

Implementation and Effects of LDC and MDC in Kentucky Districts

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Introduction

Kentucky has been a leader in the movement to more rigorous college and career ready standards to support their students' success in the 21st century. The first state to adopt new college and career ready standards (CCRS), termed the Kentucky Core Academic Standards, Kentucky and many of its districts have moved proactively and strategically to meet the challenge of more rigorous expectations and to facilitate educators and students' transition to the new demands. All students are to be on a trajectory to graduate high school, and should be prepared for college and career success. Basic skills have given way to goals for deeper learning, where students are expected to apply, reason with, communicate, and use their knowledge to solve complex problems.

This brief summarizes early evidence on the success of two tools Kentucky districts have used to support their teachers' transition to these more demanding goals: Literacy Design Collaborative (LDC) and Math Design Collaborative (MDC). With support from the Bill and Melinda Gates Foundation, LDC and MDC tools have been designed and implemented to embody the key shifts in teaching and learning that the new standards demand. By implementing the tools, teachers then engage in new pedagogy and address relevant learning goals of the Kentucky Core Academic Standards.

In the sections that follow, we provide a brief background on the two tools and our evaluation methodology. We then follow with findings for each intervention and conclude with implications of our findings across the two studies. We stress that our methods were rigorous and our findings positive, but still our study provides only an "early read" on LDC and MDC effectiveness. Our quasi-experimental design cannot separate the effects of LDC and MDC from other changes that may have been going on in the study districts and schools. Further, our study is based on a limited sample of schools and teachers in select subjects and grade levels who participated in the piloting of the tools. These included eighth grade social studies/history and science teachers and ninth grade Algebra 1 teachers who initiated their tool use during the 2010-11 or 2011-12 school years. Study results are based on data from the 2012-2013 school year. Full technical reports for each of the two studies are also available (Herman et al., 2014 and Herman et al., 2015).

Background

In this background section, we briefly describe the LDC and MDC tools and the evaluation questions our study was designed to address. A summary of our research design and instrumentation also is provided.

LDC and MDC Tools

LDC and MDC tools reflect distinct approaches to support teachers' transition that are consistent with the unique challenges in each subject. Even so, both interventions reflect a commitment to collaboration in design and co-development involving subject matter experts, education leaders, and classroom teachers.

LDC Tool

LDC provides flexible, module templates that enable middle and high school teachers to integrate CCRS standards in reading, research, and writing into their content area instruction. End-of-module, extended writing tasks provide the heart of the approach. Teachers use one of many available fill-in-the-blank templates to design content-oriented, culminating writing tasks aligned with English-language arts (ELA) standards, which are then used to organize a module of instruction. After deciding on this end-of-module task, teachers then use an LDC-specified "instructional ladder" to design activities that will help students to develop both content and requisite literacy skills to complete the writing task successfully. The steps of the ladder include core activities that scaffold student learning and provide ongoing opportunities for formative assessment. The final product (i.e., the instructional ladder and template task) is referred to as a LDC module (see <http://ldc.org> for more information).

Teachers participating in our LDC study were required to implement at least two modules during the academic year, with at least one of these targeting explanatory writing and the other targeting argument. Teachers worked individually or collaboratively with other teachers and/or specialists to create the modules, which typically underwent a process of review and refinement.

MDC Tool

MDC supports the transition by providing one- to two-day Classroom Challenges that can be used in conjunction with on-going curriculum and instruction. Each Challenge essentially is a formative assessment lesson to help secondary mathematics teachers develop, assess, and monitor their students' development of key mathematical skills and understandings. The Challenges also are intended to model and help teachers incorporate into their practice deeper mathematical reasoning and thinking. Toward this end, there are two primary types of mathematical challenges: one focusing on conceptual understanding and the other on problem solving. Teachers can choose from among 40 Challenges aligned towards high school standards and 61 Challenges geared towards middle school standards to fit with their specific curriculum.

Developed by the Shell Centre in England in collaboration with researchers at UC Berkeley, each Challenge follows the same general structure: (a) students engage in a pre-test, which presents a challenging problem or question involving previously learned concepts or principles, (b) teachers review student responses to assess student approaches, solution strategies, understandings and misconceptions, (c) students are then engaged in whole class and small group collaborative activities to discuss alternative approaches, surface misconceptions, deepen their understanding, and connect and apply their knowledge and skills in new contexts, and (d) at the end of the Challenge, students return to the initial problem or question, revise their initial responses and reflect on what understandings have been gained (see <http://map.mathshell.org> for more information about the Classroom Challenges and <http://collegeready.gatesfoundation.org/Learning/MathDesignCollaborative> for more information about MDC).

Teachers in our study typically were required to submit data on four to six Challenges over the course of the year, but in some cases teachers implemented and submitted data on many more.

Evaluation Questions

Parallel evaluation questions guided both studies:

1. *How are teachers implementing the LDC/MDC tools?*
2. *What is the impact of LDC/MDC on student learning?*
3. *What conditions and contexts influence LDC/MDC effectiveness?*

Evaluation Methodology

Samples

The LDC study included all 36 eighth grade social studies/history and science teachers and their students in the 11 Kentucky districts who were part of the Phase I and Phase II piloting of LDC, which started in the 2010-11 and 2011-12 school years respectively. Half of these teachers agreed to provide data for the implementation component of the study.

The implementation component of the MDC study drew from a population of 46 ninth grade Algebra I teachers determined to be eligible for the study based on their participation in Phase I and Phase II piloting, which occurred during the same time frame as LDC. Approximately 60% of these teachers, representing five districts, provided data for the implementation phase of this study. Later communication with districts yielded a larger sample of 59 teachers, which was used in the quasi-experimental analyses.

The majority of both the LDC and MDC samples were Phase II teachers, which means that they had only one year of implementation experience prior to the study year.

Implementation Measures

Multiple measures were used to gauge tool implementation, customized to the goals and designs of LDC and MDC respectively:

- **Web-based teacher logs:** Teachers reported in real time the extent to which and how their instruction followed the tool structure, their allocation of time to various tool components, and their use of formative assessment practices.
- **Web-based teacher surveys:** At the end of the study year, teachers responded to the same issues addressed by the logs and also shared their prior experience using the tool, extent of professional development,

leadership support, and collaboration related to tool implementation.

- **Artifact analysis:** Two LDC modules were collected from each participating LDC teacher, and student work from 4-6 MDC Challenges was collected from each MDC teacher. These were scored as measures of implementation quality.

Student Learning Measures

Special CRESST measures were used to evaluate student performance on LDC and MDC specific goals. The LDC version, termed the CRESST Integrated Learning Assessment (ILA), was designed to measure both students' literacy development relative to the CCRS in ELA and depth of content understanding in social studies/history or science. Generally mirroring LDC's demands over a two-day period, the ILAs first ask students to read several, typical disciplinary texts addressing an important topical problem and to answer reading comprehension and analysis questions that are aligned with the ELA CCRS.

On day two, students respond to an essay prompt that asks them to synthesize what they know with what they have read to produce an extended explanation or argument related to the given topic; essays are scored on multiple dimensions, using a four-point rubric. LDC social studies teachers administered an assessment on the Reconstruction period in American History, while science teachers implemented an assessment on the theory of evolution. The CRESST math assessment was designed to address the conceptual content of the five most commonly used Challenges by study teachers. The assessment includes multiple item types, including word problems requiring students to justify their reasoning and provide evidence-based explanations. The CRESST measures were administered in LDC and MDC classrooms only and thus provide an indicator of students' current learning, rather than evidence of comparative effectiveness of either tool.

Kentucky state assessment data served this latter purpose and were used as the primary indicator of tool effects on student learning. The LDC study used students'

K-PREP English-language arts, writing and social studies scores, as well as the prior years' data from KCCT, to judge program effects. The MDC study used tenth grade PLAN scores for Algebra as the primary outcome.

LDC Findings

LDC Implementation

Results from teacher logs, surveys, and analysis of teacher-created modules and student work provided at least one consistent finding: Across all sources, the data showed substantial variation across teachers in all aspects of LDC implementation, from how teachers allocated instructional time across the various components of LDC, to the primary organizational forms teachers used in their LDC instruction, the reading and writing skills they most emphasized in LDC instruction, and the specific strategies they used to formatively assess and provide students' feedback on their learning. The quality of LDC modules also varied substantially across teachers.

With this variation as a caveat, the findings provide a portrait of by whom, how, and with what positive/negative support LDC was implemented by the study sample, as well as participating teachers' impressions of the tool's effectiveness.

Who

Survey results indicate that study teachers were generally highly experienced and stable in their positions, having spent most of their careers in the same districts and schools. Almost all of the study teachers had one to two years of experience beyond their initial training in implementing LDC. All of the teachers had participated in the development of at least one LDC module and the majority had developed two or more. Although most of the teachers were required to participate in LDC, rather than having volunteered to do so, they felt committed as content teachers to help develop their students' literacy skills.

How

Log, survey, and module analysis results indicate that teachers followed the LDC framework. As indicated by the logs and surveys, students were largely engaged in independent reading and writing during LDC instruction. While teachers tended to at least touch upon a wide variety of reading and writing skills during this time, they spent relatively little time in direct strategy instruction or in delivering mini-lessons. Note-taking and summarizing appeared to be relatively frequent student activities during independent reading, and for social studies classrooms, critical reading skills such as citing and evaluating evidence and using it to draw conclusions also were in evidence. There was little attention paid to critical analysis and synthesis

skills, such as differentiating fact and opinion, comparing arguments, or analyzing authors' perspectives. In writing, teachers also reported some attention to a wide range of skills, but with a relative emphasis on elements of structure. Across both reading and writing, teachers reported engaging in frequent formative assessment, involving multiple strategies for monitoring student learning, and for responding to student misunderstandings as they occurred.

Analyses of teacher-developed modules provide a window into the quality with which LDC was being implemented. Fidelity to the LDC framework was judged a relative strength in the ratings, and ratings across most of the nine dimensions examined approached or achieved moderate levels of quality. Results, however, also suggest room for improvement, which is to be expected given participating content teachers' experience levels with LDC and with teaching literacy.

With What Support

Survey responses indicated that teachers felt their district leadership supported the LDC intervention, but school level support was less consistent across the sample. All teachers participated in professional development and found it beneficial. Teachers found their colleagues collaborative, although formal time for planning and collaboration was uneven across the sample. Nonetheless, teachers reported that collaboration with their peers was very helpful in implementing LDC. Science teachers appeared to be less involved in professional development and collaboration than were their social studies/history peers.

Attitudes Towards LDC

Teachers reported that they found LDC a helpful and effective tool in meeting a variety of goals, including implementing the Kentucky Common Core Standards, using formative assessment, incorporating literacy into content classrooms, and increasing the rigor of their writing assignments. At the same time, although teachers felt that LDC had benefited their students writing and college readiness, less than half reported that their students had "a great deal" of success on their LDC module reading and writing mini-tasks or on the final writing task. These results suggest that participating teachers may have needed additional help with the design and implementation of the modules and with their LDC instruction.

LDC Effects on Student Learning

ILA Performance

The CRESST Integrated Literacy Assessment (ILA), as previously described, provides a general barometer on student performance on LDC-like reading and writing tasks aligned with CCRS, but do not address the question of whether LDC improved student learning.

Descriptive results for both social studies and science reveal generally similar performance on their respective

ILAs. In reading, students scored approximately one-half of the total possible points, and in writing their scores were roughly 40% of the total possible. Because students' essays were scored on five, four-point dimensions, the data suggest that students' scores on each dimension hovered around two. The scoring rubric defined a Level 3 as proficient and a score of 2 as basic.

Assessment	Component	<i>n</i>	Possible score	<i>M</i> score	<i>SD</i>	Min	Max
Social Studies: Reconstruction	Reading	252	18	9.90	2.90	1	16
	Writing	253	20	8.56	2.89	5	19
Science: Evolution	Reading	166	15	7.59	3.13	0	15
	Writing	132	20	7.63	2.61	5	17

Table 1. ILA Descriptive Results

Effects on K-PREP scores

The study used advanced statistical design and analysis techniques to examine LDC effects on student learning. Coarsened exact matching (CEM) was used to create a comparison group of students from across Kentucky who were nearly identical to study LDC students in demographic characteristics, prior achievement, and selected school and district characteristics. Hierarchical linear modeling (HLM) was then used to test LDC's effect by comparing students' K-PREP performance in reading, writing, and social studies to that of the comparison group. The analysis also took account of both school and teacher effectiveness prior to LDC's implementation, based on state assessment data from 2009-2010, and controlled for all student background characteristics. The models also examined potential interactions between the LDC treatment, prior school and teacher effectiveness as well as student characteristics. For this study, a statistically significant interaction effect indicated that the treatment had differential effects on student learning depending on the school, teacher, and/or individual student's standing on the given variable. These interaction analyses should be considered highly exploratory and results treated as tentative.

Level 2 variables		Model coefficient (S.E.)
LDC treatment		0.058 (0.023)*
Level 1 treatment by student characteristic interactions	Gender	-0.004 (0.017)
	Sped	-0.110 (0.034)*
	FreeLunch	0.053 (0.017)*
	PriorAchiev	0.034 (0.011)*

Fixed effects for demographic predictors and for prior school and teacher effectiveness not shown; * $p \leq .05$.

Table 2. 2012-13 LDC Student Effect Estimates on K-PREP Reading, Including Interactions with Prior Teacher Effectiveness and Student Characteristics

Table 2 (previous page) shows HLM results for the K-PREP reading scores. The data indicate that LDC had a small but statistically significant, positive effect on students' reading performance. LDC students scored higher in reading than did their carefully matched comparison group, demonstrating that LDC had a measurable effect on students' literacy learning.

To provide a benchmark for interpreting this effect, we used a relatively new methodology to convert the effect size into a gross indicator of the number of months of learning represented (see Hill, Bloom, Black, & Lipsey, 2007). Relative to typical growth in reading from eighth to ninth grade, the effect size for LDC represents 2.2 months of schooling.

The data also shows interactions between LDC effects and student characteristics. Both students' prior achievement, based on their prior year K-PREP scores, and students' socio-economic status (SES), as revealed by their free or

reduced price lunch status, show positive interactions with the treatment. That is, LDC students who were relatively higher achieving prior to their LDC experience showed relatively greater benefit than did those who started relatively lower achieving, although the observed effect is very small. Interestingly, LDC students receiving free or reduced price lunch, who tended to be relatively lower performing, also appeared to have benefited more from LDC. Although, again, the observed effect was very small, we speculate that struggling LDC students perhaps had access to special resources (e.g., Title 1 programs, specialist teachers) that provided essential support. We did not find evidence of differential effects of LDC by gender. Controlling for other factors, special education students appear to do less well under LDC; however, the share of students falling into this category was small.

The results for the K-PREP social studies results are shown in Table 3. The coefficient for the main effect for LDC is small and not statistically significant, indicating that LDC's addition of literacy to course requirements did not diminish students' content performance. Table 2 also reveals a significant interaction between prior teacher effectiveness and LDC. LDC students taught by teachers who were relatively less effective prior to LDC benefited relatively more than did students of relatively more effective teachers. However, this interaction is difficult to interpret and should be treated cautiously given that all teachers', including science teachers, prior effectiveness scores were based on their eighth grade students' social studies performance for the study's baseline year (because Kentucky does not assess science in eighth grade).

Students' prior year performance on the K-PREP and their free or reduced price lunch status show the same, small positive interaction with LDC. LDC students who started the year relatively higher performing experienced more benefit from LDC in their social studies performance, as did students who were from a relatively lower SES, as evidenced by their free or reduced price lunch status. We did not find differential treatment effects of LDC by gender or special education status.

It should also be noted that the results for K-PREP writing showed neither a main nor an interaction effects for LDC and thus are not presented here (for more detail, see Herman et al., 2014).

Level 2 variables		Model coefficient (S.E.)
LDC treatment		-0.026 (0.023)
LDC treatment by teacher effectiveness		-0.288 (0.082)*
LDC treatment by student characteristic interactions	Gender	0.013 (0.016)
	Sped	-0.007 (0.037)
	FreeLunch	0.039 (0.019)*
	PriorAchiev	0.050 (0.017)*

Fixed effects for demographic predictors and for prior school and teacher effectiveness not shown; * $p \leq .05$

Table 3. 2012-13 LDC Student Effect Estimates on Social Studies K-PREP Scores, Including Interaction with Teacher Effectiveness

MDC Results

MDC Implementation

Results from teacher logs, surveys and analysis of student work from MDC's Classroom Challenges, indicate that teachers adhered to the MDC challenge design and followed expected guidelines. At the same time, however, like the LDC results, the data from all sources suggest that teachers differed in their specific implementation strategies. This included how much time teachers spent on the pre-test to how they allocated instructional time across the Challenges' various components, composed peer groups, responded to struggling students, and the strategies they used to formatively assess and provide students' feedback on their learning. Analysis of student work on the Challenges also showed variation in teachers' success.

With this variation as a caveat, the findings provide a portrait of by whom, how, and with what support MDC was implemented by the study sample, as well as participating teachers' impressions of the tool's effectiveness.

Who

Study teachers showed a range of teaching experience, with an average of about nine years. Most had spent the bulk of their careers in their current districts and schools. Nearly two-thirds indicated that they had volunteered, rather than being required, to work with the MDC tool. Most teachers, as noted earlier, had only one year of experience implementing MDC beyond their initial training year. On average, study teachers implemented six Challenges during the study year and five during the prior year.

How

Nearly all teachers reported that they completely or mostly adhered to the MDC guidelines in implementing their Challenges, which typically took two to three days for them to complete. Teachers, however, varied considerably in the time they spent analyzing students' pre-tests and in the time and specific strategies they used in implementing each component (i.e., the pre-test, collaborative small group activity, whole class instruction, and post-test). Although teachers tended to deviate from guidelines in the feedback they provided to students about their pre-test performance, their reported interactions during small group collaborative activities and whole class instruction were in sync with

MDC's productive struggle philosophy. Teachers raised questions, asked students to explain their reasoning, solicited feedback from peers and asked students to self reflect, rather than providing students directly with answers.

Analyses of student performance on the Classrooms Challenges, as judged by evidence of student learning from pre- to post-test, however, shows a somewhat different picture of implementation fidelity. In general, these analyses showed that teachers had difficulty helping students to achieve the Challenge goals. Results indicate that improvements in student understanding were generally scant and evidence of misconceptions remained. Students appeared to particularly struggle with mounting explanations of their reasoning.

With What Support

Survey responses indicated that teachers felt strong support for MDC from district leadership, but school level principal support was less consistent across the sample. The majority (75%) reported participating in professional development to prepare for MDC implementation and all who did found it beneficial. Although formal time for collaborative planning and feedback varied across the sample, the great majority of teachers reported meeting informally at least every other week to discuss their MDC work. Teachers also reported that they found their peers to be highly collaborative and the collaboration helpful to their MDC implementation.

Attitudes Towards MDC

Teachers were very positive about key MDC pedagogical strategies such as teacher as facilitator, asking guiding questions and peer-to-peer problem solving, and also found the small group and plenary approaches helpful to student learning. Although they felt that that the Challenges benefited students conceptual understanding and mathematical thinking, they reported that sizeable proportions of their students struggled during the Challenges and failed to achieve a firm grasp of the intended target—on average they felt that only about half of their students reached this level. As with the LDC findings, these results suggest that participating teachers may have needed additional help with the implementation of the modules and with their MDC instruction.

MDC Effects on Student Learning

CRESST Math Measure

The CRESST measure, as previously noted, was specifically designed to align with the mathematics concepts addressed in the five Challenges that were most commonly used by study MDC teachers. The assessment also addresses students' ability to justify their reasoning, explain major concepts, and practices highly valued in CCRS. Student performance on the measure serves as a barometer of the status of MDC students learning, but because the assessment was administered only in MDC classrooms, it could not be used to examine MDC effectiveness.

Descriptive results on student performance are shown in Table 4. On the extended response items, in which students were called upon to justify their solutions to word problems and explain mathematical concepts, students achieved only about one-quarter of the total possible points. Their performance was only slightly better on the multiple choice and short answer item types. We return to this issue in the conclusion, but the data suggest the distance students remain from the expectations of CCRS.

Type	<i>n</i>	Possible score	<i>M</i> score	<i>SD</i>	Min	Max
Extended response	471	11	2.83	2.26	0	10
Multiple choice and short answer	471	22	6.71	3.62	0	18
Overall	471	33	9.55	5.39	0	28

Table 4. Descriptive Statistics for CRESST Math Assessment

Effects on PLAN algebra scores

As with the LDC study, our MDC analyses used sophisticated CEM techniques to create a comparison group of students from across Kentucky who were nearly identical to the MDC students in demographic characteristics, prior achievement, and selected school and district characteristics. HLM was used to test MDC's effect by comparing students' PLAN performance in algebra to that of the comparison group. The analyses also took account of both school and teacher effectiveness prior to MDC's implementation, based on state assessment data from 2009-2010, and controlled for all student background characteristics. The models also examined potential interactions between the MDC treatment, prior teacher and school effectiveness, and student characteristics. A statistically significant interaction effect indicates that MDC had differential effects on students' learning, depending upon their school and/or teacher's prior effectiveness and/or their individual demographic or prior achievement. These interaction analyses should be considered exploratory and any results should be treated

Level 2 variables		Model coefficient (S.E.)
MDC treatment		0.130 (0.030)**
MDC treatment by teacher effectiveness		0.420 (0.178)**
MDC treatment by student characteristics interaction	Female	0.005 (0.026)
	Special education	0.070 (0.044)
	Free/reduced price lunch	0.027 (0.039)
	Prior Achievement	0.030 (0.016)

Fixed effects for demographic predictors and for prior school and teacher effectiveness not shown. * $p \leq .05$. ** $p \leq .01$.

Table 5. 2012-13 MDC Student Effect Estimates on PLAN Algebra, Including Interaction with School and Teacher Effectiveness

MDC Effects on Student Learning (cont.)

as tentative. Two different HLMs using slightly different approaches to modeling students' exposure to LDC teaching were estimated, and results were very similar across the two models.

Table 5 (previous page) reveals both main and interaction effects for the MDC treatment for one of the two models. The treatment shows a small, statistically significant, positive effect on students' PLAN performance in algebra, indicating that students who experienced MDC learned more than students who did not have the benefit of MDC. As with LDC, we used recently developed methodology to convert the observed effect size for MDC into a gross indicator of the number of months of learning represented (see Hill et al., 2007). Relative to typical growth in mathematics from ninth to tenth grade, the effect size for MDC represents 4.6 months of schooling.

The results also show an interaction effect for prior teacher effectiveness, but in the opposite direction to that found for LDC. Here we find a positive interaction effect with MDC, meaning that students whose teachers were more effective prior to using MDC, as measured

by their students' (pre-MDC) state assessment scores in mathematics, benefited more from MDC compared to students with lower "value-added" teachers. We speculate that the more effective teachers had higher pedagogical knowledge in mathematics (see, for example, Hill et al., 2007) that enabled them to implement MDC better. The interaction between treatment and student prior achievement was close to being statistically significant at the 5 percent level in the model shown. In the alternate model, the statistical significance of the interaction effects were reversed, with the student prior achievement interaction being statistically significant and the prior teacher effectiveness interaction approaching significance (See Herman et al., 2015 for additional detail). Given the likely relationship between teacher quality and student achievement, these inconsistencies are understandable. The combined findings suggest MDC students who were relatively higher achieving prior to their MDC experience and/or those whose teachers were more effective prior to using MDC benefited more from the intervention compared to their peers.

Implications

LDC and MDC are very different tools but our Kentucky studies of them reveal a strong similarity in at least one respect: They both show promising, positive results in supporting teachers' transition to the Kentucky Core Academic Standards expectations for college and career readiness and in improving student learning. At the same time, however, study findings suggest challenges that LDC and MDC will need to overcome to move to higher levels of success.

Positive Effects on Student Learning

That LDC and MDC show statistically significant results on students' state assessment scores in reading and mathematics respectively are results worth celebrating. These positive findings are particularly so in light of both study teachers' limited prior experience implementing the tools and the limited dosage students experienced. That is, study teachers had only one or two years of experience with LDC or MDC prior to the study year, and for the great majority it was only one year. Based on research on teachers' implementation of new practices, this is insufficient time for teachers to become fully comfortable and competent with the kinds of new pedagogical practices that LDC and MDC represent (Coburn, 2003; Hargreaves & Fullan, 2012). Consider that LDC requires that content teachers teach literacy, a new responsibility for which they have had little or no prior training. MDC, for its part, emphasizes student-centered pedagogies and the engagement of students' mathematical thinking and problem solving learning, in contrast to the teacher-directed approaches and low-level learning goals that have been dominant in traditional mathematics curriculum (U.S. Department of Education, 2008).

Intervention dosage is another factor to consider in evaluating LDC and MDC effects. In general, the longer and more intensive the treatment, the more likely an intervention is to show measurable effects. LDC teachers typically implemented two modules of two-to-three weeks' duration each during the study year, meaning that LDC-oriented coursework totaled four-to-six weeks, only a small fraction of the full academic year. For MDC, participating teachers were expected to implement between four and

six Challenges, meaning that students were engaged only 8-12 days of the school year.

Nonetheless, the studies found statistically significant learning effects for both tools, the approximate equivalent of 2.2 months of schooling for LDC and 4.6 months for MDC. Given their contexts of early implementation and limited dosage, these small effects are noteworthy.

Positive Effects on Teachers

The effects found for student learning are matched by teacher enthusiasm for the two tools. Across LDC and MDC, teachers were positive about the professional development they received and reported that they found the tools helpful and effective in meeting a variety of goals, including implementing Kentucky Core Academic Standards, using formative assessment, incorporating more complex thinking and problem solving into curriculum and instruction, and improving student learning. Teachers' reports about their fidelity of tool implementation provided additional evidence of their positive attitudes.

Struggles in Moving to Higher Standards

While our study found positive effects on teachers and students, findings also demonstrated the challenge of moving to Kentucky's more rigorous Core Academic Standards. We see evidence of this challenge in students' low performance on measures specifically designed to reflect the deeper learning demands of new college and career ready standards and in teachers' reports that sizeable proportions of their students are struggling relative to the goals of LDC and MDC. Our analysis of LDC and MDC classroom artifacts also indicate that some teachers struggled in their implementation efforts, as would be expected given this early stage of implementation.

That some teachers and students struggled is not meant to imply that current standards are unattainable or that college and career ready expectations for students should

be reduced—after all, we know that returning to prior standards will not get our children to 21st century success. However, the evidence does suggest that change will not come overnight and that both teachers and students will need support to meet the challenge. The issue is two-fold: (a) how to address the needs and better prepare students and teachers who may not yet be ready to be successful with the challenges of LDC and MDC; and (b) how to modify and/or adapt the tools to scaffold teacher and student learning more effectively.

Achievement Gap Implications

Although we regard findings of the interaction between student characteristics and treatment effects as tentative and subject to further validation, the consistency in results across measures and across LDC and MDC is striking. While the overall results indicated that both tools were effective for all students, the interaction findings suggested that initially higher achieving students benefited more than did initially lower achieving students. Such a finding makes intuitive sense in that lower achieving students have most likely been exposed to the “drill and kill” test preparation curriculum of the past, are least likely to have acquired the prior grade knowledge and skills expected by the Kentucky Core, and are least likely to have been engaged in the deeper conceptual understanding and applications that mark the new standards.

However understandable, the findings thus suggest that, in the absence of additional scaffolding and supports for low achieving students, LDC and MDC are likely to be gap enhancing. Study findings on the interaction between prior teacher effectiveness and treatment reveal a similar story—students of relatively more effective teachers appeared to benefit more from MDC than did students of relatively less effective teachers. To the extent that low achieving students are more likely to be assigned to relatively less effective teachers, these students will be doubly disadvantaged.

Study findings of a positive interaction between LDC and students’ free and reduced price lunch status offers promise for future inquiry. The results suggest that, controlling for prior achievement and other background characteristics, students who are more economically disadvantaged fare relatively better under LDC than their more advantaged peers. These results were not found for MDC.

Strengthening Implementation

Although teachers reported implementing all components of both LDC and MDC, the findings suggest substantial variation in how they implemented each tool and in the relative time and specific strategies they used in doing so. The study did not achieve strong findings with regard to what aspects of implementation mattered most or of what specific strategies were most effective. The findings are suggestive, however, of some factors that might be important to success: District support for the two interventions was clear across the sample, yet principal or local school support was more variable, suggesting a potential problem point. Teachers found their peers highly collaborative and helpful in implementing the two tools. The extent of such collaboration tended to be associated with MDC success. Moreover, having a teacher who volunteered to participate in MDC, rather than having participation required, was associated with MDC effects on student learning.

Conclusions

In summary, our studies reveal that study teachers are enthusiastic about both LDC and MDC, and that both showed important effects on student learning. Even so, study results also suggest areas for improvement. Content teachers who implement LDC likely will be more successful to the extent they have expertise in supporting students' literacy development. Mathematics teachers who implement MDC likely will be more successful to the extent they possess sufficient pedagogical-content knowledge to effectively scaffold students' productive struggle with complex mathematical concepts and problems. Struggling students may need additional supports and strategies to acquire the prerequisite knowledge and skills assumed

by MDC's Classroom Challenges to move their productive struggles to success in new mathematical understandings and problem solving.

We leave it to future research to examine the generalizability of these findings in the larger samples of teachers and schools that are now implementing LDC and MDC. Cost effectiveness studies also should be of interest. Future research and development also should continue the quest to identify both the most critical aspects of implementation in improving student learning and key infrastructure and supports that students and teachers who currently are struggling need to propel their success.



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