but also recommendations

for selecting appropriate learning activities or estimating the expected completion time, which were often summarized in digital guides (e.g., [19], [54]). In addition to digital guides, orientation videos or tutorials were also used sporadically (e.g., [60], [68]). Gynther [39] utilized a recommendation system in their courses that developed competency profiles and provided suggestions based on self-assessment.

Activity calendars were incorporated into certain training programs to offer teachers an overview of upcoming course activities, as well as those that had already been completed (e.g., [93]). In some cases, learning outcomes were also displayed, or optional tasks were suggested (e.g., [56], [85], [95]). Tools designed to help teachers track their learning progress were used on a limited basis: for instance, Brennan et al. [12] employed a design notebook for this purpose, while dashboards were used for similar functions in Dahri et al. [23] and Jocius et al. [47]. Self-assessment checklists and grade lists were infrequently used and were restricted to online-only formats (e.g., [68], [103]).

Tools for language selection [51], complexity analysis [22], or participant grouping [108] were utilized infrequently. In instances where participants had questions or needed additional information, some programs offered tools that allowed teachers to seek assistance beyond directly contacting the instructor. Written forms such as digital problem books, glossaries, or FAQs were employed for this purpose (e.g., [68]). Rarely, teachers received support for classroom practice after completing the PD program, such as lesson plan templates [54] or access to course journals and permanent course materials [56].

Virtual reality (VR) was mentioned in n = 25 cases. Virtual worlds were utilized only rarely and predominantly in online-only formats, with a strong emphasis on the development of teachers' digital competencies. A distinction can be made between OTPD programs that took place entirely in virtual spaces and those in which only partial activities were conducted within virtual worlds (e.g., virtual excursions, as seen in [97]). In the studies by Mystakidis et al. [79] and Walkington et al. [104], nearly all interactions occurred within a virtual space. Both studies also incorporated augmented reality (AR) technology, which was mentioned in only one other study within the sample, namely Sompong et al. [93]. In other cases, teachers interacted with avatars in the context of games (e.g., [67]) or during task completion (e.g., [15]). Simulations were particularly relevant in OTPD programs focused on science or mathematics, where the content of the courses was often designed to foster didactic competencies, such as lesson planning (e.g., [72], [101]).

Artificial intelligence (AI) was employed in n = 19 cases, primarily in connection with performance evaluation. Another infrequent application of AI was in communication via chatbots (e.g., [101], [103]). A course based exclusively on AI was presented in Chaipidech et al. [17]. Although an intelligent tutoring system (ITS) was used in the course discussed by Marocco et al. [66], the role of course instruction and the potential involvement of an instructor were not elaborated further. In Gunter and Reeves's [38] training program, it was demonstrated that an instructor can still lead a teacher training course despite the integration of AI. While the AI-based system provided recommendations for course progression, these were reviewed and, where necessary, supplemented by the instructor.

5 DISCUSSION

The analysis of 115 studies identified evidence-based design features that may be relevant for the future design and development of digital teacher training programs,

as well as for their evaluation. The findings indicate that BL formats dominate, albeit to a limited extent, and that the formats differ only slightly in terms of their organizational structure and media-pedagogical approach. The results reveal that current online-only and BL teacher PD programs tend to span over longer periods. This not only facilitates the distribution of learning content and reduces performance pressure ([6]), but also allows sufficient time for reflection, testing, and discussion of the material. This structure aligns with the demand for continuous PD tailored to individual needs [26], [61]. However, it should be noted that most studies did not specify the actual learning time required within the stated training period. Given the challenges and demands associated with integrating digital training into the everyday work of teachers, such information would have been valuable.[9]

The results also show that, even in online-only formats, social presence is maintained through a combination of asynchronous and synchronous phases. Although physical exchange is not possible in online-only formats, synchronous phases can help ensure social presence, as well as foster motivation and engagement among teachers. However, online-only formats carry the risk of anonymity and isolation, which can sometimes lead to reduced participation or even dropout [34]. Creating shared learning experiences, bridging physical distances, and providing opportunities for networking beyond written communication are key requirements. The diverse integration and use of discussion forums demonstrate that synchronous learning opportunities (e.g., f2f sessions) are not a necessary criterion for establishing and maintaining social presence. Discussion forums not only provide space for collaborative work but also allow participants to share ideas with one another and with the instructor [57]. Moderated and structured discussions, in particular, have been shown to positively contribute to the teacher training process (e.g., [89]). The role of the instructor in facilitating OTPD courses is of significant importance for the implementation and ultimate success of training [30], [57]. This was also emphasized in studies that relied on a mix of guided and self-directed learning in their training interventions (e.g., [80]) or that did not involve the presence of an instructor [68], [78]. Digital tools such as tutorials, guides, etc., as described in some of the analyzed studies, appear to be an appropriate complement in this context. However, it remains questionable whether such tools can fully replace an instructor, as the content of the training session also likely plays a significant role. This is a limitation of the present study, as it did not examine the content of the training programs. For example, it is unclear whether a particular technology is suitable or unsuitable for teaching certain content or how it can be applied in other disciplines that do not currently use these specific tools. Future research should address these gaps in order to develop a content-specific understanding of digital training design. The extent to which guidance in digital training interventions can be provided exclusively or partially by AI-driven systems, such as ITS, has been scarcely explored (e.g., [37], [17]). Despite promising results, further studies are needed to determine whether AI-based systems can replace instructors, offer more efficient alternatives, or be used in a complementary and particularly effective manner [14].

Additionally, the results show that the majority of OTPD courses analyzed focused on action-oriented learning opportunities and were cautious about the deductive acquisition of content. Especially in the context of fully online training courses, it seems possible to encourage teachers to engage actively with the learning content using educational technologies. At the same time, the active exploration and use of educational technologies (for the teachers' own learning purposes) provide

[9] For instance, with regard to individual workload, it makes a difference whether a multi-week training program requires 10 hours or 30 hours of learning time.

opportunities to strengthen individual media literacy and reflect on the use of technologies in teaching practice and student learning. It can be assumed that new tools, such as VR or game-based learning, are particularly suited for acquiring didactic skills (e.g., [104]). Initial positive findings in this regard should be further validated by future research.

6 CONCLUSION

The aim of this systematic mapping study was to apply systematic criteria to describe the current landscape of research on OTPD and to highlight the predominant formats currently offered, as well as how these are conceptualized and designed. The 115 studies reviewed represent a combination of BL and online-only formats for the professionalization of teachers across various subjects and school levels. Despite their diversity, these studies allow for the identification of emerging trends in the design and development processes of OTPD programs. Social teaching-learning theories, as well as collaborative and action-oriented learning approaches, were integral to many OTPD courses. Notably, only half of the studies referenced the guidance of an instructor. Although a variety of tools and media were commonly used, discussion forums and videos, along with LMS, were the most frequently mentioned. It was also evident that technologies were employed for a range of purposes and to varying degrees. More innovative technologies, such as VR, AR, and AI, were described less frequently, with AI primarily being linked to e-assessment.

To enhance the relevance of these findings for future program designs and considerations for their optimization, as well as to address the ongoing research gap regarding the effectiveness of OTPD courses, it is necessary to revisit the studies with a focus on the content orientation of the training programs, their effectiveness, and their evaluation. These aspects are central to the research focus of many of the studies analyzed. For instance, further investigation is needed to determine whether the frequent use of discussion forums and videos is associated with positive outcomes in terms of effectiveness and user perception and to explore the potential of less frequently used, innovative tools in this context. It is well established that the effectiveness of digital training cannot be attributed to the use of a specific technology alone; rather, such an assessment must consider a range of other design elements and contextual factors [30], [57], [64], [81]. Among the key factors is the content to be conveyed in the training [26]. It is possible that certain technologies may be more suitable for teaching specific competencies when combined with different teaching-learning strategies. By analyzing the perceptions of both teachers and trainers, further insights can be gained into the value of OTPD programs and their optimal design [57].

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