Enhanced Learning Maps Project
Year 4 Impact Study Report

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Executive Summary

The Enhanced Learning Maps (ELM) project was funded with a four-year U.S. Department of Education Enhanced Assessment Grant.[1] The Center for Assessment and Accountability Research and Design (CAARD) at the University of Kansas (KU) coordinated the project and it was administered by the Kansas State Department of Education (KSDE). In addition to KSDE, three other state education agencies (SEAs) were partners with the project. Those SEAs included the Alaska Department of Education, the Missouri Department of Education, and the Wisconsin Department of Public Instruction.[2]

The goal of the ELM project was to produce learning maps for individual English language arts (ELA) and mathematics standards and coherent groups of standards to help teachers plan instruction that is sensitive to cognitive development. In Years 1-3 ELM project staff developed and refined ELA and mathematics learning maps and instructional units to accompany the maps. In Years 2-3 teachers were recruited from the participating states and received two-day training and ongoing support in the use of the learning maps and units. The final year of the grant examined the impact of the ELM project on the performance of students whose teachers participated in the project (i.e., 2018-19 school year). McREL International, the third-party evaluator, conducted the impact study in collaboration with ELM project staff.

Participating teachers and states provided student-level data.[3] Propensity score matching (PSM) methods were used to identify matched comparisons. Because each state has its own state standardized assessments that were not directly comparable with each other, the matching and analyses were conducted separately for each state and for each subject area (ELA and mathematics). In total, five small studies were conducted to examine the impact of the ELM project on student achievement, including Alaska ELA, Alaska mathematics, Kansas ELA, Kansas mathematics and Wisconsin mathematics.[4] More details regarding these study samples are described in the Impact Study Design and Methods section.

Key Findings

Following are the key findings for each of the three research questions that guided the study. The primary question of interest focused on the impact of ELM on student performance. The

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[1] The funding period was October 1, 2015 – September 30, 2019. A six month no-cost extension was received extending the grant to March 31, 2020. Year 1 was October 1, 2015 – September 30, 2016; Year 2 October 1, 2016 – September 30, 2017; Year 3 October 1, 2017 – September 30, 2018; and Year 4 October 1, 2018 – September 30, 2019.

[2] The Iowa Department of Education was originally a partner but discontinued participation in Spring 2017.

[3] Data were not available from Missouri; hence not included in the impact study. During the time the ELM project was implemented Missouri teachers were adopting and learning new standards which may have had an impact on Missouri's low participation rate (i.e., other competing state priorities).

[4] No Wisconsin ELA teachers provided student data; therefore a study was not conducted for impact on Wisconsin ELA outcomes.

second research question examined whether differing levels of teachers' ELM unit implementation impacted student performance.[5] The third research question was exploratory and focused on whether there were differences in student performance for differing number of years teachers participated in the ELM project. It is important to note that the samples included in the impact analyses are small subsamples (5-17%) of all teachers who participated in the project; hence generalizability of the findings from this impact analyses is limited.

Research Question 1: Are there differences in student performance for students experiencing the intervention (i.e., students' teachers used the ELM units) and a control group of students?

Findings of the impact analyses did not find a significant effect of ELM on student achievement outcomes for either ELA or mathematics.

Research Question 2: Are there differences in student performance for students of teachers who have high, medium, and low usage of the ELM units?

One interesting finding was found with the Kansas mathematics sample. That is, students of the high implementers (teachers used at least five ELM mathematics units in their instruction) and medium implementers (teachers used three to four ELM units in their instruction) seemed to have higher mathematics scores compared to students of the low implementers (teachers used one or two ELM units in their instruction). That is, although there is no statistical significance on students' mathematics achievement between low implementers and medium implementers ($p = 0.052$) or between low implementers and high implementers ($p = 0.080$), the magnitude of the difference between them were not negligible (ES = 0.19 – 0.24). This finding is consistent with the theory—students of teachers with a higher level of implementation may benefit more from the intervention compared to students of teachers with a lower level of implementation.

Research Question 3: Are there differences in student performance for students of Cohorts 1 and 2 teachers and students of Cohort 3 teachers)?

Exploratory analyses examining the relationship between teachers' prior experience with ELM before project Year 4 and the student achievement outcome revealed some mixed findings. First, with the Alaska mathematics sample, students of teachers with prior experience with ELM before Year 4 (Cohorts 1 and 2 teachers) had significantly *lower* mathematics scores compared to students of teachers who were not involved in the ELM project at all (i.e., comparisons) ($p = 0.028$), and the magnitude of the difference was practically significant (ES = 0.51). In contrast, students of teachers without prior experience with ELM before Year 4 (Cohort 3 teachers) had significantly *higher* mathematics scores compared to comparisons ($p = 0.006$), and the magnitude of the difference was educationally significant (ES = 0.46).

[5] Teacher implementation data was gathered through a Spring 2019 implementation survey.

With the Kansas mathematics sample, students of teachers with prior experience with ELM before Year 4 (Cohorts 1 and 2 teachers) had significantly *higher* mathematics scores compared to students of teachers who were not involved in the ELM project at all (i.e., comparisons) ($p < 0.001$), and the magnitude of the difference was educationally significant (ES = 0.28). In contrast, students of teachers without prior experience with ELM before Year 4 (Cohort 3 teachers) had significantly *lower* mathematics scores compared to comparisons ($p = 0.008$); yet, the magnitude of the difference was minimal (ES = 0.11).

Summary and Recommendations

The overall findings from the impact analyses revealed that ELM students and non-ELM students did not differ in ELA and mathematics achievement scores across all five study samples (see Key Findings, Research Question 1). However, some additional exploratory analyses seemed to provide some interesting findings (see Key Findings, Research Questions 2 and 3).

Considering the findings from the impact analyses within the context of implementation, based on the Spring 2019 implementation survey data, a fairly substantial percentage of respondents (36%) indicated that they did not teach any of the ELM units in 2018-19. Furthermore, approximately one fourth of the respondents did not access the ELM maps following the training. Of the teachers who used the ELM units, three fourths said they taught one or two of them. Taking into consideration the 27 teachers who provided student data, 15 responded to the implementation survey. Nearly one half of those 15 teachers (47%) indicated they taught one or two units in 2018-19 (defined as low implementors) while an additional 40% taught three or four units (medium implementors). A small percentage (13%) reported teaching five or more units (high implementors).

Although there is no evidence to support the efficacy of ELM units on student ELA and mathematics outcomes (Research Question 1), the exploratory analyses and results provided some encouraging findings (Research Questions 2 and 3). The following recommendations are provided for implementation of similar projects and future study of the use of the Enhanced Learning Maps.

1. The implementation survey data suggests usage of the units was low and a number of teachers did not access the learning maps beyond the training. Processes and structures should be identified to support teacher implementation. For example, consider school-level recruitment and implementation and identifying an implementation coordinator (i.e., literacy or math coach trained in ELM).
2. By design, the project was developed in Year 1, initially implemented in Years 2 and 3 and refinements were made based on teacher feedback, and scaled up within each partner state in Year 4. This was an ambitious cycle and consequently, the project was scaled up immediately after development. It is recommended that greater focus be placed on material development and understanding implementation prior to undertaking scale up.
3. The ELM project represented a partnership with a higher education research institution and state education agencies (SEA). Critical to the ELM project's sustainability is having strong partnerships with each SEA throughout the project lifespan. The SEAs are the key to

sustaining the project beyond the life of the grant. Given that ELM requires structure support (e.g., transfer of the software to the appropriate servers, updating the maps and units), it is important to discuss whether and how to build the states' capacity to do that after the grant as part of the project objectives.

4. Very few of the teachers provided student data. Coupled with low levels of implementation, it was difficult to draw any conclusions about the impact of ELM on students' performance. Consider recruitment at the school or district levels versus the teacher level. This approach has several benefits including having multiple teachers in a building that are trained and able to support one another, students having greater exposure to ELM, and efficient collection of student data (i.e., individual teachers relieved of that burden).

ELM Development and Implementation

The Enhanced Learning Maps (ELM) project was funded in October 2015 by a four-year U.S. Department of Education Enhanced Assessment Grant.[6] The Center for Assessment and Accountability Research and Design (CAARD) at the University of Kansas (KU) coordinated the project and it was administered by the Kansas State Department of Education (KSDE). In addition to KSDE, three other state education agencies (SEAs) were partners with the project. Those SEAs included the Alaska Department of Education, the Missouri Department of Education, and the Wisconsin Department of Public Instruction.[7] McREL International was hired as a third-party evaluator to gather data and report on the implementation and outcomes.

The goal of the ELM project was to produce learning maps for individual English language arts (ELA) and mathematics standards and coherent groups of standards to help teachers plan instruction that is sensitive to cognitive development for grades 2-8. The ELM project unfolded over four large cycles which entailed development, initial implementation, and scale up. In Year 1 (2015-16) the focus was on development: learning map structure and technology to support, learning maps for ELA and mathematics (one map for each content area), and instructional units and resources. See Appendix A for ELA and mathematics map view samples.

In Years 2 and 3, corresponding to cycles 2 and 3, the maps and instructional units were made available to teachers in the participating states. Beginning in spring 2016, ELM project staff and state partners recruited ELA and mathematics elementary and middle school teachers to participate in the project (i.e., Project Year 1). A total of 43 teachers (25 ELA teachers and 18 mathematics teachers) were invited to participate in what was referred to as Cohort 1. Cohort 1 teachers participated in a three-day workshop in Kansas City held July 6–8, 2016. The following year (i.e., spring 2017, Project Year 2), 57 teachers (21 ELA teachers and 36 mathematics teachers) were invited to participate in Cohort 2. In addition, 25 Cohort 1 teachers (11 ELA teachers and 14 mathematics teachers) opted to continue participating in the project. A three-day workshop for Cohort 1 and 2 teacher participants was held in Kansas City on June 20–22, 2017.

During the training, teachers learned how to access the online ELM maps and instructional units. Following the training, the teachers were expected to continue to explore and use the ELM maps in their ELA or mathematics instruction, teach six instructional units, and complete feedback surveys at the end of each instructional unit. ELM staff provided ongoing support throughout the school years as teachers implemented the units and used the learning maps. Supports included webinars; phone, e-mail and video communication with project staff; newsletters; and resources embedded in the instructional units such as teacher notes, videos, and research summaries.

[6] The funding period was October 1, 2015 – September 30, 2019. A six month no-cost extension was received extending the grant to March 31, 2020. Year 1 was October 1, 2015 – September 30, 2016; Year 2 October 1, 2016 – September 30, 2017; Year 3 October 1, 2017 – September 30, 2018; and Year 4 October 1, 2018 – September 30, 2019.

[7] The Iowa Department of Education was originally a partner and discontinued participation in Spring 2017.

In Years 2 and 3, the intent was that the teachers would implement six instructional units in ELA or mathematics and provide feedback on those units. Using an iterative development process, ELM project staff made adjustments and improvements to the learning maps and units based upon teacher feedback.

The fourth large cycle, Years 3-4, focused on large-scale use and providing access to the learning maps and instructional units to more teachers in each of the participating states. Teachers and other educators (e.g., principals and instructional coaches) were recruited by each state department of education. Two-day trainings were held in each of the four participating states in January, June, and July 2018.[8] Nearly 300 educators participated in the four state-level trainings with Kansas and Alaska trainings each having more than 100 participants.[9] A relatively small number of educators (less than 30) attended the Missouri and Wisconsin trainings. Although the majority of returning 1 and 2 participants opted to attend the Year 3 training, it was not required in order to continue participation in the ELM project. As requested, ELM project staff provided ongoing support in using the learning maps and instructional units. Support included the delivery of webinars (which were archived for later viewing), chats, real-time support (phone, e-mail, and video), newsletters, and the ELM website.

As was the case in previous years, it was hoped that teachers would implement at least six instructional units in their classrooms along with using the ELA or mathematics map views that were available beyond those that were a part of the ELM units (see Table 1 for the number of ELM units available by grade level). Each unit included several resources: ELM unit map view, teacher notes, teacher notes video, summary of research, instructional activities, student handouts, and student feedback/solution guide.

Table 1. Number of ELM Units

Grade Level	ELA Units	Mathematics Units
Second	6	6
Third	6	6
Fourth	6	7
Fifth	6	6
Sixth	6	7
Seventh	6	6
Eighth	5	6
Total	**41**	**44**

For the fourth year of the project (2018-19 school year) there were a total of 248 participants across the four states. The majority of the Year 4 participants were from Cohort 3 (n=190). Forty-

[8] A one-day training was also held with 29 elementary school educators in Fairbanks School District in Alaska. Educators participating in this training are not included in the impact study.
[9] The majority of participants were teachers but also included instructional coaches and administrators.

two (42) and 16 participants were from Cohorts 2 and 1, respectively. Table 2 shows the breakdown of Year 4 participants by state and cohort.

Table 2. Year 4 ELM Participants

State	Cohort 1	Cohort 2	Cohort 3	Total
Alaska	4	10	62	76
Kansas	5	20	107	132
Missouri	2	4	5	11
Wisconsin	5	8	16	29
Total	**16**	**42**	**190**	**248**

Year 4 ELM Implementation in Classrooms

To learn more about the implementation and impact of the ELM project, McREL administered an online survey in spring 2019 to the 248 participants (16 Cohort 1, 42 Cohort 2, and 190 Cohort 3). The survey was available for a 4-week period and three e-mail follow-ups were extended for non-respondents. There were a total of 76 respondents for a response rate of 31%. Three of the respondents were instructional coaches or administrators and their responses are excluded from the analysis.

The survey included Likert-type scale items on ELM unit implementation, project experiences, organization and administrator support, use of maps and impact on instructional practice, and teacher beliefs. Open-ended questions gathered information on the impact of the ELM project at the teacher (e.g., content knowledge and instructional practice) and student levels (i.e., changes in student learning). Included in this report is a summary of implementation findings and teachers' perceptions of impact. For a comprehensive summary of all survey findings see ELM Project Cohorts 1, 2, and 3 Survey Results, June 2019.

The majority of respondents taught fifth grade (27%) while another one-fourth taught sixth grade (25%) (see Table 3). Most teachers had been teaching between two and five years (71%) and about one-fourth had been teaching between six and ten years (27%). (Table 4). The majority of teachers were from Kansas (56%). About one-fifth were from Wisconsin (22%) and slightly less than one-fifth were from Alaska (18%). A few respondents were from Missouri (4%) (see Table 5). As a point of comparison, the percentage of 2018-19 participants taking part in each state is as follows: Kansas – 53% (*n*=130), Wisconsin – 12% (*n*=29), Alaska – 31% (*n*=76), and Missouri 5% (*n*=11). Tables 3-5 also show the percentage of teachers trained for each of these demographics (i.e., grade level currently teaching, number of years full-time teaching experience, and state represented).

Table 3. Grade Level Currently Teaching

Grade Level	Percentage of Survey Respondents	Percentage of Total Training Participants Y1-3
Grade 2	16.4%	18.5%
Grade 3	20.5%	20.1%
Grade 4	23.3%	20.1%
Grade 5	27.4%	21.8%
Grade 6	24.7%	14.4%
Grade 7	23.3%	15.8%
Grade 8	19.2%	14.1%
Other Responses for Survey Respondents: Grades K-12 (*n* = 1), Grade 1 (*n* = 1), Grades 4-6, (*n* = 1), Grades 9-12 (*n* = 2), Grade 9 (*n* = 1), Grades 10-11 (*n* = 1) Other Responses for Training Participants: Kindergarten (*n* = 4), Grade 1 (*n* = 7), Grades 2-5 (*n* = 32), Grades 6-8 (*n* = 8), Grades 6-12 (*n* = 1), ASDN (*n* = 1), LKSD (*n* = 1)	9.6%	18.1%

Note: The number of survey respondents was 73. The number of unique participants in the trainings and for whom it was applicable to indicate grade levels currently teaching was 298. Percentages may not add up to 100 because respondents had the option to select all responses that applied.

Table 4. Number of Years Taught Full Time

<table>
<tr><th>Years</th><th>Percentage of Survey Respondents</th><th>Percentage of Total Training Participants Y1-3</th></tr>
<tr><td>1</td><td>1.4%</td><td rowspan="2">37.2%</td></tr>
<tr><td>2-5</td><td>71.2%</td></tr>
<tr><td>6-10</td><td>27.4%</td><td>28.6%</td></tr>
<tr><td>11-15</td><td>0.0%</td><td>14.1%</td></tr>
<tr><td>16-20</td><td>0.0%</td><td rowspan="2">20.1%</td></tr>
<tr><td>21 or more</td><td>0.0%</td></tr>
</table>

Note: The number of survey respondents was 73. The number of unique participants in the trainings who indicated the number of years full-time teaching was 234. This information was received from the ELM participant application and response options were1-5 years, 6-10 years, 11-15 years, or 16 or more years. Percentages may not add up to 100 due rounding.

Table 5. State Represented

State	Percentage of Survey Respondents	Percentage of Total Training Participants Y1-3
Alaska	17.8%	34.8%
Kansas	56.2%	44.9%
Missouri	4.1%	7.7%
Wisconsin	21.9%	12.5%

Note: The number of survey respondents was 73. The number of unique participants in the trainings from these four states was 336. Percentages may not add up to 100 due rounding.

ELM Units Implementation

Overall, ELA and mathematics teachers varied slightly in the number of ELM units they fully implemented in the 2018-19 school year. Three fourths of the teachers responding to the survey implemented one or two of the units (75%) (see Table 6). Of the 21 ELA teachers, over one-third (38%) taught one unit and approximately one-fourth taught two units (24%). Of the 35 mathematics teachers, most taught either one unit (34%) or two units (29%).

Table 6. Number of ELM Units Fully Implemented

Overall (n = 47)		ELA (n = 21)		Mathematics (n = 35)	
Number of Units	Percentage	Number of Units	Percentage	Number of Units	Percentage
1	42.6%	1	38.1%	1	34.3%
2	31.9%	2	23.8%	2	28.6%
3	10.6%	3	4.8%	3	11.4%
4	12.8%	4	14.3%	4	8.6%
5	12.8%	5	14.3%	5	8.6%
6	0.0%	6	0.0%	6	0.0%
More than 6	8.5%	More than 6	4.8%	More than 6	8.6%

Note: Respondents had the option to respond for both ELA and Mathematics; percentages may not add up to 100% due to this or rounding.

Teachers who reported they did not use any of the ELM units were asked via an open-ended survey item to explain their reasons. Twenty-six teachers (seven ELA, thirteen mathematics, and six in both content areas) said they did not implement any units. The most common reasons were a lack of time and feeling overwhelmed with other teacher duties (three ELA teachers, five mathematics teachers, two teachers in both content areas) and feeling the units did not align with their need (two ELA teachers, three mathematics teachers, two teachers in both content areas). One teacher said, "Both curriculum for ELA and mathematics were new. That was all I could put on my plate. I tried, but it just didn't work. The training was not as much as I had wanted."

Teachers also cited having issues with the program (three mathematics teachers and four teachers in both content areas) and encountering unforeseen circumstances (two ELA teachers and three mathematics teachers) as reasons for not using ELM units. One teacher said, “I was unable to implement these units because my district has blocked the ELM website with the new filter they put into place this year.”

The ELM project staff provided several resources for teachers to use as a part of each unit. Respondents were asked to describe the extent that they referenced or used the resources for each content area when planning and delivering instruction. They were also asked to describe any challenges experienced when using the resources. The order of most used materials was the same between ELA and mathematics instruction, however, the percentage of usage varied across the two content areas. For ELA, the materials most frequently used by respondents were as follows: Instructional Activities (95%), Student Handouts (90%), ELM Unit Map View (90%), Teacher Notes (68%), and Student Feedback/Solution Guide (58%). Respondents reported less use of the Summary of Research (37%) and the Teacher Notes Video (32%). Figure 1 illustrates the extent that respondents reported using the ELM materials in their ELA instruction.

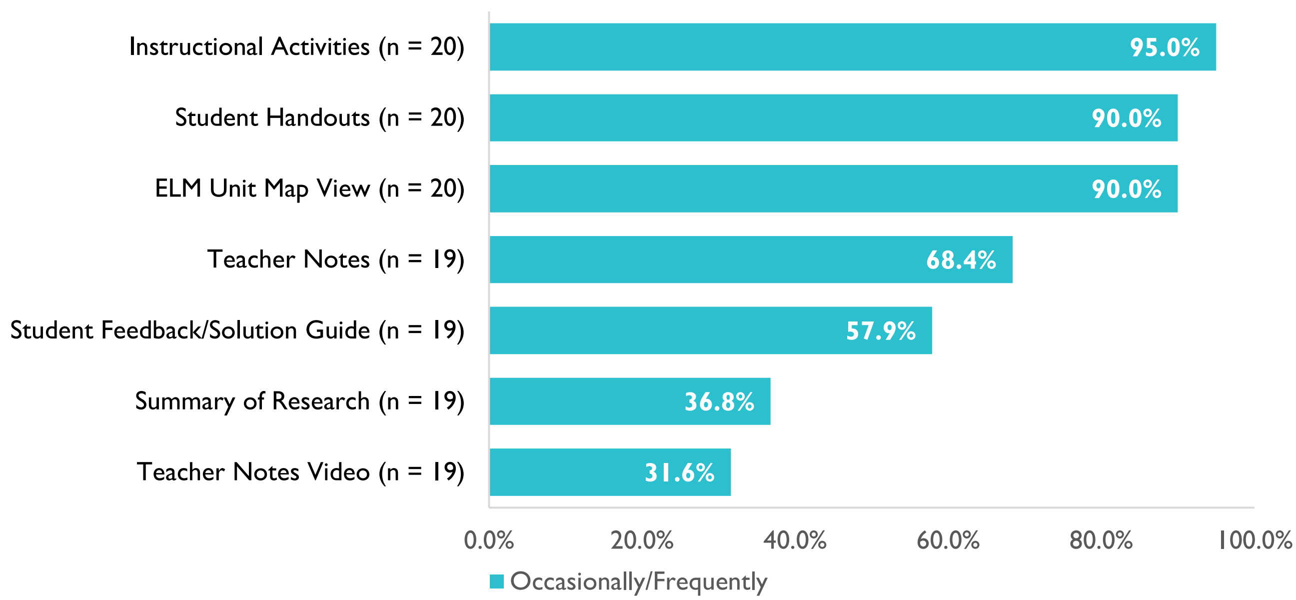

Figure 1. Use of ELM Materials in ELA Instruction

For mathematics instruction, the materials most frequently used by respondents were as follows: Instructional Activities (88%), Student Handouts (77%), ELM Unit Map View (74%), and Teacher Notes (56%). Respondents reported less use of the Student Feedback/Solution Guide (44%), Summary of Research (27%) and the Teacher Notes Video (18%). Figure 2 illustrates the extent that respondents reported using the ELM materials in their mathematics instruction.

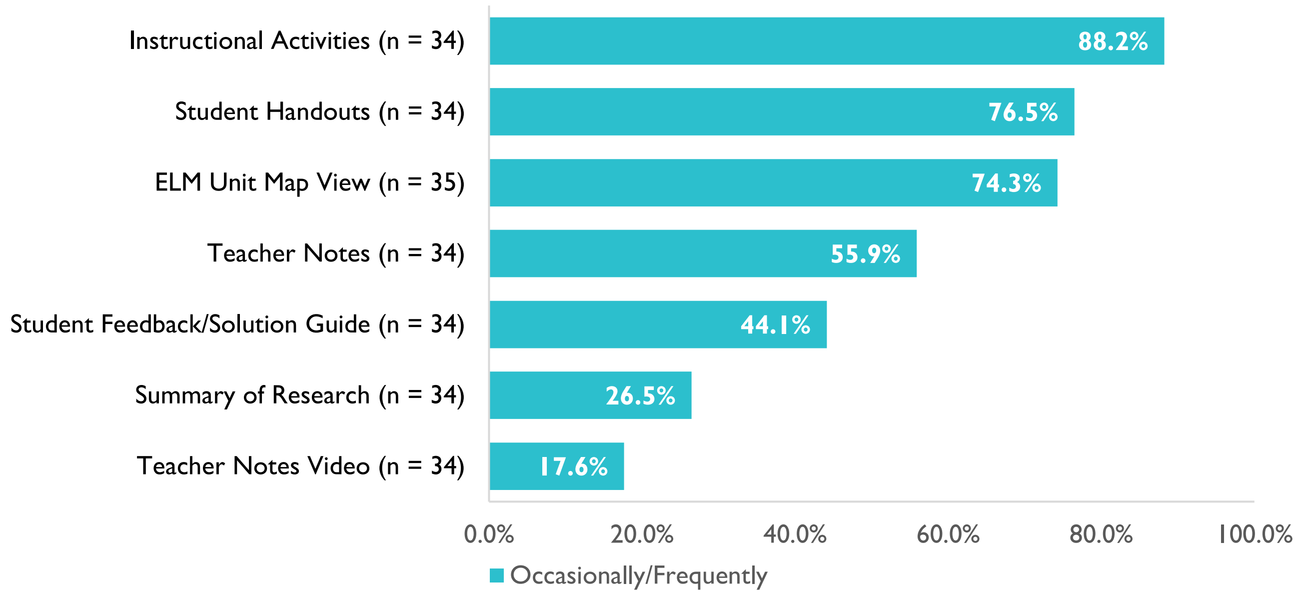

Figure 2. Use of ELM Materials in Mathematics Instruction

A total of 32 teachers (nine ELA, seventeen mathematics, six both) reported challenges in response to the open-ended question*: If you experienced any challenges implementing the ELM resources, what were they?* Challenges teachers reported included time, usage difficulty, content and resource availability, district standards, and needing to make modifications based on student need. Issues with time were the most common challenge, including feeling overburdened with other teaching responsibilities, the time it takes to implement ELM with a large number of students, and the timing of trainings available.

Difficulty with usage and lack of resources available were also common concerns. Usage issues ranged from connectivity issues to finding the tool difficult to use. Lack of content and resources was articulated by both mathematics and ELA users. One respondent indicated that answer guides would be helpful. Several respondents stated that there simply were no resources for the grades they taught. One ELA respondent discussed a lack of resources and a delay in new ones being created, saying,

> *The challenges I experienced were on the lack of materials offered as compared to lower grades ELA or any of the mathematics units. There were hardly any items contained in the grade 8 ELA units. I was disappointed in that and was waiting for additional materials to be added. Some things were added over the course of the year, but not nearly the amount as for mathematics.*

Some teachers indicated that the issues they faced in implementation had nothing to do with the program itself, but rather issues from the district. Others implied that the lessons were too difficult for their students as written and needed to be modified.

Teachers were asked *If a Student Locater Tool was available for an ELM unit you taught, did you use it*? Forty-seven teachers responded to this question, with only 28% indicated that they did use the

Student Locator Tool. Of the forty-seven teachers who responded, 32% were participating in the ELA ELM content area, 51% were participating in the mathematics ELM content areas, and 17% were participating in both content areas. ELA and mathematics were similar in that about one fourth of respondents indicating using the Student Locator Tool (27% and 25%, respectively) whereas over one third of the respondents participating in both content areas indicating using the tool (38%).

Teachers who indicated that they did use the Student Locator Tool were then asked how helpful they found the tool to be. Over two thirds of respondents (69%) who used the tool found it to be either moderately or greatly helpful. The remaining one-third (31%) found it only slightly helpful. These response rates were similar regardless of which content area the respondent was participating.

Respondents were asked how the use of the ELM resources changed their view of formative assessment. Forty-six teachers responded to this question (15 ELA, 23 Mathematics, 8 participating in both content areas). One fourth of teachers indicated that they were using assessments differently than before. They started to use observations, questioning, and informal assessment to drive instruction. One ELA teacher reported that her view of formative assessments and how to use data from them changed, sharing, "I used to view formatives as something else to grade; now, I use them to help individual students."

Many teachers also said that they gained a better understanding of the learning process their students are going through and how to determine where they are in that process. Teachers also stated that their teaching practices had changed as a result of using formative assessments, with some giving specific examples of how their teaching practices had been impacted (e.g. "It gave me ideas about how to respond to student' misconceptions"). Few teachers stated that there was no impact or change, though some responded that they saw the value, but there weren't enough resources to use with their grade level.

Use of Enhanced Learning Maps and Impact on Instructional Practice

Teachers were asked to discuss their uses of the learning maps and the subsequent impact on their instructional practice. Nearly half of respondents (49%) reported they accessed the learning maps to plan for and teach the ELM units (see Table 7). Slightly less than half of the respondents (45%) said they used the learning maps to plan for and teach state standards beyond those addressed in the ELM units.

Table 7. Purposes in Accessing the Learning Maps

For what purposes did you access the learning maps?	Percentage
Planning for and teaching the ELM units (*n* = 36)	49.3%
Planning for and teaching state standards beyond those addressed in the ELM units (*n* = 33)	45.2%
Did not access beyond the ELM training (*n* = 19)	26.0%
Other (*n* = 8)	11.0%
Other: Identifying prerequisite skills and creating individual student learning plans; Planning for and teaching state standards to children not at grade level; Individual students; I showed a few colleagues; Want to use for planning but never got the chance; When thinking about prior skills necessary to teach a standard and show mastery in it; Creating learning maps for groups and individuals; Organize connections between skills, standards, and grade levels	

Note: Percentages may not add up to 100 because respondents had the option to select all responses that applied.

Figure 3 displays ways in which teachers have used the learning maps to enhance their instructional practices. Most teachers agreed that they used the maps to adjust instructional practice to keep students moving towards their learning goals (77%), identify where students are at in their learning and what they should learn next (76%), work with struggling learners (76%), and personalize learning (70%). The least common practice of using the maps was to communicate students' progress with parents (26%).

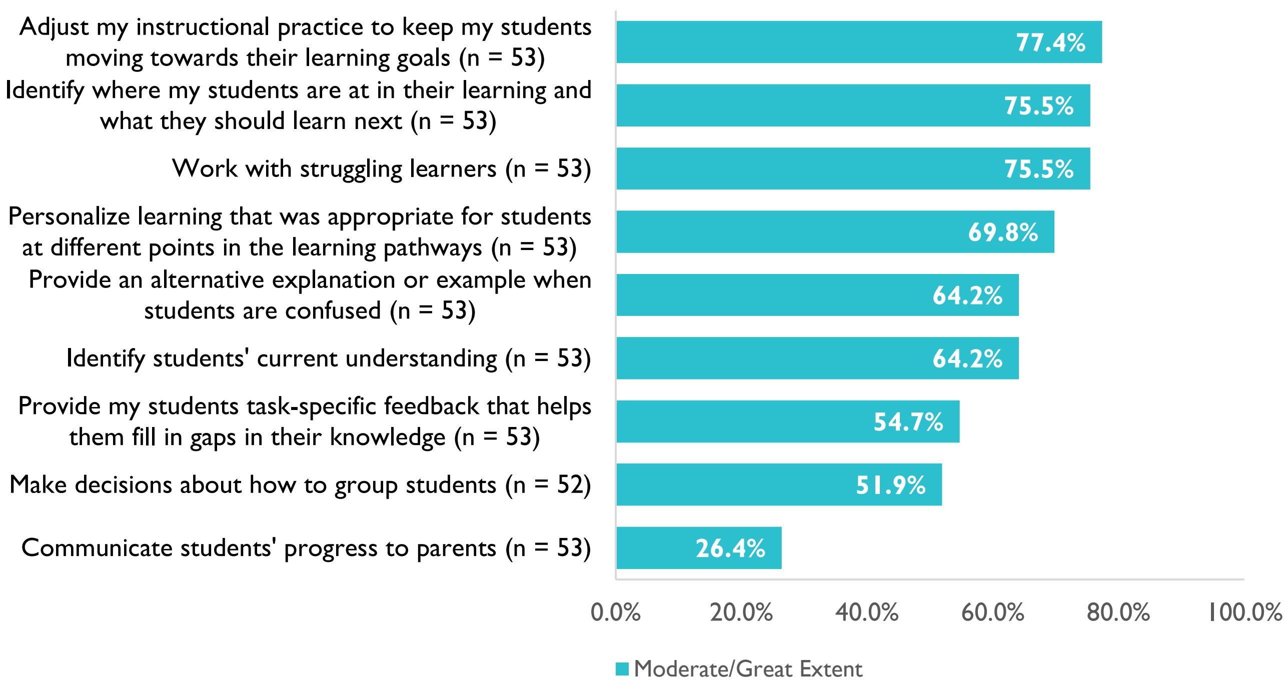

Figure 3. ELM Usage

Impact of Learning Maps on Knowledge of ELA and Mathematics

Respondents were asked to identify the impact of the learning maps on their knowledge of ELA and mathematics. Forty-two teachers responded (12 ELA, 23 mathematics, and seven from both content areas). The most common response focused on the changes that occurred in the way they teach the respective content areas. For example, teachers said that as a result of the learning maps, they are able to identify where gaps and deficits may be and address them properly. Other teachers spoke of the new, research-based lessons that they were using after being introduced to ELM. Fewer spoke of feeling better supported in their instruction through improved knowledge.

Many respondents (four ELA, eight mathematics, and two from both content areas) discussed their increased understanding of the learning process their students are going through. ELA teachers spoke of understanding how skills develop over time. Similarly, mathematics teachers indicated that they have a better understanding of how students learn mathematics in general. One mathematics teacher said, "It has helped me understand the progression of learning that must occur for students to learn and integrate new mathematical knowledge into their memory."

Over one fourth of teachers indicated that, as a result of using the learning maps, they now recognize how different skills are connected. Most spoke of how skills are connected and some even expanded to discussing how the standards in general are connected. One teacher who participated in both content areas spoke specifically of the learning path that became clear by using the maps.

> *I loved the learning maps as they provide a sequence of connected skills and concepts that provide a path to learning a state standard. There are specific chunks of understanding that are necessary before a student can get to the next step. The maps reminded me about these distinct skills which we can't assume our students have.*

Similar to the previous changes discussed, some teachers spoke of the improved understanding of foundational knowledge a student needs to learn a particular concept. Mathematics teachers indicated now recognizing the prerequisite skills needed for a student to learn a unit. One ELA teacher said that they are now aware of what comprehension needs to be in place to prepare for upcoming tasks.

Fewer teachers discussed just a general improvement to their knowledge and perspectives about the content areas they taught. One teacher said they didn't believe their knowledge changed much through using the learning maps, but then went on to discuss changes to teaching practices and recognizing connections between skills.

Impact of Learning Maps on Instructional Practices

Survey respondents were asked to reflect on their instructional practices prior to their experiences with ELM and now by responding to the prompt: *I used to …. But now I ….* Forty-seven teachers responded (12 ELA, 27 mathematics, and eight from both content areas). The most common response reflected a shift from using a set curriculum to changing instruction to fit student needs. For example, teachers said that prior to using learning maps they would just use the curriculum as written. Now, teachers report that they will change things as needed, whether through smaller group instruction, finding new resources, or stepping back and working on foundational skills. A mathematics teacher shared this new experience:

> *I used to blindly follow my curriculum. Now I constantly search for relevant resources to enhance the learning of the kids in my class. I cross reference materials and select the option that best fits the needs for the moment. In some cases, the ELM maps have provided me with the path and ability to see which path to follow for certain learners. It has helped me target specific standards.*

An ELA teacher added,

> *I used to follow the curriculum verbatim, now I have a bit more gray areas where I enhance, or reteach. The ELM has helped me do a better job with more fidelity than merely my gut instinct.*

Respondents also reported that they used to just keep moving forward with curriculum in class. Now teachers report that they recognize the importance of foundational knowledge and the skills needed to master a concept. An ELA teacher spoke of this shift, saying "I used to do a lot of moving forward regardless of what students could or could not do based on formative assessments but now I offer more options for students based on what their skills and deficits are." The same number of teachers also said that they used to follow typical teaching practices, such as just asking for answers or lecturing. Now, they report including the students more in discussion. This was particularly true of mathematics teachers. One said,

> *I used to teach processes and algorithms, but now I teach kids understanding. I stop to ask questions to assess the students understanding, and I move on.*

A small number of mathematics teachers also described a change in confidence. They discussed previously floundering and believing that tracking all that they needed was difficult. After being introduced to ELM, they reported having more confidence in their teaching and having ELM resources as a very useful tool to reduce burden. The same number of mathematics teachers also reported previously struggling to find resources but now using those that ELM provides, with one teacher explaining, "I used to spend a lot of time searching for resources and activities but now I can find many resources in one place."

Respondents from both content areas also discussed previously seeing skills as isolated but now seeing them as connected. A couple of teachers also said that their use of formative assessments has changed, with one ELA teacher stating, "I used to be unaware of the best practices of formative assessments but now I can use formative assessments to adjust my teaching." A small number of participants also used the opportunity to speak of overall satisfaction with the tool, recognizing how difficult it is to create a tool that works for different content areas, and generally changing. An even smaller number of respondents reported believing they experienced no change. One mathematics teacher said, *As far as any great cognitive shifts, I don't think I had any. I only used one student lesson (a place value activity that had students modeling the relative size of each place value position) and disliked my results, so I didn't choose to use another.*

Survey respondents also indicated the extent to which the use of the learning maps impacted their instructional practices, as shown in Figure 4. Three fourths (76%) of respondents said that the extent that they have more information to work one-on-one with students is moderate to great. Furthermore, a majority report their ability to make decisions about individual students' needs (60%), their use of questioning strategies to gather evidence of student thinking (59%), and their understanding of how students think (59%) have all changed by a moderate to great extent.

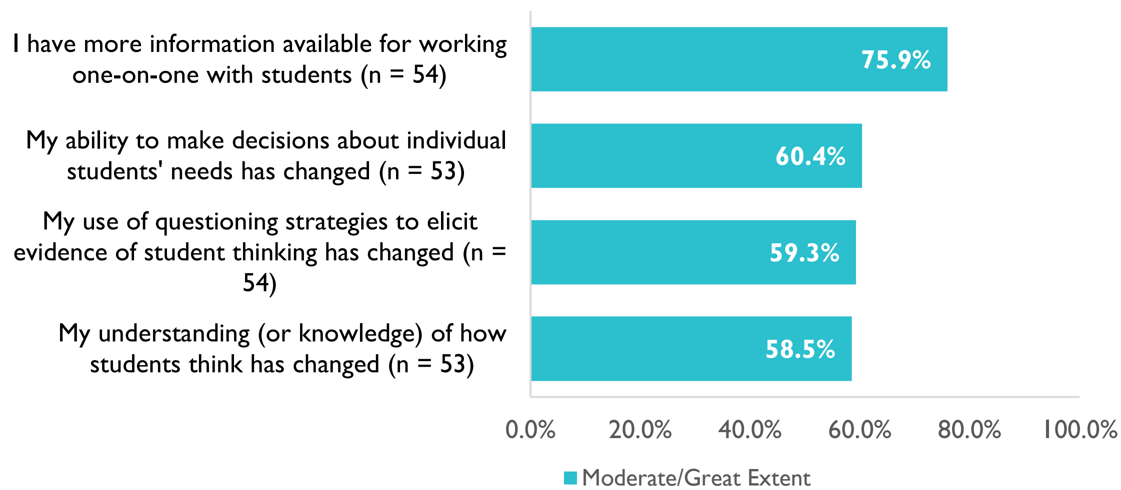

Figure 4. Impact of Learning Maps on Instructional Practice

Changes in Student Learning

The key themes that emerged from ELM participants' responses to what changes they observed in student learning include students have better understanding of topics, instructional changes positively impact students, students' skill set increased, increased student confidence, and improved performance. Thirty-seven teachers (nine ELA, 22 mathematics, and six participating in both content areas) answered this question.

Students' understanding has improved.

Three ELA teachers, six mathematics teachers, and two teachers participating in both content areas reported evidence of students understanding of topics improving. Many cited seeing "ah-ha!" moments happening in the classroom more often than before ELM was being used. One ELA teacher said,

I have observed that by going back to where the first misconception of a skill occurred, my students have had more "Ah-Ha!" moments when we "plug" the hole in their learning. Students have become more acceptable of *stopping and going back to find out where the "holes" are. In fact, one student said,"[Teacher], can we use the bubbles to find out my holes?" Success for sure!*

The respondents also stated that students are having an easier time grasping new concepts and have a better understanding of what each new unit is covering. Some respondents indicated that students are also realizing the steps needed to accomplish a goal.

Instructional changes are impacting the students.

Twelve teachers (four ELA, seven mathematics, and one from both content areas) spoke specifically of changes they've made to their instructional practices that they believe have impacted the students. Most discussed individualizing their instruction and students recognizing that as a positive change. One teacher spoke of her ability to better recognize student deficiencies and support them better. Another teacher said that the new methods of teaching foster better learning, specifically saying "methods of instruction are also very beneficial to fostering mathematicians rather than memorization."

Improved skills.

Two ELA and six mathematics teachers reported improved skill development in students. The ELA teachers both discussed an improvement in recognizing the steps needed to take to get to their goal, and how they seek resources on their own to accomplish that goal. The mathematics teachers reported students using problem solving strategies that had been taught for the learning maps, stating their learning targets, and self-assessing.

Some mathematics teachers also described the skills students are developing in being able to recognize and articulate their mistakes. One mathematics teacher said, "Students use more mathematics specific explanations in their response and are able to sometimes find their mistake when they are explaining their reasoning to me.'"

Increased confidence.

Five respondents (three mathematics and two from both content areas) commented on changes in student confidence. They discussed being able to see the changes in their students as they act with confidence now that they understand the content. One mathematics teacher reported seeing students taking more risks and attempting challenges without anxiety that they used to have. One teacher gave a specific example around test taking, stating, "Students shared their confidence in being prepared for a test instead of fear of taking a test."

Improved performance.

Two ELA and two mathematics teachers reported achievement and performance improvements. These teachers spoke of changes in testing scores, successful outcomes when trying new problems, and mastery of specific units of ELM. One mathematics teacher wrote in detail the concepts their students mastered:

> *I know that my students have learned the concept of place value more thoroughly in the past two years since I have been using the ELM unit 2.NBT.A.1,2. I have used it for the past 2 years and 90% of my students have mastered the concept in those years. Before, when I just used the regular curriculum, I had lower mastery and I know students had a great deal of trouble understanding expanded form of numbers. Now they understand it more fully using the numeral cards in Lesson 2. My students also have shown better understanding and mastery of arrays after using Unit 2.RA.B.3 than they have shown in the past using our regular curriculum only.*

Few teachers did indicate that there were no changes to student learning. Two teachers specified this was due to not using the program as much as they had originally planned.

Implementation Survey Summary

Following is a synopsis of key findings from the 73 teachers who responded to the implementation and impact survey.

Unit Implementation

- A majority of mathematics teacher respondents (63%) fully implemented one or two of the ELM units while 29% implemented between three and five units. Nearly 9% implemented more than 6 units.
- Similarly, 62% of ELA teacher respondents fully implemented one or two units and 33% implemented between three and five units. However, less than 5% fully implemented six or more units.
- More than one third of the respondents (36%) said they did not implement any units. Reasons for not using the ELM units included time, feeling overburdened with teaching duties, units not aligning with need, and issues using the program.
- When teaching a unit, the majority of respondents (approximately three fourths or more) reported they used the Instructional Activities, Student Handouts, and ELM Unit Map View to occasionally or frequently. The Summary of Research and the Teacher Notes Video were less frequently identified by respondents as materials they used.

Use of Maps

- Respondents most frequently reported using learning maps in planning for and teaching the ELM units (49%) or planning for and teaching state standards (45%).
- Approximately two thirds or more of teachers used the learning maps to adjust instructional practices to keep students moving towards learning goals (77%), identify where students are at in their learning (76%), work with struggling learners (76%), and personalize learning that was appropriate for students at different points in the learning pathways (70%).

- Respondents were less likely to use the maps to communicate students' progress to parents (26%).

Impact on Knowledge

- The most common impact on knowledge (40%) was changed instructional practices due to better understanding of the content areas.
- One third of teachers (33%) also reported increased understanding of the learning process their students are experiencing. A similar number (29%) reported having better knowledge of how different skills and standards are related.

Impact on Instruction

- Three fourths of respondents (76%) indicated that they now have more information available for working one-on-one with students.
- The majority of respondents also reported their ability to make decisions about individual students' needs (60%), their use of questioning strategies to gather evidence of student thinking (59%), and their understanding of how students think (59%) have all changed by a moderate to great extent.
- One fourth of respondents (26%) reported that because of their use of the learning maps they now individualize their instruction and modify it rather than using a set curriculum just as it is written.
- Respondents also indicated (15%) that they now stop to recognize the importance of foundational knowledge and having their students have the necessary skills to move forward to their goals rather than just getting through their curriculum. The same number of participants (15%) report involving students more in the learning process.

Impact on Student Learning

- Nearly one third of respondents (32%) indicated that they believe their students have a better understanding of content and they are seeing more "ah-ha!" moments in their classroom.
- One fifth of respondents (22%) also report their students having improved skills and problem-solving.
- Respondents also indicated that their students now appear to have more confidence (14%) and are performing better on particular units of study (11%).

Impact Study Design and Methods

In Year 4 (2018-19 school year), McREL conducted a study to examine the impact of the Enhanced Learning Maps on the performance of students whose teachers participated in the project.[10] The study was guided by three research questions. The primary question of interest focused on the impact of ELM on student performance. The second research question examined whether differing levels of teachers' ELM unit implementation impacted student performance. The third research question was exploratory and focused on whether there were differences in student performance for the differing number of years teachers participated in the ELM project. Research questions (RQ) were as follows:

RQ1. Are there differences in student performance for students experiencing the intervention (i.e., students' teachers used the ELM units) and a control group of students?

RQ2. Are there differences in student performance for students of teachers who have high, medium, and low usage of the ELM units?

RQ3. Are there differences in student performance for students of Cohorts 1 and 2 teachers and students of Cohort 3 teachers?

McREL conducted the impact study in collaboration with ELM project staff at KU. ELM project staff were responsible for establishing data sharing agreements with each state and securing the majority of the data. McREL performed propensity score matching (PSM) to identify the comparison group, conducted the analyses to answer each research question, summarized the findings, and authored this report. In the following sections, the data collection methods were described first because they were the methods used to determine the samples included in the impact analysis, followed by a description of the study samples as a result of the matching.

Data Collection Methods

Several different data sources were used to respond to the research questions. To answer research question 1 (*Are there differences in student performance for students experiencing the intervention [i.e., students' teachers used the ELM units] and a control group of students?*), student level demographic and achievement data and school-level demographic and achievement data were required. Research question 2 (*Are there differences in student performance for students of teachers who have high, medium, and low usage of the ELM units?*) required data on teachers' usage of the maps as well as student level achievement data. Research question 3 (*Are there differences in student performance for students of Cohorts 1 and 2 teachers and students of Cohort 3 teachers*) also necessity examining student level achievement data and teacher participation data. Following is a description of the data used in the impact study.

[10] Student data were not available from Missouri; hence it is not included in the impact study.

Student Level Demographic and Achievement Data

ELM project staff established data sharing agreements with each state partner for the purposes of receiving student-level demographic and achievement data for grades 4-8.[11] More specifically, the following data were used to conduct the PSM (See Appendix B for detail on the PSM methods):

Student-level 2018-19 demographic data:

- Race/ethnicity
- Gender
- Individualized Education Program (IEP)
- English Language Learner (ELL)
- Grade level

Student-level 2017-18 student achievement data (pretest covariate):

- ELA scale score
- Mathematics scale score

Student-level 2018-19 student achievement data:

- ELA scale score
- Mathematics scale score

In addition to requesting data from the states, ELM project staff also requested that each participating teacher provide basic student-level demographic data for their students using a secure online system (i.e., KITE). Student information includes student names, identification numbers, gender, birthdate, district and school names). Teachers were to provide this data for each student with whom the ELM maps and units were used (i.e., received the treatment) in 2018-19. After receiving the data from the states and teachers, ELM project staff merged the data sets and transmitted the de-identified data for McREL for the matching and analysis.

Extant Data

As a part of the ELM project application, participants were asked to provide demographic information (e.g., gender and race/ethnicity). ELM project staff maintained a database that included this information along with other data points such as whether they were a Cohort 1, 2, or 3 participant and the content area using the ELM units and learning maps (e.g., ELA, mathematics, or

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[11] Although the ELM project included grades 2-8 teachers, the impact study was limited to grades 4-8 since state level assessments are administered at grades 3-8. Baseline data (i.e., state assessment) were not available for students in grade 1-2.

both). ELM project staff merged the teacher participant data with the student-level data that ELM teachers provided in KITE.

Selection of a group of matched comparison students who were enrolled in similar schools as students in the participating schools required the need for 2018-19 school-level demographic data (or the most recently available) and 2017-18 school-level student achievement data. ELM project staff located this publicly available data and merged with the student and demographic data provided by each state. Specifically, the following data points were retrieved and used in the matching process:

School-level 2018-19 demographic data:

- School type (e.g., public, private, charter, etc.)
- Locale (e.g., urban, suburban, rural)
- School size
- Building type (i.e., elementary school, middle school, high school, elementary and middle school, middle and high school, K-12)
- % of students receiving free or reduced lunch

School-level 2017-18 student achievement data:

- % of students meeting proficiency in state standardized mathematics assessment
- % of students meeting proficiency in state standardized ELA assessment

ELM project staff added a variable to each state's student data set to identify the students who were in the treatment group (i.e., ELM students) and non-ELM students. Once all the data described above were merged into one comprehensive data set per state, ELM project staff generated a proxy identification number in a manner consistent with Family Educational Rights and Privacy Act (FERPA) regulations. Student names and student identification numbers were removed from the data set (i.e., deidentified data). Each state's deidentified data set was transmitted to McREL via access to a password protected server.

Teacher Survey

ELM project staff developed an online system for teachers to report implementation data on an ongoing basis in 2018-19. However, few teachers provided data. Therefore, it was determined to use data collected from the McREL Implementation and Impact Survey. The number of units taught reported by responding teachers was used as a proxy measure to define high, medium, and low usage (data needed to answer Research Question 2). McREL merged the relevant data from the teacher survey with the state data sets provided by ELM project staff.

Impact Study Samples

To understand the impact of ELM on student ELA and mathematics outcomes, state standardized assessment data were used to measure student achievement. Among the three participating states (Alaska, Kansas, and Wisconsin), state standardized assessments are administered to students from grades 3 to 8. Hence, the study samples only included students from grades 4 to 8 who would have both baseline and outcome data available for the matching and impact analysis. According to the project records, 76 teachers from the state of Alaska participated in the ELM training in Year 4. Of those, four teachers provided the data needed for the impact analyses with a response rate of 5%. For the state of Kansas, 18 out of 132 ELM teachers provided the data with a response rate of 14%. For the state of Wisconsin, five out of 29 ELM teachers provided the data with a response rate of 17%. Table 8 shows the breakdown of the number of teachers who provided student data for the matching and analyses by state and subject area. It is important to note that the samples included in the impact analyses are small subsamples (5-17%) of all teachers who participated in the project in Year 4; hence the generalizability of the findings from this impact analyses is limited.

Table 8. Study Samples Provided by State and Subject Area Before Matching

State	# Teachers Provided Student Data for the Impact Study				# Students	# Associated schools
	Cohort 1	Cohort 2	Cohort 3	Total		
ELA						
Alaska	0	0	2	2	53	2
Kansas	0	1	3	4	69	3
Wisconsin	0	0	0	0	0	0
Mathematics						
Alaska	0	1	1	2	45	2
Kansas	1	3	10	14	492	14
Wisconsin	1	0	4	5	110	5

Propensity Score Matching (PSM)

PSM was conducted for each study sample to identify a group of comparison students who came from schools that were similar to ELM schools and whose demographic characteristics were similar to ELM students.[12] The matching and impact analyses were conducted separately for each state because the state standardized tests across the three participating states were not directly comparable. Table 9 shows the sample sizes of the final matched samples by state and subject area. Details of PSM methods and processes are reported in Appendix B.

[12] The ELM project was a teacher-level intervention. The teacher is the unit of the implementation; hence, teacher-level covariates should be considered in the matching algorithm (Osborne, 2008). However, the participating states were unable to provide teacher-level data. Therefore, the matching was conducted at student-level by including both school-level and student-level covariates in the matching algorithm.

Table 9. Matched Sample Sizes by State and Subject Area

Study	After Matching						
	# Schools		# Students				
	ELM	Non-ELM	ELM (Total)				Non-ELM
			C1	C2	C3	Total	
ELA							
Alaska	1	29	0	0	48	48	217
Kansas	3	25	0	14	44	58	290
Mathematics							
Alaska	2	5	0	7	28	35	145
Kansas	14	63	3	131	332	466	2068
Wisconsin	2	14	0	0	92	92	397

C = cohort

Tables 10-14 describes the characteristics of the final study samples that were used in the impact analyses. Standardized mean differences of the covariates are also reported in the tables and were used to ascertain baseline equivalence on the covariates as a result of the matching. Rubin (2001) suggests that the standardized differences of means should be less than 0.25.

Table 10. Alaska ELA Sample Characteristics

Covariates	ELM Group			Non-ELM Group			Standardized Mean Difference
	n	*M*	*SD*	*n*	*M*	*SD*	
School Level							
ELAMet	48	0.06	0.00	217	0.04	0.03	0.22
Student Level							
Male	48	0.48	0.50	217	0.43	0.50	0.09
ELL	48	0.67	0.48	217	0.64	0.48	0.06
G6 [a]	48	0.52	0.50	217	0.54	0.50	0.04
G7 [a]	48	0.19	0.39	217	0.11	0.32	0.23
G8 [a]	48	0.29	0.46	217	0.35	0.48	0.12
ELA0	48	457.04	29.00	217	455.59	27.95	0.05

Note. All schools were small (with equal or less than 400 student enrollment) public schools serving students from kindergarten to 12th grade in the rural areas. All schools have 100% of students receiving free or reduced-price lunch. All students were from racial/ethnic minority backgrounds. All students were non-IEP students. Weights were applied when calculating the means and standard deviations.

[a] Fifth graders were the reference group.

Table 11. Kansas ELA Sample Characteristics

Covariates	ELM Group			Non-ELM Group			Standardized Mean Difference
	n	*M*	*SD*	*n*	*M*	*SD*	
School Level							
Rural [a]	58	0.43	0.50	290	0.44	0.50	0.03
MS [b]	58	0.19	0.40	290	0.20	0.40	0.02
MSHS [b]	58	0.24	0.43	290	0.25	0.43	0.02
SchFRPM	58	36.11	6.16	290	34.72	8.20	0.18
ELAMet	58	42.37	7.86	290	41.51	8.19	0.11
Student Level							
Minority	58	0.98	0.13	290	0.98	0.14	0.02
Male	58	0.45	0.50	290	0.49	0.50	0.09
G5 [c]	58	0.57	0.50	290	0.56	0.50	0.03
G6 [c]	58	0.19	0.40	290	0.20	0.40	0.03
G7 [c]	58	0.24	0.43	290	0.24	0.43	0.01
ELA0	58	296.48	21.77	290	297.23	21.48	0.03

Note. All schools were small public schools with equal of less than 400 student enrollment. All students were non-IEP and non-ELL students. Weights were applied when calculating the means and standard deviations.

[a] Suburb schools were the reference group.

[b] Elementary schools were the reference group.

[c] Fourth graders were the reference group.

Table 12. Alaska Mathematics Sample Characteristics

Covariates	ELM Group			Non-ELM Group			Standardized Mean Difference
	n	*M*	*SD*	*n*	*M*	*SD*	
School Level							
Rural [a]	35	0.20	0.41	145	0.23	0.42	0.07
SchFRPM	35	0.56	0.14	145	0.62	0.13	0.30 [c]
MathMet	35	0.33	0.05	145	0.33	0.06	0.07
Student Level							
Minority	35	0.69	0.47	145	0.71	0.46	0.05
Male	35	0.51	0.51	145	0.55	0.50	0.06
ELL	35	0.17	0.38	145	0.13	0.34	0.11
G6 [b]	35	0.80	0.41	145	0.82	0.39	0.04
Math0	35	495.54	41.43	145	494.32	41.33	0.03

Note. All schools were small (with equal to or less than 400 student enrollment) public elementary schools. All students were non-IEP students. Weights were applied when calculating the means and standard deviations.

[a] City schools were the reference group.

[b] Fourth graders were the reference group.

[c] The value was higher than the recommended cut-off value of 0.25. Therefore, there is some imbalance between the ELM group and the non-ELM group in terms of the % of students receiving free or reduced-lunch price. This variable was entered in the analytic model again to account for the baseline imbalance.

Table 13. Kansas Mathematics Sample Characteristics

Covariates	ELM Group			Non-ELM Group			Standardized Mean Difference
	n	*M*	*SD*	*n*	*M*	*SD*	
School Level							
Public	466	0.97	0.16	2068	0.98	0.13	0.07
Suburb [a]	466	0.17	0.37	2068	0.17	0.37	0.00
Town [a]	466	0.22	0.41	2068	0.24	0.43	0.05
Rural [a]	466	0.54	0.50	2068	0.54	0.50	0.00
Medium [b]	466	0.42	0.49	2068	0.42	0.49	0.00
Large [b]	466	0.24	0.43	2068	0.19	0.40	0.12
MS [c]	466	0.77	0.42	2068	0.71	0.46	0.13
ESMS [c]	466	0.03	0.16	2068	0.03	0.16	0.00
SchFRPM	466	50.38	13.93	2068	50.84	14.60	0.03
MathMet	466	32.20	10.83	2068	32.93	11.31	0.07
Student Level							
Minority	466	0.95	0.22	2068	0.95	0.22	0.00
Male	466	0.49	0.50	2068	0.50	0.50	0.02
ELL	466	0.09	0.29	2068	0.08	0.28	0.04
G5	466	0.19	0.39	2068	0.16	0.36	0.08
G6	466	0.41	0.49	2068	0.32	0.46	0.19
G7	466	0.31	0.46	2068	0.35	0.48	0.08
G8	466	0.03	0.16	2068	0.03	0.17	0.00
Math0	466	292.25	22.99	2068	290.55	21.86	0.08

Note. All students were non-IEP students. Weights were applied when calculating the means and standard deviations.

[a] City schools were the reference group

[b] Small districts were the reference group

[b] Elementary schools were the reference group

Table 14. Wisconsin Mathematics Sample Characteristics

Covariates	ELM Group			Non-ELM Group			Standardized Mean Difference
	n	*M*	*SD*	*n*	*M*	*SD*	
School Level							
Medium [a]	92	0.84	0.37	397	0.89	0.31	0.17
MS [b]	92	0.84	0.37	397	0.86	0.35	0.07
SchFRPM	92	40.60	9.48	397	41.91	7.57	0.16
MathMet	92	0.45	0.09	397	0.46	0.09	0.13
Student Level							
Minority	92	0.21	0.41	397	0.22	0.42	0.03
Male	92	0.50	0.50	397	0.48	0.50	0.04
ELL	92	0.07	0.25	397	0.09	0.28	0.08
G7 [c]	92	0.84	0.37	397	0.86	0.35	0.07
Math0	92	617.46	30.89	397	622.32	40.05	0.13

Note. All schools were public schools in rural areas. All students in the sample were non-IEP students. Weights were applied when calculating the means and standard deviations.

[a] Small size districts were the reference group.

[b] Elementary schools were the reference group.

[c] Fourth graders were the reference group.

Data Analysis

Two-level hierarchical linear modeling[13] was used to address the first research question—*Are there differences in student performance for students experiencing the intervention (i.e., students' teachers used the ELM units) and a control group of students?* program. This analysis method explicitly took into account the structure of the data where students are nested within schools. The hierarchical linear model was run separately for each of the study samples. Additionally, all relevant covariates used in the matching, as shown in Tables 10-14, were entered in the analytic model for the purpose of control.

The second research question is—*Are there differences in student performance for students of teachers who have high, medium, and low usage of the ELM units?* To answer this question, the data provided by the states were merged with the teacher survey data. In the survey, teachers were asked to provide a rating on two items–*In this school year, how many ELM English language arts units did you use to deliver instruction to students? In this school year, how many ELM mathematics units did you use to deliver instruction to students?* The ELA item was used to measure ELA teachers' level of implementation, and the mathematics item was used to measure mathematics teachers' level of implementation. Each item had seven categories of responses: (1) 1 unit, (2) 2 units, (3) 3 units, (4) 4 units, (5) 5 units, (6) 6 units, and (7) more than 6 units. Teachers who selected (1) and (2) were grouped as low

[13] By design, ELM project was a teacher-level intervention. All students taught by the participating teachers received the intervention. However, limited by the available data, the matching was conducted at the student-level. When analyzing the data to estimate the effect of the intervention, the treatment status was entered at the student-level.

implementers; teachers who reported (3) and (4) were grouped as medium implementers; and teachers who reported (5), (6) or (7) were grouped as high implementers. Depending on the sample size of the final sample after data merging, [14]linear regression or multilevel model[15] was employed to examine the relationship of the level of implementation and student achievement outcomes while taking student and school-level covariates into account.

The third research question is— *Are there differences in student performance for students of Cohorts 1 and 2 teachers and students of Cohort 3 teachers?* By the end of the project period, ELM participants had different years of experience with ELM, ranging from one to three years. To explore whether teachers with more years of experience with ELM may be more effective, exploratory analyses were conducted by taking teachers' years of experience with ELM into account. Instead of treating all ELM students as one treatment group, two dummy variables were entered in the model using the non-ELM students as the reference group to present teachers' years of experience with ELM—NoPriorELM (1 = students of Cohort 3 teachers, 0 = non-ELM students) and PriorELM (1 = students of Cohorts 1 and 2 teachers, 0 = non-ELM students). It is important to note that PSM balanced the *total* ELM group with the *total* control group rather than the subgroups (teachers with various years of experience with ELM) with corresponding control groups. Therefore, findings from this part of the analyses should be considered exploratory. If there is interest to further examine whether teachers with more years of experience with ELM are more effective, researchers should consider conducting the matching separately for each subgroup. This analysis was conducted with the study samples that had students where the teachers represented more than one cohort (see Table 8). This included the Kansas ELA, Alaska mathematics, and Kansas mathematics study samples.

Effect sizes for these analyses were calculated using Hedge's g, which is the adjusted mean difference divided by the unadjusted pooled within-group standard deviation (U.S. Department of Education, 2014). It is important to consider the magnitude of an effect when placing findings into a broader context. Statistical significance will measure whether a program effect is due to chance, whereas effect sizes measure the strength or magnitude of the program's effectiveness and are not sensitive to the sample sizes. McREL researchers consider an effect size of 0.25 or greater to be educationally meaningful, and an effect size between 0.13 and 0.20 to be substantively important. These benchmarks are based on the What Works Clearinghouse's methodological guidelines (U.S. Department of Education, 2014) and on a Lipsey et al. (2012) article, which reported an average effect size of 0.13 for 227 randomized controlled trials that examined the effect of curricula or broad instructional programs.

[14] When the number of clusters is small (e.g., smaller than 5), linear regression is more appropriate. To account for the clustering effect, cluster dummy variables were created and entered into the model.
[15] In this analysis, teacher's level of implementation is treated as a teacher-level predictor. Therefore, a three-level multilevel model was conducted when the sample size (e.g., number of teachers and schools remained in the sample after merging the datasets) is sufficient for such analysis.

Findings

This section discusses findings from the impact analyses. The analyses were conducted separately using five study samples. Findings are organized by study sample, and with each study sample, findings for the three proposed research questions (RQ) were presented. It is important to note that the study samples from the participating states were only a subset of students who were impacted by the program, generalizability of the findings were limited.[16] Additionally, each study sample involved students from different socioeconomic backgrounds within different school contexts, findings across five studies may not be directly comparable.[17] Readers should interpret the findings with these limitations in mind.

Alaska ELA Outcome

Study sample. The Alaska ELA sample included 48 ELM students from two schools as well as 217 non-ELM students from 29 schools. All schools were small K12 public schools with student enrollment numbers equal to or smaller than 400. Within these schools, both ELM and non-ELM, 100% received free or reduced-price lunch. All of the ELM and the selected non-ELM students were non-IEP students from racial/ethnic minority backgrounds. The sample included students from grades 5 to 8. More details regarding student demographic characteristics are reported in Table 10.

RQ1. Impact estimate. Two-level hierarchical linear modeling was conducted to examine the impact of the ELM on student ELA outcomes. Results showed that ELM students did not differ from non-ELM students on their ELA achievement as measured by the Alaska state standardized assessment ($\beta = 1.80$, $SE = 10.6$, $p = 0.462$, ES = 0.07).

RQ2. Relationship between levels of implementation and student outcomes. All students remained in the study sample after merging the state data with the survey data were taught by one teacher. Therefore, this study sample cannot be used to address Research Question 2.

RQ3. Exploratory analysis of impact estimates by teachers' years of experience with ELM. All ELM students who remained in the study sample after the matching were taught by one Cohort 3 teacher. Therefore, this study sample cannot be used to address Research Question 3.

Kansas ELA Outcome

Study sample. The Kansas ELA sample included 58 ELM students from three schools as well as 290 non-ELM students from 58 schools. All schools were small public schools with student enrollment equal to or less than 400. Within these schools, about one third (34-36%) of the students

[16] The samples included in the impact analyses are small subsamples (5-17%) of all teachers who participated in the ELM project.
[17] No Wisconsin ELA teachers provided student data; therefore a study was not conducted for impact on Wisconsin ELA outcomes.

received free or reduced-price lunch. All of the ELM and the selected non-ELM students were non-IEP students, and the majority of them (98%) were from racial/ethnic minority backgrounds. The sample included students from grade 4 to 7. More details regarding student demographic characteristics are reported in Table 11.

RQ1. Impact estimate. Two-level hierarchical linear modeling was conducted to examine the impact of the ELM on student ELA outcomes. Results showed that ELM students did not differ from non-ELM students on their ELA achievement as measured by the Kansas state standardized assessment (β = -0.22, *SE* = 2.42, p = 0.928, ES = 0.01).

RQ2. Relationship between levels of implementation and student outcomes. After merging the state data with the teacher survey data, two teachers remained in the merged dataset—one from Cohort 3 and one from Cohort 2. The Cohort 3 teacher reported that, in Y3, he/she used four ELM English language arts units to deliver instruction to students (medium implementer). The Cohort 2 teacher reported that, in Y3, he/she used two ELM English language arts units to deliver instruction to students (low implementer). Linear regression model was conducted, and results showed that the relationship between level of implementation and student ELA achievement was not statistically significant (β = 2.36, *SE* = 7.15, p = 0.744, R^2 = 0.004[18]).

RQ3. Exploratory analysis of impact estimates by teachers' years of experience with ELM. Within the ELM group, 14 students were taught by one Cohort 2 teacher and 44 were taught by three Cohort 3 teachers. Findings of the exploratory analysis revealed that teachers' prior experience with ELM before grant Year 3 seemed to have a negative association with student ELA achievement. That is,

- ELM students whose teacher had prior experience with ELM before grant Year 3 had significantly lower ELA scores compared to non-ELM students whose teachers were not involved in the project at all (β = -18.51, *SE* = 8.36, p = 0.028), and the magnitude of the difference was practically significant (ES = 0.51).
- ELM students whose teachers had no prior experience with ELM before grant Year 3 had significantly higher ELA scores compared to non-ELM students whose teachers were not involved in the project at all (β = 16.77, *SE* = 6.00, p = 0.006), and the magnitude of the difference was educationally significant (ES = 0.46).

Given the limitation of the analyses—The matching balanced the difference between the total ELM group and the total control group rather than the ELM subgroups and the control group. These findings should be interpreted with caution and should only be considered as exploratory.

[18] Level of implementation explained 0.4% of the variance in student ELA outcomes.

Alaska Mathematics Outcome

Study sample. The Alaska mathematics sample included 35 ELM students from two schools as well as 145 non-ELM students from five schools. All schools were small public schools with student enrollment numbers equal to or smaller than 400. All of the ELM and the selected non-ELM students were non-IEP students, and more than two thirds (69-71%) were from racial/ethnic minority backgrounds. The sample included students from grades 4 and 6. More details regarding student demographic characteristics are reported in Table 12.

RQ1. Impact estimate. Two-level hierarchical linear modeling was conducted to examine the impact of the ELM on student mathematics outcomes. Results showed that ELM students did not differ from non-ELM students on their mathematics achievement as measured by the Alaska state standardized assessment (β = 5.57, SE = 5.10, p = 0.276, ES = 0.15).

RQ2. Relationship between levels of implementation and student outcomes. After merging the state data with the teacher survey data, only one teacher remained in the merged dataset. Therefore, this study sample cannot be used to address Research Question 2.

RQ3. Exploratory analysis of impact estimates by teachers' years of experience with ELM. Within the ELM group, seven students were taught by one Cohort 2 teacher and 28 were taught by one Cohort 3 teacher. Findings of the exploratory analysis revealed that teachers' prior experience with ELM did not make a difference. That is, students whose teacher had prior experience with ELM before grant Year 3 did not differ from the non-ELM students whose teachers had no experience with ELM at all (β = -4.90, SE = 4.64, p = 0.291, ES = 0.18) in ELA scores. Additionally, students whose teacher had no prior experience with ELM before grant Year 3 did not differ from the non-ELM students whose teachers had no experience with ELM at all (β = 1.25, SE = 2.71, p = 0.644, ES = 0.05) in ELA scores.

Kansas Mathematics Outcome

Study sample. The Kansas mathematics sample included 466 ELM students from 14 schools as well as 2,068 non-ELM students from 63 schools. Ninety-eight percent of the students were enrolled in the public schools. All of the ELM and the selected non-ELM students were non-IEP students, and 95% were from racial/ethnic minority backgrounds. The sample included students from grades 4 to 8. More details regarding student demographic characteristics are reported in Table 13.

RQ1. Impact estimate. Two-level hierarchical linear modeling was conducted to examine the impact of the ELM on student mathematics outcomes. Results showed that ELM students did not differ from non-ELM students on their mathematics achievement as measured by the Kansas state standardized assessment (β = -0.03, SE = 0.86, p = 0.976, ES = 0.00).

RQ2. Relationship between levels of implementation and student outcomes. After merging the state data with the teacher survey data, eight teachers remained in the merged dataset.

The level of implementation ranged from two units to more than six units. Three-level multilevel modeling was conducted to examine the association between levels of implementation and student mathematics outcomes while taking student-level and school-level covariates into account. Teachers were grouped into three groups: low implementers, medium implementers, and high implementers. Using this information, two dummy variables were created and entered in the analytical model to examine whether there is a difference between low implementers and medium implementers, or between low implementers and high implementers. Results revealed that, the difference between low implementers and medium implementers was not statistically significant ($\beta = 5.78$, $SE = 2.39$, $p = 0.052$); yet, the magnitude of the difference was not negligible (ES = 0.24). Similarly, the difference between low implementers and high implementers was not statistically significant ($\beta = 4.56$, $SE = 2.17$, $p = 0.080$), but the magnitude of the difference was not negligible (ES = 0.19).

RQ3. Exploratory analysis of impact estimates by teachers' years of experience with ELM. Within the ELM group, three students were taught by one Cohort 1 teacher, 131 students were taught by three Cohort 2 teachers, and 332 were taught by 10 Cohort 3 teachers. Findings of the exploratory analysis revealed that teachers' prior experience with ELM before grant Year 3 seemed to have a positive association with student mathematics achievement. That is,

- ELM students whose teacher had prior experience with ELM before grant Year 3 (Cohort 1 and Cohort 2 teachers) had significantly higher mathematics scores compared to non-ELM students whose teachers were not involved in the project at all ($\beta = 7.16$, $SE = 1.60$, $p < 0.001$), and the magnitude of the difference was educationally significant (ES = 0.28).
- ELM students whose teachers had no prior experience with ELM before grant Year 3 had significantly lower mathematics scores compared to non-ELM students whose teachers were not involved in the project at all ($\beta = -2.72$, $SE = 1.03$, $p = 0.008$). However, the magnitude of the difference was minimal (ES = 0.11).

Given the limitation of the analyses—The matching balanced the difference between the total ELM group and the total control group rather than the ELM subgroups and the control group. These findings should be interpreted with caution and should only be considered as exploratory.

Wisconsin Mathematics Outcome

Study sample. The Wisconsin mathematics sample included 92 ELM students from two schools as well as 397 non-ELM students from 14 schools. All schools were public schools in the rural areas with 41-42% of students receiving free or reduced-lunch price. All of the ELM and the selected non-ELM students were non-IEP students, and 21-22% of the students were from racial/ethnic minority backgrounds. The sample included students from grade 4 and 7. More details regarding student demographic characteristics are reported in Table 14.

RQ1. Impact estimate. Two-level hierarchical linear modeling was conducted to examine the impact of the ELM on student mathematics outcomes. Results showed that ELM students did not differ from non-ELM students on their mathematics achievement as measured by the Wisconsin state standardized assessment ($\beta = 2.10$, $SE = 4.03$, $p = 0.603$, ES = 0.04).

RQ2. Relationship between levels of implementation and student outcomes. After merging the state data with the teacher survey data, only two teachers remained in the merged dataset. Both teachers reported the same level of implementation—used one ELM mathematics unit in their instruction. Therefore, this study sample cannot be used to address Research Question 2.

RQ3. Exploratory analysis of impact estimates by teachers' years of experience with ELM. All ELM students who were remained in the study sample after matching were taught by three Cohort 3 teachers. Therefore, this study sample cannot be used to address Research Question 3.

Summary and Recommendations for Future Research

The overall findings from the impact analyses revealed that ELM students and non-ELM students did not differ in ELA and mathematics achievement scores across all five study samples. However, some additional exploratory analyses seemed to provide some interesting findings.

First, when examining the association between teachers' level of implementation and student outcomes, one study sample provides some promising findings—With the Kansas mathematics sample, students of the high implementers (teachers used at least five ELM mathematics units in their instruction) and medium implementers (teachers used three to four ELM units in their instruction) seemed to have higher mathematics scores compared to students of the low implementers (teachers used 1 or two ELM units in their instruction). That is, although there is no statistical significance on students' mathematics achievement between low implementers and medium implementers ($p = 0.052$) or between low implementers and high implementers ($p = 0.080$), the magnitude of the difference between them were not negligible (ES = 0.19 – 0.24). This finding is consistent with the theory—students of teachers with a higher level of implementation may benefit more from the intervention compared to students of teachers with a lower level of implementation.

Second, exploratory analyses examining the relationship between teachers' prior experience with ELM before project Year 4 and student achievement outcome revealed some mixed findings. These findings are summarized below.

- With the Alaska mathematics sample, students of teachers with prior experience with ELM before Year 4 (Cohorts 1 and 2 teachers) had significantly *lower* mathematics scores compared to students of teachers who were not involved in the ELM project at all (i.e., comparisons) ($p = 0.028$), and the magnitude of the difference was practically significant (ES = 0.51). In contrast, students of teachers without prior experience with ELM before Year 4 (Cohort 3 teachers) had significant *higher* mathematics scores compared to comparisons ($p = 0.006$), and the magnitude of the difference was educationally significant (ES = 0.46).

- With the Kansas mathematics sample, students of teachers with prior experience with ELM before Year 4 (Cohorts 1 and 2 teachers) had significantly *higher* mathematics scores compared to students of teachers who were not involved in the ELM project at all (i.e., comparisons) ($p < 0.001$), and the magnitude of the difference was educationally significant (ES = 0.28). In contrast, students of teachers without prior experience with ELM before Year 4 (Cohort 3 teachers) had significant *lower* mathematics scores compared to comparisons ($p = 0.008$); yet, the magnitude of the difference was minimal (ES = 0.11).

In theory, one would expect that teachers with prior experience with the project would be more effective and their students would perform better compared to comparisons. Findings from the Kansas mathematics sample supported the hypothesis; however, findings from the Alaska mathematics sample did not support the hypothesis. Regardless, given the exploratory nature of the analysis, interpretation of the findings should be with caution (see the Data Analysis section for the limitation of the exploratory analyses). A limitation is that the study samples only represented small subgroups of the students that were impacted by the project. Only 5% to 17% of the participating teachers provided the data needed for the analyses, findings of the current impact analyses cannot be generalized to the population impacted by the project nor the larger population across the participating states. Most importantly, with only a small number of teachers providing data, there is a concern of self-selection bias. Teachers who provided data may be different from the teachers who did not provide the data for the project in terms of their engagement and motivation characteristics.

Considering the findings from the impact analyses within the context of implementation, based on the Spring 2019 implementation survey data, a fairly substantial percentage of respondents (36%) indicated that they did not teach any of the ELM units in 2018-19. Furthermore, approximately one fourth of the respondents did not access the ELM maps following the training. Of the teachers who used the ELM units, three fourths said they taught one or two of them. Taking into consideration the 27 teachers who provided student data, 15 responded to the implementation survey. Nearly one half of those 15 teachers (47%) indicated they taught one or two units in 2018-19 (defined as low implementors) while an additional 40% taught three or four units (medium implementors). A small percentage (13%) reported teaching five or more units (high implementors).

Although there is no evidence to support the efficacy of ELM units on student ELA and mathematics outcomes (Research Question 1), the exploratory analyses and results provided some encouraging findings (Research Questions 2 and 3). The following recommendations are provided for implementation of similar projects and future study of the use of the Enhanced Learning Maps.

1. The implementation survey data suggests usage of the units was low and a number of teachers did not access the learning maps beyond the training. Processes and structures should be identified to support teacher implementation. For example, consider school-level recruitment and implementation and identifying an implementation coordinator (i.e., literacy or math coach trained in ELM).
2. By design, the project was developed in Year 1, initially implemented in Years 2 and 3 and refinements were made based on teacher feedback, and scaled up within each partner state in Year 4. This was an ambitious cycle and consequently the project was scaled up immediately after development. It is recommended that greater focus be placed on material development and understanding implementation prior to undertaking scale up.
3. The ELM project represented a partnership with a higher education research institution and state education agencies (SEA). Critical to the ELM project's sustainability is having strong partnerships with each SEA throughout the project lifespan. The SEAs are the key to sustaining the project beyond the life of the grant. Given that ELM requires structure support (e.g., transfer of the software to the appropriate servers, updating the maps and units), it is important to discuss whether and how to build the states' capacity to do that after the grant as part of the project objectives.
4. Very few of the teachers provided student data. Coupled with low levels of implementation, it was difficult to draw any conclusions about the impact of ELM on students' performance.

Consider recruitment at the school or district levels versus the teacher level. This approach has several benefits including having multiple teachers in a building that are trained and able to support one another, students having greater exposure to ELM, and efficient collection of student data (i.e., individual teachers relieved of that burden).

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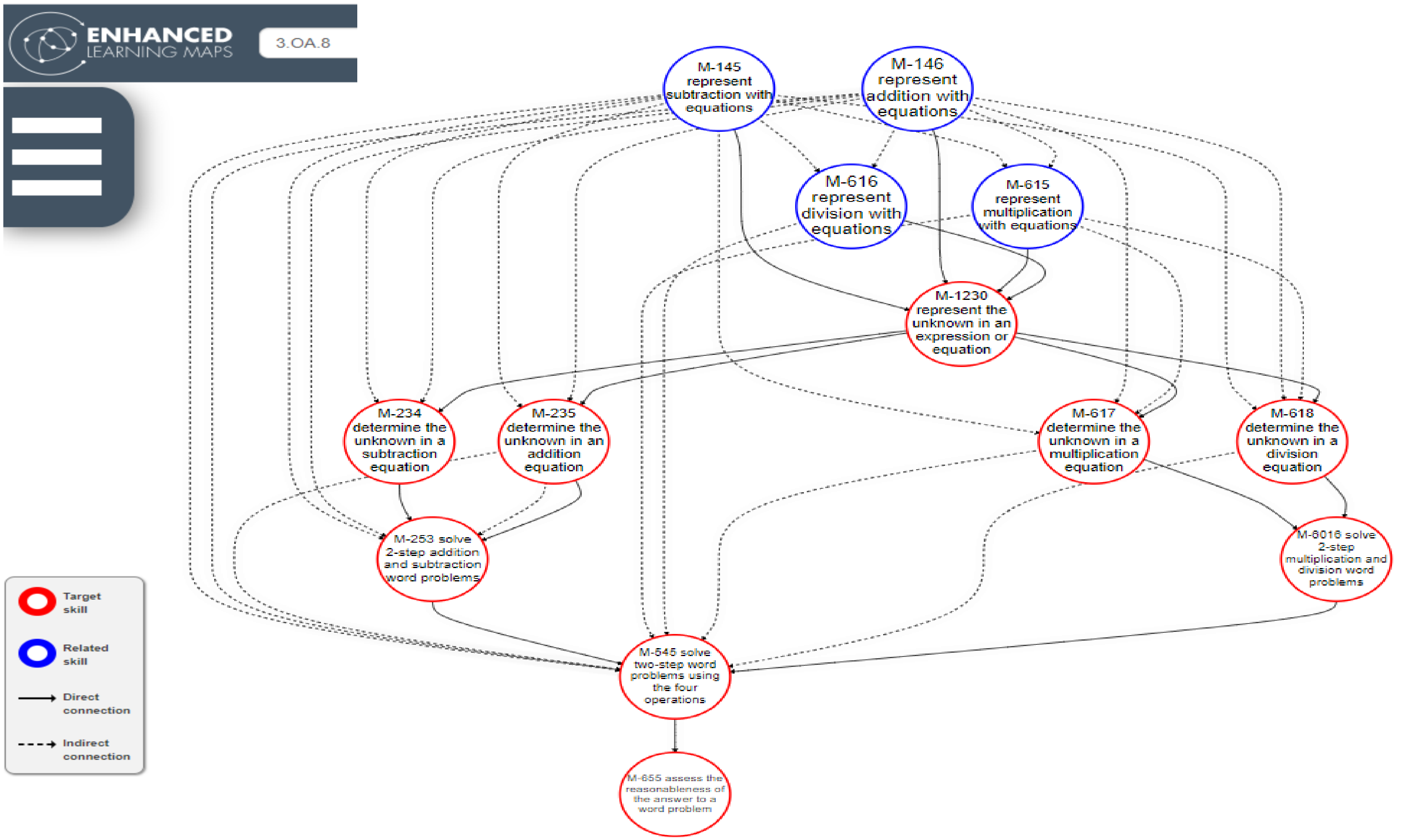
Appendix A: ELA and Mathematics Map View Samples

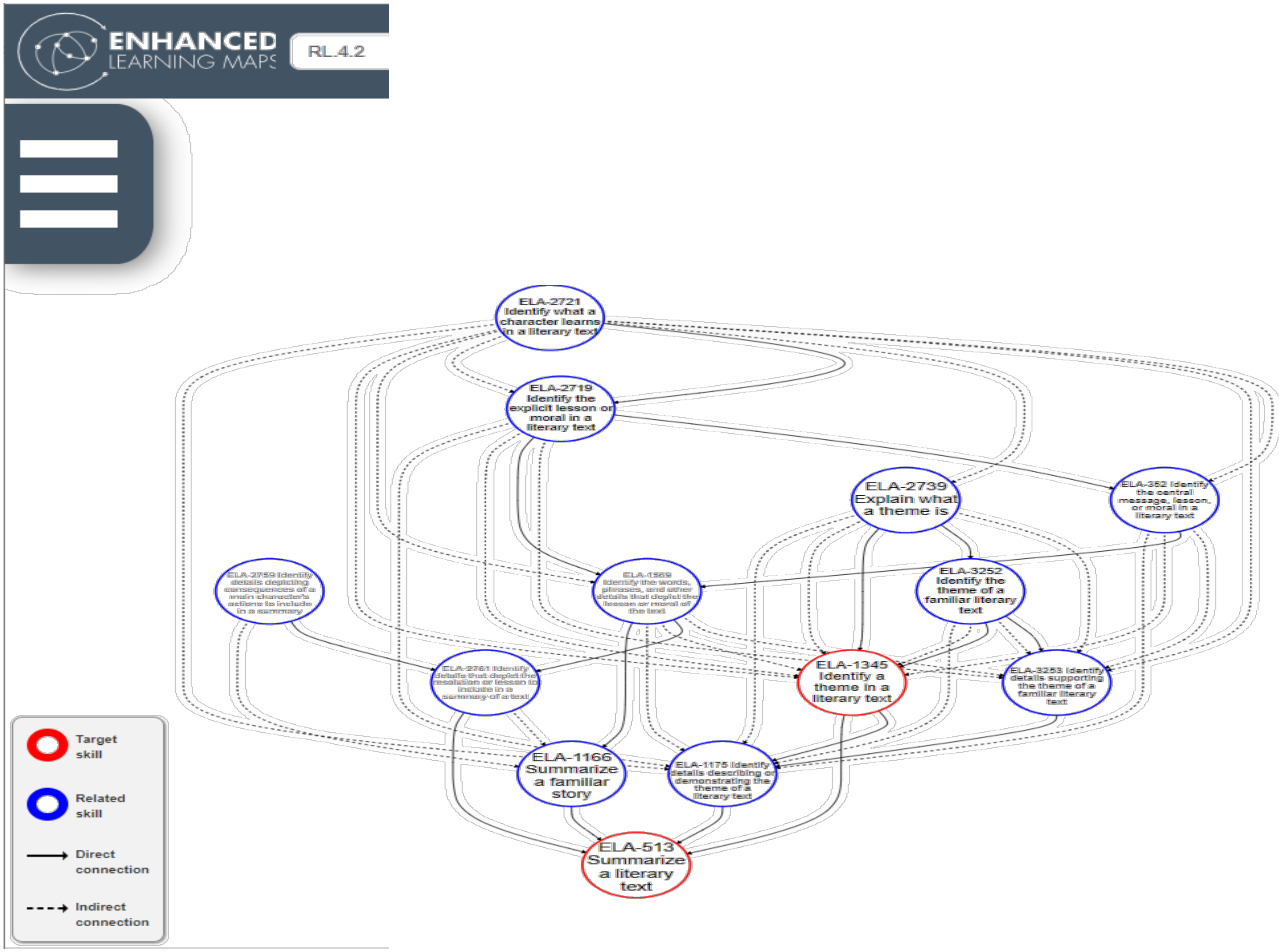
Example Mathematics Learning Map for Standard 3.OA.8

3.OA.8: Solve two-step word problems using any of the four operations. Represent these problems using both situation equations and/or solution equations with a letter or symbol standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. This standard is limited to problems posed with whole numbers and having whole-number answers.



Example English Language Arts Learning Map for Standard RL.4.2

RL.4.2: Determine a theme of a story, drama, or poem from details in the text; summarize the text



Appendix B: Summary of PSM Results

Matching was conducted separately by subject area and state. The matching methods and procedures used to identify each study sample are described in this appendix.

Matching Methods

PSM was conducted to identify matched comparisons for the five study samples that examined the impact of ELM on student outcomes. Specifically, two studies including study samples from Alaska and Kansas that examined the impact of ELM on student ELA achievement, and three studies including study samples from Alaska, Kansas, and Wisconsin that examined the impact of ELM on student mathematics achievement.[19] With each study sample, matching was done using logistic regression to obtain a propensity score representing the probability that a unit with certain characteristics was assigned to the treatment group. After propensity scores were estimated, a one-on-five nearest neighbor matching algorithm with a caliper of 0.20 and without replacement was used to identify five comparison students per ELM student based on the specified school- and student-level covariates. Table A1 shows the list of covariates that were included in the matching. Some covariates may be coded differently depending on the characteristics of the study samples. Additionally, PSM requires complete information. Therefore, cases with missing data on the covariates were removed before matching. In some cases, some school-level covariates were omitted from the matching algorithm if it would drastically decrease the sample size when the covariates were included in the matching. Variations in terms of the coding and covariates included in the matching, if any, were presented in Table A1.

Table A1. Covariates

Covariate	Definition	Variables included in the matching
School-Level Covariates		
School Type	School types include public, private and charter. All ELM schools in the Alaska_ELA, Alaska_Mathematics, Kansas_ELA, Wisconsin_Mathematics data sets were public schools; hence, non-public schools were removed from the datasets before matching. In the Kansas_Mathematics dataset, ELM schools were either public or charter schools. A binary variable was created with public as 1 and charter as 0.	Public
School Locale	Alaska_ELA: ELM schools were either in the town or rural areas. A binary variable was created with rural as 1 and town as 0. Schools that were not located in a town or rural areas were removed from the dataset before matching.	Rural

[19] No Wisconsin ELA teachers provided student data; therefore a study was not conducted for impact on Wisconsin ELA outcomes.

Covariate	Definition	Variables included in the matching
	Alaska_Mathematics: ELM schools were either in the city or rural areas. A binary variable was created with rural as 1 and city as 0. Schools that were not located in a city or rural areas were removed from the dataset before matching.	
	Kansas_ELA: ELM Schools were either in the suburb or rural areas. A binary variable was created with rural as 1 and suburb as 0. Schools that were not located in a suburb or rural areas were removed from the dataset before matching.	
	Kansas_Mathematics: ELM schools were located in city, suburb, town or rural areas. A binary variable was created with rural as 1 and others as 0.	
	Wisconsin_Mathematics: ELM schools were either in the suburb or rural areas. A binary variable was created with rural as 1 and suburb as 0. Schools that were not located in a suburb or rural areas were removed from the dataset before matching.	
School size	Schools with equal to or less than 400 students were categorized as small size schools; schools with student enrollment between 401 and 800 were categorized as medium size schools; schools with equal or greater than 801 schools were categorized as large size schools. Two dummy variables were created and used in the matching with small schools serving as the reference group.	Medium; Large
Building Type	Alaska_ELA: ELM schools were either elementary or K-12 schools. Schools that were not elementary or K-12 were removed from the dataset before matching. A binary variable was created with elementary as 1 and K-12 as 0.	ES
	Alaska_Mathematics: ELM schools were all elementary schools. Schools that were not elementary schools were removed from the dataset before matching.	--
	Kansas_ELA: ELM schools were either elementary, middle, or middle/high schools. Schools that were not elementary, middle or middle/high schools were removed from the dataset before matching. Two dummy variables were created and used in the matching with elementary schools serving as the reference group.	MS; MSHS
	Kansas_Mathematics: ELM schools were either elementary, elementary/middle, or middle schools. Schools that were not elementary, elementary/middle, or middle schools were removed from the dataset before matching. Two dummy variables were created and used in the matching with Elementary schools served as the reference group.	ESMS; MS
	Wisconsin_Mathematics: ELM schools were either elementary or middle schools. Schools that were not elementary or middle schools were removed from the dataset before matching. A	ES

Covariate	Definition	Variables included in the matching
	binary variable was created and used in the matching with elementary schools as 1 and middle schools as 0.	
Percentage of students in the free or reduced-lunch meal program (FRPM)	Percentage of enrolled students in the FRPM program.	SchFRPM
Percentage of students meet or master grade level standards	Percentage of enrolled students who met or mastered grade level standards on the state standardized assessments in mathematics and ELA.	ELAMet; MathMet
Student-level Covariates		
Minority	Students who were from racial/ethnic minority backgrounds were coded as 1, and students who were White/Caucasian were coded as 0.	Minority
Gender	Male students were coded as 1 and female students were coded as 0.	Male
IEP status	Students with IEP were coded as 1 and non-IEP students were coded as 0.	IEP
ELL status	ELL students were coded as 1 and non-ELL student was coded as 0.	ELL
Grade level	Alaska_ELA: ELM students were in 5th, 6th, 7th, and 8th grades. Students who were not in these grade levels were removed from the sample before matching. Three dummy variables were created with 5th grade as the reference groups.	G6, G7, G8
	Alaska_Mathematics: ELM students were in either 4th or 6th grade. Students who were not 4th or 6th grades were removed from the sample before matching. A binary variable was created with 4th grade as 0 and 6th grade as 1.	G6
	Kansas_ELA: ELM students were in 5th, 6th and 7th grades. Students who were not in these grade levels were removed from the sample before matching. Two dummy variables were created with 5th grade as the reference groups.	G6 and G7
	Kansas_Mathematics: ELM students were in 4th to 8th grades. Four dummy variables were created and used in the matching with 4th graders served as the reference group.	G5, G6, G7, G8
	Wisconsin_Mathematics: ELM students were in 4th to 7th grades. Three dummy variables were created and used in the matching with 4th graders served as the reference group.	G5, G6, G7
Student baseline achievement score	Student achievement scale score in mathematics or ELA obtained at baseline.	ELA0, Math0

After the matching process was complete, balance diagnostics were conducted to check the quality of the matches. First, an examination of the distribution of propensity scores was conducted to assess common support via a graphic diagnostic. Then, three numerical balance measures were used to check covariate balances (Rubin, 2001):

- The ratio of the variances of the propensity scores in the two groups must be close to 1.0. Rubin (2001) suggests that the variance ratios should be between 0.5 and 2.0.
- The difference in the means of the propensity scores in the two groups being compared must be small. Rubin (2001) suggests that the standardized differences of means should be less than 0.25.
- For the percent of balance improvement, the larger the percent, the better the PSM results.

During the matching process, cases that did not have similar comparisons were removed from the datasets by the program. Table A2 is a snapshot of the types of covariates included in the matching for each study sample.

Table A2. Crosswalk of Covariates by Study Sample

Covariate	Alaska	Kansas	Alaska	Kansas	Wisconsin
School-level Covariates					
School type				x	
School locale	x	x	x	x	x
School size	x	x	x	x	x
Building type	x	x	x	x	x
Percentage of FRPM students	x	x	x	x	x
Percentage of students meeting or mastering grade level standards [a]	x	x		x	x
Student-level Covariates					
Minority	x	x	x	x	x
Gender	x	x	x	x	x
IEP status	x	x	x	x	x
ELL status	x	x	x	x	x
Grade level	x	x	x	x	x
Student baseline achievement score	x	x	x	x	x

[a] The variable was omitted from the matching because the matched sample size was decreased drastically when the variable was included in the matching. Additionally, for the Alaska Mathematics dataset, the matched ELM students and comparisons were balanced on all covariates included except SchFRPM. The standardized mean difference on SchFRPM was 0.30.

Table A3 summarizes the sample sizes for each study before and after the matching. As part of the matching process, students without matched comparisons based on the specified school- and student-level covariates were automatically removed from the dataset. Across the study samples, the student-level retention rate ranged from 78% to 97%.

Table A3. Sample Sizes Before and After PSM Matching by Study

Study	Before Matching				After Matching				% Retention (Student Level)
	# Schools		# Students		# Schools		# Students		
	ELM	Non-ELM	ELM	Non-ELM	ELM	Non-ELM	ELM	Non-ELM	
ELA									
Alaska	2	207	53	6992	1	29	48	217	90.6%
Kansas	3	605	69	86806	3	25	58	290	84.1%
Mathematics									
Alaska	2	43	45	2360	2	5	35	145	77.8%
Kansas	14	796	492	156257	14	63	466	2068	94.7%
Wisconsin	5	751	110	112857	2	14	92	397	83.6%

Note. Numbers reported under the "Before Matching" columns were the samples with cleaned datasets (completed data) before the matching. Numbers reported under the "After Matching" columns were the samples after the matching.

As a result of matching, the standardized mean differences on all key covariates were less than 0.25 across all datasets with one exception—for the Alaska Mathematics dataset, the standardized mean difference on SchFRPM was 0.30. Therefore, the baseline equivalence was established for all study samples except the Alaska Mathematics sample. The means and standard deviations of the covariates for each study sample are reported in the report body (see Impact Study Samples section).