Professional Learning and Mathematics Achievement in Kentucky Public Schools: A Cross-Grade Band Analysis

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Abstract: This study examined whether educators' perceptions of professional learning were associated with school-level mathematics achievement in Kentucky public schools. Using Impact Kentucky Working Conditions Survey data and Kentucky Summative Assessment mathematics results, the study analyzed elementary, middle, and high school patterns separately. Professional Learning Topic Total was compared with Mathematics Proficient/Distinguished and Mathematics Novice rates through descriptive statistics, correlations, quartile comparisons, and ANOVA. Results showed the clearest and strongest associations in elementary schools, with more modest patterns in middle and high schools. Findings suggest that teacher perceptions of professional learning may provide useful school improvement data.

Keywords: Professional Learning, Mathematics Achievement, Teacher Perceptions, Working Conditions, Kentucky Schools, School Improvement

Introduction

More than 90% of American educators indicated participation in professional learning in the 2025 school year (U.S. Government Accountability Office [GAO], 2026). It is evident that educators rely on professional learning opportunities for a variety of reasons: structured learning of professional knowledge, improve practice, access resources, and collaboration with colleagues (Rashid et al., 2025; Rojas et al., 2025). Admiraal and Roberg (2023) noted that access and barriers to professional learning are also of significance. Educator insight suggested that professional learning is often credited for teacher professional growth (Rashid et al., 2025; Rojas et al., 2025). However, the question remains: can professional learning opportunities also be linked to student achievement on state assessments?

Literature Review

By capturing teacher perceptions on the Impact KY survey, this study examined teachers' perceptions of whether professional learning opportunities are associated with

mathematics achievement on the Kentucky Summative Assessment. School divisions collect an abundance of teacher perception data every year. Teacher perception data may be especially useful because it captures features of the school environment that are difficult to observe through achievement data alone, including professional support, collaboration, and the perceived value of professional learning opportunities. A review of the literature indicated that teacher perceptions matter, there are ways to make professional learning valuable, collaboration with colleagues can influence teaching practice, and there is a strong relationship between effective mathematics instruction and achievement (Richter et al., 2011).

Teacher Perceptions and Working Conditions as Meaningful School Data

Reported teacher perceptions can be used to determine and analyze the working conditions of a school. For this study, working conditions were broadly defined as the teacher's responsibilities, conditions, and resources, including professional learning, teacher support, opportunities for collaboration, overall workload, and school climate. Research also suggests that teachers' perceptions of working conditions are meaningful in understanding the structures, systems, and environment of a school (DeMatthews et al., 2025; Geiger & Pivovarova, 2018; Jerrim, 2025; Olsen & Anderson, 2007). Working conditions must be viewed as meaningful data in school contexts.

It is also important to note the impact of working conditions. Research confirmed working conditions of a school influence teacher retention, job satisfaction, and overall teacher well-being (Geiger & Pivovarova, 2018; Jerrim, 2025). It was also evident that when working conditions were perceived negatively by teachers, job satisfaction was also scored lower, thus teacher turnover rates increased (Jerrim, 2025). Olsen and Anderson (2007) determined low teacher perceptions of working conditions also attributed to high teacher burnout. Their findings go even further to suggest that teachers who perceived working conditions positively were more likely to be engaged in their instruction and saw higher student outcomes. The literature suggested that if teacher perceptions have an influence on variables like teacher satisfaction, teacher perceptions may also impact achievement.

Teacher Perception of Value in Professional Learning Opportunities

Eccles and Wigfield (2002) define value to include perception, usefulness, and enjoyment. Teachers' perceptions of value not only included importance, usefulness, and enjoyment of professional learning opportunities, but also, the relevance and applicability to practice (Eccles & Wigfield, 2002; McChesney & Aldridge, 2021; Richter & Richter, 2024). It is important to note that accessibility and participation in professional learning opportunities does not guarantee there will be perceived value in the professional learning (Sims & Fletcher-Wood, 2021; Yamagata-Lynch & Haudenschild, 2009). Content relevance was also found to be valuable. Content relevance was defined as the degree to which professional learning connected to the subject matter being taught (Richter et al., 2011). Professional learning that was content specific enhanced teacher content knowledge, instruction, and overall student achievement (Richter et al., 2011; Didier et al., 2025). Research indicated that math content specific professional learning was crucial for

mathematics achievement because math instruction is sequential and involves precise language and representations (Adams et al., 2023; Darling-Hammond et al., 2017; Lynch et al., 2025).

Collaboration for Instructional Improvement

Teachers perceived collaborative professional learning opportunities to have high value. Educators have defined collegial learning as professional learning that includes collaboration and learning from colleagues to improve one's own practice (Mydin et al., 2024; Simion et al., 2026; Wullschleger et al., 2025). Collegial learning involved shared planning, coaching, discussion, research and student data analysis (Brodie, 2019; Mydin et al., 2024; Nordgren et al., 2021). Nordgren et al. (2021) noted that collegial learning can involve two types of collaboration among teachers: surface-level and instructionally focused. Surface-level collaboration involved practical low-demand tasks such as sharing resources and scheduling assessments while instructionally focused collaboration is intended for deeper learning and reflection to improve practice. Instructionally focused collegial learning had a higher impact on teacher learning and instruction (Christensen & Jerrim, 2025; Ma et al., 2025; Tichnor-Wagner et al., 2025). Collegial learning must also involve teacher agency, a teacher's ability to lead and shape their own teaching practice, because it maintained teachers' accountability as both a learner and sharer during collegial learning (Brodie, 2019). Studies found that when teachers had agency while involved in collaborative dialogue, they were more likely to share practical ideas, which had a higher impact on classroom change (Christensen & Jerrim, 2025; Grimm, 2024).

Connecting Perceptions to Mathematics Achievement

Teachers who viewed professional learning opportunities as valuable were more likely to be engaged in their instruction with students, thus leading to positive achievement outcomes (Lynch et al., 2025; Ventista & Brown, 2023). This body of research suggests that strong mathematics instruction may be linked to higher mathematics achievement (Lynch et al., 2025; Richter et al., 2011). By understanding teachers' perceptions of mathematics professional learning opportunities, stakeholders can not only anticipate the impact on math instruction and professional teacher growth, but, make informed predictions and decisions of math achievement.

Summary and Rationale

Existing research provided clear evidence that teacher perceptions matter and must be considered when analyzing the impact of working conditions of schools. It was also noted in the literature that teachers found value in professional learning when they were able to collaborate through instructionally focused collegial learning and found content relevance in professional learning. Studies determined that teachers' perceptions could influence classroom instruction, indicating a potential effect on academic outcomes.

The literature on professional learning mainly examined professional learning design, participation, teacher satisfaction, or teacher growth. Less research was available on the association between teachers' perceptions of professional learning and academic

achievement. An even smaller amount of research looked specifically at mathematics achievement. By using the Impact KY survey and Kentucky Summative Assessment data, this study will contribute to the limited literature examining whether teachers' perceptions of professional learning are associated with school-level mathematics achievement.

Research Questions

The study was guided by four research questions that examined educator perceptions of professional learning and mathematics student achievement in Kentucky public schools:

RQ1. Do schools in the highest quartile of Professional Learning Topic Total demonstrate higher Mathematics Proficient/Distinguished rates than schools in the lowest quartile?
RQ2. Do schools in the highest quartile of Professional Learning Topic Total demonstrate lower Mathematics Novice rates than schools in the lowest quartile?
RQ3. What is the magnitude of the Q4-Q1 difference in Mathematics Proficient/ Distinguished and Mathematics Novice rates within each grade band?
RQ4. To what extent is Professional Learning Topic Total associated with mathematics achievement when the topic score is treated as a continuous school-level variable?

Methodology

Research Design

This study used a descriptive, nonexperimental quantitative design to examine whether educators' perceptions of professional learning were associated with school-level mathematics achievement in Kentucky public schools. The design was associative rather than causal. It examines whether schools where teachers report more favorable professional learning conditions also tend to show stronger mathematics outcomes. Analyses were conducted separately for elementary, middle, and high schools because school structure, assessment context, and mathematics instruction differ by grade band.

Data Sources and Measures

Professional learning data were drawn from Impact Kentucky Working Conditions Survey results. The study used the Professional Learning Topic Total as the primary school-level perception measure. Three items helped define the construct: the value of available professional development opportunities, the helpfulness of colleagues' ideas for improving teaching, and the relevance of professional development opportunities to the content teachers teach. The 2023-2024 survey included more than 40,000 educator responses and a 77.6% participation rate.

Mathematics achievement data were drawn from spring 2024 Kentucky Summative Assessment results for all students. Two outcomes were used: Mathematics Proficient/Distinguished and Mathematics Novice. The first outcome represented students reaching the two highest performance levels. The second represented students performing at the lowest level.

Sample and Matching Procedures

Separate analytic files were created for elementary, middle, and high schools. Professional learning records were matched with mathematics achievement records using school-level identifiers. Schools were retained when they had valid Professional Learning Topic Total values and usable mathematics outcomes. As seen in Table 1, the final mathematics sample included 511 elementary schools, 164 middle schools, and 166 high schools.

Table 1. Sample size variation between professional learning and KSA mathematics data.

Grade Band	Prof. Learning Schools	KSA-Matched	Unmatched	Excluded	Final KSA n	Match Rate	Final Rate
Elementary	565	541	24	30	511	95.8%	90.4%
Middle	170	167	3	3	164	98.2%	96.5%
High	172	168	4	2	166	97.7%	96.5%

Note: Professional Learning schools represent Impact Kentucky records with Professional Learning Topic Total values. Final KSA n reflects the schools retained for mathematics analyses after matching and removing records without usable mathematics outcomes.

Data Analysis

Descriptive statistics were calculated for Professional Learning Topic Total and both mathematics outcomes within each grade band. Pearson and Spearman correlations then examined associations between Professional Learning Topic Total and mathematics achievement. Spearman correlations were included because relationships between school perception data and achievement may not be perfectly linear.

Schools were then assigned to quartiles within grade band based on Professional Learning Topic Total. Q1 represented the least favorable professional learning perceptions, and Q4 represented the most favorable. Ties at quartile cut points were retained. Q4-Q1 planned comparisons were calculated for both mathematics outcomes, with Cohen's d estimating practical differences. One-way ANOVA tested whether outcomes differed across all four quartiles.

Results

Descriptive results showed meaningful variation across grade bands. Professional Learning Topic Total averages were highest in elementary schools and lower in middle and high schools. Mathematics Proficient/Distinguished rates declined across grade bands, while Mathematics Novice rates were higher in the secondary samples, as seen in Table 2.

Table 2. Descriptive statistics for professional learning topic total and mathematics achievement

Grade Band	PL Topic Total M (SD)	Math P/D n	Math P/D M (SD)	Math Novice n	Math Novice M (SD)
Elementary	65.44 (14.46)	511	43.35 (15.82)	511	23.13 (12.20)
Middle	57.86 (14.35)	164	39.09 (14.03)	164	31.58 (11.59)
High	54.92 (13.92)	166	37.02 (11.48)	166	32.57 (9.03)

Note: Professional Learning Topic Total reflects percent favorable. Math P/D and Math Novice values represent school-level KSA percentages.

Correlation results were directionally consistent. In each grade band, Professional Learning Topic Total was positively associated with Mathematics Proficient/Distinguished and negatively associated with Mathematics Novice. The coefficients were modest, which is expected in school-level studies using aggregated perception and achievement measures, but, as seen in Table 3, the pattern did not reverse across outcomes or grade bands.

Table 3. Correlations between professional learning topic total and mathematics achievement

Grade Band	Outcome	n	Pearson r	Spearman rho
Elementary	Math P/D	511	.23***	.21***
Elementary	Math Novice	511	-.25***	-.24***
Middle	Math P/D	164	.21**	.20*
Middle	Math Novice	164	-.19*	-.20*
High	Math P/D	166	.18*	.10
High	Math Novice	166	-.20*	-.14

*Note: Topic Total reflects percent favorable for the Professional Learning category. Math P/D and Math Novice are school-level KSA percentages. * p < .05. ** p < .01. *** p < .001.*

Q4-Q1 comparisons clarified the practical pattern. In every grade band, Q4 schools had higher average Mathematics Proficient/Distinguished rates and lower average Mathematics Novice rates than Q1 schools. The elementary differences were largest: an 8.70 percentage-point advantage in Mathematics Proficient/Distinguished and a 7.68 percentage-point reduction in Mathematics Novice. Middle school differences were smaller but meaningful. As seen in Table 4, High school differences were weaker, but remained in the expected direction.

Table 4. Q4-Q1 planned comparisons by grade band and mathematics outcome

Statistic	Elem Math P/D	Elem Math Novice	Middle Math P/D	Middle Math Novice	High Math P/D	High Math Novice
Q1 n	125	125	40	40	42	42
Q1 M	37.91	27.63	36.65	33.35	35.38	34.45
Q1 variance	178.84	152.12	178.23	130.34	104.29	61.62
Q4 n	133	133	40	40	41	41
Q4 M	46.62	19.95	42.67	28.93	39.15	30.93
Q4 variance	268.57	132.35	169.25	95.76	159.48	105.42
M difference	8.70	-7.68	6.02	-4.43	3.77	-3.53
Pooled SD	15.00	11.91	13.18	10.63	11.47	9.12
Cohen's d	0.58	-0.64	0.46	-0.42	0.33	-0.39

Note: Q1 and Q4 represent the lowest and highest quartiles of Professional Learning Topic Total within each grade band. Mean difference was calculated as Q4 minus Q1. Positive values indicate higher Q4 performance, while negative values indicate lower Q4 novice rates. Math P/D = Mathematics Proficient/Distinguished.

ANOVA results tested the full four-quartile pattern. In the elementary sample, quartile differences were statistically significant for both mathematics outcomes. Middle and high school ANOVA results were not statistically significant, although observed patterns generally aligned with the planned comparisons, as seen in Table 5.

Table 5. ANOVA results for professional learning quartiles and mathematics achievement

Grade	**Outcome**	**n**	**dfb**	**dfw**	**F**	**p**	**eta^2**
Elementary	Math P/D	511	3	507	6.71	< .001	.038
Elementary	Math Novice	511	3	507	7.84	< .001	.044
Middle	Math P/D	164	3	160	2.07	.107	.037
Middle	Math Novice	164	3	160	1.87	.137	.034
High	Math P/D	166	3	162	0.98	.404	.018
High	Math Novice	166	3	162	1.22	.305	.022

Note: Quartiles were assigned within each grade band using Professional Learning Topic Total. The tables report statewide reports only.

Discussion

The findings provide a credible basis for continuing this study. The central contribution is the consistency of the pattern. Professional Learning Topic Total moved in the desired direction with both mathematics indicators: higher professional learning perceptions were associated with more students reaching Proficient/Distinguished and fewer students scoring Novice.

The elementary findings are strongest. Correlations, Q4-Q1 comparisons, and ANOVA results pointed in the same direction. The Q4-Q1 differences are large enough to matter in school improvement conversations because they may represent a meaningful number of students moving into stronger performance levels or out of the lowest achievement category.

The middle school findings also support continued attention, although with more caution. Q4-Q1 differences favored schools with stronger professional learning perceptions, and the correlation results were statistically significant. The nonsignificant ANOVA results suggest that the low-to-high quartile contrast may be more informative than the full four-quartile test.

The high school findings were weakest, but should not be dismissed. Q4-Q1 differences remained in the expected direction, and Pearson correlations were statistically significant. Weaker results may reflect the difficulty of linking a schoolwide professional learning measure to high school mathematics outcomes, where course enrollment, prior achievement, credit accumulation, and varied pathways complicate interpretation.

The findings also suggest that professional learning should not be reduced to attendance at professional development sessions. The Impact Kentucky items point toward perceived usefulness, instructional fit, and collegial exchange. Those are leadership conditions, not merely program features.

Limitations

Several limitations should guide interpretation. The study used school-level data, so findings cannot be interpreted as evidence about individual teachers or students. The design was nonexperimental and cross-sectional, so causal claims are not appropriate. Professional learning measures were based on educator perceptions and did not directly measure content, duration, quality, or implementation fidelity.

The study did not control for student demographics, school funding, staffing stability, prior achievement, or other contextual variables that may influence mathematics outcomes. High school outcomes may be especially difficult to interpret through a schoolwide professional learning measure because students are distributed across different courses and pathways. The matching process also reduced the analytic sample, although the final sample remained strong.

Implications for Practice

The findings suggest that school and district leaders have a practical reason to examine professional learning perception data alongside achievement data. A school with weak mathematics outcomes and weak professional learning perceptions may require a

different response than a school with weak mathematics outcomes but favorable professional learning perceptions. In the first case, leaders may need to redesign the professional learning system itself. In the second, leaders may need to examine curriculum alignment, intervention structures, staffing, or student-level supports.

For leadership preparation programs, the study provides a practical data-use example. Candidates can examine working condition survey data alongside achievement data and then develop improvement questions grounded in both. This moves the task beyond simple data review and asks aspiring leaders to interpret relationships between adult professional conditions and student outcomes while avoiding causal overreach.

Future research should study schools in the highest professional learning quartile more closely, especially those with stronger mathematics results. Quantitative results can identify the pattern. Qualitative follow-up could help explain whether those schools have more coherent professional learning structures, stronger teacher collaboration, better content alignment, or more actionable instructional support.

Conclusion

This study provides evidence that educator perceptions of professional learning are associated with school-level mathematics achievement in Kentucky public schools. The strongest evidence appeared in the elementary sample, where correlations, Q4-Q1 comparisons, and ANOVA results converged. Middle school results were more modest but directionally supportive. High school results were weaker, which may reflect the complexity of high school mathematics pathways and the limits of a schoolwide professional learning measure.

The findings do not prove that professional learning caused higher mathematics achievement. They do show that professional learning perceptions are not merely background information. In this statewide sample, schools where teachers viewed professional learning more favorably tended to have stronger mathematics performance and lower novice rates. That makes professional learning perception data worthy of continued attention in both research and practice.

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