Community for Advancing Discovery Research in Education

Math and Science Education with English Language Learners: Contributions of the DR K-12 Program

Targeted Study Group Working Paper

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Introduction

Although educational leaders, policy makers, and researchers have long emphasized the importance of science, technology, engineering, and mathematics (STEM) for the country's continued prosperity, increasing participation in STEM has remained a challenge for both the education and scientific communities (Pearson & Fechter, 1994; National Academies, 2007; President's Council of Advisors on Science and Technology, 2010; American Association for the Advancement of Science, 1989). A historic imbalance in STEM participation persists, whereby proportionately fewer female and minority students, enroll in STEM courses and seek employment in STEM professions (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2010).

Among those underrepresented in STEM are individuals who are English Language Learners (ELL), a sizable subgroup (5.3 million) among the country's elementary and secondary (PK-12) students; a subgroup whose growth is outpacing that of the overall PK-12 student population (The National Clearinghouse for English Language Acquisition and Language Instruction Educational Programs, 2010; Aud et al, 2010).

The difference between the academic performance of English-proficient and ELL students is substantial. For example, National Assessment of Educational Progress (NAEP) math results in 2005 revealed that nearly half (46%) of ELL 4th graders scored below basic in math as compared to 11 percent of their white, 40 percent of their Black and 33 percent of their Hispanic peers. As students age, the gap widens: 71 percent of 8th grade ELL students scored below basic in math as compared to 21 percent of white, 59 percent of Black, and 50 percent of Hispanic 8th graders (Fry, 2007). The NAEP results in science are equally disparate: in 2005, 72 percent of 4th grade ELL students scored below basic while the same was true of 29 percent for non-ELL students. Likewise, 88 percent of 8th grade ELL students scored below basic compared to 39 percent for non-ELL students (Grigg, Lauko, & Brockway, 2006).

Historically the subject area instruction of ELLs in math and science has received limited attention by the research community, which has instead focused on English proficiency and literacy of ELLs (Lee, 2005). Thus, the research fields of math and science education have developed independent of the research field involving ELLs. However, this trend is beginning to fade as science and math education researchers and their ELL education peers have begun to crossover to one another's domains to produce new understandings and strategies in math and science education specific to the needs of English Language Learners.

ELL and the National Science Foundation's Discovery Research K-12 Program

For its part, the National Science Foundation's (NSF) Discovery Research K-12 (DR K-12) program is contributing to the growth of knowledge in these areas of crossover by funding ELL math and ELL science education projects that seek to understand and improve STEM learning and STEM instruction with ELLs. Across DR K-12's first three cohorts of awardees, the program supported 18 such projects (11 in math education and 7 in science education). These projects involve 41 investigators—principal investigators (PIs) and co-PIs—who are seeking to develop new knowledge, education approaches, and educational materials for ELL students and their teachers in math and science.

At the DR K-12 Annual PI meeting in 2009, the first ELL-affinity group session was held to initiate a discussion of how DR K-12's Community for Advancing Discovery Research in Education (CADRE), a network supporting the efforts of the DR K-12 researchers, might facilitate their projects' success. An informal poll taken during the session produced a series of hypotheses describing the role DR K-12 is playing in extending the lines of inquiry in ELL and science and math education in important ways. Participants' responses suggested that the DR K-12 projects may be addressing different questions than what the fields' have traditionally pursued; they may be more likely to be conducted by researchers who possess expertise in math and/or science education than ELL; they may be more likely to be large-scale and involve more than one school district, and may even collect data from multiple states; and may be more likely to focus on secondary education rather than elementary education. Should these hypotheses hold true, the session's attendees concluded that the DR K-12 projects have the potential to make a considerable contribution to the knowledge base on math and science education of ELLs. The group then asked CADRE to investigate and assess the merit of these hypotheses.

To investigate the contribution of the DR K-12 portfolio to the knowledge base on math and science learning among ELLs, CADRE designed a study to explore the ELL work that is being conducted in the DR K-12 projects. This paper summarizes the work of this study. It begins with a description of the methodology employed, followed by a presentation of the findings, and finally a discussion of the conclusions drawn from this work. The findings are organized into discussions about the expertise held by the DR K-12 ELL researchers and research teams, the characteristics of the ELL research being conducted by the DR K-12 projects, and a comparison of the research conducted by the DR K-12 projects with published research on ELL-science education and ELL-math education.

Methodology

Building on the hypotheses generated during the ELL-affinity group session at the 2009 DR K-12 PI meeting, this study investigated the following specific research questions:

1. What is the expertise of the investigators working on the DR K-12 ELL projects?
2. What are the key characteristics and objectives of the DR K-12 ELL projects?
3. How does the DR K-12 portfolio compare with the work typical of the larger fields of ELL math education and ELL science education?

To answer these questions, we performed content analyses of the DR K-12 projects' proposals and the *curricula vitae* (CVs) of their PIs and co-PIs. We also conducted structured literature searches for research on ELL and math education and updated an existing review of ELL and science education (Lee, 2005) widely considered a seminal synthesis of the field. Finally, we compared the results of the portfolio analysis with our review of the fields to consider how the DR K-12 ELL portfolio might be distinguished from the larger fields of research.

CV Analysis

The first research question was addressed through an analysis of investigators' CVs. We searched the Internet for the CVs of PIs and co-PIs, and directly requested copies in cases where we could not find them; we were able to secure CVs for all 41 researchers. Occasionally, researchers had websites with pertinent information (e.g., course listings) that we used to supplement the information in their CVs. Eleven of the CVs we obtained were not dated; of those that were, approximately more than half were from 2010 and a third from 2009; two additional CVs were from 2008, and two from 2006. It is important to note that some CVs contained more information than others and varied in length between 2 and 56 pages. Our analysis was based on the assumption that researchers include their most prominent work (publications, conferences, courses, and grants), which in turn would speak to their most salient interests and areas of expertise.

We reviewed the CVs for indicators of content expertise across five proxies: field of highest degree, articles published in peer-reviewed/refereed journals (since 2000), grants awarded (since 2000), papers presented at conferences (since 2000), and courses taught. For four of the five proxies, data were available for more than three-quarters of the researchers. Exhibit 1 displays the number and percentage of researcher CVs coded for each of the proxies.

Exhibit 1: Availability of Data on Expertise Proxies for the CV Analysis

Expertise Proxy	N (%) All Researchers	N (%) PIs Only
Field of highest degree	41 (100%)	18 (100%)
Peer-reviewed articles (since 2000)	39 (95%)	16 (89%)
Grants awarded (since 2000)	36 (88%)	16 (89%)
Conference papers (since 2000)	32 (78%)	12 (67%)
Course lists*	23 (56%)	10 (56%)

*9 researchers (6 PIs, 3 co-PIs) are not professors at universities, as indicated by their current title and/or employer.

We coded the degree fields and the titles of presentation papers, peer-reviewed articles, grants, and courses according to the following substantive categories: ELL-language and literacy (ELL/LA); cultural and discursive studies in education; equity in education; math education; science education; other education; mathematics; science (including computer science and psychology not specified as educational psychology); and other. To identify each researcher's expertise evidenced within each

proxy, we coded each entry according to the categories specified above, then counted the number of entries (e.g., classes, peer-reviewed articles, grants, and conference papers included on the CVs) and the number of times a given category was indicated; we credited a researcher with demonstrated expertise in an area when at least a quarter of his/her entries within a proxy were coded in a category. Finally, we created a composite indicator of expertise for each researcher by looking across all proxies for evidence of demonstrated expertise in each substantive category.

Portfolio Analysis

The second research question was addressed through a content analysis of project materials. To analyze the substance of the work conducted by the projects in the DR K-12 portfolio, we uploaded into NVivo (a software package that facilitates the coding and retrieval of relevant content) the project abstracts, proposal narratives, responses to reviewer questions, and annual reports that the projects had shared with CADRE. The materials were coded in each of the following areas: research goals and priorities, intellectual merit, broader impact, research rationale, research approach, ELL component, and researcher expertise. The content of each coded category was then analyzed.

Literature Searches

The third research question required a comparison of the DR K-12 portfolio with the larger field of published research, necessitating literature searches to find peer-reviewed published articles involving ELLs and math and/ or science education. We searched the ERIC and EBSCO databases[1] using the following terms: "math" or "math educat*"[2] or "science" or "science educat*" in combination with "English Language Learner," "ELL"; "Dual Language Learner", "DLL," "bilingual"; "Limited English Proficient," "LEP"; "English Speakers of Other Languages," "ESOL." Math searches in the ERIC and EBSCO databases included all literature published since 1966. As the science searches were intended to update a pre-existing literature synthesis (Lee, 2005), we looked for peer-reviewed articles published between 2005 and September 2010.

To ensure that we had located the key articles in each field, we conducted additional searches of specific journals including: *Elementary School Journal*, *Harvard Educational Review*, *Journal of Research in Science Teaching Science Education*, *Journal of Research in Mathematics Education*, and the journals published by AERA (e.g., *Educational Evaluation and Policy Analysis*). These follow-up searches focused on articles published since 2000. Furthermore, as recommended by Ohkee Lee, we ran specific Google searches on three authors (L. Khisty, J. Moschkovich, and R. Gutierrez) whose work focuses on issues of ELL and math education. We also shared our list of publications with the DR K-12 researchers, who offered other possibilities that we investigated.

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[1] All journal databases available through EBSCO were searched, including: Academic Search Complete; Biomedical Reference Collection: Corporate; Business Source Corporate; EconLit; Environment Complete; MEDLINE; SocINDEX; Psychology and Behavioral Sciences Collection.

[2] The asterisk is used to identify results with all possible endings such as education, educating, educator, etc.

Abstracts for the identified literature were reviewed to select articles meeting the following six criteria. The first five are similar to those utilized in Lee's synthesis (2005), while the last one is distinct. We did not include literature reviews or conceptual pieces. We looked for studies that were:

1. Published in peer-reviewed journals (conference proceedings were not included).
2. Directly addressing ELLs in science and/or math education.
3. Written in English.
4. Focused on K-12 ELL students.
5. Empirical, including experimental and quasi-experimental studies; descriptive studies; correlational studies; surveys; ethnographic, qualitative or case studies; and studies using large-scale achievement data.
6. Conducted within the United States.

In total, we identified 63 peer-reviewed articles addressing ELLs and science (40 articles) and/or math education (29 articles); these articles were associated with 28 ELL-science and 26 ELL-math studies. The full texts of these articles were then reviewed and the characteristics of the studies were coded. We then created a matrix similar to the one constructed to capture the characteristics of the DR K-12 ELL projects to facilitate comparison between the larger fields of research and the DR K-12 ELL portfolio.

Results

The results of our study are presented below. We first discuss the expertise of the investigators of the DR K-12 projects, then the projects they are conducting, and finally a comparison of the work being funded by DR K-12 to research that has been published. The work being conducted by the DR K-12 projects and the research published in the literature fall into four domains: student learning, instruction, assessment, and curriculum. These domains were represented within both the science and math education focused studies. Brief descriptions of the DR K-12 projects included in these analyses are included in Appendix A, organized by content area and domain.

Expertise of DR K-12 Investigators

Expertise of PIs and co-PIs

We coded the demonstrated expertise of PIs and co-PIs by looking at the field in which they obtained their highest degree, their peer-reviewed published articles, conference papers, and grants, and the courses they taught (Exhibit 2). Looking across the proxies, 11 researchers demonstrated expertise in ELL/LA in at least one of the proxies. This was less than one-third the number of researchers demonstrating expertise in either math or science education (34) or in math or science (38).

Exhibit 2: Disciplinary Expertise, All Researchers (n=41)

Proxy	N	Any Math and/or Science Education	Any ELL/LA	Any Math and/or Science*
Field of highest degree	41	7	1	19
Peer-reviewed articles	39	26	10	30
Grants awarded	36	26	7	28
Conference papers	32	17	9	20
Courses taught	23	10	4	15
Any proxy	**41**	**34**	**11**	**38**

* Includes mathematics, science, computer science, and psychology (where not specified as educational psychology, such as empirical or cognitive psychology) as well as math and/or science education.

We observed similar trends among only the projects' PIs (Exhibit 3). While nearly 90 percent of the PIs demonstrated expertise in math and/or science education (16), less than a third demonstrated expertise in ELL/LA (5).

Exhibit 3: Disciplinary Expertise, PIs Only (n=18)

Proxy	N	Any Math and/or Science Education	Any ELL/LA	Any Math and/or Science*
Field of highest degree	18	3	0	7
Peer-reviewed articles	16	14	4	14
Grants awarded	16	13	4	12
Conference papers	12	6	4	6
Courses taught	10	5	1	5
Any proxy	**18**	**16**	**5**	**16**

* Includes mathematics, science, computer science, and psychology (where not specified as educational psychology, such as empirical or cognitive psychology) as well as math and/or science education.

Math and/or Science vs. ELL Expertise in DR K-12's ELL Portfolio

The fields of ELL science education and ELL math education are emerging as researchers from different backgrounds—math/science education and ELL/LA education—cross domains. To assess whether more researchers in the DR K-12 portfolio are entering from backgrounds in ELL/LA or math/science education, we looked at the researchers who had demonstrated expertise in one area, but not the other.

It is more common for a researcher to show expertise in either math/science education and/or a math/science discipline than only in ELL/LA, suggesting that more DR K-12 researchers conducting

work in math or science education and ELL have come from math/science education than from ELL/LA research. This trend is the same whether we look solely at PIs or at all investigators. Across all researchers, PIs and co-PIs, on DR K-12 ELL projects, 37 demonstrated expertise in math/science and/or math/science education without expertise in ELL/LA, while three demonstrated expertise in ELL/LA and not in math/science or math/science education (Exhibit 4).

Exhibit 4: Comparison of Expertise in Math/Science and Math/Science Education and ELL/LA, All Researchers (n=41)

Proxy	N	Only Math/Science / Math/Science Education*	Only ELL/LA
Field of highest degree	41	19	1
Peer-reviewed articles	38	25	4
Grants awarded	36	28	6
Conference papers	35	17	6
Courses taught	33	15	3
Any proxy	**41**	**37**	**3**

*Includes mathematics, science, computer science, and psychology (where not specified as educational psychology, such as empirical or cognitive psychology).

When looking at PIs alone, only one researcher has exclusive expertise in ELL/LA, while 15 demonstrated expertise in math/science or math/science education but not ELL/LA (Exhibit 5).

Exhibit 5: Comparison of Expertise in Math/Science and Math/Science Education and ELL/LA, PIs Only (n=18)

Proxy	N	Only Math/Science or Math/Science Education*	Only ELL/LA
Field of highest degree	18	7	0
Peer-reviewed articles	16	11	1
Grants awarded	16	12	3
Conference papers	12	5	3
Courses taught	10	5	1
Any proxy	**18**	**15**	**1**

*Includes mathematics, science, computer science, and psychology (where not specified as educational psychology, such as empirical or cognitive psychology).

Science vs. Math Expertise in DR K-12's ELL Portfolio

Our analyses suggested that researchers conducting work with ELLs in math or science education were more likely to have a background in math or science than to have a background in ELL/LA. However, it is less clear whether more are coming from math or science. Our analysis found that across the DR K-12 portfolio of ELL projects, math projects outnumber science projects by four. As shown in Exhibit 6, our analysis found that more researchers have their highest degree in a science-related field rather than math; however, more have published peer-reviewed articles, presented conference papers, been awarded grants, and taught courses in math/math education only than in science/science education only.

Exhibit 6: Comparison of Expertise in Math, Science, and ELL/LA, All Researchers (n=41)

Proxy	N	Only Math	Only Science *	Only ELL/LA
Field of highest degree	41	6	13	1
Peer-reviewed articles	38	15	8	4
Grants awarded	36	19	8	6
Conference papers	35	12	5	6
Courses taught	33	8	6	3
Any proxy	**41**	**17**	**7**	**3**

* For the purposes of this analysis, computer science and psychology are categorizes as "science" disciplines.

Among PIs only, the results were similar. Our analysis found that more researchers demonstrated science expertise as measured by highest degree; however, math expertise dominated the remaining proxies (Exhibit 7).

Exhibit 7: Comparison of Expertise in Math, Science, and ELL/LA, PIs Only (n=18)

Proxy	N	Only Math	Only Science *	Only ELL/LA
Field of highest degree	18	2	5	0
Peer-reviewed articles	16	8	3	1
Grants awarded	16	10	2	3
Conference papers	12	4	1	3
Courses taught	10	4	1	1
Any proxy	**18**	**8**	**2**	**1**

* For the purposes of this analysis, computer science and psychology are categorizes as "science" disciplines.

Math, Science, and ELL Expertise Across Teams

Twelve of the DR K-12 ELL projects listed a PI and at least one co-PI, so that the expertise represented on the research team spanned beyond a single researcher. We analyzed the

demonstrated expertise resident on the research teams and found that three project teams consisted of individuals with demonstrated expertise in all three areas of math and/or science education, ELL/LA, and science or math (Exhibit 8). Two projects' teams demonstrated expertise in math/science education and ELL/LA but lacked disciplinary math/science expertise. Twelve projects did not have key members with demonstrated expertise in ELL/LA and one project did not have team members with demonstrated expertise in math/science education.

Exhibit 8: Expertise within DR K-12 Research Teams (PIs and co-PIs)

Research Team	Math/Science Education	ELL/LA	Math/Science
1	●		●
2	●		●
3	●		●
4	●		
5	●		●
6	●		
7	●	●	●
8		●	
9	●	●	
10	●		●
11	●	●	
12	●		
13	●		
14	●		
15	●		
16	●	●	●
17	●		●
18	●	●	●

●= Expertise resident in research team of PI and co-PIs.

For research teams that did not demonstrate expertise at the PI and co-PI level, we then considered the expertise represented in the project's advisory groups and affiliated researchers (not identified as co-PIs). The additional expertise contributed by advisory groups and affiliated researchers is shown with X's in Exhibit 9. These individuals helped fill gaps in expertise on seven projects, but eight projects still lacked demonstrated expertise in ELL/LA, one project lacked math/science education expertise, and five were missing demonstrated disciplinary math/science expertise.

Exhibit 9: Expertise within DR K-12 Research Teams (PIs, co-PIs, and Advisory Groups)

Research Team	Math/Science Education	ELL/LA	Math/Science
1	●		●
2	●	X	●
3	●	X	●
4	●		
5	●	X	●
6	●		X
7	●	●	●
8		●	
9	●	●	
10	●		●
11	●	●	X
12	●		
13	●		
14	●	X	X
15	●		X
16	●	●	●
17	●		●
18	●	●	●

●= Expertise resident in research team of PI and co-PIs.

X= Expertise resident in advisory group or non-co PI research team members.

Characteristics of DR K-12 Projects

Focus of Projects

Slightly more projects focus on math education (7) than science education (11). The most salient topics addressed by the projects are instruction (7) and curriculum development (6), following by student learning (3), scaling-up (1), and assessments (1). Brief summaries of the DR K-12 projects that consider ELL are provided in Appendix A.

More than half of the projects (10) focus on the middle school years, while eight investigate learning in primary school and three in high school (note: four projects addressed both elementary and middle school years). While the content for the middle school years is split evenly between the subject areas (5 in math, 5 in science), the primary school projects are more likely to be science (5 in science, 3 in math) while the high school projects are all focused on Algebra I.

Science education projects are more likely to focus exclusively on ELLs while the math education projects are slightly more likely to study ELLs as a sub-group. In half of the projects (9), either ELL students or their teachers are the specific focus; this was true in five science projects and four math projects. These projects that focus on ELL specifically involve the primary school level (5) and/or middle school (6), while only one targets high school students. The remaining half of the projects

focus on groups underrepresented in STEM or on diverse learners and include ELLs as one of the multiple sub-groups considered. Of these projects, two are in science and seven are in math; three involve students/teachers in primary school, four in middle school, and two in high schools.

Although ELLs in the United States are a heterogeneous group, for example in the native languages spoke, this diversity is not always acknowledged in the project materials. For example, a specific language is not identified in most projects; 12 projects did not identify the ELLs' language of origin, while four indicated "Spanish" and two identified "Hispanic" students (presumably Spanish speakers).

Objectives

The majority (14 of 18) of the DR K-12 ELL projects intends to develop, test, and/or refine interventions or curricula and related materials or tools in math or science education; one project will organize a conference; two are exploratory; and one will produce a book on instructional "lessons learned." Six projects contain a technology component and five also emphasize learning science through inquiry. As the majority of projects are developing and testing interventions, curricula etc., most have research questions that consider the intervention's efficacy in improving the outcomes of interest. Three projects consider both efficacy and implementation of these interventions, while four others are more exploratory in nature.

Research Design and Methods

Projects employ a variety of research approaches (Exhibit 10) and gather data from various sources. Eight projects are using experimental or quasi-experimental designs; 10 others are primarily descriptive in nature, which is not surprising given that the interventions, materials, etc. being studied are typically in early stages of development and do not yet warrant more rigorous evaluation designs nor larger-scale testing. Almost all (17) of the projects will use both quantitative and qualitative methods. Specific measures that are used include: teacher and student interviews, assessment results, classroom observations, teacher logs, and student and teacher surveys.

All but one project (a conference) will collect data, and eight projects will collect data across multiple sites (defined as minimally two school districts; see Exhibit 10); none will utilize an extant, nationally representative dataset to answer their research questions. While all projects had not selected sites at the time of their proposals' submission, the sites reported collecting data at sites that are generally urban (13, 72%) with one science project including a rural community. While sites are frequently located in the West, however, no geographic area hosts a majority of the projects. The science projects tend to be less regionally diverse than the math projects. Four math projects (22%) collect data in more than one geographic region while one project includes sites across the country.

Outcomes

The projects' proposals describe intended outcomes across three levels: teacher, student, and the field overall. For students, the researchers aim to make STEM more accessible and increase their participation in the disciplines (see Exhibit 10). While all student projects intend to improve math and science skills, content knowledge, and STEM achievement (14), the science education projects

are slightly more likely to consider student achievement measures and more than four times as likely to analyze English proficiency outcomes as the math projects.

Several projects will also assess student outcomes including improving attitudes and increasing confidence and engagement (6) and literacy (4). Projects are assessing a variety of teacher outcomes including changing beliefs and attitudes (4), increasing pedagogical content knowledge (9), and improving classroom practice (9). Of the projects that articulate the intent to "expand the field" and "make a contribution to knowledge," more focus on expanding knowledge regarding underrepresented or diverse student groups (10) than on specifically expanding knowledge concerning ELL and math/science education (7). Several want to set standards or principles that enable future materials to better serve students. One project seeks to provide a model for informal/formal education partnerships.

Conceptual and Theoretical Frameworks

The conceptual and theoretical frameworks are not clearly identified in four proposals. Of the 14 projects for which we could ascertain the project's framework, six utilize general student learning models that are not specific to ELLs. For example, one project is guided by the theory that increasing teacher knowledge and teacher efficacy-based beliefs improves ELLs' achievement. Another project focuses on providing resources for teachers to engage their students (not specifically ELLs) in scientific explanation and argumentation to improve their science achievement. Five projects, however, discuss frameworks utilizing socio-cultural theories. For example, one states that the project understands learning as a social activity situated within a context in which people, cultural signs, and tools interact; students develop common ways of thinking and communication as they interact over time. Lastly, four science projects (but no math projects; see Exhibit 10) are guided by linguistics and semiotics theoretical frameworks.

Exhibit 10: DR K-12's ELL Projects by Content Area

Study Attribute*	All Projects (n=18)	Science Projects (n=7)	Math Projects (n=11)
Research Methods			
Mixed methods	17 (94%)	7 (100%)	10 (91%)
Research Design			
Experimental or quasi-experimental design	9 (50%)	4 (57%)	5 (45%)
Descriptive	9 (50%)	3 (43%)	5 (45%)
Research Scale			
Multiple sites**	8 (44%)	3 (43%)	5 (45%)
Conducted by research team	12 (67%)	5 (71%)	7 (64%)
Community Type			
Rural	1 (6%)	1 (14%)	0
Urban	13 (72%)	4 (57%)	9 (82%)
Geography			
Northeast	5 (28%)	2 (29%)	3 (27%)
Southeast	2 (11%)	0	2 (18%)
Midwest	4 (22%)	0	4 (36%)
Southwest	6 (33%)	1 (14%)	5 (46%)
West	8 (44%)	4 (57%)	4 (36%)
More than one region	4 (22%)	0	4 (36%)
Intended Outcomes			
STEM achievement	14 (78%)	6 (86%)	8 (73%)
English proficiency or literacy	4 (22%)	3 (43%)	1 (9%)
Student engagement outcomes	6 (33%)	2 (29%)	4 (36%)
Theoretical Frameworks			
Linguistic theories	4(22%)	4 (57%)	0

* One project organized a conference and accordingly did not include a research design.

** Studies that collect data in at least two school districts are considered multi-site projects.

Comparison of DR K-12 Portfolio to Published Research

We compared the work funded under the DR K-12 program to the larger fields of ELL-science education and the ELL-math education to explore the unique contribution that the DR K-12 projects have the potential to make. Overall, we found that there were more differences between the field of ELL science education and the DR K-12 ELL science projects, while the DR K-12 ELL math projects were more comparable to the existing efforts in its larger field, as represented by research published in peer reviewed journals.

To identify the research studies in ELL science education, we used the results of a recent synthesis of the literature on science education with ELLs (Lee, 2005), and a systematic literature search of the research published since 2005. To identify the research studies in ELL math education, we conducted a systematic literature search of research going back to 1966. Descriptions of the research studies identified through our literature searches are included in Appendix B (science) and Appendix C (math), organized by primary research domain—learning, instruction, assessment, curriculum, teacher education.

ELL Science Education

The DR K-12 ELL science education projects varied from the studies published in the field since 2005 in that half of the field's efforts focus on ELL science instruction and a quarter on student learning while more than half of the DR K-12 projects (57 percent) focus on developing curriculum and 29 percent focus on instruction (see Exhibit 11). Unlike the DR K-12 science ELL projects, a few of the published studies addressed three secondary topics of interest, including scaling-up programs, consequences of policy, and most frequently, students' home environment (21 percent).

We also compared the research designs utilized by the field and DR K-12 to address ELL science education topics (Exhibit 12). We made two comparisons: the first with Lee's seminal synthesis (informed by articles published between 1982 and 2004), and the second with the studies uncovered through our search for research published since 2005. Lee (2005) found that the field utilized a range of theoretical and disciplinary perspectives. However, most used qualitative methods and tended to produce small-scale, descriptive studies conducted by individual researchers; few of the studies used either an experimental or quasi-experimental design. She found that few of the studies evaluated the impact of intervention programs on ELLs' science achievement and English proficiency, the achievement gaps among linguistic groups, or the results across different levels of English proficiency. She also characterized the "sophistication with linguistic issues" as "uneven," stating that most did not consider the "complexities inherent in the construction of language."

Exhibit 11: Topics Addressed by DR K-12 ELL Science Projects and the Field

Topic	Field of ELL Science Education (n=28)	DR K-12 ELL Science Projects (n=7)
Primary		
Assessment	6 (23%)	1 (14%)
Curriculum	2 (8%)	4 (57%)
Instruction	13 (50%)	2 (29%)
Pre-service Teacher Education	3 (11%)	1 (14%)
In-service Professional Development	7 (25%)	1 (14%)
Other	6 (21%)	0
Student Learning	7 (25%)	0
Secondary		
Program Scale-Up	1 (4%)	0
Home Environment	6 (21%)	0
Policy	1 (4%)	0

We found that the field has made some progress over the last five years (Exhibit 12), perhaps in response to the research agenda Lee put forward in her 2005 synthesis. Our analysis of the research published since 2005 suggests that more studies are using mixed (21 percent) or quantitative methods (29 percent), although the use of qualitative methods only is still more prevalent (36 percent). Just as Lee found among studies published before 2005, we found that majority of the more recent studies are still descriptive, and only a third use a quasi-experimental design. We did see evidence, however, that since 2005 a larger number of studies are being conducted by research teams (as indicated by the articles' authors) and include data collected from at least two school districts. More studies are using linguistic and discursive theories to frame their research, and almost half are now considering measures of student achievement; few however, are considering student literacy or engagement outcomes.

Our comparison of the DR K-12 ELL science projects indicates that the DR K-12 ELL-science education projects differ in important ways from those in the studies identified in Lee's published synthesis and our updated literature search. A larger portion of the DR K-12 science projects, than the broader field, are using experimental or quasi-experimental designs and using mixed methods to answer their research questions. The DR K-12 projects are more likely to be analyzing student science or math achievement results and more frequently are assessing changes in the ELL students' levels of English proficiency. They are also slightly more likely than the field to be investigating student engagement.

Exhibit 12: Characteristics of DR K-12 ELL Science Education Projects and Larger Field *

Study Attribute	Field of ELL Science Education to 2004*	Field of ELL Science Education, 2005 to Sept 2010 (n=28)	DR K-12 ELL Science Education Projects (n=7)
Research Methods			
Mixed methods	rare	6 (21%)	7 (100%)
Quantitative methods only	rare	8 (29%)	0
Qualitative methods only	most	10 (36%)	0
Research Design			
Experimental or quasi-experimental design	rare	9 (32%)	4 (57%)
Descriptive	most	18 (64%)	3 (43%)
Research Scale			
Multiple sites **	infrequent	7 (25%)	3 (43%)
Conducted by research team	infrequent	20 (71%)	5 (71%)
Intended Outcomes			
STEM achievement	few	12 (43%)	6 (86%)
English proficiency or literacy	few	4 (14%)	3 (43%)
Student engagement, agency, empowerment outcomes	rare	5 (18%)	2 (29%)
Theoretical Frameworks			
Linguistic theories	rare	15 (54%)	4 (57%)

* As described in Lee, 2005.

** Studies that collect data in at least two school districts are considered multi-site projects.

We also compared the settings in which published studies and the DR K-12 ELL science education projects have and are collecting data (Exhibit 13). DR K-12 projects are more likely to collect data from sties in at least two school districts (43 percent vs. 25 percent) oftentimes in the West (57 percent), while the field is slightly more likely (although does so rarely) to have collected data from multiple geographical regions or have utilized nationally representative datasets (7 percent vs. 0 percent). It also appears that the DR K-12 projects may be more likely to collect data from rural communities than the field.

Exhibit 13: Setting of DR K-12 ELL Science Projects and the Larger Field

Location	Field of ELL Science Education, 2005 to Sept 2010 (n=28)	DR K-12 ELL Science Education Projects (n=7)
Geographical Location		
Nationally Representative Sample	2 (7%)*	0
Northeast	3 (11%)	2 (29%)
Southeast	5 (18%)	0
Midwest	2 (7%)	0
Southwest	1 (4%)	1 (14%)
West	8 (29%)	4 (57%)
More than One Region	2 (7%)	0
Community Setting		
Rural	1 (4%)	1 (14%)
Urban	19 (68%)	4 (57%)

* Totals do not add to 100% as in 7 studies, geographic location of the data collection could not be determined.

ELL Math Education

We made similar comparisons between the DR K-12 ELL math projects and those of the field (Exhibit 14). Because there is no synthesis of math education ELL comparable to the Lee synthesis, the single comparison for the DR K-12 math ELL projects was to those studies we identified through our search for the literature. We found that about half of both published studies field (50 percent) and the DR K-12 portfolio (45 percent) are focused on math instruction. The DR K-12 portfolio included more studies that are investigating in-service, teacher professional development than the field (36 percent vs. 4 percent). Almost a quarter of the field has pursued work related to assessments while none of the DR K-12 has. Instead, the DR K-12 projects are more likely to focus on curriculum than the field (18 percent vs. 8 percent). The DR K-12 projects also include more projects that are involved with scaling up of programs than the field (46 percent vs. 0 percent).

Exhibit 14: Topics Addressed by DR K-12 ELL Math Projects and the Field

Topic	Field of ELL Math Education (n=26)	DR K-12 ELL Math Projects (n=11)
Primary		
Assessment	6 (23%)	0
Curriculum	2 (8%)	2 (18%)
Instruction	13 (50%)	5 (45%)
Pre-service Teacher Education	1 (4%)	0
In-service Professional Development	1 (4%)	4 (36%)
Other	11 (42%)	1 (9%)
Student Learning	5 (19%)	1 (9%)
Secondary		
Program Scale-Up	0	5 (46%)
Home Environment	2 (8%)	1 (9%)
Policy	2 (8%)	1 (9%)

Comparing the research designs, we found that the ELL math DR K-12 projects are similar to the field in some ways (Exhibit 15). For example, they use experimental or quasi-experimental designs in similar proportions. Common outcomes for both are student quantitative achievement measures. However, the DR K-12 projects are more likely to use mixed methods (91 percent vs. 23 percent), while quantitative only methods were the most popular approach within the field (42 percent). DR K-12 math ELL projects were also more likely to examine student engagement outcomes (36 percent vs. 8 percent), less likely to consider student literacy outcomes (9 percent vs. 31 percent), and less likely to utilize linguistic theories as their studies' frameworks (0 vs. 31 percent).

We also compared the settings in which the field and the DR K-12 ELL math education projects have and are collecting data (Exhibit 16). While the field was much more likely to utilize nationally representative extant datasets (19 percent vs. 0), the DR K-12 projects are slightly more likely to collect data from at least two school districts (45 percent vs. 38 percent), which were more often located in more than one geographical region (36 percent vs. 19 percent). The Western states were again the most popular locations for both the field, however, the DR K-12 projects are at least three times as likely to be collecting data in the Northeast (27 percent vs. 8 percent), the Midwest (36 percent vs. 12 percent), or the Southwest (46 percent vs. 4 percent) than the field. The field is more likely to collect data from rural communities than the DR K-12 projects (12 percent vs. 0).

Exhibit 15: Characteristics of DR K-12 ELL Math Education Projects and the Larger Field

Study Attribute	Field of ELL Math Education (n=26)	DR K-12 ELL Math Projects (n=11)
Research Methods		
Mixed methods	6 (23%)	10 (91%)*
Quantitative methods only	11 (42%)	0
Qualitative methods only	5 (19%)	0
Research Design		
Experimental or quasi-experimental design	11 (42%)	5 (45%)
Descriptive	15 (58%)	5 (45%)
Research Scale		
Multiple sites**	10 (38%)	5 (45%)
Conducted by research team	16 (62%)	7 (64%)
Intended Outcomes		
STEM achievement	20 (77%)	8 (73%)
English proficiency or literacy	8 (31%)	1 (9%)
Student engagement, agency, empowerment outcomes	2 (8%)	4 (36%)
Theoretical Frameworks		
Linguistic theories	8 (31%)	0

* One project organized a conference and accordingly is not included in the attribute counts.

** Studies that collect data in at least two school districts are considered multi-site projects.

Exhibit 16: Setting of DR K-12 ELL Math Projects and the Larger Field

Location	Field of ELL Math Education (n=26)	DR K-12 ELL Math Projects (n=11)
Geography		
Nationally Representative Sample	5 (19%)*	0
Northeast	2 (8%)	3 (27%)
Southeast	4 (15%)	2 (18%)
Midwest	3 (12%)	4 (36%)
Southwest	1 (4%)	5 (46%)
West	7 (27%)	4 (36%)
More than one region	5 (19%)	4 (36%)
Community Type		
Rural	3 (12%)	0
Urban	17 (65%)	9 (82%)

* Totals do not add to 100% as in 4 studies, geographic location of the data collection could not be determined.

Conclusions

CADRE conducted this study to understand the work that is being supported by the NSF's DR K-12 program to advance our understanding of ELLs' learning in science and mathematics. The study was designed to answer three research questions that explore who is being supported by DR K-12, what work are they conducting, and what are they contributing to the field. The work consisted of a classification of researchers' expertise through a review of CVs, a categorization of their research through coding extant project materials, and a comparison of the work funded by the DR K-12 program to the broader research fields represented by research published in peer-reviewed journals, which involved a broad search of the literature and coding of the characteristics of published research. Below, the findings from our analyses are used to answer the study's research questions.

What is the expertise of the investigators working on DR K-12's ELL projects?

Whether we looked across all key investigators or limited the scope to PIs, the DR K-12 investigators more often bring expertise in math or science education, or math or science disciplines, than in ELL. Similarly, within research teams, expertise in math or science education was most common, followed by expertise in a math or science discipline; expertise in ELL was the area most often lacking within research teams.

What are the key characteristics and objectives of the DR K-12 ELL projects?

DR K-12 projects are conducting research with ELLs related to science/math instruction, science assessment, science/math curriculum, and student learning of science/math. There are slightly more math (11) than science (7) projects within the portfolio. More than half of the projects focus on the middle school level, than the elementary and high school years. The majority of projects are developing and testing curricula or other interventions, thus most have research questions that look at the intervention's efficacy. Projects employ a variety of approaches, including experimental or quasi-experimental designs (8) and descriptive studies (10). Most projects take a mixed methods approach (17), and more than half are being conducted in multiple sites (11).

How does the DR K-12 portfolio compare with the work typical of the larger fields of ELL math education and ELL science education?

Our comparisons found differences between DR K-12 projects and the published research for both ELL science education and ELL math education, although the differences varied between the disciplines.

DR K-12 ELL science projects compared pretty favorably to the research that has been conducted within the broader field, both the pre-2005 literature that was summarized by Lee (2005) and the research that has been published since. More than half of DR K-12 science projects are using experimental or quasi-experimental designs and using mixed methods to answer the research questions as compared to only one-third of research published since 2005. The DR K-12 ELL-science projects are more likely to be collecting data from at least two school districts (43 percent vs. 32 percent). They are also more likely to be analyzing student achievement results (86 percent within the DR K-12 portfolio vs. 43 percent in studies published since 2005) and changes in the ELL students' levels of English proficiency (43 percent in the DR K-12 projects vs. 14 percent in the studies published since 2005).

Although the DR K-12 ELL math projects were similar along a number of dimensions, they varied in some important ways from the broader set of research studies that have been published in the journals. Specifically, DR K-12 projects are more likely to use mixed methods (91 percent within the DR K-12 portfolio vs. 23 percent in the published literature). In addition, the DR K-12 projects are slightly more likely to be designed as a multi-site studies than those in the field (45 percent and 38 percent, respectively). They were, however, less likely to use linguistic or theoretical frameworks (0 vs. 31 percent) or include English proficiency outcomes (9 percent vs. 31 percent).

Discussion

Our analysis suggests that DR K-12 projects can make a valuable contribution to our understanding of math and science education among ELLs, should the projects meet their objectives. This knowledge is increasingly important as the ELL population represents a significant and growing proportion of U.S. elementary and secondary students. As teams form to investigate related topics,

they may consider how they will include expertise in linguistics and language learners. It may also be advisable for more projects to consider students' English proficiency as well as measures of student engagement and interest in STEM. In doing so, the future research can continue to contribute in important ways to the burgeoning fields.

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Appendix A. Description of DR K-12 Projects

Exhibit A.1: Descriptions of the DR K-12 ELL Projects

Primary Investigator	Title	Summary
Assessment		
Guillermo Solano-Flores	Design and Use of Illustrations in Test Items as a Form of Accommodation for English Language Learners in Science and Mathematics Assessment	Investigates the effectiveness of vignette illustrations in test items as a strategy of test accommodation for ELL students.
Curriculum		
Jacqueline Barber	R&D: The Role of Educative Curriculum Materials in Supporting Science Teaching Practices with English Language Learners	Looks at the effects of educative curriculum materials, focusing on teachers of ELL students
Barbara Crawford	Fossil Finders: Using Fossils to Teach about Evolution, Inquiry and Nature of Science	Develops curriculum through which grade 5-8 students examine and identify fossils to enhance their understanding of the nature of science and evolutionary concepts, as well as to motivate them to learn more about science
Martin Gartzman	R&D: An Architecture of Intensification: Building a Comprehensive Program for Struggling Students in Double-Period Algebra Classes	Designs, develops, and tests the efficacy of student and teacher instructional materials and software for double-period courses in elementary algebra
E. Paul Goldenberg	Transition to Algebra: A Habits of Mind Approach	Creates and tests the effects of instructional materials focused on developing conceptual understanding and mathematical habits of mind that will enable students to succeed in elementary algebra
Beverly Irby	Collaborative Research: A Longitudinal Randomized Trial Study of Middle School Science for English Language Learners (Project MSSELL)	Consists of a two-year randomized trial evaluation of a curriculum model that has been enhanced to improved science achievement and academic English proficiency of middle school ELL students

Exhibit A.1: Descriptions of the DR K-12 ELL Projects

Primary Investigator	Title	Summary
Carolyn Knox	Collaborative Online Projects for ELL Students (COPELLS)	Studies the effects of linguistically sensitive science instructional materials by translating into English, enhancing, and testing effects of a series of Collaborative Online Projects (COPs) originally written in Spanish
Instruction		
Kathryn Chval	CAREER: A Study of Strategies and Social Processes that Facilitate the Participation of Latino English Language Learners in Elementary Mathematics Classroom Communities	Looks at how third grade mathematics instructors can better serve the needs of ELLs and develops corresponding professional development materials
Mark Driscoll	R&D: Fostering Mathematics Success in English Language Learners	Studies the effects of the Fostering Geometrical Thinking Toolkit (FGTT) program on participating middle grades teachers of ELL students
Catherine Fosnot	R&D: Project Delta: Digital Environments for the Learning and Teaching of Algebra	Extends an existing library of CD-ROM digital learning environments by adding an algebra strand and evaluating the impact of the new algebra materials on elementary teacher development
Kara Paul Jackson	SGER: Equity and Access to High-Quality Instruction in Middle School Mathematics	Develops tools to appropriately measure equity-related aspects of mathematics instruction
Jennifer Jacobs	Toward a Scalable Model of Mathematics Professional Development: A Field Study of Preparing Facilitators to Implement the Problem-Solving Cycle	Tests the effectiveness of the Problem-Solving Cycle model of mathematics professional development
Kate McNeill	Supporting Grade 5-8 Students in Writing Scientific Explanations	Prepares a book and a research study to investigate the impact of that book and accompanying professional development on teachers' beliefs and classroom practices to support grade 5-8 students in writing scientific explanations

Exhibit A.1: Descriptions of the DR K-12 ELL Projects

Primary Investigator	Title	Summary
Patricia Stoddart	Effective Science Teaching for English Language Learners (ESTELL): A Pre-Service Teacher Professional Development Research Project Across Three Universities in California	Conducts an experimental study on the impact of the ESTELL elementary teacher education program for preparing novice teachers to teach science to ELLs and a qualitative study on program implementation
Learning		
Carole Beal	R&D: Closing the Math Achievement Gap for English Language Learners: Technology Resources for Pre-algebra	Studies how ELLs solve word problems and then develops online programs to help them solve these problems more effectively
Jeffrey Choppin	Investigating Equitable Discourse Practices in Mathematics Classrooms: Conference Proposal	Plan and conduct conference designed to synthesize and disseminate research findings on the best ways to promote equitable access and opportunities for all students to participate, to learn mathematics with understanding, and to understand the place of mathematics in students' life worlds
Cathy Kinzer	Scaling Up Mathematics Achievement (SUMA)	Tests the scalability and replicability of the systemic Gadsden Mathematics Initiative
Karin Wiburg	Math Snacks: Addressing Gaps in Conceptual Mathematics Understanding with Innovative Media	Develops and evaluates the efficacy of computer-mediated animations and games designed to increase student conceptual understanding and skills in core mathematical topics of middle grades

Appendix B. Research in Science Education and ELL

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Science Learning					
Describes implementation of an after-school program focusing on invention and exploration	Basu, S.J. & Barton, A.C. (2007)	Low-income (6th and 7th grade), predominantly Puerto Rican and Latino, who attended a middle school in New York City	—	Student observations, student interviews, student work	Ethnography (qualitative analysis)
Examines impact of at-home computer use on science learning outcomes of students from four ethnic backgrounds (Caucasian, Hispanic, African American, Asian)	Chang, M. & Kim, S. (2009)	Nationally representative sample (ECLS-K) focusing on computer access and computer use on science achievement of elementary school students, focusing on effects for racial and linguistic minorities	Computer access, computer use	Early Childhood Longitudinal Study (ECLS-K)'s database, a nationally representative sample	Statistical analysis (series of regression analyses)
Examines role of gesture when teaching students fluent in Spanish but with little or no English comprehension	Church, R.B., Ayman-Nolley, S. & Mahootian, S. (2004)	51 first grade students in Chicago, 26 from mainstream English speaking classroom, and 25 from bilingual program where students speak Spanish only	Video instruction combining speech with gesture	Pre, post student assessments	Quantitative analysis of learning tests

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Analyzes the text and discourse within bilingual classes where popular culture sources of students' science understanding are used	Ciechanowski, K.M. (2009)	2 3rd grade bilingual science classes in a Spanish/English immersion school	—	Science textbook, popular culture movie, classroom observations	Textual analysis
Implements and assesses a broader inquiry-based, instructional intervention intended to create greater equity in science and literacy education for diverse elementary students	Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005); Lee, O., Buxton, C., Lewis, S., & LeRoy, K. (2006); Lee, O., Deaktor, R., Enders, C. & Lambert, J. (2008)	Large-scale study of professional development intervention at six urban elementary schools with significant numbers of culturally and linguistically diverse students	PD for instructional congruence, inquiry-based learning; atypical lesson where teacher relies on more English proficient students to interpret; educational policies	Elicitation sessions of student pre and post-knowledge assessments, student assessments	Significant tests of means between pre/posttests
Assessess professional development intervention (curriculum and workshops) for science teachers in 15 urban elementary schools	Lee, O., Mahotiere, M., Salinas, A., Penfield, R. D., & Maerten-Rivera, J. (2009); Lee, O., Penfield, R., & Maerten-Rivera, J. (2009)	Elementary school teachers in an urban school district with a linguistically and culturally diverse student population	Professional development to increase science content knowledge and promote inquiry-based science instruction	Student writing samples, student assessments, teacher surveys, classroom observation, scored fidelity of implementation (based on observation)	Mixed methods (textual analysis and HLM, multi-level models)
Analyzes discourse of student's explanation of seasonal variation in daylight hours in 6th grade class	Radinsky, J., Oliva, S., & Alamar, K. (2010)	6th grade science class in a small elementary school with an all-Latino student population		Classroom observation	Case study (qualitative analysis)

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Science Instruction					
Uses longitudinal data from Educational Longitudinal Study, estimated the effects of ESL placement on adolescents' college preparedness and academic achievement	Callahan, R., Wilkinson, L, & Muller, C. (2010)	More than 15,000 high school sophomores included in the nationally representative sample from the Educational Longitudinal Study	ESL (language assistance programs) placement	Educational Longitudinal Study database	Statistical analysis (descriptive statistics, multi-level propensity scores, HLM)
Explores results of survey of teachers in a community having experienced rapid growth in its immigrant population	Cho, S., & McDonnough, J.T. (2009)	33 high school science teachers of English as a Second Language students in central Virginia	--	Teacher survey	Survey statistical analysis (descriptive statistics, % respondents, mean, standard deviation
Discusses how reliance on use of written discourse over other practices can results in unequal distribution of opportunities for students to demonstrate knowledge	Crawford, T. (2005)	1 elementary school teacher in Southern California with significant number of students from ethnic minority backgrounds (Hispanic)	--	Student work, classroom observations, student artifacts (notebooks, student writing, student projects, homework), teacher artifacts, student interviews, teacher interviews, parent interviews	Ethnography

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Describe language of school science (LSS) and how it differs from everyday language	Fang, Z. (2006)	Middle school science textbooks and researchers' experience in helping US middle school science teachers	--	Science textbooks, researcher experience	Textual analysis
Describes how a teacher created an environment for students to use both English and Spanish in a science classroom	Goldberg, J., Enyedy, N., Welsh, K.M. & Galiani, K. (2009)	Spanish in a 6th grade science classroom where English is the official language of instruction	--	Classroom observations	Case study, discursive analyses
Explores the effect of classroom response system (CRS) intervention on science teacher's discourse style in a sheltered English science classroom	Langman, J. & Fies, C. (2010)	1 teacher and 12 students in an intermediate-level sheltered English science classroom in a urban high school in the southwest	Classroom response system (CRS), a technology -supported intervention emphasizing dialogic inquiry, that supports user "voting" via transmitter	Field notes, classroom observations, class debriefing, class focus groups	Case study, discursive analyses, time use analysis
Implements and assesses a broader inquiry-based, instructional intervention intended to create greater equity in science and literacy education for diverse elementary students	Lee, O. & Luykx, A. (2005); Lee, O, Luykx, A., Buxton, C., & Shaver, A. (2007); Luykx, A., Lee, O. & Edwards, U. (2008); Shaver, A., Cuevas, P., Lee, O., & Avalos, M. (2007)	Large-scale study of professional development intervention at six urban elementary schools with significant numbers of culturally and linguistically diverse students	PD for instructional congruence, inquiry-based learning; atypical lesson where teacher relies on more English proficient students to interpret; educational policies	Researchers' experiences implementing intervention, classroom observation, teacher interviews, teacher surveys, teacher focus groups, student assessments	Mixed methods (discursive analysis, statistical analyses (means, standard deviations, gain score analysis using HLM of pre post tests))

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Five-year study of a professional development intervention (curriculum and workshops) for science teachers in 15 urban elementary schools	Lee, O., Adamson, K., Maerten-Rivera, J., Lewis, S., Thornton, C. & LeRoy, K. (2008); Lee, O., Lewis, S., Adamson, K., Maerten-Rivera, J., & Secada, W. (2008); Lee, O., Maerten-Rivera, J., Penfield, R. D, Leroy, K., & Secada, W.G. (2008)	Elementary school teachers in an urban school district with a linguistically and culturally diverse student population	Professional development to increase science content knowledge and promote inquiry-based science instruction	Classroom observation, teacher interviews, teacher surveys, student math and science assessments	Mixed methods (statistical analyses and content analysis of open-ended responses)
Examines change in beliefs/practices of elementary teachers who shared language and culture of their students, highlighting challenges in establishing instructional congruence	Lee, O. (2004)	Six bilingual Hispanic teachers working with 4th grade, mostly Hispanic students	--	Classroom observation, teacher interviews	Qualitative analysis
Describes the resources and strategies used by middle school teachers, urban fellows, and a district science staff developer to minimize the marginalization of science in their school	Rivera Maulucci, M.S. (2010)	Middle school teachers, urban fellows, and district science staff person in a high-poverty, low-performing urban school	--	Research journal, classroom observation, teacher interviews	Critical narrative inquiry (ethnography and narrative inquiry - qualitative analysis)

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Examines the effect of intentional vs. implicit approach to English oral language development in young children	Spycher, P. (2008)	39 ethnically and linguistically diverse kindergarten students in 2 classrooms with the same teacher in an urban CA school	Vocabulary intervention utilizing an intentional and explicit approach	Student vocabulary assessment via elicitation, student interviews, teacher interviews, classroom observations, teacher's blog, videotapes of lessons, student work	Mixed methods (descriptive statistics, two-ANOVA, paired t-tests)
Explores effects of rural high school's science course placement practices on Latino student success in science	Zuniga, K. Olson, J.K., & Winter, M. (2005)	157 limited English proficiency students in a rural high school	Course placement policy whereby students with limited English proficiency were tracked into a science course intended for students with learning disabilities	School records (including family survey completed upon enrollment, GPA, and standardized test scores in science)	Statistical analyses comparing Latino and non-Latino students
Science Assessment					
Uses state high-stakes test results to examine factors influencing science achievement in an urban school district	Maerten-Rivera, J., Myers, N., Lee, O. & Penfield, R. (2010)	Results from state tests of 23,854 fifth-grade students from 198 schools in a large urban school district with diverse student population	--	Student state achievement tests	Descriptive statistics and multi-level modeling

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Examines assessments for linguistic minority students in life science courses to make written assessments more accessible and equitable for advanced ELL students	Siegel, M.A. (2007)	Students in middle school life science courses in 2 CA schools with linguistically and culturally diverse student populations	--	Student assessments	Statistical analyses (regression of pre-post test results)
Examines validity of one state's standards-based assessments in math and science among 5th and 8th grade students for ELL groups	Young, J. W., Cho, Y., Ling, G., Cline, F., Steinberg, J. & Stone, E. (2008); Young, J.W., Steinberg, J., Cline, F., Stone, E., Martiniello, M., Ling, G., & Cho, Y. (2010)	ELLs and native English speakers' results on math and science standards-based assessments in 5th and 8th grade	--	Standards-based math and science assessments in one state for 5th and 8th graders in 2005/6, state administrative data	Statistical analyses (summary statistics on number correct scores, internal reliability values, standard errors, factor analyses)
Implements and assesses a broader inquiry-based, instructional intervention intended to create greater equity in science and literacy education for diverse elementary students	Luykx, A., Lee, O., Mahotiere, M., Lester, B., Hart, J. & Deaktor, R. (2007)	Large-scale study of professional development intervention at six urban elementary schools with significant numbers of culturally and linguistically diverse students	PD for instructional congruence, inquiry-based learning; atypical lesson where teacher relies on more English proficient students to interpret; educational policies	Student assessments	Discursive analysis

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Science Curriculum					
Studies sustained implementation and use of Integrated Science Program (ISP)	Larkin, D.B., Seyforth, S.C. & Lasky, H. J. (2009)	7 high school science teachers using the ISP curriculum	9th grade integrated science curriculum, an introductory science course to help students develop necessary skills for scientific inquiry	Department chair interviews, teacher interviews	Case study
Studies the effects of a Conservation of Matter unit	Lynch, S., Kuipers, J., Pyke, C. & Szesze, M. (2005)	1,500 8th grade students in MD middle schools with diversity in ethnic, linguistic, and socio-economic backgrounds of students	"Guided inquiry" curriculum	Student assessments, classroom observation (videotape)	ANCOVA and ANOVA if pre/posttests and ethnography
Explores robotics curriculum used to teach middle school physics to LEP and ESL students	Robinson, M. (2005)	3 8th grade physics teachers (one of an ELL class, a regular class with ELL students, and an afterschool class) using Robolab	Robolab (inquiry-based learning in robotics-physics)	Teacher interviews	Case studies (qualitative analysis)
Examines the implementation of reform-based high school chemistry curriculum	Roehrig, G.H., Kruse, R. A. & Kern, A. (2007)	27 high school chemistry teachers in a large, urban school district with a linguistically and culturally diverse student body	Inquiry-based, high school chemistry curriculum	Teacher interviews and classroom observations	Mixed methods (quantitative correlations and content analysis)

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Describes an evolution unit around hands-on use of LEGO robots to improve English language writing and speaking ability	Whittier, L.E. & Robinson, M. (2007)	29 students (primarily native Spanish speakers) in two middle school life science classes where teachers used Lego Robotics	Inquiry-based use of Lego Robotics to teach principles of evolution	Pre and post student assessments	Descriptive statistics (mean score comparison of pre and post)
Science Teacher Education					
Explores experiences of first-year science teacher during school year to improve strategies to prepare pre-service teachers to instruct ELLs	Buck, G., Mast, C., Ehlers, N., & Franklin, E. (2005)	1 beginning teacher of middle-level ELLs, a science teacher educator/ researchers, ELL researcher, graduate assistant in a Midwestern school	—	Meeting notes, classroom lesson plans, classroom observations, teacher interviews, student interviews, student work	Action research (Qualitative analysis)
Studies pre-service teachers during their final year of training, investigating how to develop culturally responsive teachers through coursework and field experiences	Settlage, J., Southerland, S.A., Smith, L.K. & Ceglie, R. (2009)	Pre-service elementary education teachers participating in student teaching placements	Pre-service teacher field placements	Pre-service self-efficacy and belief surveys, pre-service teacher interviews	Statistical analyses

Exhibit B.1: Science Education and ELL Studies (2005 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Examines teacher training textbooks to determine the extent to which they discuss strategies for teaching ELLs	Watson, S., Miller, T.L., Driver, J., Rutledge, V. & McAllister, D. (2005)	25 best-selling textbooks	—	Textbooks	Textual analysis

Appendix C. Research in Math Education and ELL

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Math Learning					
Examines relationship of English proficiency and math performance in high school students math performance	Beal, C. R., Adams, N.M. & Cohen, P.R. (2010)	442 (of whom 209 were ELLs) 9th grade students in algebra I classes in four high schools in Los Angeles	Web-based tutorial	State math assessments, state English language development test, student surveys, teacher ratings of students	Statistical analyses (regressions)
Explores the role of an NCTM standards-based curriculum and teaching and learning mathematics for social justice	Gutstein, E.(2003)	7th/8th grade teacher in an urban school where the vast majority of students are Latino and low socio-economic status	—	Participant observations, student surveys, school records, student journals, student assessments, student work	Ethnography (practitioner-research, textual analysis, qualitative analysis)
Explores computer use as an educational tool to improve math achievement for ELL students	Kim, S. & Chang, M. (2010)	4 waves of data for students included in the Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K), a database of a nationally representative sample	Computer use	ECLS-K, a nationally representative database	Statistical analyses (regression analysis, HLM)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Assesses school-related attitudes, math coursework, and math achievement of Hispanic high school students who had been enrolled in bilingual program in elementary school	Lindholm-Leary, K. & Borsato, G. (2005)	139 high school Hispanic students in CA who were previously ELLs or native English speakers who had enrolled in a bilingual program during elementary school	Two-way bilingual program in elementary school	Student surveys, student assessments	Statistical analyses (mean, standard deviations, chi-squared tests)
Assesses English-Korean bilingual students language difficulties with solving math word problems	Whang, W. (1996)	6 elementary and junior high English-Korean bilingual students	--	Student assessments, student interviews	Case studies (qualitative analysis)
Math Instruction					
Explores vocabulary and literacy instruction techniques for ELL students who are deaf/hard of hearing	Cannon, J.E., Fredrick, L.D. &. Easterbrooks, S.R. (2010)	4 ELL students who are deaf or hard and hearing in a 5th grade classroom	Multimedia materials	Student elicitations (vocabulary assessments)	Case studies (descriptive statistics)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Examines long-term effects of teacher instructional grouping practices on math achievement of language minority students	Chang, M. (2008)	4 waves of data for 11,776 ELL and non-ELL students from various ethnic groups in the Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K), a database of a nationally representative sample	Grouping practices	ECLS-K, a nationally representative database	Statistical modeling (multilevel and general linear modeling methods)
Investigates the effect of within-class grouping on math achievement in language-minority students	Chang, M., Singh, K., & Filer K. (2009)	4 waves of assessments of children from kindergarten through 5th grade included in the nationally representative sample in the Early Childhood Longitudinal Study-Kindergarten cohort	Ability grouping	ECLS-K, a nationally representative database	Statistical analyses (ANOVA, multi-level modeling)
Explores changes in teachers' perceptions of the ELL student needs, effectiveness of instructional techniques while participating in a professional development program	Friend, J., Most, R., & McCrary, K. (2009)	70 teachers and their 235 ELL students in two urban middle schools in Kansas	Professional development for content-area teachers to earn ESL certification	Student assessments, teacher surveys	Mixed methods (paired t-tests and content analysis)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Investigates how technology is in mathematics education in a Title I school	Ganesh, T.G. & Middleton, J.A. (2006)	1 linguistically and culturally diverse multi-grade (2nd & 3rd) classroom in a Title I school ELL students in mixed class	Technology	Classroom observations, teacher interviews, school, district, and teacher documents (e.g., curriculum, model lessons, state standards)	Case study (qualitative analysis)
Explores the role of an NCTM Standards-based curriculum and teaching and learning mathematics for social justice	Gutstein, E. (2003)	1 7th/8th grade teacher in an urban school where the vast majority of students are Latino and low-socio economic status	--	Classroom observations, student surveys, school records, student journals, student assessments, student work	Ethnography (practitioner-research, textual analysis, qualitative analysis)
Explores efforts of successful instruction of Latina/o students in high school math	Gutiérrez, R. (2002)	3 high school math teachers who have advanced Latino/a students in higher level mathematics courses	--	Teacher interviews, student interviews	Case studies (qualitative analysis)
Examines ELL students' learning trajectories relative to their school environments	Han, W. & Bridglall, B.L. (2009)	5 waves of data for ~17,000 for whom home-language data was available in the Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K), a database of a nationally representative sample	School factors (instructional services)	ECLS-K, a nationally representative database	Statistical analyses (growth curve modeling)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Explores characteristics of "talk" in the classroom and its impact on what students learn by analyzing teacher's interactions w/ 5th grade Latino ELL students	Khisty, L.L. & Chval, K.B. (2002)	2 5th grade teachers, 1 whose Latino students have made gains in math achievement	Mathematical discourse (instructional talk)	Classroom observation (including audio and videotapes)	Case study (qualitative analysis)
Analyzes discussion occurring during a third grade math discussion on geometric shapes to illustrate how one teacher supported a students' math discussion	Moschkovich, J.N. (1999)	Third grade ELL teacher	—	Transcript of a classroom lesson	Discursive analysis
Explores a teacher's use of individualized self-instruction math checklists for students with learning disabilities to help students	Zrebiec Uberti, H., Mastropieri, M.A., & Scruggs, T.E. (2004)	Third grade classroom inclusive of ESL and students with learning disabilities	Student self-monitoring checklist	Student assessments, student worksheets, student checklists	Statistical analyses (paired t-tests)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Math Curriculum					
Describes the development of HELP Math, a web-based supplemental curriculum emphasizing math vocabulary for ELL students	Freeman, B. & Crawford, L. (2008)	154 middle school students across three Colorado school districts	Web-based supplemental curriculum providing sheltered instruction in mathematical vocabulary and academic concepts	Student focus groups, teacher focus groups, student surveys, teacher surveys, student assessments	Case study (primarily qualitative analysis)
Describes the Hispanic Math Project field trial of a multi-media tutorial program that teaches measurement	Kinard, B. & Bitter, G.G. (1997)	Hispanic elementary students and their teachers	Technology-based, interactive instructional tool	Expert reviews, student assessments, teacher interviews, student interviews	Mixed methods (Chi square, t-tests, and correlations)
Math Assessment					
Studies impact of accommodations in test taking conditions	Abedi, J. (2009)	666 ELL students in 4th grade (304 were ELLs) and 643 8th graders (290 were ELLs) in a single urban school district in Southern California	Computer testing as an accommodation for ELL students	Student math assessments (NAEP & TIMSS), English reading proficiency tests, student survey	Statistical analyses
Explores relationship of ELL status and opportunity to learn in an algebra course	Abedi, J. & Herman, J. (2010)	602 8th grade students in southern California	Opportunities to learn (time)	Teacher surveys, student surveys, student reading comprehension, and student math assessments	Statistical analyses (HLM)

Exhibit C.1: Math Education and ELL Studies (1966 to September 2010)

Topic	Study	Participants/Setting	Focus of Intervention	Data Collection	Data Analysis
Analyzes math test scores in Maryland to compare ELL performance with those of fully English proficient students	Brown, C.L. (2005)	3rd grade ELL and fully English proficient (FEP) students taking the Maryland School Performance Assessment Program tests in 2000	Literacy-based performance assessments (LBPA) where students read multi-level questions and explain how to solve a math problem with words	Student assessments	Statistical analyses (t-tests, multiple linear regressions)
Examines the linguistic complexity in math word problems as source of differential item functioning (DIF) for ELL students	Martiniello, M. (2008) Martiniello, M. (2009)	4th grade MCAS (Massachusetts' state exam) math exam administered in 2003; 24 4th grade ELL students from 6 urban schools in Massachusetts	--	Student "think aloud" interviews, coding of math assessments, student assessments	Mixed methods (textual analysis, statistical analyses, including descriptive statistics, differential item functioning (DIF), ordinary Least Squares multiple regression)
Compares ELL and non-ELL 8th graders' scores on NAEP math word problems to determine if text operates differently for subgroups	Ockey, G. J. (2007)	1,174 7th and 8th grade students (including 372 ELL students) who took the National Assessment of Educational Progress (NAEP) in 1992	--	Student assessments	Statistical analyses (descriptive analyses, differential item functioning techniques)