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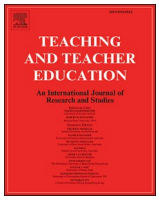
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Review article



Differentiating instruction: Understanding the key elements for successful teacher preparation and development

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ABSTRACT

Primary and secondary school teachers are expected to adapt their teaching to the diverse educational needs of students through differentiated instruction (DI). This review included 29 peer-reviewed published articles from 2010 to 2020 evaluating the contribution of preservice and in-service teacher programs for DI. We synthesized program components, outcomes and contextual interplay. Results indicate that successful programs incorporate active learning, collaboration and reflection and were often longitudinal, comprehensive and addressed attitudes, knowledge and skills. Contextual (school) factors acted as facilitators and impediments to program efficacy. Balancing school ambitions with realistic expectations is a concern. Educational and policy implications are further discussed.

1. Introduction

Diversity in education is indisputable, and differences between students are inherent in classroom contexts (Belfi et al., 2012). This applies even more to urban environments where there is often a heterogeneous student population in terms of sociocultural backgrounds, home environments and languages and countless related characteristics that influence the quality of life and the dynamics of power and privilege (Gaikhorst, 2014; Matsko & Hammerness, 2014). This calls on teachers to optimize the growth of each student by accepting and recognizing that students have different ways of learning and responding to instruction (Gay, 2018; Tomlinson, 2014). Differentiated instruction (DI) is a comprehensive teaching approach that intends to maximize the learning outcomes of all students in the classroom and decrease the achievement gap (Denessen, 2017; Gheyssens et al., 2020; Griful-Freixenet et al., 2020; Steenbergen-Hu et al., 2016). While most teachers espouse these anticipated benefits of DI in meeting student needs, its actual adoption in practice by teachers is considered a major challenge and remains critical (Suprayogi et al., 2017). Teachers often need additional preparation and practice to be equipped for implementing DI in their classrooms (Dixon et al., 2014). For the last decade in particular, we have seen an increase in efforts aimed at developing and monitoring programs to effectively prepare and equip teachers for this task (Parsons et al., 2018). Even though the growing body of literature on DI offers some starting points, there is still no consensus on how to effectively prepare and professionalize teachers for DI (Bondie et al., 2019; Deunk et al., 2018; Smets, 2019). The present review study aims to uncover and describe what the literature tells us about teacher preparation and training programs targeted at improving teachers' competence for tailoring their education to the diverse learning needs of students.

1.1. Differentiated instruction

DI is a philosophy and praxis of teaching and learning rooted in the acknowledgment of student differences and aimed at tailoring instruction to support each student's growth and development (Deunk et al., 2018). In the research literature, DI initially focused on teaching for gifted students, then evolved into a set of instructional practices aimed at special education inclusion classrooms, and further developed into a mainstream teaching approach for meeting the needs of all learners in regular classrooms (Graham et al., 2021; Stradling & Saunders, 1993). This widespread adoption of DI has concurrently given rise to a proliferation of concepts and strategies (Bondie et al., 2019). Therefore the concept can be characterized by a degree of ambiguity and lack of clear-cut definition (Deunk et al., 2018; Graham et al., 2021; Smets & Struyven, 2018; Van Geel et al., 2019). Although DI is not precisely

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delineated and unambiguously operationalized in the literature, there is an emergent understanding of its comprehensive characteristics. Jager et al. (2022) identified both deliberateness and adaptiveness as common ground when responding to differences between learners in the heterogeneous classroom. Tomlinson and Imbeau (2010) argued that the core of DI is the teacher's adaptation of content, process, product and affect in response to perceived differences in learners' readiness, interests, and learning profile. This involves teachers recognizing students' learning needs, adjusting learning objectives, curriculum content, instructional methods, learning tasks, and ongoing assessment of student development (Prast et al., 2015; Van Geel et al., 2019). DI is supported by a positive attitude towards diversity and the recognition of students' diverse backgrounds, encompassing students with varying levels of academic readiness, diverse cultural backgrounds, and a range of learning abilities (Gay, 2010; Wilkinson & Penney, 2014). To provide a clear delineation of DI for this review, we define it as a proactive approach that incorporates inclusive strategies to create tailored, accessible learning experiences that meet the educational needs of all students within the classroom.

1.1.1. Research on the impact of DI

The literature provides indications that DI positively impacts students' learning outcomes. Deunk et al. (2018) identified a modest positive impact of DI on student performance in primary education. In secondary education, research revealed small to moderate effects of DI on learning outcomes (Smale-Jacobse et al., 2019). Steenbergen-Hu et al. (2016) demonstrated in their second-order meta-analysis, that student learning outcomes benefited from within-class ability grouping, a closely aligned teaching approach. DI can also impacts students' social and emotional development, as Pozas et al. (2020) indicated. In addition to these potential benefits of DI and its substantial premises, it is relevant to consider some limitations of research on DI, as pointed out by Smale-Jacobse et al. (2019) and Graham et al. (2021). The diffuse conceptualization of DI, the different processes and procedures used in providing it, and the paucity of details regarding teacher professionalization for implementing DI collectively highlight the importance of critically exploring this area and suggest that a study of ways to support teachers in learning about and implementing DI is warranted.

1.1.2. Knowledge, skills, and attitudes for DI

DI can be understood as a teacher competency, that is, an integrated set of knowledge, skills and attitudes (Keuning et al., 2017; Korthagen, 2004). This presumes that developing teacher competence for DI necessitates the consideration of teachers' knowledge, skills, and attitudes. Implementing DI requires from teachers to know when and how to teach specific content effectively and to have knowledge of approaches that enable pupils to be taught effectively (Smets, 2019). When teachers integrate knowledge about DI into their existing knowledge frameworks about teaching and learning, this can strengthen DI implementation (Van Geel et al., 2022). Since the transfer of knowledge about DI to practice is often challenging, it is recommended that teacher development programs pay explicit attention to the implementation process (Gheyssens et al., 2020).

Effectiveness of DI primarily hinges on the teacher's actions, specifically, how they deliberately, proactively, and effectively adapt instruction to meet the diverse learning needs of their students, for example by adapting materials for diverse learners and using appropriate instructional strategies (Tomlinson et al., 2003; Van Geel et al., 2019). The initial step in achieving this is the development of skills. Practical classroom experience stands out as the most advantageous factor for DI skill development (Van Geel et al., 2022). Teacher self-efficacy positively impacts the implementation of DI and is reinforced by classroom experience with DI (Dixon et al., 2014).

Teacher qualities for DI extend beyond teacher knowledge and practical skills, as attitudes also play a crucial role. Teacher attitudes toward immigrant and marginalized students have been shown to lessen teachers' expectations, both those they have of themselves to be effective teachers and those they have of their pupils (Rubie-Davies, 2010). These expectations steer and deeply affect the way teachers behave toward their students, which is subsequently perceived by students and to which they respond in terms of behavior and school performance (Denessen, 2017; Dweck, 2015). Dweck (2015) argued that a growth mindset should be developed for teachers to believe that most student learning can be achieved through dedication and hard work. From this viewpoint, every student is capable of being successful, which emphasizes and fosters the teacher's responsibility for the learning of all students in the classroom. According to this perspective, teacher attitudes act as a filter for knowledge, influence the formulation of a problem or task, and guide teacher's intent and actions in the classroom (Fives and Buehl, 2008). Critically reflecting on one's own beliefs and how these beliefs influence their instructional behaviors can challenge and alter these beliefs, providing an impetus to change teacher behavior (Akiba, 2011; Gay, 2010).

1.2. Teacher development for DI

Implementing DI is a complex matter in which multiple types of knowledge, skills and attitudes are intertwined in an integrated way (Van Geel et al., 2022). There are numerous indicators that both preservice and in-service teachers should be guided and supported in the effective development of DI competence (Eysink et al., 2017; Feiman-Nemser, 2001; Gaikhorst, 2014; Matsko et al., 2022; Ruys et al., 2012; Van Geel et al., 2019).

1.2.1. Teacher preparation for DI

Maulana et al. (2015) stressed the complexity of DI and indicated that effectively developing competencies for DI takes time and that basic teaching skills are considered a prerequisite. Other studies emphasized the importance of paying attention to DI as early as during teacher education, because (1) knowledge and skills gained during initial teacher education would be key to successful implementation of differentiation, and (2) it allows DI to be presented as the standard teaching approach, rather than introducing it later as an additional and complementary approach (Brevik et al., 2018; D'Intino & Wang, 2021; Dee, 2010; De Neve & Devos, 2016; Matsko & Hammerness, 2014; Scarparolo & Subban, 2021; Specht et al., 2016; Van Geel et al., 2022; Wertheim & Leyser, 2002). Although teacher education programs meet the demands placed on them by addressing DI in their curricula, they often offer only an introduction to theory (D'Intino & Wang, 2021). This cursory introduction to differentiation is a start, but may not provide enough depth to support teachers to effectively put DI into practice.

1.2.2. Teacher professional development for DI

Ongoing professional development throughout in-service teachers' careers is considered indispensable for teachers to (learn to) respond well to the learning needs of their students (Gheyssens et al., 2020; Smets, 2019; Van Geel et al., 2019). TPD initiatives encompass processes and activities designed to improve teachers' classroom practices, with a consequential impact on student learning outcomes (Guskey, 2002; van Veen et al., 2012). The overarching goal is to create a diverse and effective teaching force that can adapt to the changing needs of students and teaching. Professional development opportunities for in-service teachers are often provided by educational consultants who have acquired expertise in DI. TPD offerings take many different formats and range from a half-day PD to a long term sustained program. Most schools do not have access to extensive programs, due to limited resources or other considerations (Sims & Fletcher-Wood, 2021). Kahmann et al. (2022) conducted a meta-analysis providing an overview of characteristics and effectiveness of 27 (quasi-) experimental studies focused on DI and revealed a medium effect of such programs on teacher measures. They furthermore exposed a need for more explicit statements about the programs theory of improvement to support effective evaluation and

enable better-informed program adjustments.

1.2.3. Effectiveness of teacher professional development

Over the past two decades, researchers have identified components of teacher professional development (TPD) that may bring about positive change in teacher attitudes, knowledge, and skills (Borko, 2004; Darling-Hammond et al., 2017; Guskey, 2003; van Veen et al., 2012). Specifically, Darling-Hammond et al. (2017) reviewed 35 methodologically rigorous studies that demonstrated positive links between TPD and teacher practice and identified effective TPD characteristics. According to Darling-Hammond et al. (2017) effective TPD is (1) content focused, (2) incorporates active learning strategies, (3) supports structured teacher collaboration, (4) makes use of models and modeling of effective practice, (5) integrates coaching and support of experts, and (6) provides opportunities for feedback and reflection. The (limited) success of TPD in DI is often associated with the opportunities and constraints for successful implementation provided by the context of the program (Gaitas & Alves Martins, 2017; Sims & Fletcher-Wood, 2021; Suprayogi et al., 2017; Van Geel et al., 2022). Desimone (2009) provided a conceptual framework for research on effective TPD that presents core features of effective TPD and incorporates context as an important mediator and moderator influencing the professional development of teachers.

1.3. Present study and research questions

The purpose of the current study is to build on previous research and explore the components, ingredients and contextual integration of TPD related to DI. This is further specified in the following research questions: (1) which components do current teacher programs for DI contain? (2) what are effective ingredients of teacher programs for DI, and (3) which contextual factors influence the success of teacher programs for DI?

2. Methodology and methods

The objective of this descriptive review is to provide a comprehensive and detailed synthesis of studies on the effects of DI teacher training programs, aimed at providing a deeper understanding of effective key elements. The reporting is in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement. By analyzing relevant research on DI teacher training programs, we seek to understand the breadth and depth of the existing body of studies and identify gaps that need to be explored. In doing so, the steps of Xiao and Watson (2019) were followed: (1) literature search, (2) screening for inclusion (3) quality assessment, (4) extracting data and (5) analysis. These steps aim to systematically assess the content and methodology of the collected studies and contribute to a well-structured and robust assessment process.

2.1. Literature search

In light of the observation of Parsons et al. (2018) that researchers turned to professional development in DI as a research topic around the year 2010, we considered studies focused on the evaluation of preservice and in-service teacher programs for DI published between 2010 and 2020.

A search syntax (see Fig. 1) was formulated to systematically browse the three commonly used databases within the field of educational research (ERIC, PsycINFO and Web of Science). The trial search was repeatedly checked against already known primary studies that belong in the set (Kitchenham & Charters, 2007). The search syntax used was composed of terms for DI, e.g.: ‘differentiation’, ‘individualized’, ‘adaptive’, ‘situated’, ‘culturally responsive’, These were combined (AND) with terms for ‘teacher education’, ‘preservice teacher education’, ‘teacher training’, ‘professional development’ and ‘professional learning’. An asterisk (*) was used as a wildcard.

2.2. Screening for inclusion and quality assessment

Aiming at systematic reporting, a Prisma flowchart (see Fig. 2) was used to depict the flow of information through the different selection phases of included studies. (Moher et al., 2009). Initially, 4917 publications were identified (n = 3698 unique publications after removing duplicates using Zotero software). Backward reference searching resulted in three more articles. This strategy was used to ensure comprehensive coverage of the relevant literature by identifying relevant studies that were not included in the databases searched or our search terms were not present in the title, abstract, or keywords. To narrow our selection, we uploaded the documents’ abstracts in the Rayyan QCRI web application which scoped the abstracts of n = 3701 documents. Rayyan QCRI enables to collaboratively assess a large volume of articles systematically, enhances efficiency and reduces the risk of human errors.

Table 1 lists the inclusion and exclusion criteria. We included studies based on the following inclusion criteria: (1) the publication was available in the English language; (2) the study was published in peer-reviewed scholarly journals 2010–2020; (3) the program was aimed at primary or secondary school teachers. Early childhood and kindergarten were excluded for reasons of comparability; (4) the program targeted

The following electronic databases were searched on 30 Dec 2020; ERIC (1950 references), PsycINFO (1415 references), Web of Science (1552 references).

All searches were based on the ERIC search strategy below

1. individualized instruction/ OR (((adapt* OR differentiat* OR individuali*ed OR culturally responsive OR diversity OR diverse OR heterogeneity) ADJ3 (teach* OR instruction* OR learning OR classroom* OR curricul* OR mixed ability)) OR differentiation OR differentiat* strateg* OR diversity teaching OR funds of knowledge OR personali*ed scaffolding OR differentiat* education OR individuali*ed education OR culturally responsive education OR diversity education OR effective differentiation OR academically responsive OR situated learning OR low-track* OR ability group* OR pacing).ti,ab,id.
2. teacher education/ OR preservice teacher education/ OR teacher education programs/ OR beginning teacher induction/ OR (teacher training OR teacher education OR (teacher* ADJ3 (induction OR professional development OR program* OR support* OR professional learning OR competenc*))).ti,ab,id.
3. learner variance.ti,ab,id.
4. (1 AND 2) OR 3
5. limit 4 to peer reviewed
6. limit 5 to 2000-current

Key: / = subject heading, ti = title, ab = abstract, id = key concepts (other keywords added by ERIC indexers to supplement the subject headings)

Fig. 1. Search strategies for electronic databases.

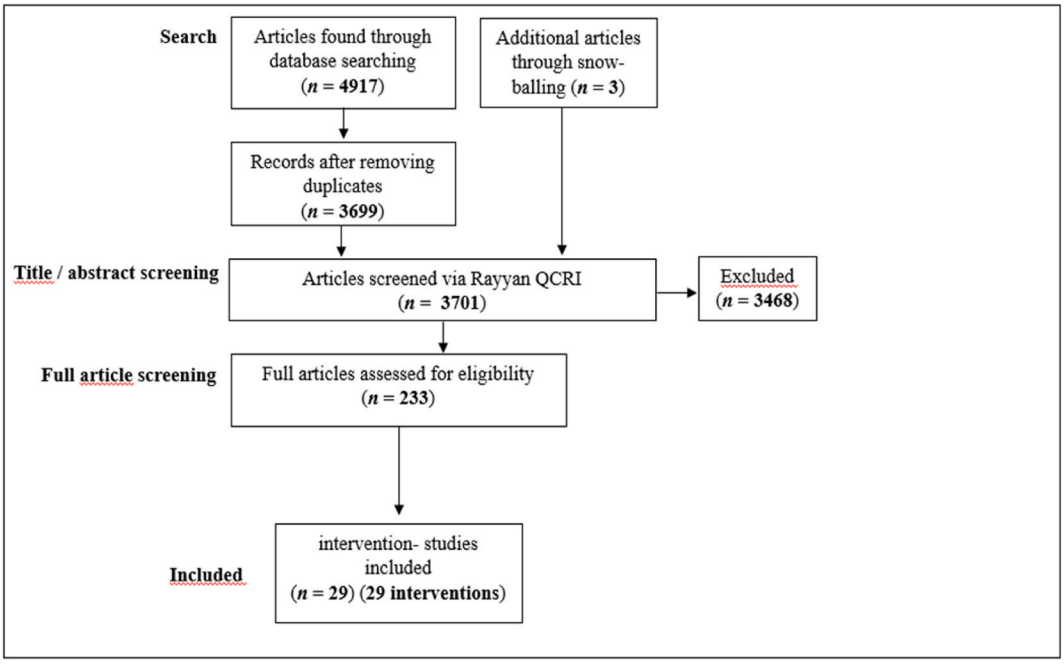


Fig. 2. Prisma flow chart (based on Moher et al., 2009).

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Publications in English language area	Outside English language areas
Peer-reviewed articles and working papers 2010–2020	Conference papers and dissertations
Primary and secondary school	Nontarget f.e. early childhood, disabled, elderly
Preservice, and in-service teachers	Outside area of teacher training/ professionalization
Differentiation, adaptive teaching, culturally responsive teaching	Other teaching skills

preservice and/or in-service teachers; and (5) the outcome variables reflected DI. We aimed at *generic* approaches to DI (and approaches that can be deployed as such) and excluded studies focused on specific subject-related didactic approaches, for example on language teaching, that do not belong within the focus of this review.

The studies (n = 3701) titles, abstracts and subject headings (if available) were screened based on the inclusion and exclusion criteria. Potentially eligible studies (n = 233) were obtained in full text and evaluated to determine study eligibility. We removed 188 studies, and, for reasons of reliability, 45 studies were assessed for eligibility by two researchers. These researchers conducted independent reviews of the 45 manuscripts in parallel, reading the full text using the criteria for inclusion. Discrepancies were discussed and resolved. After collaborative deliberation, studies considered outside the scope were excluded from the sample. A total of 32 studies were deemed appropriate for quality assessment. To reassure and refine the credibility and trustworthiness of the findings, the Critical Appraisal Skills Programme (CASP) (2019) checklist for qualitative research, an appraisal tool that systematically checks the research's value, was used. Even though not all the studies were of a qualitative nature, this tool was considered useful for all studies to assess the approach in terms of validity, outcomes and relevance. Full texts were evaluated for quality by the first author. Debatable cases were rescreened by at least two researchers and discussed in the research team, and it was jointly decided which articles to include. The final sample of included outputs consisted of 29 primary studies.

2.3. Extraction and analysis

The 29 articles were coded using a qualitative data analysis software program (MAXQDA). Research team consultations led to refinement of the coding structure. The selection of meaningful text passages and interpretations of their meaning were systematically verified for reasons of accountability. First, for each study, the formal reference was annotated (author, journal, country), the target group, the program's aim(s) and outcome measures: teacher knowledge, skills, attitude or student performance. If there was a positive effect of a training program (measured or observed improvement), the results of a study were categorized with a '+'. If there was a partially positive effect (an improvement on certain aspects but not on others) then the results of a study were categorized with a '+/−'. If no or negative effects were reported after a program, the outcomes were categorized with '-'. It is important to note that qualitative studies often reported different outcome measures, such as changes in participants' perspectives or teachers' reported experiences.

The coding of the program components was grounded in a theoretical framework of effective general teacher professionalization by Darling-Hammond et al. (2017), who built on extensive literature. The categories and subcategories presented in Table 2 were developed through a multi-step process that involved both deductive and inductive approaches. We started with this theoretical framework as a foundation and adapted the initial coding framework to the specific context of our study. This adaptation involved revising, adding, or combining codes to better align with the findings from the data collected from the primary studies. Multiple rounds of reading and re-reading put forward new subcategories and definitions. To enhance the validity and reliability of the coding process, multiple researchers were involved. Discrepancies were resolved through discussion and consensus-building.

For the coding of the program context, the model of Desimone (2009) was used, which makes a distinction between contextual factors that relate to the school (type, physical environment, school culture, leadership, policy, collaboration and support structures) and to the teacher (s) (prior knowledge, teacher qualities). When program context was explicitly mentioned as of supposed influence on the program's success, it was included in the results section of this study. Contextual factors were classified as *facilitators* if it was stated that the contextual factor positively influenced the program's effect or success. The studies were

Table 2
Classification of program components.

Main category and components		Abbv.	Brief description
Content focus	Teacher issues	IS	Focus on daily issues and concerns of teachers in the specific context in which they operate
	Student learning	SL	Focus on specific student populations with targeted strategies to support student achievement
Active learning	Practice in design	PD	Design of lesson plans or teaching strategies
	Simulation-Based Learning	PS	Engagement with content in role play or otherwise amplified real experience
	Practice in Classroom	PC	Implementation of learning content in actual classrooms with students
	Classroom Inquiry	IQ	Constructing, trying out, and reflecting on new teaching strategies
Collaboration	Collaboration with peers	CP	One-on-one or small-group interactions with colleagues or other professionals beyond the school
	Collaboration with students	CS	Structured collaborative activities with (prospective) students
Use of Models and modeling	Curricular Models	CM	Provision of a vision of practice through, e.g., student work samples or demonstration lesson plans
	Modeling of Instruction	MI	Provision of a vision of practice by engaging teachers in demonstration lessons with effective instruction
Coaching and Expert Support	Coaching	CA	Guiding and facilitating learning in the context of practice
	Expert instruction	EX	Sharing of content, evidence-based practice and expertise
Feedback and Reflection	Reflection	RF	Provision of time and opportunity for teachers to think about, receive input on, and make changes to teacher practice
	Feedback	FB	Redirecting or refocusing teachers' practice to thoughtfully move to expert visions of practice

classified as *barriers* if the factor negatively influenced the program's effect or success. Quotes from the studies were added to illustrate the results.

To enforce systematic and transparent coding, we conducted an approach where the coding of passages was also performed by another researcher (Miles et al., 2014). Any differences were discussed in the research team until consensus was reached and the coding was adjusted to reflect the outcome of this discussion. For rigor of the analysis, approximately 10% of the final coding of fragments were rated by two raters and the interrater reliability measure (Cohens k) (Moher et al., 2009) revealed a near perfect interrater agreement in interpretation ($k = 0.88$).

3. Results

The programs for DI in the sample targeted both preservice (13) and in-service (15) teachers (see Table 3). One study used a combined focus on both target groups. Most studies focused on secondary education (17), and a smaller number focused on primary education (7) or a combination of (preservice) primary and secondary education (4). The final sample of outputs (29) consisted of 18 qualitative, two quantitative and nine mixed methods studies. Twelve studies in the sample can be regarded as *process oriented* and intended to describe *how* DI learning

Table 3
Program specifications, descriptions and objectives.

Study	Geographical setting	Target group	Teacher training program description and objectives
Acquah (2020)	Finland	Preservice teachers	Twelve weeks; modeling of culturally responsive teaching strategies and activities, including line-up games, group discussions, critical reflection, writing autobiographies, and structured field experiences combined with post-experience reflection Achieve transformative learning manifest by re-evaluating stereotypes, misconceptions and teacher beliefs
Assaf (2015)	United States	Preservice teachers Primary school	Six months; service-learning project and field-base TE program Scaffold prospective teachers to become culturally responsive in their teaching
Dack (2018; 2019; 2020)	United States	Preservice teachers Secondary school	Fourteen weeks; explicit modeling meetings, whole-group and small-group discussion, and workshops Develop knowledge of and attitudes toward (Tomlinson's model of) differentiated instruction
Duquette (2016)	Canada	Preservice teachers Primary school	Nine weeks; (preparatory) SE course, guided reflection questions on used strategies and weekly discussions on possible solutions Develop personal and practical knowledge about students and refine DI practices
Goodnough (2010)	Canada	Preservice teachers Secondary school	Biweekly sessions and a three-week learning block. Short readings, content input and models. Inquisitive collaborative work on messy, open-ended problems concerning DI Explore the principles of DI and how these principles could be translated into classroom practice
Kuehl (2018)	United States	Preservice teachers Primary school	Six weeks; simulated experience of one-on-one conferencing while receiving peer support Learn to practice differentiated instruction
LaBelle (2016)	United States, the	Preservice teachers Secondary school	Eight weeks; lectures and structured reflective assignments Support the development of teacher beliefs
Seglem and Garcia (2015)	United States	Preservice teachers Secondary school	Structured meetings in a shared virtual space Increase understanding of urban students and develop teacher beliefs toward student learning
Wan (2015)	Hong Kong	Preservice teachers Primary and secondary school	Thirteen weeks; sessions providing theories and practical implications, workshops, professional sharing by experts, in-class and online group

(*continued on next page*)

Table 3 (*continued*)

Study	Geographical setting	Target group	Teacher training program description and objectives
			discussions, poster presentation, and school visits Support the development of differentiated instruction
West (2016)	United States	Preservice teachers Secondary school	Eight weeks; coteaching course by an English professor and a SE teacher Develop skills for teaching SE students and for working effectively together with specialists in public school contexts
Whiteker (2018)	United States	Preservice teachers Primary and Secondary school	Two years; master's curriculum with emphasis on diversity and inclusion, e.g., course on culturally responsive teaching methods with emphasis on student-generated problem-based learning methods and differentiated instruction Prepare teachers to work with diverse learners
Beltramo (2017)	United States	In-service teachers Secondary school	Guided dialogues between teachers and students Construct and leverage new knowledge about students and subsequently enact more adaptive teaching practices
Blik et al. (2015)	Netherlands	In-service teachers Vocational school	Sixteen weeks; instruction, sample lessons on video, role play, own lesson recording (video), instructional coaching, coaching and self-assessment Change teacher behavior from prescriptive to interactive instruction
Bower (2012)	Australia	In-service teachers Secondary school	Eight weeks; three workshops and a mentoring session Improve the ability to differentiate the curriculum with the use of webtools and SRS's
Brigandi (2019)	United States	In-service teachers Primary school	Six months; 2-h whole-group sessions, workshops, and practice to increase cross-curricular strategies Develop attitudes toward and knowledge and skills regarding gifted education
de Graaf (2019)	Netherlands	In-service teachers Secondary school	One year; five 3-h sessions, lesson design cycles with increased complexity Support the redesign of lessons according to DI while matching work context, within a limited amount of time and with limited resources
Mellom (2018)	United States	In-service teachers Primary school	Two years; one week-long IC training (instructional conversation), teacher-led communication between small groups of students, and coaching support throughout one practice year Meet the needs of language learners and other

Table 3 (*continued*)

Study	Geographical setting	Target group	Teacher training program description and objectives
			culturally and linguistically diverse students
Nazzal (2011)	United States	In-service teachers Secondary school	One year; PST course for mastery DI students Implementation of DI strategies
Öztürk (2019)	Turkey	In-service teachers Preschool, primary school, secondary school	one year; one shot workshops and supported 50-h in-service training Address the educational needs of all students including the disadvantaged such as disabled and SEN students
Prast (2018)	Netherlands	In-service teachers Secondary school	One year; cyclical learning pathway, 10 x 3 h instruction for strategies Develop a better response to the educational needs of students and, thus, improve student performance
Schipper (2020)	Netherlands	In-service teachers Secondary school	One year; a learning pathway consisting of two learning cycles Acquire knowledge about and insight into (the learning of) students and improve the quality of didactical decisions and lesson design
Sharp (2018)	Australia	In-service teachers Secondary school	Whole school professional learning approach targeted at heads of faculty and whole of the staff Change understandings, attitudes and practices related to differentiated instruction
Smets and Struyven (2020)	Belgium	In-service teachers Secondary school	Action research: Instruction, implementation in practice, collaborative practice and expert coaching Scaffold and support implementation of DI
Valiandes (2017)	Cyprus	In-service teachers Secondary school	Two years, subject-oriented training sessions and workshops, active reflective practice, continuous support channels and structured collaboration Improve confidence and ability to design and apply differentiated instruction
Yuen (2018)	Hong Kong	In-service teachers Primary school	Three-hour lectures, guest speakers, interactive workshops, active practice, feedback Enhance professional knowledge and confidence of teachers in adopting differentiation strategies, plan and deliver lessons for gifted students
Bersh (2018)	United States	In-service teachers Preservice teachers	Six weeks; autobiography writing, and guided reflective interview Provide insight into how own experiences are intertwined with own teacher identity and beliefs and how this shapes (future) teachership

manifests, for example, Dack (2018) and Smets et al. (2020). Two (quasi)-experimental studies were included (Prast et al., 2018; Schipper et al., 2020) and five studies used a pre- and posttest design without a control group to evaluate the programs (Blik et al., 2015; Nazzal, 2011; Valiandes & Neophytou, 2017; Wan, 2015; West & West, 2016). Eleven studies focused on program success in terms of (often qualitative) program evaluation.

3.1. Program components

The identified components of the programs in the studies from the research sample are described in this section (see Table 4) and categories are discussed in terms of frequency of occurrence. In Table 2 a brief description of (sub)categories of program components has been provided. It should be noted that active learning was the most comprehensive category with four subcategories.

Active learning The data indicate that active learning is considered important for DI learning, as it had a presence in as many as 25 programs (see Table 4). In our analysis, a distinction was made between practice in design (found 19 times), simulated-based learning (6), practice in the classroom (18) and classroom inquiry (7). Preservice teachers developed differentiated lesson plans with modified instruction based on readiness, interest, or learning profile (Dack, 2018). The intended instructional innovation can be further clarified and concretized for teachers by means of practice in simulation. Blik et al. (2015) mentioned teachers who prepared short lessons for their colleagues and acted them out as a role play. Practice in the classroom was a common characteristic in several programs, for example, teachers redesigning biology lessons in three successive cycles (de Graaf et al., 2019). In preservice programs, teacher internships were often used to practice DI in the classroom. The teacher program Teachers' Professional Development Program for DI (PDD) aimed to develop teacher confidence and ability in designing and applying DI by designing lesson plans and implementing them in the classroom (Valiandes & Neophytou, 2017). Practice in simulation was most frequently found in programs targeted at changing teacher attitudes, for example, simulation games for exploring cultural frames of reference (Acquah & Szelei, 2020). Nine programs made use of forms of inquiry. These programs present cyclical/research cycles, problem-based learning (PBL) or professional learning communities. Schipper et al. (2020) evaluated a cyclical adaptive teaching program with teachers who collaboratively identified a research focus, studied the curriculum, designed a lesson, taught the lesson, and observed, and evaluated in a team. PBL was used as a basis for systematic and investigative learning through small, collaborative teacher groups on messy, open-ended problems concerning DI (Goodnough, 2010).

Feedback and reflection Twenty-two programs have utilized reflective exercise and feedback, for example, by offering guided reflection questions to teachers concerning their teaching approach (LaBelle & Belknap, 2016) or through writing an autobiographical narrative to elicit teachers' views on and choices regarding teaching (Assaf & López, 2015). Reflection was the most frequently found characteristic in programs that aimed at developing teacher attitudes. This applied both to studies in which attitudes was trained among other competencies and to studies that exclusively targeted attitudinal change. Assaf and López (2015) described how teachers shared learning and insights on the walls, with visual representations, quotes, and explanations. Feedback (17) was also frequently encountered in the sample studies. The use of feedback was most frequently found in studies focusing on skill development (12).

Collaboration Fostered teacher collaboration was found in 19

Table 4
Program components and outcomes.

Study	Content focus		Active learning				Colla-boration		Models Modeling		Coaching Expert		Feedback Reflection		Outcomes			
	IS	SL	PD	PS	PC	IQ	CP	CS	CM	MI	CA	EX	RF	FB	**K**	**S**	**A**	**SP**
Acquah (2020)		x	x	x	x		x		x	x			x		+		+	
Assaf (2015)			x				x	x					x	x			+	
Dack (2018; 2019)	x		x						x			x	x	x	+/−		+	
Duquette (2016)	x				x	x					x		x	x		+		
Goodnough (2010)	x		x	x		x	x		x	x				x	+		+	
Kuehl (2018)				x		x	x	x					x	x			+	
LaBelle (2016)													x				+	
Seglem (2015)		x		x			x	x	x	x			x	x			+	
Wan (2015)			x				x			x		x					+	
West (2016)					x				x	x							+	
Whiteker (2018)			x		x	x	x						x				+	
Beltramo (2017)				x		x		x						x		+	+	
Blik (2015)	x		x	x	x		x		x	x	x		x	x		+		
Bower (2012)			x		x				x	x	x			x	+	+	+	
Brigandi (2019)			x		x				x			x	x		+	+/−	+	
de Graaf (2019)	x		x		x	x	x		x	x			x	x			+	
	IS	SL	PD	PS	PC	IQ	CP	CS	CM	MI	CA	EX	RF	FB	**K**	**S**	**A**	**SP**
Mellom (2018)		x			x			x			x		x				+/−	
Nazzal (2011)					x											+/−		
Öztürk (2019)	x	x	x		x		x			x			x			+/−	+	
Prast (2018)	x	x	x		x		x			x				x		+/−		+/−
Schipper (2020)		x	x		x	x	x				x	x	x	x		+/−	+	
Sharp (2018)			x		x		x		x	x	x	x	x	x	+	+/−	+	
Smets (2020)	x	x	x		x	x	x				x					+/−		
Smets (2020)	x		x		x		x		x		x	x				+/−		
Valiandes (2017)	x		x		x	x	x		x		x	x	x	x		+	+	+
Yuen (2018)			x		x		x		x			x		x	+	+		
Bersh (2018)													x				+	
	10	7	18	6	18	9	17	5	13	11	8	7	16	15				
	IS	SL	PD	PS	PC	IQ	CP	CS	CM	MI	CA	EX	RF	FB	**K**	**S**	**A**	**SP**

Note.
If there has been positive growth, improvement, or change following a teacher program, the outcomes are categorized with a "+". If there has been partial growth, improvement, or change after a program, the outcomes are categorized with "+/−". For example, there are sub-competencies that show growth, and sub-competencies that do not show growth. If no growth or negative growth has been measured after a program, the outcomes are categorized with '-'.

programs and was further categorized into collaboration with peers and collaboration with students. Collaboration with colleagues was found most often in programs targeted at developing DI skills (16 out of 22). The program reported by Valiandes and Neophytou (2017) was aimed at promoting structured collaboration between teachers in the program on the premise that teacher-learning communities enhance teacher DI practice. Collaboration with students was also often found in programs focused on attitudinal change (12 out of 20). Kuehl (2018) discussed a PBL-based program that supported collaborative learning to critically examine and reflect on teacher beliefs related to learning and diverse learners in the regular classroom. Four studies described collaborative structures between teachers and students. Kuehl (2018) details a pre-service teacher project in which teachers and marginalized students worked together. They read the same novel and engaged in a discussion via an online dialogue journal to create teacher awareness of the need to approach individual students differently and create more understanding of how to guide them accordingly.

Content focus This category was present in 17 teacher programs and included a connection of teacher learning to teachers' daily issues (11) and a focus on student learning (6). Program components within this category were comparatively most frequently found in programs that focus on DI skill development (12). De Graaf et al. (2019) report, for example, on a program in which teachers' issues and personal interests were met. The project reported by Seglem and Garcia (2015) was aimed at providing teachers with the opportunity to learn more about how to navigate the language of their students' cultures, assess their students' needs and improve their students' language use and communication.

Models and modeling The use of models and modeling was evident in 16 programs and was divided into curricular models and modeling of instruction (see Table 4). Curricular models were found in 14 programs, for example, the use of best practices of DI lesson design or examples of differentiated student assessment. Modeling of instruction was found in 11 programs. Goodnough (2010) recounted group sessions watching a video of a teachers effectively practicing DI. Acquah and Szelei (2020) mentioned teacher educators modeling instructions by employing activities and strategies that preservice teachers can use in their own future work, such as line-up games, group discussions and structured field experiences.

Programs that aimed to enhance DI knowledge all made use of some form of modeling.

Coaching and expert support In 13 of the programs, various forms of coaching and expert instruction were encountered. Seven evaluated programs made use of experts. Brigandi et al. (2019) mentioned an educational researcher that provided whole group sessions about gifted education for teachers. Some programs provided classroom support through coaching on the job, such as an individual mentoring session that supported teachers who felt the need for more individualized support (Blik et al., 2015).

A large proportion of the programs (19) had a duration of three months to one year, and six studies reported learning trajectories that took over a year. Sometimes the actual training phase was cut into two or more parts with an internship or practice in the classroom to deepen the learning experience. In-service teachers were proportionally more likely to be offered programs with longer durations than preservice teachers.

3.2. Program effectiveness

In this subsection, the reported general effects in Table 4 are related to the research designs and used measurements of the studies (see Table 5). A distinction was made between measurements of knowledge, attitude, satisfaction and skills. We present an overview of the findings related to teacher attitudes, teacher knowledge, teacher satisfaction, teacher self-reported skills, and teacher skills observed directly.

Teacher attitudes Sixteen studies reported programs aimed at developing teacher attitudes toward differentiation. Fifteen (out of 16)

Table 5
Overview of study design and measurements.

Study	Study design	Data collection methods	*N*
Acquah (2020)	One group, posttest	Learner reports	2
Assaf (2015)	One group, posttest	Interviews; documents; Learner reports	15
Dack (2018)	One group, posttest	Interviews; observations; documents; learner reports	15
Dack (2019)	One group, posttest	Interviews; observations; documents; learner reports	18
Dack (2020)	Multiple case study	Interviews; observations; documents	2
Duquette (2016)	One group, posttest	Interviews; documents	4
Goodnough (2010)	One group, posttest	Documents; interviews; learner reports	32
Kuehl (2018)	One group, posttest only	Documents; learner reports	22 teachers
LaBelle (2016)	One group, posttest only	Documents	183 teachers
Seglem (2015)	Multiple case study	Documents; learner reports	16 teachers
Wan (2015)	One group only pre- and posttest	Questionnaires; interviews; focus groups	27 teachers
West (2016)	One group only pre- and posttest	Interviews	3 teachers
Whiteker (2018)	Multiple case study	Questionnaires; interviews; focus groups	22 teachers
Beltramo (2017)	One group, posttest only	Observations; interviews; documents	2 teachers
Blik (2015)	One group only pre- and posttest	Observations; questionnaires; documents	13 teachers
Bower (2012)	One group only pre- and posttest	Questionnaires; documents	24 teachers
Brigandi (2019)	Single case study	Interviews; observations; learner reports	1 teacher
de Graaf (2019)	One group, posttest only	Documents; questionnaires; learner reports; interviews	5 teachers
Mellom (2018)	Quasiexperimental pre- and posttest with treatment and control group	Observations; documents; learner reports	147 teachers
Nazzal (2011)	One group only pre- and posttest	Observations; interviews; questionnaires	2 teachers
Öztürk (2019)	One group, posttest only	Focus groups	27 teachers
Prast (2018)	Quasiexperimental pre- and posttest	Questionnaires; documents	182 teachers (exp.) 115 teachers (cont.) 3657 students (exp.) 1867 students (contr.)
Schipper (2020)	Quasiexperimental pre- and posttest	Interviews; observations	37 teachers

(*continued on next page*)

Table 5 (*continued*)

Study	Study design	Data collection methods	*N*
			(exp.) 26 teachers (cont.)
Sharp (2018)	Multiple case study	Questionnaires; interviews; observations; learner reports	22 teachers
Smets (2020)	One group, posttest	Observations; documents; interviews; focus groups	10 teachers 38 students
Smets (2020)	One group, posttest	Interviews; documents	20 teachers
Valiandes (2017)	One group, pre- and posttest	Observations; interviews	14 teachers
Yuen (2018)	One group, posttest	Questionnaires	67 teachers
Bersh (2018)	Multiple case study	Interviews; documents; learner reports	8 teachers

studies showed positive outcomes in this respect. The most common characteristics of these attitude-oriented programs were reflection (10), practice in design (10), collaboration with peers (9) and the use of feedback (8).

Teacher knowledge We did not find programs solely focused on knowledge development. However, in some programs knowledge development preceded skill acquisition (Brigandi et al., 2019; Dack, 2019; Sharp et al., 2018). Dack (2019) explored how the understanding of DI evolved among preservice teachers. Programs for preservice students more often emphasized, among other things, the development of knowledge about DI. All programs aimed at increasing DI knowledge report growth in this aspect.

Teacher satisfaction Three studies reported teacher satisfaction with the program. Yuen et al. (2018) found positive outcomes by measuring participants' satisfaction with a lecture, the perceived value of the workshop and the perceived effectiveness of the trainer/facilitator.

Teacher skill - self report Studies that measured the program's success by self-assessment of DI skills (5) showed a predominantly positive picture (Bower, 2012; Öztürk, 2019; Prast et al., 2018; Wan, 2015; Yuen et al., 2018).

Teacher skill - direct observation or student assessment The picture is somewhat more diffuse when the success of the programs was measured by observation of teacher behavior in the classroom or student assessment, as was the case in 10 studies. Most of the studies demonstrate skill growth, albeit with a caveat. We observed, for example, a short-term increase in skills observed, but only a partial increase in DI skills, rather than across all aspects. Some studies indicated that skills only increased in some respondents or did not indicate retention. To illustrate, Schipper et al. (2020) reported that teachers perceived various important changes in their attitudes and teaching skills, but no effects were found by means of structured observation. Prast et al. (2018) also measured the effect in terms of student performance and did not find effect. These robust studies that reported (partial) skill growth described programs primarily focused on practice in classroom (8), in design (7), teacher collaboration (6), reflection (6), coaching (6) and the use of feedback (6). The characteristics that emerged most often in studies that showed a (partial) increase in skills development were practice in design (13), practice in the classroom (14), teacher collaboration (11), connection to teacher issues (10) and use of feedback (7). It is also noticeable that 12 of the 15 programs reporting (partial) skill development had characteristics within at least four of the main categories (see Table 2), providing a broad, comprehensive program. An example of an extensive comprehensive program can be found in the work of Prast et al. (2018). They described the application of strategies in practical exercises where teachers collaboratively prepared a mathematics lesson, with a specific focus on differentiation. In this program, one teacher delivered the lesson while recording it on video, after which the group collectively evaluated the lesson. In addition to their active participation in team meetings, the teachers were also required to review selected literature and apply specific differentiation strategies in their mathematics lessons.

3.3. Findings regarding context

The success of the teacher programs in relation to their context was discussed in 16 of the studies (see Table 6). This section provides an overview of the contextual factors that are described in the studies as being expected to influence program success. The factors were classified as facilitators and barriers if it was reported that the contextual factor was (amply) available and positively (facilitators) or negatively (barriers) influenced the program's effect or success. A single factor could function as either a facilitator or a barrier, depending on circumstances. As described in chapter two, the coding structure was broken down into three contextual categories: school, teacher characteristics and student characteristics (Desimone, 2009). In this section, the factors that were most frequently identified as facilitators or barriers are discussed.

Facilitators A supportive (collaborative) school culture was found in schools where structured collaboration was stimulated (Kuehl, 2018; Schipper et al., 2020; Sharp et al., 2018). The premise that changes in teacher practice require leadership support at multiple levels formed the basis of a school-wide approach as reported by Sharp et al. (2018). In this program, which was perceived positively, the school curriculum was aligned with the philosophy and practices of DI.

Adequate preparation through training enhanced participants' prior knowledge and was also identified as a facilitator for learning to differentiate instruction (Dack, 2018, 2019; Duquette & Dabrowski, 2016). The physical learning environment is a tangible category that appeared both as barrier and as facilitator. Brigandi et al. (2019)

Table 6
Contextual facilitators and barriers for effectiveness.

Context	S	T	Facilitator	Barriers
Time	x	x	Valiandes & Neophytou, 2017	Bower, 2012; Nazzal, 2011; Öztürk, 2019; Dack, 2018; Brigandi et al., 2019.
Suitable physical learning environment	x		Brigandi et al. (2019)	Nazzal, 2011; Öztürk, 2019
(Collaborative) school culture	x	x	Kuehl, 2018 Schipper et al., 2020; Sharp et al., 2018	Dack, 2020; Nazzal, 2011
School needs and priorities	x		Kuehl (2018)	Prast et al. (2018)
School leader	x	x	Sharp et al., 2018; Prast et al., 2018	Nazzal, 2011; Dack & Triplett, 2020
(School and national) policy			Sharp et al. (2018)	Dack & Triplett, 2020; Schipper et al., 2020 Nazzal (2011)
Sense of urgency	x	x	Prast et al. (2018)	Prast et al. (2018)
Authentic learning context	x		Seglem & Garcia, 2015	West et al., 2016
Teacher concerns			Blik et al., 2015; Brigandi et al., 2019; de Graaf et al., 2019	
Prior knowledge		x	Dack, 2018; Dack, 2019; Duquette, 2016	Nazzal (2011)
Work experience		x		Prast et al., 2018; Wan, 2015
Personality traits		x	Brigandi et al. (2019)	Brigandi et al. (2019)

Note.
S = school contextual factors that relate to the school.
T = contextual factors that relate to the teacher.

mentioned that "overall, the climate in the classroom was open and accepting, complex, with varied student groupings that promoted high student mobility" (p. 381).

Barriers In five of the studies the factor time was mentioned as a barrier (Bower, 2012; Brigandi et al., 2019; Dack & Triplett, 2020; Nazzal, 2011; Öztürk, 2019). Some teachers indicated that they received insufficient time facilitation for the program or otherwise experienced time pressure. "I guess I'm just concerned about how much time we have in the classroom to do some of these things […] I get all the puzzle pieces, but I never have time to put the pieces together" (Brigandi et al., 2019, p. 383).

When the school's curriculum was not in line with the principles and practice of DI, this could inhibit the DI learning process (Dack & Triplett, 2020; Nazzal, 2011; Schipper et al., 2020). For example, a school curriculum characterized by standardization and high-stakes testing compelled teachers to be less inclined to implement DI. "They were afraid that if they differentiated too often, for example differentiation of product, they wouldn't be able to cover the curriculum before the test" (Nazzal, 2011, p. 23). Schipper et al. (2020) described how the national school curriculum employs content-focused learning objectives, which are challenging to align with the underlying principles of DI. The absence of a supportive school learning culture created barriers to DI learning and practice, as mentioned by Dack and Triplett (2020) and Nazzal (2011). Prast et al. (2018) related the postponement of the teacher program for one year to the unexpected lack of results. "Possibly, schools in Cohort 1 were ready and motivated, whereas schools in Cohort 2 had to wait for one year during which motivation or priorities for PD may have changed" (p. 31). (Beginning) teachers with little work experience sometimes seemed overwhelmed by the vastness and multiplicity of learning the complex concept of DI (Prast et al., 2018; Wan, 2015).

Finally, work experience, physical space, and personal characteristics were mentioned as barriers to learning differentiation. (Prast et al., 2018; Wan, 2015). Nazzal (2011) and Öztürk (2019) mentioned the absence of a suitable physical learning space as a barrier for DI learning. Brigandi et al. (2019) described how the personality traits of teachers continuously interact with the learning process. "Some of her personal characteristics or personality traits that get in the way (…) Perfectionism, organization, and control" (p. 383).

4. Discussion

Primary and secondary school teachers are expected to adapt their teaching to the diverse educational needs of students through DI (OECD, 2010, 2018; UNESCO, 2017). An overview of effective elements of teacher programs for DI had not yet been provided. Our literature review included 29 peer-reviewed articles, evaluating components, outcomes and contextual interplay of preservice and in-service teacher programs for DI.

4.1. Teacher programs for DI

General TPD encompasses a wide variety of forms, types, dimensions, and components. The most prevalent components in teacher programs targeted at DI we found were practice in design and classroom, teacher collaboration and reflective exercise. Teachers need to be provided with opportunities to practice DI strategies to effectively learn DI (Tomlinson & Imbeau, 2010). The assumption that DI is an integrated competence would assume that programs offering activities that coherently focus on attitudes as well as skills and knowledge are the most complete and optimal for DI learning. Therefore, teacher programs made use of practice in design and classroom to move from theory to planning and, subsequently, to implementing DI activities. When schools offer social infrastructures that foster collaborative learning with colleagues, teachers succeed better in meeting the challenges of a diverse classroom (Fogarty & Pete, 2011; Wenger, 1998). Teachers who observe each other's differentiated lessons, give each other feedback, and are provided time to prepare together can put into practice what they have learned. An noteworthy addition is that some programs employed structured collaboration with (future) students. Through structured collaboration with students, (preservice) teachers gained knowledge about students' levels of achievement and knowledge of pupils' pedagogical needs, interests, relationships, motivations, and preferred problem-solving strategies which in turn supports effective DI (Van Geel et al., 2019). In further comparison to the broader TPD literature it is noticeable that there is significant emphasis on attitudinal development in teacher programs for DI. Attitudinal development is considered underlying and supportive for the development of DI skills (Akiba, 2011; Fives & Buehl, 2008), which was reflected in many of the studies in this review. Reflective exercise enables teachers to gain self-awareness about their practice and its impact on their students, which mediates teacher practice. When teachers reflect on and discuss their own beliefs, knowledge, attitudes, and experiences related to DI, they feel more prepared and more confident to work with diverse learners (De Neve & Devos, 2016).

4.2. Effective ingredients

The results of our analyses showed that there is not easy procedure where the following steps guarantee effectively trained DI (Frerejean et al., 2021; Suprayogi et al., 2017). We found, however, that participation in teacher programs can support improvements in knowledge about, skills for and attitudes toward DI. Program components that we discuss within this framework because they were frequently part of successful programs are practice in design and classroom, collaboration, reflection, coaching, and the use of feedback A notable difference from more general TPD is that DI is something that is ideally developed through practical exercises in the field. Real-life examples of differentiated lesson plans and teacher practice of various learning scenarios helped teachers to recognize patterns and to make better instructional decisions concerning DI. Teacher collaboration was considered valuable and powerful and contributed to participants' understanding of their own teaching and student learning. Reflecting on Fogarty and Pete (2011), teacher collaboration is grounded in theories that highlight the social nature of human learning and emphasize collaboration as a key to increasing teachers' knowledge and efficacy to develop teacher practices. Collaborative approaches such as Lesson Study or participation in professional learning communities (PLCs) generate opportunities for teachers to exchange experiences within a group and engage in collective learning.

Attitudinal change can be considered a prerequisite for effective DI implementation. Some of the programs in the included studies mainly aimed at fostering a positive attitude toward student learning by critically examining teachers' assumptions, biases and prejudice toward students. These learning approaches, most often characterized by reflective exercise, emerged as useful and relevant and showed positive outcomes. Coaching and feedback furthermore enabled teachers to gain more awareness about their practice and its impact on their students, which helped them redesign and adapt their classroom practices.

In essence, an effective teacher learning program for DI is comprehensive and complete, moving from lesson design to teaching practice, where feedback and coaching help in critically assessing and enhancing one's own practice. Most programs reporting teacher growth incorporated several program characteristics, offering a comprehensive and well-rounded program. This makes it difficult to pinpoint which characteristics contributed to the programs' effectiveness, but underlines the importance of overall comprehensiveness, completeness and time span. Furthermore, research outcomes without unequivocal positive effects were not considered program failures by the authors, who recognized the complexity of learning DI (Prast et al., 2018; Schipper et al., 2020; Smets et al., 2020).

4.3. Interaction with context

The efficacy of a teacher program is influenced by the context in which the program is situated (De Neve & Devos, 2016; Desimone, 2009; Kerry & Kerry, 1997; VanTassel-Baska & Stambaugh, 2005). We included the programs context to gain a better understanding of this interaction. Several contextual factors acted as facilitators and barriers. In particular, it appeared that contextual factors at the school level inhibited and facilitated teacher learning for DI. Teacher and student personality traits are difficult to control and in constant interaction with the learning process, both helping and hindering DI learning, but school-level factors are more amenable to influence and control for educators and policy makers. Time and time pressure emerged primarily as a constraining factor leading to the abandonment of activities that were not considered priorities by teachers (Valiandes & Neophytou, 2017). This aligns with Gaikhorst (2014) and Roiha (2014) that professionalization and teacher learning should be prioritized and facilitated and should have a clear relationship with the issues teachers grapple with in their daily practice. DI is considered a complex competence which takes time and effort to effectively develop (Maulana et al., 2015). When effect and improvement are not immediately observed, teachers may abandon differentiation for other approaches perceived to be less labor-intensive quick fixes (de Graaf et al., 2019; Sherman, 2009). Novice teachers can be overwhelmed by the scope and complexity of learning DI (Wan, 2015), which calls for additional attention and support. Teachers, both consciously and unconsciously, are influenced by the requirements and standards they (think they) have to meet by the school, policies, and the curriculum. (Dack & Triplett, 2020; Schipper et al., 2020; Van Hover et al., 2011). Whether or not DI aligns with this perceived norm impacts teachers' willingness to implement DI in their lessons (Dack & Triplett, 2020; Schipper et al., 2020).

4.4. Limitations and further research

Some limitations are worth noting regarding the selection of the studies which cannot represent all the scholarship on this topic. Setting the time window to 2010–2020 excluded studies published before 2010 and after 2020. Selecting articles in English and Dutch excluded publications in other languages. Focusing on peer-reviewed journal articles excluded other forms of publications from the review. Research indicates that teachers improved DI practices more when a PD program was offered within a specific subject area (Kahmann et al., 2022). Subject-specific didactic approaches are excluded in this review given its focus on understanding subject-independent professionalization.

The selected studies present a plethora of instruments, from self-reports to observation schemes and from perceived difficulty surveys to student assessment. In line with Van Geel et al. (2019), and given the complexity and stratification of teacher qualities that are important for DI, the question is to what extent the diverse knowledge, skills and attitudes needed by teachers can be measured reliably and validly. Studies measuring program satisfaction showed significant results, but these outcomes do not make claims as to whether the teacher actually shows growth in DI competence. Direct observations of teacher practice did not consistently demonstrate the application of DI in real classroom settings. While we recognize the importance of supporting teachers in translating their new knowledge into classroom practice, This limitation underscores the need for a more comprehensive approach to evaluating the effectiveness of DI teacher training programs, allowing us to gain a better understanding of their efficacy. To address this limitation in future research, it would be valuable to explore and develop more nuanced methods for assessing the integration of DI strategies in actual teaching contexts to provide a more holistic picture of the impact of teacher training programs on classroom practice.

4.5. Conclusion and implications

In our review study, all programs focused on enhancing preservice and in-service teachers knowledge, skills, and and/or attitudes for DI. The results indicate that successful DI programs incorporate active learning, collaboration and reflection. They are longitudinal, comprehensive and address attitudes, knowledge and skills. While there are examples in the literature demonstrating effective approaches, these may not always align with the realities of schools due to the time and resources they demand, as highlighted by Sims and Fletcher-Wood (2021). This assumes a precise balance between school ambition and realistic expectations for teachers, gradually building up the learning process while accepting and leaving room for the capriciousness of learning (Gaitas & Alves Martins, 2017). When DI is regarded as a standard approach from teacher training, rather than an additional method added to the teachers' toolbox later, this can contribute to a successful implementation in education. To secure this longitudinal learning journey, it is important to sustainably focus on developing DI competencies in both preservice teacher training and in-service programs. Preservice teachers should be confronted with their underlying beliefs and attitudinal biases from the start (Dell'Angelo & Seaton, 2016) to become familiar with DI instructional strategies. In-service teacher learning should also pay attention to teacher attitudes and must provide effective teaching methods to put DI into practice. A facilitative (school) context is considered a prerequisite for the effectiveness of programs. In addition to a shared mutual vision, attention must be paid to supporting organizational bottlenecks.

DI has been on the policy agenda in many countries for several years and is part of the supervisory framework of education inspectorates; however, there is still not a clear joint vision from all parties involved. This calls for substantive collaboration between teacher training courses, schools and, ultimately, all education professionals in the entire education chain. Learning to apply DI is a valuable and necessary part of the journey for teachers to ensure that all students receive the education to which they are entitled. Education should draw out the potential from all students in the classroom; otherwise, it fails not only the students but also society as a whole.

CRediT authorship contribution statement

Berber N. Langelaan: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing - original draft, Writing - review & editing. **Lisa Gaikhorst:** Conceptualization, Methodology, Supervision, Writing - review & editing. **Wouter Smets:** Methodology, Supervision, Writing - review & editing. **Ron J. Oostdam:** Conceptualization, Project administration, Supervision, Writing - review & editing.

Declaration of competing interest

We wish to draw the attention of the Editor to the following facts which may be considered as potential conflicts of interest and to significant financial contributions to this work.

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

Data availability

No data was used for the research described in the article.

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