JÖNKÖPING UNIVERSITY
School of Education and Communication

Interventions Supporting Mathematics and Science In-service and Pre-service Teachers' Cultural Responsiveness

A Systematic Literature Review from 1995-2017.

Andrea Ritosa

One year master thesis 15 credits
Interventions in Childhood

Supervisor
Jesper Boesen

Examinator
Eva Björck-Åkesson

Spring Semester 2017

SCHOOL OF EDUCATION
AND COMMUNICATION (HLK)
Jönköping University

Master Thesis 15 credits
Interventions in Childhood

Spring Semester 2017

ABSTRACT

Author: Andrea Ritosa

Interventions Supporting Mathematics and Science In-service and Pre-service Teachers' Cultural Responsiveness

A Systematic Literature Review from 1995-2017.

Pages: 29

Culturally responsive education has been an actual topic in teacher education for decades, but most teachers still finish their education without appropriate knowledge and skills for teaching in culturally and linguistically diverse classrooms. Providing quality education to diverse learners remains a challenge, particularly in the fields of mathematics and sciences. The purpose of this systematic literature review was to describe intervention programs preparing in-service and pre-service math and science teachers for teaching in culturally diverse classrooms, and the outcomes of such programs. A search for scholarly journals evaluating such intervention programs has been carried out in several databases, resulting in nine articles included in the analysis. Intervention programs described in these articles covered several important aspects of culturally relevant education and had a limited success in developing cultural responsiveness of teachers. The construct of culturally relevant education is complex and multi-layered, and thus hard to measure without simplifying it to measurable constructs. Limitations of the study and implications for the future research and practice are discussed.

Keywords: multicultural education, culturally responsive teaching, culturally relevant pedagogy, culturally relevant education, teacher education program, pre-service teachers, in-service teachers, mathematics and science education, systematic literature review.

Postal address
Högskolan för lärande
och kommunikation (HLK)
Box 1026
551 11 JÖNKÖPING

Street address
Gjuterigatan 5

Telephone
036–101000

Fax
036162585

Contents

1 Introduction

1.1 Demographic trends in migration

In recent decades there has been a striking increase in global movements of people from undeveloped or war-affected countries to developed, OECD countries, followed by increasing numbers of refugees and asylum seekers. Among other challenges increasingly diverse populations create for host-countries, securing inclusive education for immigrant and refugee children has a critical role in facilitating their transition. Ensuring immigrants and refugees access to quality education has been, and continues to be, a concern for education systems around the world (Bourgonje, 2010; Taylor & Kaur Sidhu, 2012).

1.2 Inclusion, diversity, and culture

UNESCO (2005, pp. 12) defines inclusion as "*a dynamic approach of responding positively to pupil diversity and of seeing individual differences not as problems, but as opportunities for enriching learning*". Concept of inclusion emerged from special education focused on children with disabilities and their integration in mainstream classrooms. As it was recognized that an adaptation of curriculum, teaching, and learning strategies is necessary for successful implementation of inclusive education, the focus from disabilities expanded to include diverse groups of pupils who are in need of special support. Inclusive education is a process of strengthening the capacity of education systems to find better ways of responding to diversity and reaching out to all learners. It should guide all education policies and practices (UNESCO, 2009). It's concerned with identifying and removing barriers toward presence, participation and achievement of all learners, and particularly of those who may be at risk of marginalization, exclusion or underachievement. In inclusive classrooms, individual differences are not seen as problems to be fixed, but as opportunities for enriching learning (UNESCO, 2005).

The American National Education Association (2015, as cited in Chiu et al., 2017) defined diversity in educational contexts as *"the totality of the ways in which individuals are both alike and different, including gender, race, ethnicity, language, culture, religion, sexual orientation, class, mental and physical ability, and immigration status"*. Culture can be defined as the values, traditions, social and political relationships, and worldview created, shared, and transformed by a group of people bound together by a common history, geographic location, language, social class, and/or religion, and as such is interactive, affects a person's life, and is continually changing. Because of this, it is not

easily identified by teachers (Vavrus, 2008). In literature on culturally responsive education, which is mostly set in USA, diversity can refer to minority pupils in general, pupils of colour, English language learners, pupils who have different ethnic, cultural or language background than their White monolingual teachers, or pupils with whom teachers usually don't succeed, while some is oriented towards more particular ethnicities such as African-American, Indian-American, or Latino pupils (Zeichner, 1993).

1.3 International laws on education of immigrant and refugee children

The right to free and compulsory education at the elementary level is granted to all children in the Universal Declaration of Human Rights (UN General Assembly, 1948). The Refugee Convention (UN, 1951) and the accompanying protocol (UN, 1967) guarantee to the refugee children the same educational opportunities on elementary school level as the nationals from the host country have. The Convention on the Rights of the Child (UN, 1989) calls for states to make primary education compulsory and free for all, and to stimulate the development of accessible secondary education, mandating education that builds on a child's potential and supports his or hers cultural identity. Other international conventions such as The International Covenant on Economic, Social and Cultural Rights (UN, 1966), the International Convention on the Elimination of all forms of Racial Discrimination (UN, 1969) and the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families (UN, 1990) also touch on educational rights, as well as economic, social and cultural rights, and racial discrimination (Bourgonje, 2010). The Salamanca statement and Framework for Action on Special Needs Education claims that educational systems and programs should take into account and accommodate to diverse characteristics and needs of pupils, relying on child-centred pedagogy and inclusive orientation (UNESCO, 1994).

1.4 Barriers toward inclusion of immigrant and refugee children

Although international declarations and conventions set a foundation for inclusive education for all, implementation of these rights for diverse learners has shown to be a complex and difficult task. It has been shown repeatedly that an educational achievement gap exists between children from ethnic minorities and children from ethnically dominant populations (Azzolini, Schnell, & Palmer, 2012; Song, 2011). In most OECD countries, students without an immigrant background perform better than first-generation immigrant students while second-generation immigrant students perform somewhere between the two (OECD, 2015). Other than inequity in school

outcomes with immigrant minorities, a research set in Australia reported that Indigenous students also show achievement gaps behind non-Indigenous students (Boon & Lewthwaite, 2015).

There are many identified barriers toward inclusive education of immigrant and refugee children, and explanations for school achievement differences between them and children from ethnically dominant populations. Language barriers are most often discussed in literature as one of the most crucial reasons immigrant and refugee children have difficulties in their education (OECD, 2015). Others factor that hinder their school achievement include hostile social climate toward immigrants and refugees, racist and attitudinal barriers, lack of congruence between the culture of the school and that of the pupils and requirments for their cultural and linguistic adaptation in a new country (Boon & Lewthwaite, 2015; Pugh, Every, & Hattam, 2012; Taylor & Kaur Sidhu, 2012), contemporary neoliberal policies in education, where individualism prevails and a focus is on competition, choice and performativity (Pugh et al., 2012), refugee experiences of violence and trauma, emotional and behavioral problems (Szente, Hoot, & Taylor, 2006), low quality of previous schooling, lack of previous education or interruptions in education (Miller, 2009; OECD, 2015; Taylor & Kaur Sidhu, 2012), and their current school environments characterized by socio-economic disadvantage (OECD, 2015).

1.5 Challenges for teachers and schools in overcoming the barriers

There are several areas for improvement in meeting the needs of immigrant and refugee students identifyied in the literature. Bryan and Atwater (1999) addressed the importance of influencing teachers' implicit and explicit beliefs about student characteristics, teaching and learning, including external influences on learning such as parental involvment, family stability, and communities' influence, and about multicultural issues and appropriate teacher responses to diversity. Those beliefs reflect on classroom practices and can undermine the opportunities for inclusive education. Working with diverse populations of learners is often accompanied by feelings of unpreparedness, uncertainty and anxiety due to a lack of prior experience with diversity (Dunn, Kirova, Cooley, & Ogilvie, 2009), and low self-efficacy about implementing some aspects of culturally responsive teaching (Siwatu, Chesnut, Alejandro, & Young, 2016). It is important to move away from deficit-oriented outlooks on diversity towards seeing diversity as an asset in education (Blanchet-Cohen & Reilly, 2013).

Countries that are new to receiving refugees are still strugling with securing the most basic needs to refugee pupils. Bačáková (2011) identified several barriers towards refugee children'

participation in education in the Czech school environment, including teachers' lack of inormation about children, lack of professional development in teaching, lack of resources to support education of refugee children, bad cooperation between schools, parents and social workers, lack of individualized support with a focus on language, and age-inappropriate grade placement of refugee children. In countries with a longer immigration traditions such as Australia or UK, it has been noticed that most attention has been given to language support and to social and emotional needs of immigrant and refugee children, while other learning needs have been neglected (Taylor & Kaur Sidhu, 2012).

A curriculum that is accessible to all students, a safe and supportive school community where all students are genuinely valued and respected, responding to students' social, emotional, and intellectual needs, encouraging social connectedness and a feeling of belonging for all students, and a systematic approach to ensuring that the practices of inclusive education are embedded, sustained and evaluated, are characteristics of inclusive schools (Taylor & Kaur Sidhu, 2012). Pugh et al. (2012) suggest that an adaptation of all aspects of school is necessary for improving outcomes for all students; changes need to made on the schools' structure and organisation, in the schools' culture including values, beliefs, assumptions, patterns of behaviour and relationships within the school and in the pedagogy, that is, in approaches to teaching and learning.

Cultural identity of most teachers is different than their increasingly diverse student populations, and it is of crucial impotance that pre-service and in-service teachers are well prepared to work with diverse students, are responsive to their needs and that they become culturally competent as immigration continues and the numbers of refugees and asylum seekers increases (Chiu et al., 2017; Vavrus, 2008).

2 Theoretical background

2.1 Culturally responsive education – historical and theoretical background

The first attempt to teach culturally diverse students more effectively began in the USA, with school desegregation movements in the 1960s and 1970s (Aronson & Laughter, 2016). The cultural miss-match between the African American pupils and the school, and the failure of teacher education programs to prepare teachers for cultural and linguistic diversity were identified, but diverse learners were at the time referred to as 'culturally disadvantaged' (Zeichner, 1993). During 1980's, research on education of small scale native communities, such as Hawaiian American or Indian American was being conducted, and concepts of culturally appropriate, culturally congruent, and culturally compatible emerged, recognizing the problem of interaction between pupils and teachers, but still failing to integrate pupils' home culture into school (Ladson-Billings, 1995; Vavrus, 2008). An innovative attempt to incorporate home culture into classrooms came from Moll, Amanti, Neff, and Gonzalez (1992). Assuming households hold cultural and cognitive resources which could be useful in classroom instruction, they suggested teaching should draw on these funds of knowledge defined as *"historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being"* (Moll et al., 1992, pp. 133).

Banks (1993), an important author within the field of multicultural education, proposed five dimensions of multicultural education; *content integration* is an instructional approach where content from culturally diverse groups is used in presenting subject matter, *knowledge construction* refers to helping students understand how knowledge is created from different racial and social class perspectives, *prejudicial discrimination reduction* refers to developing positive attitudes and behaviours among students, *the equity pedagogy* relates to teaching strategies that facilitate the academic achievement of students from different racial, cultural, language, and social-class groups, and *empowering school culture and social structure* refers to organizational and cultural reorganisations on school level so that educational equity and cultural empowerment are experiences by all students (Banks, 1993; Landa, 2011).

Building on the multicultural education approach, two primary approaches emerged in educational research, challenging the prevailing deficit paradigm towards cultural diversity; culturally responsive teaching (Gay, 2000) and culturally relevant pedagogy (Ladson-Billings, 1995). Culturally responsive teaching (CRT), embodied in the work of Geneva Gay, focuses on

the teacher practice, while culturally relevant pedagogy (CRP), expressed in the work of Gloria Ladson-Billings, focuses on teacher posture and paradigm. Social justice and the classroom as a site for social change are important elements of both approaches (Aronson & Laughter, 2016).

Recognizing that the academic success of African-American students came at the expense of their cultural and psychosocial well-being, Ladson Billings (1995) offered a theoretical model, CRP, which addresses students' school achievement and high expectations from all learners, helps students to accept and affirm their cultural identity, and to develop a critical consciousness, that is, perspectives that challenge inequities that school and other institutions perpetuate. CRP is committed to collective, not merely individual, empowerment. Developing cultural competence makes it possible for students of non-dominant cultures to maintain their cultural integrity while excelling academically (Ladson-Billings, 1995; Landa, 2011; Morrison, Robbins, & Rose, 2008).

Culturally responsive teaching is defined by Gay (2000) as *"using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them. It teaches to and through the strengths of these students. It is culturally validating and affirming."* (p. 31). She uses the term culturally responsive as a compilation of ideas by various scholars, labelled as culturally relevant, sensitive, centred, congruent, reflective, mediated, contextualized, or synchronized. In CRT, cultural heritages of different ethnic groups are acknowledged as influencing students' dispositions, attitudes, and approaches to learning and are integrated into the formal curriculum. Multicultural information, resources, and materials are incorporated in all the subjects and skills routinely taught in schools. Students are taught to know and appreciate their own and each other's cultural heritages. Variety of instructional strategies is used to adapt to different learning styles. CRT builds on the students 'existing cultural skills and ways of knowing, making connections between home and school experiences and between academic abstractions and lived sociocultural realities (Gay, 2000; Sleeter, 2012).

Terms culturally responsive teaching and culturally relevant pedagogy are often used interchangeably, even though they differ in their focus. While Gay's focuses on culturally responsive teaching in the classroom, Ladson-Billings focuses on pedagogy. Aronson & Laughter (2016) consider these two approaches complementary; teaching affects competence and practice whereas pedagogy affects attitudes and dispositions. A synthesis of these complementary research approaches on teaching diverse students is proposed in an inclusive framework labelled culturally relevant education (Aronson & Laughter, 2016; Dover, 2013).

Culturally relevant education (CRE) aims to build an inclusive and welcoming school environment for all learners, increase their engagement and motivation, and close the disparity of academic and social opportunities observed between minority students and White students. Infusing the culture of ethnic minorities into the curriculum promotes a caring school environment and makes learning more culturally relevant and effective (Vavrus, 2008).

2.2 Characteristics of culturally responsive teachers

Culturally responsive teachers have a positive image of themselves and their students, perceive knowledge as socially constructed and subject to transformation, understand how culture, socioeconomic status and language influence education and school achievement and are capable of critical reflection. They are familiar with history and theory of culturally responsive education, with the economic and educational systems, problems of race and inequality, learning theory, child development and language acquisition, and importance of inclusive classrooms (Vavrus, 2008; Zeichner, 1993). They set high, non-discriminatory expectations towards all students and they communicate these expectations to them. They are active listeners, can find ways to learn about students' culture, communities, families, interests, and beliefs, and scaffold students' learning through incorporating students' culture and language into lesson and instruction. They have good subject knowledge and pedagogical skills enabling them to build on students' existing knowledge and cultural preconceptions using diverse instructional strategies, and to implement assessment practices that evaluate students' performance in a variety of contexts (Dover, 2013; Gay, 2000; Ladson-Billings, 1995; Vavrus, 2008; Zeichner, 1993).

Culturally responsive teachers' approach to teaching is holistic and comprehensive, not focused merely on end-of-year tests but also on long-term academic achievement, life-long learning, social and emotional development, development of cultural competencies and socio-political consciousness. They create inclusive classrooms and collaborative environments, as well as democratic and culturally sensitive social relations with their students. They seek to involve parents in pupils' education, and are transformative of schools and societies, challenging negative attitudes of other professionals. Finally, they recognize when their own professional dispositions may need to be adjusted and are able to develop plans to do so (Gay, 2000; Ladson-Billings, 1995; Zeichner, 1993).

2.3 Culturally responsive education and students' outcomes

Culturally responsive education has positive impacts on teaching and students' learning. Meta-analysis performed by Aronson & Laughter (2016) demonstrated that the engagement of CRE influences several student outcomes across different subject areas; mathematics, science, history and social studies, English language arts, English as a second language. Successful implementation of CRE leads to increases in academic skills and concepts, student motivation, interest in content, ability to engage content area discourses, perceptions of themselves as capable students, and in confidence when taking standardized tests.

2.4 Preparing teachers for cultural diversity

To effectively implement CRE, teachers need to use and develop their multicultural knowledge, skills, and dispositions. Developing skills for teaching in culturally diverse classroom can take place during pre-service teacher education and in-service professional development programs (Vavrus, 2008).

Preparation of pre-service teachers to teach ethnic- and language- minority students can be integrated throughout the various professional courses within the teacher education program or can be added as a separate course or a field experience to a regular teacher education. In the first, "infusion" approach, the entire programs are focused on preparing teachers for diverse classrooms, either with a variety of different ethnic groups or whit a specific group of pupils. In the second, "segregation" approach, education students are taught about topics such as diversity, multiculturalism, and anti-racist education in a course separated from the rest of the program. Segregation approach is much more common, even though research has demonstrated that education on culturally responsive teaching should be infused across education training, and not offered as a separate course, to have a long-term impact (Dunn et al., 2009; Vavrus, 2008; Zeichner, 1993). Teacher education programs for diversity most often include helping pre-service teachers to better understand and develop their own cultural identities, to examine their attitudes and values towards ethnic minorities, field experience and contact with ethnic minorities coupled with guided reflective analysis of these experiences, learning about cultures and about instructional strategies sensitive to cultural and linguistic differences (Zeichner, 1993). Professional development programs for in-service teachers can impact the teachers' perceived intercultural competence (Dejaeghere & Zhang, 2008). Participation in both in-service and pre-service education programs on cultural diversity is often voluntary, which is considered a

necessity by some (Clair & Adger, 1999) but also criticized by other researchers worried about the marginalization of teacher preparation for diverse learners (Zeichner, 1993). Some of the prerequisites for successful implementation of CRE are: having established sociocultural consciousness (conceptions of self and others), replacing the deficit perspectives of diverse students and communities, understanding how and why culture and diversity are essential for CRT and caring for students' overall well-being (Aronson & Laughter, 2016; Ladson-Billings, 1995; Morrison et al., 2008).

2.5 Cultural responsiveness in math and science education

Prospective teachers often finish their education without appropriate knowledge and skills about teaching in diverse classrooms. This is especially true for subject teachers, whose education is often focused on their discipline while equity and diversity issues are not covered in their teacher education programs. Programs concerned with the topic of teaching diverse learners usually deal with teaching in general and don't focus on teaching specific subjects, even though some content-specific strategies have been identified in culturally responsive teaching in the field of science and mathematics (Hernandez, Morales, & Shroyer, 2013). This leads to traditionally trained teachers having a harder time connecting to diverse pupils and integrating culture and language diversity into the subject content (Lee, 2005).

Achievement gaps between minority students or immigrants and ethnically dominant students have been especially significant in the fields of math and science (Buxton, 2005; European Commission, 2013; Flores, 2007). Bryan and Atwater (2002) believe that knowledge construction in science is especially influenced by culture and cultural knowledge, making science learning very challenging for students whose cultural views and ways of knowing science differ from the one taught in schools. Teaching science to immigrant or refugee children can be additionally challenging if they are not fluent in the language of instruction. Learning science demands acquisition of a specific extensive vocabulary and scientific language which differs from social language. Developing understanding should be a priority over mastering the technical vocabulary (UNESCO, 2010). Mathematics is traditionally not perceived as very connected with language, but research has shown that language facilitates mathematical thinking and learning math greatly depends on the language (Dale & Cuevas, 1992; as cited in Jarrett, 1999). Jarrett (1999) identified several approaches recommended for teaching math and science to language-minority students which enable understanding of the content before mastering the language. They include placing thematic units in the context of pupils' every-day life, pupils using language for conversing,

collaborating and tutoring one another, problem solving and inquiry activities related to pupils' real-life experiences and prior knowledge, explicit vocabulary learning during purposeful activities and investigations, encouraging classroom discourse between pupils and modifying the language to enable their participation, and encouraging pupils to express their ideas.

3 Purpose of the systematic literature review and research questions

The purpose of this systematic literature review is to explore ways to prepare in-service and pre-service math and science teachers for teaching in culturally diverse classrooms. It aims to answer two research questions:

1. What kind of intervention programs aiming to support culturally responsive education are provided to math and science pre-service and in-service teachers?

2. What are the outcomes of such intervention programs?

4 Method

4.1 Systematic literature review

To identify research on interventions used to improve teaching competencies of math and science in culturally diverse classrooms, a systematic literature review was performed. Systematic literature review is a research method and a type of literature review characterized by clearly stated question(s) it aims to answer, strictly prescribed transparent method for the search and collection of research, defined inclusion and exclusion criteria and quality assessment criteria (Jesson, Matheson, & Lacey, 2011).

4.2 Search procedure

The database search for this systematic literature review took place in March, 2017. The databases used for the search were ERIC, PsycINFO, ScienceDirect, Scopus and MathEduc. In the database PsycINFO, the Thesaurus search was performed, in the database ERIC the Thesaurus search was performed in combination with free search terms, while in other databases only free search terms were used in advanced and expert search options. Used search terms mildly varied between databases because suggested Thesaurus terms and free search terms suggestions differed, and because the database MathEduc was already restricted to math, narrowing down to math or science education wasn't necessary. All the searches were limited to scholarly articles published in English language. The search words used in the database PsycINFO were *("Preservice Teachers" OR "teacher education") AND "Cultural Sensitivity" AND ("Mathematics Education" OR "Science Education")*. This search resulted with 10 articles. The search words used in the database ERIC were *("Inservice Teacher Education" OR "Teacher Education Programs" OR "Preservice Teacher Education") AND "Culturally Relevant Education" AND (math OR science)*. In this search, 28 articles were found. The search words used in database Scopus were *("culturally responsive pedagogy" OR "culturally relevant education") AND (science OR math) AND ("teacher education" OR "preservice teacher education")*. This search resulted in 245 articles. The search words used in database MathEduc were *(culture OR diversity) AND "teacher education"*. This search yielded 171 articles. Finally, the search words used in database ScienceDirect were *"culturally relevant pedagogy" AND "teacher education" AND (math OR science)*. This search resulted in 39 articles.

4.3 Inclusion/exclusion criteria

Inclusion and the exclusion criteria used for the screening were established based on the research questions. The aim was to identify interventions used for improving pre-service and in-service math and science teachers' multicultural competencies, so only research that was describing and evaluating such interventions was considered. The focus was on interventions set in OECD countries. The time frame from 1995 onwards was chosen based on educational reforms considering culturally responsive teaching that began to take place in USA at the time (Aronson & Laughter, 2016). The extraction form with inclusion and exclusion criteria is shown in the Table 1.

Table 1

Inclusion and Exclusion criteria.

	Inclusion criteria	**Exclusion criteria**
Availability	Available full text in English	Only abstract available
Publication	Research articles published in peer-reviewed journals	Discussion papers, reports, book chapters etc., missing peer-review
Study Design	Studies evaluating an intervention with a control group or with a measure of change on at least two time points	Studies with no control group nor evaluation of intervention on at least two different time points Small case studies, N<5
Intervention	Preservice teacher education, and/or continuing professional development	Interventions on funding and policy levels, school or district level and interventions aimed at parents
	Focus on improving multicultural competencies	No focus on multicultural competencies
	Interventions with implications for math and science teachers	Interventions aimed at other subject teachers
Setting	Interventions set in OECD countries	Interventions set in other countries
	Elementary school, middle school and high school level of education	Early childhood teachers and educators
	School context	Extracurricular context
Year	1995 – 2017	Older research

4.4 Screening process – Title and abstract level

Articles collected in databases ERIC, PsycINFO, Scopus and ScienceDirect were imported to Covidence (Mavergames, 2013), an online tool facilitating the screening process in systematic literature review. After importing the 322 articles, 6 were automatically detected as duplicates, and

the 316 were left for the title and abstract screening process. Title and abstract screening of the 171 articles found in the database MathEduc was performed in the same database since they couldn't be imported to Covidence.

Out of the 316 articles imported to Covidence, 298 were excluded from the further analysis based on the exclusion criteria, mostly due to wrong study design (e.g. case studies and research with only one point of assessment) or wrong intervention and setting, leaving 18 articles for the full-text review. Out of 171 articles from MathEduc, 168 were excluded from the further analysis based on the exclusion criteria, for the similar reasons as above. Out of three articles left, 1 was a duplicate, leading to 2 articles from MathEduc being included in the full-text review. They were imported to Covidence for a full text review through other online libraries. Additionally, one more article found through hand search that didn't come up in the database searches was added for a full text review, making a total of 21 articles included in the full text review.

4.5 Selection process – Full text

Inclusion and exclusion criteria were again applied to 21 articles included in full-text screening process. During this screening, the focus was largely on the method section where intervention and assessments were described, since the goal was to examine the intervention setting, intervention activities and evaluation measures. Out of 21 articles, one was not available in full-text, 3 articles were excluded due to wrong intervention focus (no focus on multicultural competencies, N=2; not relevant for math or science classes, N=1), 2 articles were excluded due to wrong setting (afterschool setting, N=1; set in non-western country, N=1), and 6 articles were excluded due to wrong study design (no evaluation of intervention, N=2; no change assessments on at least two time points, N=4). After the exclusion of 12 articles, 9 remained for data extraction. The whole screening process is pictured in a flowchart in Appendix A.

4.6 Data extraction

Data extraction was performed using a protocol shown in *Appendix B*. Extracted information included title of the article, authors, year of publication, journal title and SCImago Journal Rank indicator, country where research took place, study rationale and purpose, research questions, study design, information about the sample of teachers and whether participation was voluntary or obligatory, about the population of children taught in diverse classes, whether intervention was integrated with the whole teacher education program or not, intervention activities, content, time

frame and place of the intervention, measurement tools, data analysis, results, limitations and implications discussed in the article.

4.7 Quality assessment

Quality assessment of the chosen articles was performed using a checklist based on COREQ checklist for qualitative research (Tong, Sainsbury & Craig, 2007) and CASP checklists for quantitative, qualitative and mixed research (CASP, 2017), adjusted to fit the context of this review. The protocol is shown in *Appendix C*. Since number of criteria differed for articles depending on their research design, comparison was made based on the percentage of criteria the articles fulfilled. Three of the articles are considered to have good quality (>70% of the quality criteria fulfilled), five articles are of moderate quality (>50% and <70% of the quality criteria fulfilled) and one articles was of low quality (<50% of the quality criteria fulfilled). Since the initial number of articles included in this systematic literature review was already small, no articles were excluded due to low quality.

4.8 Data analysis

Data analysis was performed during and after data extraction. An identification number was assigned to each study (shown in Table 2.), and was used onwards instead of referencing. General information about studies and intervention programs were analysed first to get an overview of what types of intervention programs are there for supporting culturally responsive education within math and science. To answer the first research question, descriptions of intervention programs were analysed and results were synthesised into categories of program activities and program content. To answer the second research question, outcomes of the intervention programs were analysed and grouped in different categories. Most of the studies shared a common ground in the field of multicultural education and culturally responsive education, but they used different terminology in describing contents and outcomes of intervention programs. Contents that were recognized as covering similar constructs and topics were grouped in the same category, as well as outcomes that were recognized as similar constructs.

5 Results

5.1 Overview of results

Nine articles were identified that answered the research question in a way that satisfied the inclusion criteria; they evaluated interventions supporting math or science in-service or pre-service teachers' development of culturally responsive teaching, either by observing a change in outcomes from pre- to post- intervention, or by comparing the outcomes to a control group, or by combining these two types of data. These articles were published between 1995 and 2017 in journals related to teacher education, inclusive education, science and math teaching, and education of minority pupils. A short overview of the studies can be found in Table 2, while some additional information about the studies, including quality indicators, can be found in Appendix D.

Out of nine studies included in this systematic literature review, eight were set in USA and one in Canada. Four studies evaluated interventions aimed at pre-service teachers (1,3,4,9), four studies evaluated interventions aimed at in-service teachers (2,6,7,8), and one study followed the teachers during their pre-service education and their transition to in-service (5). Out of four studies with in-service teachers, two were set in elementary schools (7,8), one in high-school (2), and one covered K-12 teachers (6), including elementary, middle and high school teachers. Five studies were concerned with science teaching (1,2,3,7,8), two studies dealt with math & science teaching (5,9), one was about teaching in general, including math & science (6), and only one study focused on math teaching (4). Two studies were quantitative studies (1,8), three were qualitative studies (2,4,9) and four were mixed methods studies (3,5,6,7). One quantitative (1), one qualitative (4) and one mixed methods study (6) had a control group while other six studies followed only the participants enrolled in an intervention from the beginning of the intervention until the end. Only one study had a follow-up one year after the intervention took place (8).

Only two interventions programs (1,5) used an "infusion" approach where preparing teachers for diverse classrooms was integrated throughout the whole teacher education program. Another intervention program (7) used integrated approach with in-service teachers, where professional development objectives included science instruction, language development and student's culture. The rest of the intervention programs were shorter programs and consisted of courses separated from regular teacher education.

Table 2

Overview of articles and intervention programs.

IN*	Authors (Year)	Country	IST/PST*	Math/Science	Intervention	Duration	Approach
1	Bravo, Mosqueda, Solís, & Stoddart (2014)	USA	PST	Science	CFSEP teacher education program	1 acad. year	Infusion
2	Brown & Crippen (2017)	USA	IST	Science	START professional development program	6 months	Segragated
3	Buck & Cordes (2005)	USA	PST	Science	An Action Research Project	1 semester	Segragated
4	Downey & Cobbs(2007)	USA	PST	Math	Field experience as a part of a math methods course	1 semester	Segragated
5	Bustos Flores, Claeys, Gist, Clark, & Villarreal (2015)	USA	PST&IST	Math & science	ATEP Program	several years	Infusion
6	Katz (2014)	Canada	IST	All subjects, math & science included	Professional development program on the school level	NS	Segragated
7	Lee, Luykx, Buxton, & Shaver (2007)	USA	IST	Science	Professional Development Intervention	2 years	Infusion
8	Haukos, Gerry, Bordeaux, LeBeau, & Gunhammer (1995)	USA	IST	Science	Teacher training	2 weeks	Segragated
9	(Brown & Crippen, 2016b)	USA	PST	Math & science	Field experience as a part of science and math methods course	1 semester	Segragated

*IN –Identification number of the study
*IST – in-service teachers; PST – pre-service teachers
*NS – Not specified

To get an insight into interventions supporting culturally responsive education provided to math and science pre-service and in-service teachers, the activities and the content of these interventions were analysed and synthesized.

5.2 Intervention activities

Activities that were implemented in the studies are listed in the Table 4. Some research described interventions in more detail and in a more systematic way than other, making it easier to extract intervention activities. Only activities that were explicitly mentioned as provided to participants were included in the analysis.

Table 3

Activities implemented in the chosen studies.

Activities: IN:	1	2	3	4	5	6	7	8	9
Opportunities for learning about CRP theories and research	X	X		X	X		X	X	X
Opportunities for exploring own beliefs on diverse populations		X	X						
Opportunities for reflection on own practices	X	X	X	X		X	X		
Opportunities for learning about culturally diverse students		X	X	X	X		X		
Critical examination of practices		X	X	X	X		X		X
Examining educational legislation and policies		X	X						
Examples and modelling of CR practices	X	X			X	X	X		
Group collaborations and discussions with peers	X	X	X		X	X	X		
Mentoring	X				X	X			
Observing classroom teaching				X	X				X
Planning/designing a CRP lesson/inclusive lesson		X	X			X	X	X	X
Trying out a CRP lesson unit or CRP activities with peers	X	X							
Field experience	X	X	X		X		X		X
Receiving feedback on practical work	X	X			X				
Exercises illustrating linguistic and cultural barriers							X		
Offering online resources for continuing professional development							X		

Activity that was most common in intervention programs is opportunities for learning about theories and research on CRP (1,2,4,5,7,8,9). This has been done either through course work, readings, or investigating and writing reports. Other very common activities have been critical

examination of common educational practices (2,3,4,5,7,9), opportunities for reflection on own practices, learning and professional development (1,2,3,4,6,7), group collaborations and peer discussions about culturally responsive education (1,2,3,5,6,7), designing a lesson that is culturally responsive or inclusive of diverse pupils (2,3,6,7,8,9), and field experiences (1,2,3,5,7,9). Some of the opportunities for reflecting on own practice was done through peer discussion but also in other ways such as autobiographical writing. Peer discussions were about various topics, and their content is covered in the 'interventions' content' section. Field experiences allowed implementation of a culturally responsive lesson in a culturally diverse classroom. They were a part of all but one program aimed at preservice teachers. For in-service teachers, field experiences were conducted in their own classrooms.

Other activities that took place in the more than half of the intervention programs included in this review are: opportunities for learning about culturally diverse pupils (2,3,4,5,7), and providing examples of CR instructions and/or classroom interactions (1,2,5,6,7). Learning about culturally diverse pupils was done through classroom observation, tutoring a pupil, interviewing a pupil, meeting an ex student, reading the provided research, or through a combination of activities. Examples of culturally responsive classroom practices were provided through modelling by the tutor, examples from the literature or lesson plans, discussions and exchange of experiences.

Receiving feedback on practical work either form peers or from the supervisor was an activity in three of the programs (1,2,5), same as observing classroom teaching (4,5,9), and mentoring (1,5,6). Feedback on practical work was given in the programs that had a field experience. Observing classroom teaching was common only in pre-service teachers' education. Mentoring refers to individual guidance through discussion and advice.

Least common activities included opportunities for exploring own beliefs on diverse populations (2,3), examining educational legislation and policies (2,3), trying out a CRP lesson unit or CRP activities with peers (1,2), offering online resources for continuing professional development (7) and exercises illustrating linguistic and cultural barriers (7).

5.3 Content of interventions

Content of interventions were mentioned in different parts of the articles; while some articles had the intervention content explicitly mentioned in the method sections, the others touched on it very briefly or made implications about favourable changes the intervention aimed to accomplish

in the intervention aims or in the results describing outcomes. Only the content that was explicitly described as provided to participants was included in the analysis.

Table 4

Content of interventions.

Content:	IN:	1	2	3	4	5	6	7	8	9
CRP theories and research		X	X		X	X		X	X	X
Students' characteristics			X		X			X		X
Science knowledge		X						X		
Integrating students' culture into lessons		X	X				X	X	X	
Student-centeredness (as opposed to content centeredness)			X							
Inclusion				X			X			
Democratic teacher-student relationship		X	X			X				
Sociocultural and critical consciousness			X							
Building a community of learners							X	X		X
Promoting inquiry based science				X			X	X	X	
Promoting academic dialogue with students		X								
Promoting complex understanding		X					X			
Differentiated assessment							X			
Language inclusion as a tool, support for ELs		X				X		X		
Reflection on owns practices or development and learning		X	X	X	X		X	X		

As already mentioned in the activities section, participants' knowledge about culturally responsive teaching was being developed in most interventions (1,2,4,5,7,8,9). Raising self-awareness and reflecting on own practice and development was also an important part of the interventions, covered in six programs (1,2,3,4,6,7). Teacher were taught how to integrate students' culture into lessons in five intervention programs (1,2,6,7,8). In four of the intervention programs, participants learned about their pupils' characteristics (2,4,7,9), including pupils' beliefs, needs, experiences, backgrounds, families and social lives. Promoting inquiry based science (3,6,7,8) was also covered in four intervention programs. Building a community of learners, learning how to include language as a lesson tool and support English learners, and creating democratic social relations with students were a part of three interventions. Building a community of learners referred to encouraging good relationships and collaboration between pupils (6,7,9). Including language into lesson and supporting ELs was taught in interventions where diversity definition

included linguistic diversity (1,5,7), but not all interventions that considered linguistic diversity had language support in their content (3,6). Creating democratic social relationship between teachers and students, although recognized as an important aspect of culturally responsive classrooms in most articles, was explicitly encouraged only in three interventions (1,2,5).

Deepening science knowledge was aimed at both pre-service (1) and in-service teachers (7). Promoting pupils' complex understanding was a specific goal of one intervention (1) and was closely tied to promoting inquiry based science in another one (6). Inclusion topic was explicitly covered only in two interventions (3,6), both of which had diversity defined in broader terms than cultural and linguistic diversity, either as underserved population of students (3) or diverse learners in general (6). Only one intervention (2) was concerned with raising sociocultural and critical consciousness and covered student-centeredness (as opposed to content centeredness) as a topic. It is important to note that awareness and promotion of both student-centeredness and inclusion were visible in other programs too, but weren't explicitly mentioned as provided to participants. Only one intervention was specifically oriented at promoting academic dialogue with students (1), and only one was concerned with differentiated assessment of pupils (6).

5.4 Outcomes of interventions

Intervention outcomes were operationalized either as a change from pre-intervention to post interventions or as a difference between experimental intervention group and a control group of participants. Different construct were used to asses outcomes, and they were assessed by various instruments, making it challenging to categorize and compare them. An attempt has been made to group the intervention outcomes into 6 categories: awareness of learning needs of diverse learners and knowledge of appropriate pedagogical strategies, implementation of these strategies into lesson plans, views of students, self-efficacy about teaching in a culturally responsive way, beliefs about importance and efficacy of culturally responsive teaching methods, and observed changes in culturally responsive teaching practices. Outcomes of interventions are represented in Table 5. Intended outcomes that were successfully achieved are marked with an 'X', and those that are not achieved are marked with a '0'. In one study (8), 'x*' was used to mark outcomes that were initially significant, but not after a one year follow-up.

Awareness of learning needs of diverse learners and knowledge of appropriate pedagogical strategies was accomplished in all three interventions that aimed for it (3,4,9). It referred either to a slight increase in knowledge about pedagogical strategies appropriate for diverse learners

measured by the questionnaire (3), greater awareness and knowledge about learning needs of diverse learners (on top of learning about teaching mathematics and about children's learning in general which was also accomplished in a control group) (4), or to increased awareness of several elements of CRP, including culturally responsive classroom environment, academic communication and contextualizing instruction in students' lives, as observed in qualitative material (9). The last study also evaluated implementation of this knowledge, but it was shown that CRP elements were inconsistently implemented into lesson planning (9).

Table 5
Outcomes of interventions.

Outcomes IN:	1	2	3	4	5	6	7	8	9
Awareness of learning needs of diverse learners and knowledge of appropriate pedagogical strategies			X	X					X
Implementation of pedagogical strategies appropriate for students from diverse backgrounds									0
Views of students		X							
Self-efficacy, confidence, and preparedness to teach			X		X	X			
Beliefs about efficacy/ importance of CR methods:									
Democratic teacher-student relationship	X								
Integrating language	0						0		
Integrating culture and interests	0						0	x*	
Instructional Conversation	0								
Challenging Activities	0								
Student-centred strategies								x*	
Changes in culturally responsive practices (observed):									
Democratic teacher-student relationship	0	X							
Language and Literacy, incorporating language into lesson	X						0		
Contextualization, incorporating culture into lesson	0	X					0		
Instructional Conversation	X								
Challenging Activities	X								
Classroom Community Building		X							
Use of differentiated instruction						X			

Views of students changed in the one intervention that aimed for it (2). Views of students changed from deficit-oriented towards resource oriented, from generalized and stereotypical

towards based on observations and experience, and from attribution of failure to pupils toward attribution of failure to school environment not meeting pupils' needs.

Increased self-efficacy was accomplished in all three interventions that aimed for it (3,5,6). It refers to an increase in confidence and preparedness to teach (3), an increase in teachers' confidence about their capacity to make a difference and in their teaching capabilities (5), and increased self-efficacy (6). Although recognized as a different constructs from self-efficacy, confidence in teaching and preparedness to teach were estimated to be similar enough to be considered as one category for the needs of this review.

Beliefs about efficacy or importance of culturally responsive teaching methods were assessed in three studies (1,7,8). It is important to know that in study nr.1, not only change from pre- to post-intervention was assessed, but that it was controlled for the change from pre- to post-intervention in the control group. To have a significant effect, change had to be bigger in the intervention group than in the control group (who also received some relevant education). Other three studies compared only pre- and post- intervention beliefs. Overall, interventions had a modest success in changing participants' beliefs about efficacy or importance of culturally responsive teaching methods. Beliefs about importance and efficacy about some of the practices were high in the pre-intervention condition so the lack of changes does not mean that these practices were considered inefficient or unimportant by the participants by the end of intervention.

Beliefs about integrating language into lesson and instruction didn't change in two interventions examining them (1,7). Changes in beliefs about integrating pupils' culture and interests into lesson were noticed in one intervention, but the effect wasn't fully sustained after one year follow-up (8). There was no change in other two interventions examining those beliefs (1,7). Some of the examined beliefs were very specific and were examined in only one of the studies. Study nr. 1 was the only one examining changes in beliefs about the role of democratic teacher-student relationship, importance of instructional conversation in science teaching and challenging activities that promote complex understanding of science. The significant change was noticed only in beliefs about the role of relationship between teacher and pupils, while there was no change in other two outcomes, in comparison to the control group. In the study nr. 8, perceived value of student-centred strategies grew after intervention but the change wasn't sustained over a one year period.

Classroom observation of teaching practices took place in four studies (1,2,6,7). In general, the implementation of learned content in classroom teaching was modest. Implementing a democratic teacher-student relationship was improved throughout one intervention (2), while in another one (1) the change was not observed, despite significant changes in beliefs about its importance in the same study. An improvement in incorporating language into lesson was also observed in one intervention (1) and not in another one aiming for it (7). Incorporating culture into lesson was the goal of three interventions (1,2,7), but it was accomplished in only one of them (2). Several unique outcomes were examined in only one of the interventions; in study 1, an improvement was observed in implementation of instructional conversation in science teaching and challenging activities that promote complex understanding of science in the intervention group, in study 2, there was an observed improvement in the classroom community building during intervention, and in the study 6, the increased use of differentiated instruction was observed in the intervention group.

6 Discussion

A lot is written about importance of preparing teachers for diverse classrooms, but scholarly articles reporting on systematic evaluations of intervention programs that aim to do that are rare. Only nine studies were identified that satisfied inclusion criteria for this systematic literature review. Among those, eight were set in USA and one in Canada. This is not surprising since North America has a much longer tradition of improving education for cultural minorities. Culturally responsive education movement was established in USA and was relevant earlier than in Europe, where the needs for it are emerging in the last decade or two.

The results showed that culturally responsive education is being promoted among pre-service and in service math and science teachers, but is more often done through separate courses, while programs integrated with general teacher education are rare. When not integrated in teacher education program, participation in courses on culturally responsive teaching is most likely voluntary. These findings are in line with Sleeter's (2012) and Zeichner's (1993) arguments on marginalization of culturally responsive education.

6.1 Reflections on findings and practical implications

Improving culturally responsive education is a complex and multi-layered process. Intervention programs aiming to develop and support multicultural skills of math and science teachers are long-lasting, supported by various theoretical approaches, include many different activities, and

cover many different topics. Most common characteristics of such intervention programs are that they provide opportunities for learning about importance of culturally responsive teaching by introducing theories and research about culturally responsive teaching, they are implemented in groups and use peer discussion as a method of encouraging critical examination of common pedagogical practices, as well as self-reflection on own teaching practices and professional development, they teach how to implement culture, and sometimes language, into classroom lessons, and they require some practical work from participants such as designing a culturally responsive lesson or include a field experience for pre-service teachers, offering a chance to implement the new knowledge in culturally diverse classroom and get feedback on it. It has been suggested that field experience alone can lead to strengthening of initial negative attitudes towards minority groups (Haberman, 1991), so it is crucial to secure education and support prior to the field experiences. Giving examples of culturally responsive teaching and classroom interactions was somewhat less common, but the need for such examples was greatly recognized (Brown & Crippen, 2016b).

To teach in culturally responsive ways, teachers need to know their students and be familiar with their cultures. Since this is a crucial component of culturally responsive teaching, it is surprising that barely more than half of intervention programs described in this review included opportunities for learning about culturally diverse pupils. Vavrus (2008) argues that active listening is a crucial skill for teachers to have. It is their responsibility not just to know their pupils, but also to find ways to learn about their pupils. Other than focusing on providing information about pupils, intervention programs could aim at enabling teachers to seek information about pupils themselves, as described in Downey and Cobbs (2007), where pre-service teachers participated in a field assignment and conducted a semi-structured interview with a pupil from different cultural background, followed by a guided reflection on the experience.

Some activities and contents were represented in only few of the intervention programs analysed. Familiarity with educational system is considered an important characteristic of culturally responsive teachers, but examination of educational legislation hasn't been common in intervention programs. Examining own beliefs about diverse pupils was also covered in only few intervention programs, despite the importance of being able to recognize own dispositions and when they need to be adjusted. Good subject knowledge is also crucial as it enables teachers to be creative in finding ways to build on students' existing knowledge and preconceptions. Increasing subject knowledge in math and sciences is especially relevant for elementary school

teachers, who can be anxious about their mastery of the subject which is necessary for integrating lesson content with students' experiences and interests (Brandt, 2005).

Some specific classroom accomplishments such as creating inclusive and collaborative environment as well as democratic relationship with pupils were less common than suggested in the literature. Promoting complex understanding, academic dialogue and inquiry based science is relatable to setting high, non-discriminatory expectations towards all students, an important characteristic of culturally responsive teachers, but was rarely covered in interventions programs, as well as learning how to implement differentiated assessment. Development of sociocultural and critical consciousness, a crucial aspect of culturally relevant pedagogy and a prerequisite for challenging inequities and negative attitudes of other professionals, was specifically aimed for in only one of the intervention programs (Brown & Crippen, 2017). Other practices that could be used to increase awareness and knowledge of culturally responsive education are exercises that illustrate linguistic and cultural barriers, and opportunities for continuing professional development as described in Lee et al. (2007).

In general, intervention programs described do not seem to be specifically oriented at math and science teaching. Most of the knowledge, skills and attitudes targeted seem to be relevant for any school subject. Few interventions covered subject (science) knowledge and a few more gave examples of culturally responsive teaching, but no content-specific strategies relevant specifically for science and mathematics have been described in a way that would allow practical replications.

Being a complex construct, cultural responsiveness of teachers is hard to assess. To evaluate whether teachers became more culturally responsive after intervention programs, the constructs of culturally responsive teaching and culturally relevant pedagogy have been simplified to measurable constructs. As Aronson and Laughter (2016) noticed in their research, the idea of cultural responsiveness is not consistent across studies, and usually only few aspects of it are addresses in individual studies. Even qualitative studies that used an inductive approach in assessing outcomes didn't cover many aspects of culturally relevant education.

In studies included in this review, cultural responsiveness has been operationalised in various ways. Measures of outcomes included changes in attitudes and beliefs about pupils and about importance of culturally responsive teaching methods, changes in knowledge and skills, changes in practical implementations of culturally responsive practices, and self-efficacy beliefs. Making a change in knowledge, skills, and self-efficacy was more likely to happen than changes in attitudes

and observed practices. Only one study had a follow-up and has shown that intervention effects weren't successfully sustained after one year.

Several factors other than intervention activities and content might have influenced the outcomes. Some of them are the size of the group receiving educational program, intensity and longevity of the program, integrated vs. segregated approach to the education program, motivation of participants depending whether their participation was obligatory or voluntary, and the ethnicity of the participants.

6.2 Methodological challenges

Most of the intervention programs included in this review lasted for months or years. It is unrealistic to expect that all activities and content covered in these programs were described in detail. Some of the papers described interventions in terms of desired outcomes, and didn't describe which methods were used to accomplish them. Elsewhere, information about intervention methods was mentioned in results section or in the appendixes. For example, in the paper by Bustos Flores et al. (2015), information about intervention content and activities was found mostly in the qualitative results section where some of the activities were connected to outcomes. As already stated in the method section, only activities and contents that were explicitly mentioned as provided to participants were included in the analysis. Since it's possible that some intervention programs included activities that weren't explicitly mentioned, the comprehensiveness of this review is questionable as the actual coverage of the content and activities in the intervention programs might have been greater than described and reported here. It is also possible that the focus on mathematics and science teaching would be more visible if descriptions of the intervention activities were more detailed.

It would be interesting to evaluate if factors such as programs' group size, intensity and duration of the program, or ethnicity of teachers participating affected the outcomes. Since data about these factors weren't systematically reported across the studies included in this review, no assumptions could have been made based on this research.

Another methodological problem was that included studies used different terminology to describe intervention aims, activities and outcomes, depending on the theoretical background the interventions were based on. An attempt has been made to synthesize similar concepts in the same categories, but the validity of this procedure is questionable, especially since only one reviewer was engaged in this process.

Peer review would have been desirable during several steps of this systematic literature review. After deciding on search terms and performing database search, a single reviewer applied inclusion and exclusion criteria to found studies. Some inclusion and exclusion criteria such as year and language of publication or setting of the intervention were easy to assess and the decision making based on these criteria was simple. Other inclusion and exclusion criteria, especially criteria related to study design and intervention programs, were more complex. It was necessary to precisely define such criteria to make the decision making during screening process unambiguous. Quality assessment tool used for this review was based on existing tools for similar purposes but needed to be adjusted to fit the context of the educational research. This adjustment, as well as quality assessment itself, was also performed by a single reviewer and there is a risk that it's biased.

Finally, it is possible that some research relevant for answering research questions were overlooked and weren't included, since no research synthesis is exhaustive (Boote & Beile, 2005). European researchers might be using different terminology related to multicultural competencies and inclusive education, and it is possible that search terms were biased towards USA studies since they were chosen based on the literature and theories coming from USA. Another reason for the bias towards research from North America was the restriction to the English language in the inclusion criteria. Relevant research might have been published in other European languages too but they weren't included in this review.

6.3 Challenges with practical implications

There are several problems with generalizing the results from studies identified in this review to broader contexts. Since teachers who are interested in pursuing professional development program in the area of culturally responsive education are more likely to implement what they learn in their classrooms, purposive sampling is very common when implementing long lasting educational interventions (Katz, 2014). On the other hand, it is questionable whether the effects of the intervention programs can then be generalized to a random population of teachers. Stable traits such as personality could also act as a constraint to development of dynamic cultural skills (Leiba-O'Sullivan, 1999). After participating in a professional development program, some teachers are more resistant than others to changes in their beliefs and instructional practices than others (Rubel & Chu, 2011). This was also the case in studies included in the review, as not all teachers showed the same level of improvement in outcomes assessed.

When generalizing to circumstances outside USA and Canada, such as current refugee crisis in Europe, it is questionable whether the same efforts in teacher education will suffice the current needs. Needs of refugee students' need to be differentiated from the needs of immigrant students (McBrien, 2005). Taylor and Kaur Sidhu, (2012) warn about the importance of understanding the particular needs of refugees, who are influenced by both pre-migration and post-migration factors, when developing appropriate educational support.

6.4 Further research implications

Intervention programs for supporting culturally responsive education consist of many activities, but are evaluated as a whole. With the available data, it was not possible to estimate which activities lead to what outcomes, or which activities were more effective than others. An attempt to do this by analysing qualitative material provided by participants was reported by Brown and Crippen (2016a). They also suggested that it is important to further examine the order of changes in outcomes to be better able to support the development of culturally responsive teachers. In general, systematic and chronological descriptions of intervention programs and of assessed outcomes are necessary to enable drawing connections between characteristics of the intervention and its outcomes (Simeonsson, 2015). It is questionable if achieved outcomes were sustainable, and complementing studies with a follow up after some period of time, as done in Haukos et al. (1995), would be necessary to see if intervention programs had a long-term success.

As already stated, culturally responsive teaching is a complex construct that is difficult to operationalize and assess in teachers. All the studies included in this review had different measures of outcomes. Culturally responsive teaching encompasses an attitudinal component, specific knowledge, skills, awareness of self and of social circumstances, and reflection of all of these components on behaviour and instructional practice. Culturally responsive teaching is hard to asses without leaving out some of the important aspects. Overcoming this challenge is important as a more unified measure of cultural responsiveness in teachers would allow a more systematic comparison of studies. Since children, as pupils and students, are the final recipients of the knowledge and skills gained in the intervention programs aimed at teachers, it would be desirable to include classroom observations when evaluating the outcomes of these programs.

The findings outlined in this review complement related research, such as Aronson and Laughter's (2016) systematic review examining how culturally relevant education is related to

positive student outcomes, and can be used to further develop appropriate teacher support for teaching culturally diverse pupils.

7 Conclusion

Intervention programs aiming to support culturally responsive education among math and science pre-service and in-service teachers are more often offered as a separate course instead of being integrated throughout teacher education, and participation in these programs is likely to be voluntary. Process of improving culturally responsive teaching skills is complex and long-lasting. It involves learning about importance of culturally responsive teaching, critical examination of common pedagogical practices, learning how to implement culture and language into classroom lessons and opportunities for practical implementation of this knowledge into culturally diverse classrooms, as well as opportunities for self-reflection on own teaching practices and professional development. Becoming familiar with pupils and their culture, as well as being provided examples of culturally responsive teaching during intervention program have been recognized as important aspects of successful intervention programs for supporting teachers' cultural responsiveness. Not all prerequisites for culturally responsive teaching have been covered in all of the intervention programs, or at least they were not reported. To assess the outcomes of these intervention programs, the constructs of culturally responsive teaching and culturally relevant pedagogy have been simplified to measurable constructs. Cultural responsiveness has been operationalised as beliefs about pupils and beliefs about importance of culturally responsive teaching methods, changes in knowledge and teaching skills, changes in practical implementations of culturally responsive practices, and self-efficacy beliefs about teaching in diverse classrooms. Changes in knowledge, skills, and self-efficacy beliefs were achieved when intended, while changes in attitudes and observed practices were a more challenging goal. It is questionable if the reported outcomes are sustainable long-term, or if they can be generalized to different settings. Even with certain limitations, this research provides a useful overview of interventions aimed at developing math and science teachers' multicultural competencies and can offer guidance in planning such intervention programs.

8 References

Aronson, B., & Laughter, J. (2016). The Theory and Practice of Culturally Relevant Education: A Synthesis of Research Across Content Areas. *Review of Educational Research*, *86*(1), 163–206.

Azzolini, D., Schnell, P., & Palmer, J. (2012). Educational Achievement Gaps between Immigrant and Native Students in Two "New Immigration Countries": Italy and Spain in comparison. *American Academy of Political and Social Science*, *643*(1), 46–77.

Bačáková, M. (2011). Developing inclusive educational practices for refugee children in the Czech Republic. *Intercultural Education*, *22*(2), 163–175.

Banks, J. A. (1993). Multicultural Education: Historical Development, Dimensions, and Practice. *Review of Research in Education*, *19*, 3–49.

Blanchet-Cohen, N., & Reilly, R. C. (2013). Teachers' perspectives on environmental education in multicultural contexts: Towards culturally-responsive environmental education. *Teaching and Teacher Education*, *36*, 12–22.

Boon, H. J., & Lewthwaite, B. (2015). Development of an instrument to measure a facet of quality teaching: Culturally responsive pedagogy. *International Journal of Educational Research*, *72*, 38–58.

Bourgonje, P. (2010). *Education for refugee and asylum seeking children in OECD countries. Case studies from Australia, Spain, Sweden and the United Kingdom.* Brussels, Belgium.

Bravo, M. A., Mosqueda, E., Solís, J. L., & Stoddart, T. (2014). Possibilities and Limits of Integrating Science and Diversity Education in Preservice Elementary Teacher Preparation. *Journal of Science Teacher Education*, *25*, 601–619.

Brown, J. C., & Crippen, K. J. (2016a). Designing for culturally responsive science education through professional development. *International Journal of Science Education*, *38*(3), 470–492.

Brown, J. C., & Crippen, K. J. (2016b). The Growing Awareness Inventory: Building Capacity for Culturally Responsive Science and Mathematics With a Structured Observation Protocol. *School Science and Mathematics*, *116*(3), 127–138.

Brown, J. C., & Crippen, K. J. (2017). The Knowledge and Practices of High School Science Teachers in Pursuit of Cultural Responsiveness. *Science Education*, *101*(1), 99–133.

Bryan, L. A., & Atwater, M. M. (2002). Teacher Beliefs and Cultural Models: A Challenge for Science Teacher Preparation Programs. *Science Education,86*(6), 821–839.

Buck, G. A., & Cordes, J. G. (2005). An Action Research Project on Preparing Teachers to Meet the Needs of Underserved Student Populations. *Journal of Science Teacher Education*, *16*, 43–64.

Bustos Flores, B., Claeys, L., Gist, C. D., Clark, E. R., & Villarreal, A. (2015). Culturally Efficacious Mathematics and Science Teacher Preparation for Working with English Learners. *Teacher Education Quarterly*, *42*(4), 3–31.

Buxton, C. A. (2005). Creating a culture of academic success in an urban science and math magnet high school. *Science Education*, *89*(3), 392–417.

Critical Appraisal Skills Programme. (2017). *CASP Checklists*. Retrieved at: http://www.casp-uk.net/casp-tools-checklists

Chiu, C. L., Sayman, D., Carrero, K. M., Gibbon, T., Zolkoski, S. M., & Lusk, M. E. (2017). Developing Culturally Competent Preservice Teachers. *Multicultural Perspectives*, *19*(1), 47–52.

Clair, N., & Adger, C. T. (1999). *Professional Development for Teachers in Culturally Diverse Schools*. Retrieved from http://files.eric.ed.gov/fulltext/ED435185.pdf

Dejaeghere, J. G., & Zhang, Y. (2008). Development of intercultural competence among US American teachers: professional development factors that enhance competence. *Intercultural Education*, *19*(3), 255–268.

Dover, A. G. (2013). Teaching for Social Justice: From Conceptual Frameworks to Classroom Practices. *Multicultural Perspectives*, *15*(1), 3–11.

Downey, J. A., & Cobbs, G. A. (2007). "I Actually Learned A Lot from This": A Field Assignment to Prepare Future Preservice Math Teachers for Culturally Diverse Classrooms. *School Science & Mathematics*, *107*(1), 391–403.

Dunn, W., Kirova, A., Cooley, M., & Ogilvie, G. (2009). Fostering intercultural inquiry in subject-area curriculum courses. *Canadian Journal of Education*, *32*(3), 533–557.

European Commission, E. C. (2013). *Thematic Working Group on Mathematics , Science and Technology: Addressing Low Achievement in Mathematics and Science*. Retreived at: http://ec.europa.eu/dgs/education_culture/repository/education/policy/strategic-

framework/archive/documents/wg-mst-final-report_en.pdf

Flores, A. (2007). Examining Disparities in Mathematics Education: Achievement Gap or opportunity Gap? *The High School Journal*, *91*(1), 29–42.

Gay, G. (2000). *Culturally Responsive Teaching: Theory, Research, and Practice. Multicultural Education Series*. New York: Teachers College Press.

Haberman, M. (1991). Can cultural awareness be taught in teacher education programs? *Teaching Education*, *4*(1), 25–32.

Haukos, Gerry, D., Bordeaux, L., LeBeau, D., & Gunhammer, S. (1995). Importance of American Indian Culture in Teaching School Science: A Follow-Up Study on JSTOR. *Journal of American Indian Education*, *34*(2), 18–26.

Hernandez, C. M., Morales, A. R., & Shroyer, M. G. (2013). The development of a model of culturally responsive science and mathematics teaching. *Cultural Studies of Science Education*.

Jarrett, D. (1999). *The Inclusive Classroom. Teaching Mathematics and Science to English-Language Learners.* Retrieved from http://educationnorthwest.org/sites/default/files/11.99.pdf

Jesson, J., Matheson, L., & Lacey, F. M. (2011). *Doing your literature review. Traditional and Systematic Techniques*. London: SAGE.

Katz, J. (2014). Implementing the Three Block Model of Universal Design for Learning: effects on teachers' self-efficacy, stress, and job satisfaction in inclusive classrooms K-12. *International Journal of Inclusive Education*, *19*(1), 1–20.

Ladson-Billings, G. (1995). Toward a Theory of Culturally Relevant Pedagogy. *American Educational Research Journal American Educational Research Journal Fall*, *32*(3), 465–491.

Landa, C. (2011). *Cultural Proficiency in Education : A Review of the Literature focused on Teachers , School Leaders , and Schools*. Boston: Gastón Institute Publications.

Lee, O. (2005). Science Education With English Language Learners: Synthesis and Research Agenda. *Review of Educational Research Review of Educational Research Winter*, *75*(4), 491–530.

Lee, O., Luykx, A., Buxton, C., & Shaver, A. (2007). The Challenge of Altering Elementary School Teachers' Beliefs and Practices Regarding Linguistic and Cultural Diversity in Science Instruction. *Journal of Research in Science Teaching*, *44*(9), 1269–1291.

Leiba-O'Sullivan, S. (1999). The Distinction between Stable and Dynamic Cross-Cultural Competencies: Implications for The Distinction between Stable and Dynamic Cross-cultural Corn petencies: Implications for Expatriate Trainability. *Journal of International Business Studies*, *30*(4), 709–725.

Mavergames, C. (2013). *Covidence* (Systematic Review Software).

McBrien, J. L. (2005). Educational Needs and Barriers for Refugee Students in the United States: A Review of the Literature. *Review of Educational Research*, *75*(3), 329–364.

Miller, J. (2009). Teaching Refugee Learners with Interrupted Education in Science: Vocabulary, literacy and pedagogy. *International Journal of Science Education*, *31*(4), 571–592.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of Knowledge for Teaching: Using a Qualitative Approach to Connect Homes and Classrooms Author(s). *Theory into Practice*, *31*(2), 132–141.

Morrison, K. A., Robbins, H. H., & Rose, D. G. (2008). Operationalizing Culturally Relevant Pedagogy: A Synthesis of Classroom-Based Research, *41*(4), 433–452.

OECD. (2015). *Helping immigrant students to succeed at school – and beyond*. Paris: OECD Publishing.

Pugh, K., Every, D., & Hattam, R. (2012). Inclusive education for students with refugee experience: Whole school reform in a South Australian primary school. *Australian Educational Researcher*, *39*(2), 125–141.

Rubel, L. H., & Chu, H. (2011). Reinscribing urban: teaching high school mathematics in low income, urban communities of color. *Journal of Math Teacher Education*, *15*, 39–52.

Simeonsson, R. (2015). *Evidence: evaluation of clinical interventions for children and families*. Online lecture. University of Jönköping. Retrieved at: https://pingpong.hj.se/courseId/17356/content.do?id=13321549

Siwatu, K. O., Chesnut, S. R., Alejandro, A. Y., & Young, H. A. (2016). Examining Preservice Teachers' Culturally Responsive Teaching Self-Efficacy Doubts. *The Teacher Educator*, *51*(4), 277–296.

Sleeter, C. E. (2012). Confronting the Marginalization of Culturally Responsive Pedagogy. *Urban Education*, *47*(3), 562–584.

Song, S. (2011). Second-generation Turkish youth in Europe: Explaining the academic disadvantage in Austria, Germany, and Switzerland. *Economics of Education Review*, *30*, 938–949.

Szente, J., Hoot, J., & Taylor, D. (2006). Responding to the special needs of refugee children: Practical ideas for teachers. *Early Childhood Education Journal*, *34*(1), 15–20.

Taylor, S., & Kaur Sidhu, R. (2012). Supporting refugee students in schools: what constitutes inclusive education? *International Journal of Inclusive Education*, *16*(1), 36–56.

Tong, A., Sainsbury, P. & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care, 19*(6), 349-357.

UNESCO (1994). *The Salamanca Statement Framework for Action on Special Needs Education.* Salamanca: UNESCO.

UNESCO. (2005). *Guidelines for inclusion: Ensuring access to Education for All.* Paris: UNESCO.

UNESCO. (2009). *Policy Guidelines on Inclusion in Education.* Paris: UNESCO.

UNESCO. (2010). *Current Challenges in Basic Science Education.* Retrieved from http://unesdoc.unesco.org/images/0019/001914/191425e.pdf

United Nations General Assembly. (1948). *Universal declaration of human rights.* Paris: UN.

United Nations General Assembly. (1951). *Convention Relating to the Status of Refugees.* Geneva: UN.

United Nations General Assembly. (1966). *International Covenant on Economic, Social and Cultural Rights.* New York: UN.

United Nations General Assembly. (1967). *Protocol Relating to the Status of Refugees.* New York: UN.

United Nations General Assembly. (1989). *Convention on the rights of the child.* New York: UN.

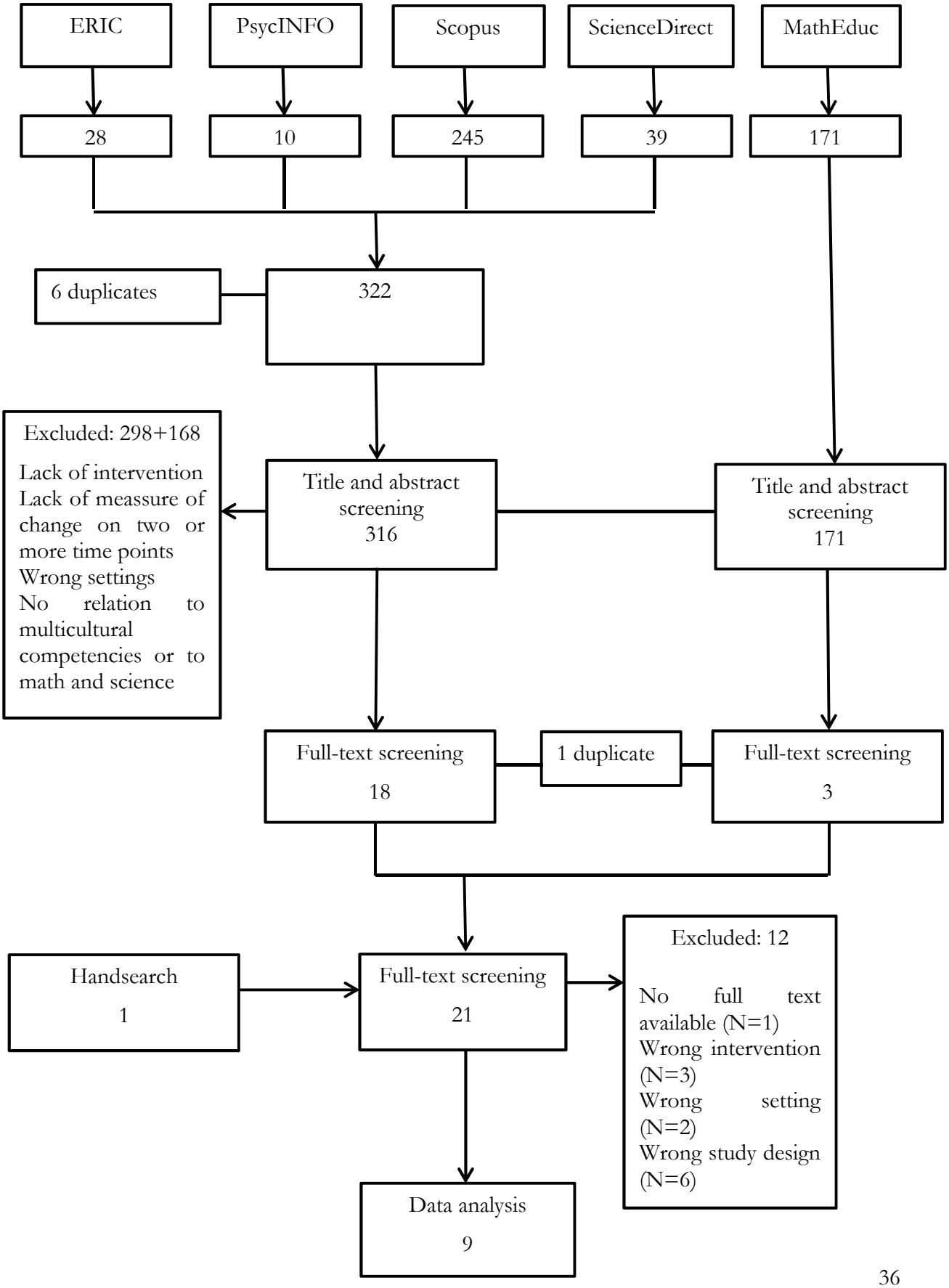
United Nations General Assembly. (1969). *International Convention on the Elimination of all forms of Racial Discrimination.* New York: UN.

United Nations General Assembly. (1990). *International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families.* New York: UN.

Vavrus, M. (2008). Culturally responsive teaching. In T. L. Good (Ed.), *21st Century Education: A Reference Handbook (vol. 2)* (pp. 49–57).

Zeichner, K. M. (1993). *Educating Teachers for Cultural Diversity*. Special Report. East Lansing: Michigan State University, National Center for Research on Teacher Learning.

Appendix A. *Flowchart showing the search procedure.*



Appendix B. *Extraction Protocol for the Full-text Screening.*

General Information	Authors Year Title Journal SJR indicator Country
Background Information, study purpose and research questions	Theoretical background Targeted children population/ operationalization of diversity Study rationale Study purpose Research question(s)
Methodology data	Type of study (Quantitatve/Qualitative/Mix-methods) Study design Was participation obligatory or voluntary?
Teacher Sample	Sample size Sampling Sample description IST / PST, school Sample description math/science
Description of the Intervention Program	What was intervention/program Was intervention approach integrated or added? Intervention activities Content of intervention Where intervention took place Time frame of the intervention/duration
Results/Intervention Outcomes	Measures of outcome Data analysis Results
Discussion	Limitations Practical implications
Quality assessment	Score on the Quality Assessment Protocol High/Medium/Low Quality

Appendix C. *Quality Assessment Protocol*

Clearly defined research question(s) (0,1)	
Sample Randomized/convenient/purposive (2,1,0) Is drop-out rate discussed (NA/0,1)	
Group comparison studies Were participants randomized? (0,1) Were the groups similar at the start of the trial, or were differences controlled for in the analysis? (0, 1) Were the groups equally treated aside from the experimental intervention (0, 1)	
Pre & post comparison studies Was the change measured with the same tool on different time points (1)	
Ethics Were ethical considerations discussed? (0,1) Is the potential conflict of interest reported by the author? (0,1)	
Intervention description Is the intervention clearly described? (0,1,2)	
Method Description Is the study method clearly described? (0,1,2)	
Measures of outcome for quantitative research Were previously validated measures used (2) or were the measures validated during the study (1) or none (0)?	
Measures of outcome for qualitative research Which methods were used for data collection (interview, observation, focus group interviews)? Were several methods used? (0, 1) Were interviews transcribed? (0, 1) Were observations taped? (0, 1) Peer-review? (0, 1) Participant-review? (0, 1) Are quotations presented? (0, 1) Were major themes clearly represented in the findings? (0, 1)	
Was there a follow up? (0,1)	
Interpretations of results Were data and findings consistent? (0,1) Generalizability of results (0,1,2) Are limitations discussed? (0,1)	
Total	

Appendix D. *Overview of the studies included in the analysis.*

IN:	QAS*	SJR indicator	Sample size (intervention group size)	Participants' ethnicity	Participants' gender (% of females)	School/Grade-level	Pupils population/ How was diversity defined and operationalized
1	82% (good)	0, 8	65 (30 in observation)	53% White, 32% Latino, 10% Asian, 5% multiracial	81% female	PST*	Pupils from culturally and linguistically diverse backgrounds
2	74% (good)	2, 56	6	Not reported	100% female	High-school	Pupils with different cultural backgrounds (black, Hispanic, native Indian)/students of color
3	68% (medium)	0, 8	19	Not reported	89% female	PST*	Diverse learners, underserved population of students (minority students, students with learning disabilities, students who live in poverty)
4	57% (medium)	N.A.*	61	95% White	91% female	PST*	Pupils from culturally diverse backgrounds
5	60% (medium)	N.A.*	100	51 Latino, 29 White, 10 African-American, 2Asian/Indian, 1 Native American, 7 "other"	76% female	Secondary schools	English learners (low-income students, students from an ethnic minority, and/or ELs)
6	56% (medium)	0, 67	58	Not reported	76% female	Grades 1-12	Second language learners, students from minority cultures, students having learning or social/emotional challenges, exceptional students
7	73% (good)	3, 8	43	20 Hispanic, 9 White, 10 Black, 1 Asian, 3 "other"	95% female	Grades 3 & 4	Student population displaying a high level of linguistic and cultural diversity, diverse ethnic, linguistic, and SES backgrounds
8	47% (low)	N.A.*	154	Not reported	Not reported	Elementary school	American Indian children
9	65% (medium)	N.A.*	19	Not reported	Not reported	PST*	Pupils with diverse cultural backgrounds

QAS* - Quality Assessment score
N.A.* - Not Available
PST* - Pre-service Teachers