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Systematic Review

Effects of a Universal Design for Learning (UDL) Training Course on the Development Teachers' Competences: A Systematic Review

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Abstract: The aim of the study was to analyze the effects of a Universal Design for Learning (UDL) training course on the competence development of teachers working in inclusive classrooms. This model provides a useful framework to address this issue, establishing evidence-based guidelines for creating learning environments that meet the needs of all learners. The move towards inclusive education requires teachers to reassess their pedagogical practices by considering the contributions of neuroscience and cognitive psychology to support effective teaching in heterogeneous classrooms. Consequently, teacher training should include, in its curricula, practices and evidence that support teachers to develop skills for working in inclusive contexts. The study aimed to answer the main research question, namely, how effective the UDL approach is in developing teachers' skills. To answer this question, a systematic review was conducted in different databases allowing the extraction and the analysis of 12 studies. Results were organized around the four dimensions linked to the model of the European Profile of Inclusive Teacher (PIT). Outcomes of the review highlighted three main findings: 1. a UDL training course has significant effects on students' diversity valuing skills; 2. the effectiveness of the course appears to be independent of its duration, delivery mode, and the type of teachers to whom it is addressed; 3. UDL training fosters the implementation of accessible lesson planning and implementation skills. Still uncertain or unexplored, however, are the effects on teachers' areas of collaboration and reflective practice.

Keywords: Universal Design for Learning; UDL; Profile of Inclusive Teachers; school accessibility; neurosciences; review

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1. Introduction

The field of special education is currently experiencing unprecedented developments, particularly with the growth of inclusive policies for children and adolescents with special educational needs (SEN). The principle of inclusion is supported by international conventions, such as the United Nations Convention on the Rights of Persons with Disabilities and the UNESCO Salamanca Statement on Principles, Policy and Practice in SNE [1]. These moves towards inclusion have raised expectations for both mainstream teachers (MT) and special education teachers (SET) [2], triggering structural changes in their roles and functions. These changes have not only impacted teachers, but also teacher training, as it is essential to provide professionals with effective pedagogical tools to respond to the increasing heterogeneity of pupils. Therefore, teacher training must address inclusive practices and develop a common language and practices between MT and SET to conceive accessible and stimulating learning environments for all learners, with their heterogeneity, resources, and needs. The issue of preparing teachers, through their initial training, to be inclusive is a central concern not only for tertiary education, but for many governments,

as evidenced by the project of the European Agency for Development in Special Needs Education. The project defines the Profile of Inclusive Teachers (PIT), a guide for the design and implementation of initial and ongoing training programs for all teachers [3]. The PIT is considered a fundamental tool for orienting and evaluating the training of MT and SET, as it highlights the essential skills, knowledge and understanding, attitudes, and values needed by all those entering the teaching profession, regardless of the subject, specialism, or age range they will teach or the type of school they will work in [3]. According to this project, four core values and related areas of competence must be developed in inclusive teacher education, as shown in Table 1.

Table 1. Profile of inclusive teachers.

Core Values	Areas of Competences
1. Valuing learner diversity Learner difference is considered as a resource and an asset to education	Conceptions of inclusive education The teacher's view of learner difference
2. Supporting all learners Teachers have high expectations for all learners' achievements	Promoting the academic, practical, social, and emotional learning of all learners Effective teaching approaches in heterogeneous classes
3. Working with others Collaboration and teamwork are essential approaches for all teachers	Working with parents and families Working with a range of other educational professionals
4. Personal professional development Teaching is a learning activity and teachers take responsibility for their lifelong learning	Teachers as reflective practitioners Initial teacher education as a foundation for ongoing professional learning and development

The four axes and their sub-components are expressed in the profile in key factors relating to the attitudes, knowledge and skills that a teacher should develop and interrelate with each other in an interdependent manner. The *first component* refers to two main conceptions of the value dimension: (a) the values that a teacher holds towards inclusive education, the ability to look at it critically and to actively promote it; and (b) the appreciation of learners' differences as normal, natural and dynamic. The importance of a dynamic mindset in relation to the potential for developing learners' abilities is demonstrated in the literature by research on teachers' growth mindset [4,5], which shows how these beliefs can have positive effects on both teachers' pedagogical practices and pupils' outcomes. Awareness of the constant evolution of learners' capacities is also reflected in the *second component*, which is the ability to set up learning environments and promote differentiated and flexible pedagogical approaches that take into consideration the variability of learners. The *third component* involves the ability to collaborate with families, colleagues, and educational networks. The sub-components of this dimension recommend the mastery of effective communication techniques and the use of successful co-teaching practices. This dimension is also interdependent with the previous one, as co-teaching aims to promote personalized teaching practices in mainstream schools [6]. The body of research on co-teaching is still poorly documented, with rare publications showing that, although co-teaching has become a practice, teachers rarely use the different possibilities to articulate co-teaching effectively [6]. Besides referring to the importance of initial and continuous training, the fourth component emphasizes the ability to use self-analysis and professional reflexivity [3] in order to foster circularity between practice, evidence through a recursive transition between planning, application, evaluation, reflection, and correction [3]. This *last component* is transversal to all those described above and suggests the inclusion in teacher education of inputs from research that nurture effective beliefs and practices to support inclusive schools. Among these inputs, contributions from neuroscience are particularly relevant.

1.1. Neuroscience and Teacher Training

Over the last three decades, significant progress has been made in improving teaching and learning thanks to advancements in brain imaging and neuroscience research that have enhanced our understanding of how the brain functions. It is interesting to note that many of the factors that facilitate or impede learning, and the resulting changes in the brain, are now better understood, leading to an improved comprehension of the fundamental principles of brain plasticity and learning [7]. Therefore, an understanding of how the brain functions, inter-individual differences in learning, and ways of sustaining students' cognitive development are essential elements that contribute to the complexity of teacher education. The contributions of cognitive neuroscience can play a crucial role in promoting inquiry-based and learner-centered practices and strategies [8].

The growing trend towards collaboration between neuroscience and learning sciences has led to the emergence of a transdisciplinary field to make their mutual knowledge usable [9]. Educational neuroscience provides new and valuable knowledge to inform educational policy and practice, offering useful strategies to improve teaching efficiency and responsiveness to the challenges of contemporary schools [10].

Currently, teacher training needs to bridge neuroscience in a way that provides an understanding of the brain while highlighting concrete pedagogical strategies to support student learning [7]. Recent literature synthesis [8] shows the positive effects of the introduction of neuroscience and related concepts into teacher education. A deeper understanding of the brain, its plasticity, and how the cortex is activated in the act of learning are factors that support both the act of teaching and learning strategies [7].

In addition to improving teachers' knowledge of neuroscientific concepts [11], the inclusion of neuroscience in training can also reduce the persistence of neuromyths in some cases [12,13]. Moreover, it can influence the selection of teaching strategies by promoting the use of student-centered pedagogical practices [14,15]. Additionally, neuroscience can facilitate the development of higher-order thinking and deep knowledge [16], and foster a better understanding of the relationship between brain function and teaching strategies [15], which can support teachers in adopting more constructive approaches. Research by Ergas et al. [17] highlighted that a cognitive neuroscience training program can also aid in transitioning from a more fixed mindset to a growth-oriented approach. These findings emphasize the importance of enriching teacher education with this new knowledge to facilitate a faster transition in terms of daily classroom practice. While it seems obvious that initial and in-service teacher training should include the dissemination of psycho-pedagogical and neuroscientific approaches to provide coherent and applicable educational strategies in the school context, the adoption of a universal conceptual framework is required. The benefit of having a commonly agreed teaching framework lies in providing a common language and shared understanding for use by MT and SET in a school. All teachers have a personal vision of good teaching based on their own experience as students or parents, their professional preparation, their experience as teachers, and their interactions with colleagues. However, simply adopting a teaching framework is no guarantee that everyone will understand it in the same way or that everyone will point out similar evidence about the different components. To achieve such consistency, training is needed to ensure a common understanding of the relevant framework [18] (p. 10). Given recent findings in teaching science, this conceptual framework should adhere to the recommendations of best practices in teaching. Evidence-based practices that support effective teaching have identified a particular approach that emerged 30 years ago to address the diversity of all learners in both inclusive and non-inclusive settings [19]. This approach is called Universal Design for Learning (UDL).

1.2. Universal Design for Learning

Largely recognized in the US, the UDL framework was introduced in the 1990s by the Center for Applied Special Technology (CAST) as a means of supporting the diverse needs of students [20] and creating equitable and accessible learning environments for all learn-

ers [21–23]. This model is grounded in evidence from cognitive neuroscience and learning sciences and focuses on student variability in instructional design. Planning a lesson from a UDL perspective proposes to abandon a "one size fits all" teaching design calibrated on a non-existent "standard learner" and aim to replace it with a priori accessibility of curricula that considers the variability present in each learner. This variability reflects the three brain networks involved in learning: (1) the recognition networks involved in the perception and processing of information in the environment, (2) the strategic networks responsible for planning and organizing procedures and skills, and (3) the affective networks that influence learner motivation and participation [21]. The principles of UDL are based on the premise that flexible options should be provided to address these three learning networks. In practice, these three dimensions are expressed in guidelines and checkpoints that encourage teachers to provide multiple means of representation, expression, action, and engagement in the task. The UDL approach aims to provide teachers with concrete ways to remove barriers to the school curriculum by making goals, materials, methods, and assessments accessible to as wide a range of students as possible [21–24].

Although interest in the UDL model has been growing in Europe in recent years, both in terms of its practical implementation and empirical research, most experimental studies on its effectiveness have been conducted in North America. Additionally, the impact of UDL interventions has only been studied in a few countries, with samples drawn from socio-cultural and economic backgrounds that are very similar [9].

While UDL is characterized as a non-prescriptive method and may be implemented in a multitude of ways, numerous studies have demonstrated the effectiveness of applying its principles to various levels of education, from early childhood [25] to school-aged children with SEN [26–31] or without SEN [32–34], and also to tertiary and university students e.g., [35,36]. In this regard, two recent reviews conducted by AlRaiwi et al. [9] and Rao [37] confirm the positive effects of UDL practices on samples of school-aged children with benefits in academic, cognitive, behavioral, and social skills. Studies considered in their review were conducted in regular, non-inclusive, and inclusive settings and special education environments. Positive effects were found both in populations with SEN and in children with neurotypical development, reinforcing the basic perspective that "what is essential for some is good for all" [21] (p. 86).

1.3. UDL in Postsecondary Education

Although there has been some research on the potential of UDL in teacher education, to the best of our knowledge, no review has yet summarized its characteristics and effects by relating them to the Profile of the Inclusive Teacher (PIT). First, there have been two systematic reviews on the more general use of UDL in post-secondary education [37,38]. Robert's [38] analysis examined the use of UDL in post-secondary education and included eight studies, three of which considered the impact of the model in teacher education [39–41], while the others aimed to evaluate or improve the accessibility of university education [42–45].

Despite promoting the use of UDL in post-secondary education, this work highlights a lack of experimental research in this context and the need for operationalization and explicit description of the principles to understand their effectiveness. Similar findings were reported in a more recent analysis [37] that examined research (13) on both pre- and post-secondary education to examine how researchers apply and evaluate Universal Design (UD). This review claimed that there is a need to adopt standard formats and languages to describe the use of UD and establish causal links between them.

Following this research, a recent systematic review [46] summarized the effectiveness of UDL training on teachers by considering quantitative and qualitative studies on the topic. This analysis considered studies published between 2016 and 2019, and the results suggest that UDL training for teachers can have positive effects both at the level of teaching practices, where there is greater implementation of the UDL framework, and at the level of teachers' perceptions of UDL knowledge, its use in the classroom, and perceived effectiveness.

The systematic reviews conducted to date on this topic confirm the interest and the need to systematize and further explore the data that research offers.

The present study differs from its predecessors in that it focused on the development of competencies needed by teachers working in inclusive settings, and starting from an updated selection of quantitative or mixed research it wants to systematize the evidence and relate it to the competencies expressed by PIT.

1.4. Aims and Research Questions

Through a systematic literature review, the present study aims to answer a main research question:

RQ 1. How effective is UDL training in developing teachers' competencies in an inclusive context?

The sub-questions are articulated around the Profile of Inclusive Teachers:

- RQ 1.1 Which studies investigate the effect of a UDL course on valuing learner diversity and with what results?
- RQ 1.2 Which studies investigate the effect of a UDL course on the ability to plan accessible lessons and with what results?
- RQ 1.3 Which studies investigate the effect of a UDL course on the ability to implement accessible lessons and with what results?
- RQ 1.4 Which studies investigate the effect of a UDL course on the attitude to work with others and with what results?
- RQ 1.5 Which studies investigate a UDL course on the attitude towards personal professional development and with what results?

In addition, a second research question is explored by this study:

RQ 2. Which characteristics determine the effectiveness of a UDL course?

2. Research Method

To answer the research questions, a systematic literature review was conducted that gathered data from existing research in the field. To ensure scientific rigor, the study followed the guidelines proposed by the PRISMA statement. The recommendations of the PRISMA statement allow clarity and transparency on the rationale for the review, how the data were selected, and the results obtained to make sure that the same procedure is reliable and reproducible. We have preregistered in the OSF database and the DOI is https://doi.org/10.17605/OSF.IO/K8X2S (accessed on 30 April 2023).

The first phase of the research search collected studies recorded in various databases. In addition to the three search engines Web of Science, OvidSP, and EBSCOhost, sources from other references were considered, including studies from the UDL-IRN database and articles from bibliographies on the subject. To be included, each study had to have integrated UDL as a framework in teacher education and evaluate its effects on teacher competence development. The studies were then categorized according to the type of effects observed in relation to the four components of the TIP. Keywords used in the searches included 'universal design for learning' OR UDL AND teacher* AND special needs OR special education AND teacher training OR teacher courses. The initial search resulted in 319 studies. Searches were reviewed and included based on the inclusion criteria relating to the objectives of this study and the methodological quality of the studies (Table 2).

Table 2. Inclusion criteria.

Study Enrolment Criteria Determined according to the PICOT method [47]	
Population	Studies including a sample of student teachers (pre-service or in-service)
Intervention	Studies with explicit reference to one or more dimensions of UDL
Comparison	Experimental or quasi-experimental studies using quantitative or mixed research designs
Outcomes	Studies on the impact of UDL training on teachers' practices or perceptions
Time	Studies published between January 2000 and December 2021
Methodological Quality Criteria Partially based on Standard Quality Assessment Criteria for Evaluating Primary Research Paper [48]	
1. Research question/objective sufficiently described	
2. Clear and appropriate design of the study	
3. Methods of data collection and analysis described in a clear and systematic way	
4. Conclusions supported by the results	
5. Studies published in a peer-reviewed journal	

The criteria for study enrollment were determined following the PICOT categorization (INESSS, 2013) which considers the 4 factors to circumscribe the field of research; population, intervention, comparison, outcomes, and time. For each factor, research inclusion criteria listed in Table 2 were identified.

Additional criteria were added to these elements to ensure the methodological quality of the selected studies. The first 4 additional criteria are based on the Standards Quality Assessment Criteria for Evaluating Primary Research Papers [48], while the criterion of peer review publication was added by the researchers.

Out of the 319 studies identified, 213 references were excluded because they were not research articles or were not relevant to the investigation. After reviewing titles and abstracts, 36 articles were selected for full reading, and 12 of them met the inclusion criteria and were included in this critical review. Figure 1 illustrates the article selection process. The data were reviewed by two independent reviewers based on the inclusion criteria to ensure the reliability of the data and to identify any discrepancies. The initial agreement was 85%, with discrepancies related to the qualitative orientation (1) and the methodological quality of the studies (1). The selection criteria indicators were reviewed and discussed to reach 100% agreement.

Methodological Quality of the Selected Studies

The selected studies were assessed with supplementary quality criteria based on the defined parameters of the Quality Assessment Standards for Primary Research Papers() [48], which outlines a checklist of 14 criteria for evaluating quantitative research. This procedure involves the assignment of scores according to the degree of satisfaction of the 14 criteria ("yes" = 2, "partial" = 1, "no" = 0). Non-applicable items ("n/a") were excluded from the calculation of the final score. The process was conducted by two independent examiners and in the event of disagreement the final scores were discussed and redefined based on parameters agreed between the two researchers. Reasons for discrepancies (6%) were due to the possibility of investigator blinding (10%—item 6), total or partial assignment of scores in the description of methods or subjects (20%—items 3 and 4), and the possibility of randomizing the sample and limiting confounding (70%—items 5 and 12). These divergences were discussed and a 100% agreement was reached. Table 3 offers an overview of the total mean scores for each of the 14 items for which '1' represents the highest possible score (100%). Articles included in the analysis of the present review scored higher than 0.6 for their structure, clarity, and methodological choice. However, the ecological nature of the studies seems to have had a negative impact on scoring at the level of randomization

and control of possible confounding variables. Even at the level of data analysis, only a few studies considered the possible blindness of the investigator, the scores obtained from some observations could therefore include a bias given by the expectations of the researchers.

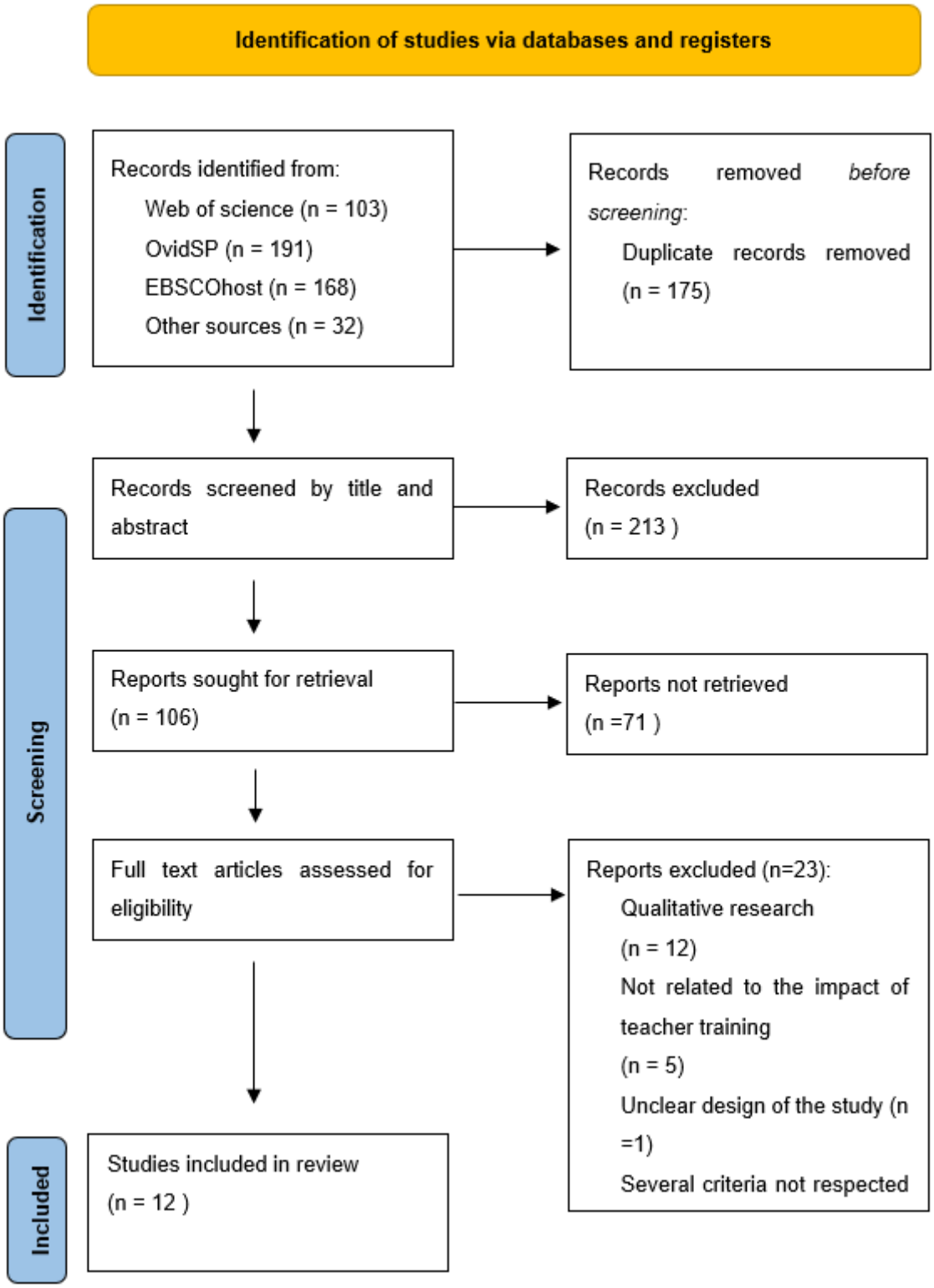


Figure 1. PRISMA flow diagram [49].

Table 3. Average scores achieved for each criterion.

	Criteria	Total Score
1	Question/objective sufficiently described?	1
2	Study design evident and appropriate?	1
3	Method of subject/comparison group selection or source of information/input variables described and appropriate?	0.875
4	Subject (and comparison group, if applicable) characteristics sufficiently described?	0.625
5	If interventional and random allocation was possible, was it described?	0.4
6	If interventional and blinding of investigators was possible, was it reported?	0.136
7	If interventional and blinding of subjects was possible, was it reported?	N/A
8	Outcome and (if applicable) exposure measure(s) well defined and robust to measurement/misclassification bias? Means of assessment reported?	0.917
9	Sample size appropriate?	0.75
10	Analytic methods described/justified and appropriate?	1
11	Some estimate of variance reported for the main results?	0.792
12	Controlled for cofounding?	0.167
13	Results reported in sufficient detail?	0.834
14	Conclusions supported by the results?	1

3. Results

The 12 studies selected for analysis in this review were published between 2000 and 2021. Table 4 shows the characteristics and topics investigated in relation to the four domains of the Profile of Inclusive Teachers (PIT). From this initial overview, it can be observed that none of the studies examined all four components in their entirety. Out of the 12 studies, 11 focused primarily on the second dimension of the PIT: supporting all learners. Two studies explored teachers' perceptions and conceptions regarding inclusion and diversity of their students, which falls under the first area of competence of the inclusive teacher: valuing student diversity [50,51]. Two other studies addressed the topic of reflective practice by covering the area of personal professional development [52,53]. No study explicitly addressed the third dimension, which is the area of collaboration and teamwork. With regard to student support, two main areas of investigation were identified: planning and implementation of accessible lessons. Most studies (8/12) focused on the improvement in planning skills following a UDL training course [40,51,54–59] while five studies examined the impact of a course on classroom practice [52,53,55,56,60].

Of these studies, three collected data on the existence of differences between teachers by job function or grade level [54,55,60]. Eight studies were conducted in the United States, two in Canada, and one in collaboration between these two countries. Only one study was conducted in Europe, in Turkey [59]. It should be noted that no study has been conducted in a French-speaking country, reflecting the lack of implementation of the UDL model, if not in Europe, at least in the French-speaking part of Europe.

Table 4. Overview of studies.

First Author, Year	Country	n	1. Valuing Learner Diversity	2. Supporting All Learners		3. Working with Others	4. Personal Profess. Develop.	Differences between Teachers
				Plan.	Impl.			
Courey, 2013 [54]	USA	45		x				
Craig, 2019 [55]	USA	143		x	x			x
Katz, 2015 [52]	CAN	58			x		x	
Katz, 2019 [53]	CAN	51			x		x	
Lanterman, 2018 [50]	USA	77	x					
Lee, 2021 [56]	USA	8		x	x			
Navarro, 2016 [57]	USA/CAN/COL	47		x				
Owiny, 2019 [51]	USA	14	x	x				
Scott, 2019 [58]	USA	52		x				
Smith, 2017 [60]	USA	14			x			x
Spooner, 2007 [40]	USA	72		x				x
Unluol, 2020 [59]	TUR	97		x				
				8	5			3
Total		678	2	11			2	

Note. Impl: Accessible lesson implementation; Plan: Accessible lesson planning.

3.1. Sample

Table 5 shows the methods and designs applied in the study, the characteristics of the sample, and the instruments used to measure the effects of the training course. In the studies examined, most of the training courses provided were aimed at Mainstream Teachers (MT). Ten of the 12 studies examined included MT in their sample, some in initial training-PT-(5 studies) and others already active in regular classes-IT-(5 studies). Of these, five studies included mixed samples of Mainstream Teachers-MT-and special education teachers-SET [40,50,55,56,60] while five studies included programs for MT only [51–53,57,59]. Only two studies [54,58] focused exclusively on SET. In terms of the occupations of the training users, selected studies sampled preservice teacher-PT and teachers already in service-IT in a balanced way [40,50,51,54,56,59]. Only one study [58] considered the constitution of mixed groups.

3.2. Materials

The 12 studies considered have a longitudinal design with a pre-test and a post-test The instruments used in this research are mostly self-reported instruments, i.e., directly linked to the measurement of the model transmitted during the course. Seven of the eight studies that examined planning used materials developed by Spooner's study [40], including a Case Study Scenario (CSS) and a Scoring Rubric on the three components of Universal Design for Learning specifically developed for the study (SRUDL Lp). Lee [56] adapted this rubric to observe the implementation of UDL principles during classroom practice,

creating a scoring system similar to the planning rubric but adapted to direct observation of classroom work (SRUDL Imp). Only one study used a different rubric to measure the effects of the training course on planning, the Teacher Success Rubric [61], used in Craig's [55] study. Lanterman's [50] study used instruments not directly related to the model presented in the course, namely the Beliefs About Learning, Teaching, and Disability Questionnaire, to measure teachers' beliefs. Other research used direct observation measures, interviews, or self-evaluation tools, such as the TBM self-assessment scale used in Katz's study [53].

Table 5. Summary of the study design, methods, and main instruments.

First Author, Year	Sample					Topic	Study Type Design	Key Methods/Instruments
	n	PT	IT	MT	SET			
Courey, 2013 [54]	45	x			x	Lesson planning, Teacher differences	Quantitative longitudinal Pre-test/post-test single group	LPT/SRUDL (LP) CSS
Craig, 2019 [55]	143	x		x	x	Lesson planning, Lesson implementation, Teacher differences	Quantitative longitudinal Pre-test/post-test	TSR
Katz, 2015 [52]	58	x		x		Lesson implementation, Job satisfaction	Mixed longitudinal Pre-test/post-test	INT/OBS SE
Katz, 2019 [53]	51	x		x		Lesson implementation, Self-efficacy	Quantitative longitudinal Pre-test/post-test	TBMSAS OBS
Lanterman, 2018 [50]	77		x	x	x	Teachers' beliefs	Quantitative longitudinal Pre-test/post-test	BLTDQ
Lee, 2021 [56]	8		x	x	x	Lesson planning, Lesson implementation	Mixed longitudinal Pre-test/post-test single group	SRUDL(LP) SRUDL(Imp) SV
Navarro, 2016 [57]	47	x		x		Lesson planning, Technology integration	Quantitative longitudinal Pre-test/post-test single group	SRUDL(LP) ADDIE
Owiny, 2019 [51]	14		x	x		Lesson planning, Perception inclusion	Mixed longitudinal Pre-test/post-test single group	IPS SRUDL(Lp) CSS
Scott, 2019 [58]	52	x	x		x	Lesson planning	Quantitative longitudinal Pre-test/post-test single group	LPT SRUDT CSS
Smith, 2017 [60]	14	x		x	x	Lesson implementation, Teacher differences, Technology integration	Mixed longitudinal Pre-test/post-test single group	INT OBS
Spooner, 2007 [40]	72		x	x	x	Lesson planning, Teacher differences	Quantitative longitudinal Pre-test/post-test RCT	LPT SRUDL(Lp) CSS
Unluol, 2020 [59]	97		x	x		Lesson planning	Quantitative longitudinal Pre-test/post-test single group	LPT SRUDL(LP) CSS
Total		6	5	5	2			
Mixed		1		5				

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. ADDIE: ADDIE educational design model [62], SE: Self-evaluation, BLTDQ: Beliefs About Learning, Teaching, and Disability Questionnaire (adapted from Glenn, 2007) [63], CSS: Case study scenario [40], IPS: Inclusion perception survey (adapted from McCray & McHatton, 2011) [64], INT: interview, LPT: Lesson plan template [40,54], OBS: Observation, SRUDL (Imp): Implementation Scoring Rubric on the Three Components of Universal Design for Learning [40], SRUDL (Lp): Lesson Plan Scoring Rubric on the Three Components of Universal Design for Learning [40], SRUDT: Scoring Rubric et Case study scenario [54], with the additional criteria «Universal design for transition» [58], SV: Survey, TBMSAS: TBM Self-assessment scale [52], TSR: Teacher Success Rubric [61].

3.3. Course Types

The training courses included in this review varied in terms of length and mode of delivery. Some studies aimed to measure the effect of short courses, involving 1 to 3 h of instruction, which introduced the guidelines and principles of Universal Design for Learning programming [40,54,59]. Other studies included workshops or larger and more in-depth sessions [52,53,55,57,58] (that integrated the methods recommended by the UDL paradigm into the course itself.

3.4. Competence Domains of the Profile of Inclusive Teacher

All the courses presented in the studies considered in this research had positive effects. As can be seen from Table 6, most of them had a statistically significant impact. The details of the effects will be analyzed in the following paragraphs in which the studies will be categorized according to the four PIT domains to which the topics of the various studies are related.

Table 6. Summary of the type of course provided.

First Author, Year	Sample	Observed Impact	Duration Mode	Reference Model Resources	Efficacy
Courey, 2013 [54]	n 45 PT SET	Lesson planning (H1) Teacher differences (H2)	Short Face-to-face	Single UDL-IRIS	H1: S H2: PS
Craig, 2019 [55]	n 143 IT SET/ MT	Lesson planning (H1) Lesson implementation (H2) Teacher differences (H3)	Long Face-to-face	Single UDL	H1: NS H2: S H3: NS
Katz, 2015 [52]	n 58 IT MT	Lesson implementation (H1) Job satisfaction and attitude inclusion (H2)	Long Face-to-face	Mixed TBM of UDL	H1: S H2: PS
Katz, 2019 [53]	n 51 IT MT	Lesson implementation (H1) Self-efficacy (H2)	Long Face-to-face	Mixed TBM of UDL	H1: S H2: NS
Lanterman, 2018 [50]	n 77 PT SET/ MT	Teachers' beliefs (H1)	Long Blended	Mixed UDL and SMD	H1: S
Lee, 2021 [56]	n 8 PT SET/ MT	Lesson planning Lesson implementation (H1)	Long Online	Mixed UDL and CBM	H1: S
Navarro, 2016 [57]	n 47 IT MT	Lesson planning (HI) Technology integration (H2)	Long Blended	Mixed UDL and ADDIE	H1: S H2: S
Owiny, 2019 [51]	n 14 PT MT	Lesson planning (H1) Perception inclusion (H2)	Long Blended	Single UDL-IRIS	H1: S H2: NS
Scott, 2019 [58]	n 52 IT /PT SET	Lesson planning (H1)	Long Blended	Mixed UDL and UDT	H1: S
Smith, 2017 [60]	n 14 IT SET/MT	Lesson implementation Technology integration (H1) Teacher differences (H2)	Long Face-to-face	Mixed UDL and ICT	H1: S H2: PS
Spooner, 2007 [40]	n 72 PT SET/ MT	Lesson planning (H1) Teacher differences (H2)	Short Face-to-face	Single UDL	H1: S H2: PS
Unluol, 2020 [59]	n 97 IT MT	Lesson planning (H1)	Short Face-to-face	Single UDL-IRIS	H1: S

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. ADDIE: ADDIE educational design model [62], CBM: Curriculum-based measurement [65], ICT: Information and Communication Technologies, SMD: social model of disability [66], TBM: Tree Block Model, UDL: Universal Design for Learning, UDT: Universal Design for Transition. S: significant results, NS: non-significant results, PS: partially significant results.

3.4.1. Competence Domain "Valuing Learner Diversity"

The dimension of valuing student diversity refers to teachers' conceptions and views on student differences and inclusive education. Table 7 summarizes the studies that found evidence of changes in teachers' values and beliefs after UDL training. The findings suggest that UDL training does not appear to have a significant impact on teachers' perceptions of teaching students with disabilities in a conventional classroom, as shown in the study by Owiny et al. [51]. However, Lantermann et al. [50] conducted a study demonstrating an impact on teachers' beliefs. They found that training on UDL principles can prompt educators to adopt a more interventionist and less pathognomonic approach to teaching. The authors of this research delivered two separate UDL courses, one in which disability was treated as an individual factor and the other in which disability was seen as the result of social construction. Interestingly, both courses managed to have an impact on teachers' attitudes regardless of the conception of disability transmitted.

Table 7. Summary of results-Valuing learner diversity.

First Author, Year	Sample	Course Type	Observed Impact	Key Methods Instruments	Efficacy
Lanterman, 2018 [50]	n 77 PT MT /SET	UDL/SMD Long Blended	Beliefs, learning, teaching, and disability	BLTDQ	S $p < 0.001$
Owiny, 2019 [51]	n 14 PT MT	UDL Long Blended	Perception of inclusion	IPS	NS

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. BLTDQ: Beliefs About Learning, Teaching, and Disability Questionnaire (adapted from Glenn, 2007) [63], IPS: Inclusion perception survey (adapted from McCray & McHatton, 2011) [64], UDL: Universal Design for Learning. S: significant results, NS: non-significant results.

3.4.2. Competence Domain "Supporting All Learners"

In terms of supporting learners, the studies reviewed focused on two aspects: planning and implementing accessible lessons.

Effect of planning. Table 8 summarizes the studies that investigated the impact of UDL training on teachers' ability to plan accessible lessons. One of the pioneering studies in this area was conducted by Spooner et al. [40] and served as a model for subsequent research. In their experiment, special and general education teachers were randomly assigned to experimental or control conditions. Participants in the experimental group received UDL training during the first hour of the class, while participants in the control group received the training one hour later. The results showed that teachers who received the UDL training used a greater variety of UDL principles in their lesson planning compared to those in the control group.

Building on Spooner's [40] seminal study, many researchers have replicated similar investigations by examining the planning capabilities of teachers [51,54–59] with particular emphasis on their ability to incorporate flexible options into lesson planning that address the three dimensions of UDL. Two studies reintroduced the 'short' course format and used the same measurement tools [54,59] while extending the findings to the design of inclusive classrooms [54]. These studies, therefore, agree that a short introductory course to the UDL model is sufficient to generate instructional planning that is more responsive to the educational needs of all students. Of the eight studies dealing with the planning, seven found significant results, with only one study [55] differing from the others in the significance of the results obtained. In this trial, a small but non-significant improvement was found in the ability to set class and lesson goals and to identify and remove barriers to learning for all students.

Table 8. Summary of results—Planning.

First Author, Year	Sample	Course Type	Observed Impact	Key Methods Instruments	Efficacy
Courey, 2013 [54]	n 45 PT SET	UDL Short Face-to-face	a. Integration of UDL principles into lesson plans. b. Further improvement in the follow-up	LPT SRUDL(Lp) CSS	a. S large ES b. S medium ES
Craig, 2019 [55]	n 143 IT SET/ MT	UDL Long Face-to-face	Goal setting Identification and removal of barriers.	TSR	NS
Lee, 2021 [56]	n 8 PT SET/MT	UDL/ CBM Long Online	Integration of UDL principles into lesson plans	SRUDL(Lp) SRUDL (Imp) SV	S $p = 0.03$
Navarro, 2016 [57]	n 47 IT MT	UDL/ADDIE Long Blended	Integration of UDL principles into lesson plans	SRUDL(Lp) ADDIE	S
Owiny, 2019 [51]	n 14 PT-MT	UDL Long Blended	a. Integration of UDL principles into lesson plans. b. Further improvement in the follow-up	SRUDL(Lp) CSS	a. S $p < 0.05$ b. NS
Scott, 2019 [58]	n 52 IT/ PT SET	UDL/ UDT Long Blended	a. Integration of UDL principles into lesson plans. b. Further improvement in the follow-up	UDT- LPT SRUDT CSS	a. S $p < 0.00$ b. S $p < 0.05$
Spooner, 2007 [40]	n 72 PT SET/MT	UDL Short Face-to-face	Integration of UDL principles into lesson plans a. representation b. action expression c. engagement	LPT SRUDL(Lp) CSS	a. S $p < 0.001$ b. S $p < 0.001$ c. S $p = 0.011$
Unluol, 2020 [59]	n 97 PT MT	UDL Short Face-to-face	Integration of UDL principles into lesson plans	LPT SRUDL(LP) CSS	S $p < 0.05$

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. ADDIE: ADDIE educational design model [62], BLTDQ: Beliefs About Learning, Teaching, and Disability Questionnaire (adapted from Glenn, 2007) [63], CBM: Curriculum-based measurement [65], CSS: Case study scenario [40], INT: interview, LPT: Lesson plan template [40,55] OBS: Observation, SE: Self-evaluation, SRUDL (Imp): Implementation Scoring Rubric on the Three Components of Universal Design for Learning [40], SRUDL (Lp): Lesson Plan Scoring Rubric on the Three Components of Universal Design for Learning [40], SRUDT: Scoring Rubric et Case study scenario [54] with the additional criteria «Universal design for transition» [58], SV: Survey, TBMSAS: TBM Self-assessment scale [52], TSR: Teacher Success Rubric [61], UDL: Universal Design for Learning, UDT: Universal Design for Transition. S: significant results, NS: non-significant results, ES: Effect Size.

Trends in data from some research [40,55,56] suggest that teachers, after training, are more inclined to provide differentiated options for the dimensions of 'representation', 'action, and 'expression' and less in the area of 'engagement', but this trend was not found in all contributions.

Effect on implementation. Only five studies examined the impact of a UDL course on the effective ability to implement accessible lessons (Table 9). These 5 studies implemented courses lasting more than three hours, with positive and statistically significant results for four of them [52,53,55,56]. Only one study [56] validated the consistency between the writing of the lesson plan and its real implementation in the classroom by extending the field observation and supplementing the data with coded analysis of video lessons that were in accordance with the presented lesson plans. However, other research considered in this review focused on practice in natural environments by including researchers' classroom observation or recorded video lessons in the analysis tools [52,53,55,60]. Results of the review tend to show that teachers who participated in the training made significant changes in their teaching practices regarding the implementation of UDL in the classroom, providing more differentiated instruction [52,53,55,60], improving their ability to address classroom barriers and provide accessible instruction for all students [55], offering variations in

assignment types and student groupings, and increasing the organization of work in small groups of students and decreasing frontal teaching [52,53].

Table 9. Summary of results—Implementation.

First Author, Year	Sample	Course Type	Observed Impact	Key Methods Instruments	Efficacy
Craig, 2019 [55]	n 143 IT MT/SET	UDL Long Face-to-face	Implementation of UDL principles in the classroom	TSR	S $p = 0.3$
Katz, 2015 [52]	n 58 IT MT	TBM of UDL Long Face-to-face	Teaching activities and student grouping structures	INT/OBS SE	S $p < 0.001$
Katz, 2019 [53]	n 51 IT MT	TBM of UDL Long Face-to-face	Teaching practices: task typology, student groupings, differentiated instruction	TBMSAS OBS	S $p < 0.001$
Lee, 2021 [56]	n 8 PT MT/SET	UDL/ CBM Long Online	Implementation of UDL principles in the classroom	SRUDL (Imp) SV	S
Smith, 2017 [60]	n 14 PT MT/SET	UDL/ ICT Long Face-to-face	Implementation of UDL principles in the classroom and technology integration	INT/OBS	-

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. CBM: Curriculum-based measurement [65], INT: interview, ICT: Information and Communication Technologies, OBS: Observation, SE: Self-evaluation, SRUDL (Imp): Implementation Scoring Rubric on the Three Components of Universal Design for Learning [40], SV: Survey, TBM: Tree Block Model [66], TBMSAS: TBM Self-assessment scale [52], TSR: Teacher Success Rubric [61], UDL: Universal Design for Learning, UDT: Universal Design for Transition. S: significant results.

3.4.3. Competence Domain "Personal Professional Development"

The area of personal professional development was explored in terms of reflective practice. Two studies were conducted by the same author and aimed to investigate the effects of UDL-based training on teacher self-efficacy and perceptions of their students (Table 10). Complementary qualitative data in mixed-method research revealed an increase in teachers' positive perceptions of their students' social and behavioral progress, as well as an increase in self-efficacy and a decrease in stress [52]. On the other hand, the same author, a few years later, found that the UDL training course did not have a significant impact on teachers' perceptions of their own practice. The results of this research [53], indicate that teachers did not perceive differences in their teaching of social and emotional learning to their students between pre- and post-test, nor did they perceive significant changes in systems and supports. However, they did report a significant difference between pre- and post-test in their perceptions of their use of inclusive teaching practices.

Table 10. Summary of results—Personal professional development.

First Author, Year	Sample	Course Type	Observed Impact	Key Methods Instruments	Efficacy
Katz, 2015 [52]	n 58 IT MT	TBM of UDL Long Face-to-face	Self-perception teaching practice	INT/OBS SE	NS
Katz, 2019 [53]	n 51 IT MT	TBM of UDL Long Face-to-face	a. Perception of socio-emotional learning b. Perception of systems and structures c. Perception of inclusive practices	TBMSAS	a. NS $p = 0.75$ b. NS $p = 0.18$ c. S $p = 0.04$

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. SE: Self-evaluation, INT: interview, OBS: Observation, TBM: Tree Block Model [67], TBMSAS: TBM Self-assessment scale [52], UDL: Universal Design for Learning. S: significant results, NS: non-significant results.

3.4.4. Differences between Teachers

Table 11 presents the studies that collected data on the differences between types of teachers in integrating UDL content into their practice. The only significant marker comes from Spooner's research [40], which highlights the higher integration of UDL principles into lesson plans by Special Education Teachers compared to General Education Teachers. In particular, a significant difference is revealed in the larger opportunities provided by special education teachers to encourage and support student action and expression. Smith's research [60], while presenting data on non-comparable groups, finds a more sustained improvement in inclusion classes than specialized education classes in terms of both positive integration of the UDL model and supporting technology. The study identifies the co-teaching model as a resource for implementing differentiated and accessible lessons.

Table 11. Summary of results—Differences between teachers.

First Author, Year	Sample	Course Type	Observed Impact	Efficacy
Craig, 2019 [55]	143 IT SET/MT	UDL Long Face-to-face	Different UDL integration between: a. special and general education teachers b. school level	a. NS b. NS
Smith, 2017 [60]	14 PT SET/MT	UDL e ICT Long Face-to-face	Differences between non-inclusive and inclusive classes a. UDL integration b. technology	Non-comparable group
Spooner, 2007 [40]	72 PT SET/MT	UDL Court En présentiel	Different integration of UDL between SET and MT a. Representation b. Action and expression c. Engagement d. Total	a. NS b. S $p = 0.01$ c. NS d. S $p = 0.004$

Note. PT: Pre-service Teachers, IT: In-service Teachers, MT: Mainstream Teachers, SET: Special Education Teachers. ICT: Information and Communication Technologies, UDL: Universal Design for Learning. S: significant results, NS: non-significant results.

4. Discussion

The purpose of this study was to answer several research questions aimed at evaluating evidence from previous studies related effectiveness of UDL in teacher education. Regarding the effects and benefits of a UDL course in teacher education, the synthesis of the research considered seems to show that a course based on the UDL model benefits both general and special education teachers The overview of the data reviewed suggests that the inclusion of the UDL framework in training may contribute to the development of skills defined in the Profile of Inclusive Teacher (PIT).

The first research question examined the PIT competence areas enriched by this approach. The review shows that the UDL training has positive effects on three out of the four components defined in the PIT. Studies on the first two dimensions, "*Valuing learner diversity*" and "*Supporting all learners*", report significantly positive effects. However, no research with quantitative data was available for *Working with others*, and surveys collected uncertain and contradictory data for personal and professional development. Regarding the first component, "*Valuing learner diversity*", the studies considered in this review investigated the effects of UDL training on both areas of competence highlighted by the Profile of Inclusive Teachers, namely conceptions of inclusive education and teachers' views of learner differences [3].

According to the findings of the research considered, a UDL training course does not seem to significantly affect the teachers' conceptions of inclusion [51]. This finding is not in line with expectations of this approach [21] but can be explained by the scores already high at baseline which did not increase significantly after intervention. On the other hand, UDL training seems to have an effect on the teacher's view of learners' differences and the recognition of variability in ways of learning. The UDL approach appears to have significant effects in terms of beliefs and conceptions about learning and disability [50].

Indeed, Lanterman's [50] research findings show how much a UDL framework can help move away from an innate and fixed idea of human intelligence. These data join what emerged from Ergas's [17] research on the embedding of neuroscience in education, which emphasized the potential of neuroscientific knowledge in supporting a more dynamic teacher mindset. This aspect is particularly interesting because the literature shows how much the teacher's mindset, and his or her knowledge of neuroscientific principles related to learning, can importantly determine the effectiveness of his or her teaching practices by making them more learner-centered [8,15].

Regarding the second component, "*Supporting all learners*", the synthesis shows that a UDL course seems to have positive effects in terms of student support, the results of studies conducted in this area show promising evidence of competencies in terms of planning and implementing lessons that are more responsive to student diversity, differentiated and accessible. This leads to the suggestion that this area of the PIT can also be enriched by the UDL approach in both central aspects, namely the promotion of learning (academic, practical, social, and emotional of all students) and the effectiveness of pedagogical approaches to teach in classrooms, corroborating the expectations set out by EADSNE [3]. In particular, results point towards the effective management of heterogeneous classrooms as a cornerstone for the effective transmission of the UDL model to create flexible environments, making them accessible to as many students as possible, supporting the statements of researchers in this field [20,21,23]. The ability to design lessons that take into account student variability and attempt to overcome curricular barriers is a key research issue, as evidenced by 11 of the 12 selected studies that addressed this issue e.g., [40,51,56]. The only study that did not take this key point is that of Lantermann [50]. The surveys presented in the sections on planning and implementation showed several interesting results indicating beneficial effects on three of the four elements of curricular action; UDL approach aims to make objectives, materials, methods, and assessments more flexible [21]. Results suggest changes in teachers' ability to act on objectives, materials, and methods [52,53,55,60]. No research, however, explicitly referred to changes in terms of evaluative practices.

The ability to implement accessible lessons has been expressed mainly in terms of planning (in 8 studies) and is less investigated in terms of real implementation (in 5 studies). This may be due in part to the multidimensionality of the UDL approach, which can make systematic observation practice complex, as Mitchell [19] points out in his synthesis. One element that may limit the generalizability of significant results at the level of the ability to elaborate differentiated lesson plans concerns the use of tools, which is limited to rubrics that refer to the structure of the model itself. The only study not to obtain significant results is in fact that of Craig [55] who used different measurement rubrics than the other studies [40,51,54,56–58]. This leads to confirmation of the hypothesis that UDL courses have the potential to help teachers plan and implement support for the three learning networks but do not significantly affect other components, such as the ability to set goals and to identify and remove barriers to participation. Although the topic of *planning* has been the most discussed, the analysis leads to the assertion that there is a lack of deeper research on the topic that examines teachers' planning skills from multiple perspectives, that uses different tools to measure the accessibility and effectiveness of lessons, and that can recursively examine planning from a UDL perspective with effective implementation in the classroom.

With regard to the ability "*Working with others*", results show that there is no study that explicitly examines, in a quantitative way, the possible effects of a UDL course on the third dimension of the PIT. The only research that mentions it is Smith's [60] study which highlights how co-teaching can be a resource for making lessons more accessible. In this context, it would be particularly interesting to investigate the impact in terms of collaboration with other professionals and families. This trend is part of a general lack of quantitative research investigating the relationships between teaching practices and co-teaching practices.

Concerning the ability "*Personal professional development*", the fourth dimension the PIT, declined to *reflective practice*, was explored in this review in terms of teacher self-efficacy. The findings emerging from the selected studies showed that there is still limited evidence on the impact of UDL on teachers' sense of efficacy, in some cases contradicting outcomes from qualitative surveys [52,53]. Further research in this area should be conducted to provide a more solid overview of the impact of the UDL model on teachers' perceptions and attitudes and, more generally, on the conative aspects of the profession.

The second research question focused on the characteristics that determine the effectiveness of a UDL course. Similar to the findings of Sanchez's (XX) review, the selected research does not provide any significant clues as to the characteristics that may influence the impact of the training. Its effectiveness seems to be independent of the type of teachers it is aimed at, whether they are in initial or continuing training, general or special education teachers, except for some trends found in Spooner's research [40]. Even a short introductory course on the UDL framework appears to influence teachers' ability to design accessible lessons, confirming the findings of Spooner et al. [40]. The type of training provided, in terms of the number of hours or mode of delivery, as a result, it does not appear to be a determining factor in the effectiveness of the controlled variables. These findings are consistent with the results of broader research on UDL in tertiary education [37,38] which suggest the need to adopt standard formats and languages to describe the use of UDL practices. In the context of UDL training, this translates into the need to make more explicit and operational, the content and evaluation methods applied to courses to understand in more detail the variables that determine their effectiveness.

5. Implication for Practice

The results of the review show that training courses on the UDL approach seem to benefit teachers independently of their role and parallel work in the field. The UDL approach may be a good way to develop the Profile of Inclusive Teachers (PIT) as it provides useful operational tools to support the variability of students and consequently to support the teacher's teaching action in increasingly diversified classrooms. Although significant data has not been collected at the level of all PIT components, the various dimensions of PIT are interrelated and may influence each other interdependently. As has been shown in the literature, the teacher's values and beliefs can influence teaching practices, which in turn help to influence the attitude to collaboration and a sense of self-efficacy [68,69]. Thus, training seems to offer interesting synergies for promoting an inclusive school. Among the promising contents to be included in teacher training programs, evidence emerging from the reviewed studies suggests the integration of modules that weave together the contributions of neuroscience and evidence-based pedagogical practices in the learning sciences. Improved connectivity between these disciplinary fields should be sought to create synergies that support the expansion and ecology of cognitive neuroscience research while providing practice settings that support the development of new empirical evidence.

6. Limitations and Forces

This review has several strengths and limitations. One strength is that it is the first study to present a review that examines the relationship between UDL training and the components of the PIT, aiming to identify its domains of effectiveness and areas that still require exploration. Additionally, the study was conducted with rigor and underwent a double review process to ensure the quality of the selected studies. However, this selection procedure also led to several limitations. Firstly, the results are based only on 12 studies, most of which have a small sample size, making it challenging to perform a meta-analytical treatment of the data. Secondly, the selected studies are limited to quantitative or mixed data. Qualitative data, which could provide additional insights and a deeper understanding of trends, were excluded from the selection process. Moreover, only research that explicitly referred to the UDL model was considered, while studies that only consider some of its dimensions or guidelines were excluded. Other selection criteria, such as publication of

research in peer review, may have compromised access to interesting studies that could help enrich this type of analysis. This category could include studies that did not have promising results and for which publication was discouraged. An additional selection bias might be generated by the choice of databases and keywords that have given prominence to studies indexed in these registries and especially related to English-speaking culture. The considerations drawn in the results could thus have been influenced by the method of extraction and selection of studies.

Finally, it is essential to note that, as Danielson [18] pointed out, a conceptual framework for teaching, even if based on good practices, cannot guarantee effective teaching. This depends on the way the framework is used, the professional culture of the school and teacher, and the teacher's commitment to continuously improving their practice.

7. Further Research

Future research should continue to investigate the impact of the UDL model on teacher education. Although some studies have explored the classroom effects of UDL training, further research is needed to assess how teachers transfer and apply UDL principles in their work context. In addition, there is a need to validate the model using measurement tools outside the model and to thoroughly assess the impact of UDL practices on various aspects of teacher self-efficacy. It is also recommended to investigate the effects of this model on collaboration between professionals and families. Finally, future research on the impact of UDL training should focus on understanding in more detail which variables have the potential to make the courses effective, both in terms of content and delivery methods.

8. Conclusions

The purpose of this review was to provide a general overview of how the UDL framework can support teachers in their practice in increasingly heterogeneous classrooms. The results indicated that the UDL model can provide support to the dimensions considered in the Profile of Inclusive Teachers [3]. Specifically, this approach contributes to the flexibilization of teaching action in terms of lesson planning and teaching. Following a UDL course, teachers increase their ability to integrate the principles into their planning and teaching action. The dimension that affects teachers' values and beliefs also seems to benefit from this input, although this dimension would need further investigation. This review also showed that there are no systematic differences when comparing teachers according to their function, school grade, or experience, both of whom seem to be able to benefit from this approach in their own practices. Results indicate that further research is still needed to verify the effectiveness and impact of UDL training, both to investigate the components of PIT and to investigate possible side effects.

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