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RESEARCH BRIEF

Office of Research, Assessment, Data, Accountability, and Reporting

Formative Instructional Practices, Self-Efficacy, and Math Achievement in 4th Grade

Abstract

This study of 4th-grade students in Oregon found that higher self-efficacy is associated with higher mathematics summative test scores, consistent with prior research linking self-efficacy to math achievement. Two formative instructional practices—opportunities for math feedback and help, and opportunities for math discussion—positively influence self-efficacy, with opportunity for math discussion exerting an impact approximately seven times greater than opportunities for feedback and help. Furthermore, opportunities for math discussion indirectly support math achievement through its influence on self-efficacy, suggesting that increasing classroom opportunities for math discussions can boost both student confidence and performance in mathematics.

Key Takeaways

- 4th grade students with higher self-efficacy tend to have higher scores on mathematics summative tests in Oregon. These findings align with prior studies indicating a positive association between self-efficacy and math achievement.
- Two formative instructional practices (i.e., opportunities for math feedback and help, and opportunities for math discussion) positively influence self-efficacy. Opportunities for math discussion have a considerably larger impact on self-efficacy than opportunities for math feedback and help (approximately seven times larger).
- Via its influence on self-efficacy, opportunities for math discussion have an indirect association with math achievement. This suggests increasing opportunities for classroom math discussions will not only increase student self-efficacy but also improve student math achievement.

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Introduction

This study examines the direct and indirect associations between formative instructional practices, self-efficacy, and math achievement for 4th grade students who participated in both the 2023-24 administrations of the Student Educational Equity Development (SEED) survey and the Oregon Statewide Assessment System (OSAS) mathematics summative test. Although our study focuses exclusively on 4th grade students and mathematics, we intend to explore these same associations at different grades, content areas (e.g., English language arts, science), and across student groups (e.g., gender, race/ethnicity) as part of future research.

Our study proceeds as follows. First, we discuss self-efficacy, its theoretical basis and sources, its influence on student outcomes (e.g., math achievement), and its connection with formative instructional practices. Second, we discuss our sample, outcome, covariates, and statistical methodology. Third, we discuss the findings. Fourth and finally, we conclude this study with a discussion connecting our findings with current efforts and initiatives at the Oregon Department of Education (ODE) and a brief discussion of the study's limitations. Supplemental information includes two tables and the reference list.

Background

Self-efficacy represents a student's beliefs about their ability to perform a specific task (e.g., adding integers or graphing a linear equation)[1]—it can be thought of as a student's confidence in their ability to succeed. Empirical and theoretical research point to a positive association between a student's self-efficacy and academic achievement[2], such that students with higher degrees of self-efficacy tend to have greater persistence and tackle more challenging tasks. However, this association is complex and includes both direct and indirect connections between self-efficacy, its theoretical sources, and academic achievement.[3]

According to social cognitive theory, self-efficacy engages cognitive, motivational, affective, and selective processes which translate competence into successful action, behavior, and performance.[4] Students with higher self-efficacy anticipate learning opportunities, set challenging goals, and predict learning outcomes (cognitive processes); expend greater effort, persist longer in the face of learning obstacles, and attribute learning to effort rather than intelligence or luck (motivational processes); implement strategies, tools, and actions to manage stress and anxiety (affective processes); and identify, create, and participate in learning environments they perceive to foster success (selective processes). Essentially, self-efficacy regulates how students think, act, feel, and interact with their environment, and this results in successful performance on assignments, activities, projects, and tests.

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[1] Bandura (1977).

[2] Bandura (1977); Honicke and Broadbent (2016); Pajares (1996); Valentine et al. (2004); Yang, Maeda, and Gentry (2024).

[3] Caprara et al. (2011); Gebauer et al. (2020); Hwang et al. (2016); Olivier et al. (2019); Talsma et al. (2018).

[4] Bandura (1997).

Self-efficacy has four theoretical sources: mastery experiences, social persuasion, vicarious experiences, and emotional and physiological states.[5] Mastery experiences are past successful actions, behaviors, or performance. Prior experience successfully adding integers would be an example of a mastery experiences. Social persuasion is positive, supportive, and actionable feedback and encouragement from credible sources. Actionable feedback or suggestions on a math task or praise for contributions to a project from classmates or a teacher are examples of social persuasion. The opportunity to observe the successful actions, behaviors, or performance of peers, are vicarious experiences. An example is a student observing a classmate successfully graph a linear equation. Emotional and physiological states are feelings and physical responses an individual experiences while interacting with stimuli. The anxiety, stress, or excitement a student experiences while solving a math problem is an example of emotional and physiological states. The use of social and emotional learning (SEL) competencies to help students to recognize, interpret, and manage emotions is an example of a way to regulate emotional and physiological states while working through challenging tasks.[6]

We view the theoretical sources of self-efficacy as representing formative instructional practices (i.e., processes teachers and students use to gather evidence about learning to make decisions about instruction[7]) because they entail opportunities for students to gather evidence about prior and current performance. This occurs via support, encouragement, and feedback from classmates and their teachers; and meaningful discussions with classmates and their teachers. These formative instructional practices entail mastery experiences, social persuasion, vicarious experiences, and emotional and physiological states. For instance, while support, encouragement, and feedback clearly represent social persuasion, teachers and classmates also have opportunities to remind students of their successful prior performance on a task or assignment (mastery experiences) or how they were able to successfully navigate a stressful learning activity (emotional and physiological states). Students are able to develop vicarious experiences when they observe their classmates and their teachers modeling correct practices, understanding, and reasoning within classroom discussions. Lastly, students and teachers have opportunities to create mastery experiences within classroom discussions as part of learning by doing.

Figure 1 is a theoretical model of associations between math self-efficacy, its theoretical sources (i.e., mastery experiences, social persuasion, vicarious experiences, and emotional/physiological states), and math achievement. According to social cognitive theory and past empirical research, we would expect the theoretical sources to directly influence math self-efficacy, and, in turn, we would expect math self-efficacy to directly influence math achievement. We include

[5] Bandura (1977); Britner and Pajares (2006); Chen and Usher (2013); Joet et al. (2011); Usher and Pajares (2008); Usher and Pajares (2009).
[6] Durlak et al. (2011); Mahoney, Durlak, and Weissberg (2018); SEL standards and resources in Oregon.
[7] Black and Wiliam (2009); Heritage (2007).

two formative instructional practices in Figure 1, *Opportunities for Math Feedback and Help* and *Opportunities for Math Discussion*[8], which we intend to examine as a representation of the sources of math self-efficacy.

Opportunities for Math Feedback and Help refers to how often students felt they received (i) math help when they needed it, (ii) helpful comments on a math task or activity from their teacher, and (iii) helpful comments on a math task or activity from classmates. *Opportunities for Math Discussion* represents how often students perceive that they (i) talked about new or difficult math vocabulary with their teacher or classmates, (ii) worked in pairs or small groups to talk about a math problem, and (iii) talked with the whole class about a math problem the class was working on.

Figure 1

Theoretical model for the direct and indirect associations between sources of self-efficacy, formative instructional practices representing these sources, math self-efficacy, and math achievement

Methods

This study uses student level data from the 2023-24 administrations of the Student Educational Equity Development (SEED) survey and the Oregon Statewide Assessment System (OSAS)

[8] Andersson and Palm (2017); Black and Wiliam (1998); Hattie and Timperley (2007); Havnes et al. (2012); Ruiz-Primo and Furtak (2006); Wisniewski et al. (2020).

mathematics summative test. 22,709 4th grade students participated[9] in both the SEED survey and the OSAS math test during the 2023-24 school year.[10] We use the OSAS mathematics scale score to represent *Math Achievement* and 15 questions from the 4th grade SEED survey[11]: three questions for *Opportunities for Math Feedback and Help*, three questions for *Opportunities for Math Discussion*, and nine questions for *Math Self-Efficacy*. Lastly, we use several student background characteristics including *Students Experiencing Poverty*, *IEP Status (students with disabilities receiving special education services)*, *English Learner Status*, mid-year *Mobility*, and *Attendance*[12]. We use structural equation modelling[13] to examine the direct and indirect associations between *Opportunities for Math Feedback and Help*, *Opportunities for Math Discussion*, *Math Self-efficacy*, and *Math Achievement* (while controlling for student background characteristics).[14]

Figure 2

Empirical model for the direct and indirect associations between formative instructional practices, math self-efficacy, and math achievement[15]

[9] Not all students in Oregon had an opportunity to participate in the 2023-24 SEED survey; however, the demographics of SEED survey participants are reasonably similar to the demographics of K-12 students in Oregon public schools. See the SEED Survey 2023-24 State Report for more details.

[10] 16,563 4th grade students had complete data (i.e., no missing data in SEED survey item responses). This represents approximately 73 percent of the students who participated in both the 4th grade SEED survey and the OSAS math test in 2023-24.

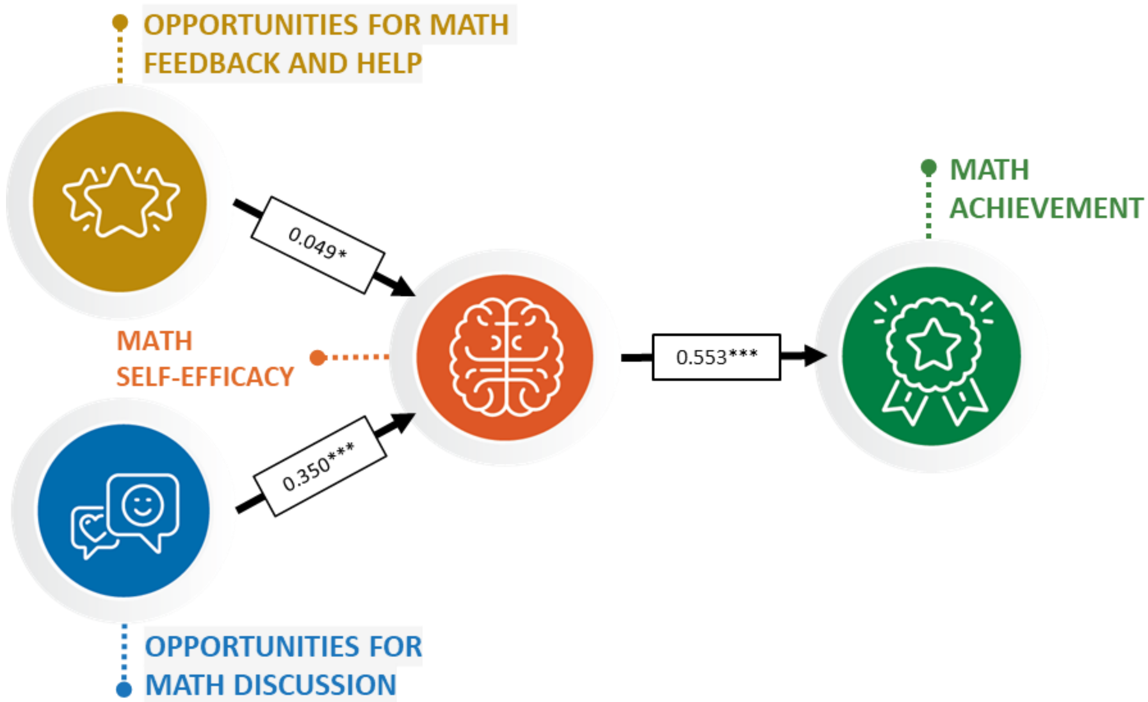
[11] See pages 5 and 7 of the 4th grade SEED survey to view the 15 survey questions.

[12] Attendance refers to the percentage of days a student attends—[days present/(days present + days absent)] × 100.

[13] We use R version 4.4.2 and *lavaan* version 0.6-19 to estimate the structural equation model.

[14] Structural equation modeling is a multivariate analytic approach that integrates confirmatory factor analysis (CFA) and multivariate linear regression to estimate the direct and indirect associations between observable and unobservable variables. Our study's structural equation model consists of three CFA models (one for each unobservable variable—*Opportunities for Math Feedback and Help*, *Opportunities for Math Discussion*, and *Math Self-efficacy*) and one multivariate linear regression which models *Math Achievement* conditional on the unobservable variables and the student background characteristics.

[15] Asterisks indicate the level of statistical significance for each estimate. * is $p \le .05$, ** is $p \le .01$, and *** is $p \le .001$. For instance, the estimate for the association between *Opportunities for Math Feedback and Help* and *Math Self-Efficacy* is statistically significant with a p-value less than $\alpha = .05$ (meaning the probability of us observing this estimate by chance, assuming the null hypothesis is true, is very rare and would occur less than 5 percent of the time).



Findings

Figure 2 displays the empirical associations between formative instructional practices, *Math Self-efficacy*, and *Math Achievement*. *Opportunities for Math Feedback and Help* and *Opportunities for Math Discussion* have a statistically significant and direct positive association with *Math Self-efficacy*, and *Math Self-efficacy* has a statistically significant and direct positive association with *Math Achievement* after controlling for student background characteristics (e.g., *Students Experiencing Poverty*, *IEP Status*, *English Learner Status*, *Mobility*, and *Attendance*). These associations support the theoretical model and match what we observe in the research literature.[16] In other words, students' confidence in their math ability is higher when they have more opportunities for math feedback and help, and classroom discussions. Subsequently, students will have higher math achievement (as measured by OSAS mathematics summative assessments) when they have higher confidence in their math ability.

All associations are positive between formative instructional practices, *Math Self-efficacy*, and *Math Achievement*; however, the size of the association differs substantially. For *Opportunities for Math Feedback and Help*, the size of the association with Math *Self-Efficacy* is very small (that is, a change in *Opportunities for Math Feedback and Help* results in a very small change in Math *Self-Efficacy*).[17] On the other hand, for *Opportunities for Math Discussion*, the association with *Math Self-Efficacy* is moderate (albeit seven times larger than the association for

[16] Chin and Kameoka (2002), Honicke and Broadbent (2016), and Valentine et al. (2004).

[17] This very small association represents 4.9 percent of a standard deviation in *Math Self-Efficacy*.

Opportunities for Math Feedback and Help).[18] The very small association between *Opportunities for Math Feedback and Help* and *Math Self-Efficacy* may be due to unmeasured variations in the nature of the feedback (uninformative or untimely feedback)[19], educator use of feedback[20], student perceptions of usefulness[21], the characteristics of the students (e.g., prior mathematical knowledge), or the characteristics of the specific mathematics task.[22]

The association between *Math Self-efficacy* and *Math Achievement* is moderately large[23] and more than twice as large as the associations between the student background characteristics (e.g., *Students Experiencing Poverty*, *IEP Status*, *English Learner Status*, *Mobility*, and *Attendance*) and *Math Achievement*.[24] The magnitude of the association between *Math Self-efficacy* and *Math Achievement* relative to student background characteristics is promising given perceptions that student background characteristics (e.g., poverty, socioeconomic status) are the strongest predictors of student achievement. This finding is encouraging because, unlike student background characteristics, *Math Self-efficacy* is malleable.[25]

The indirect associations between the formative instructional practices (specifically *Opportunities for Math Discussion*) and *Math Achievement* are very promising[26], and suggest that, for example, providing students more opportunities to discuss mathematics (e.g., practices, concepts, reasoning, etc.) with classmates and their teacher (either one-on-one, in pairs or small groups, or as a whole class) strengthens their self-efficacy and subsequently improves their math achievement. This echoes findings from recent empirical research[27] and promising practices in Hillsboro School District.

Conclusion

Improving math achievement via a focus on student self-efficacy and increasing opportunities for students to discuss math is very encouraging. Several initiatives and projects at the Oregon Department of Education (ODE) align with the findings in this brief as well as offer schools and districts tools, resources, and practices to connect the sources of self-efficacy (both theoretical and empirical) and self-efficacy to increase achievement. Examples of these projects include the Oregon Math Project (OMP), SEL, and Formative Assessment. For instance, the engagement, pathways, and belonging cornerstones of the OMP focus on modeling and exploration of various problem-solving strategies, encouragement to explore a variety of strategies, use of

[18] This moderate association represents 35.0 percent of a standard deviation in *Math Self-Efficacy*.
[19] Wisniewski et al. (2020).
[20] Yin et al. (2008).
[21] Rakoczy et al. (2019).
[22] Fyfe and Brown (2018).
[23] This association represents 55.3 percent of a standard deviation in *Math Achievement*.
[24] See Table 1 in the Supplemental Materials for more details.
[25] Yang, Maeda, and Gentry (2024).
[26] See Table 2 in the Supplemental Materials for more details.
[27] Chin and Kameoka (2002).

mathematical discourse (in pairs, small groups, or whole class), and building upon successful mathematical experiences. Additionally, SEL presents research-based evidence of increased positive social behavior and reduced emotional distress. This includes a focus on self-efficacy and developing tools to reduce stress and anxiety (which, as we mentioned previously, is an example of emotional and physiological states). Lastly, formative assessment and the emphasis on eliciting evidence of learning from students, especially via opportunities to discuss math, is a valuable through line which links the OMP, SEL, self-efficacy, and math achievement together.

Finally, although the associations we observe are promising and connect with empirical research and current practice, it is unclear if these associations are uniform across student identities, schools and districts, content areas, or grade levels. Recent empirical research suggests that students, according to their respective identities, may experience these associations differently.[28] Thus, we urge caution when interpreting the results and applying them to practice. We invite further quantitative and qualitative research by colleagues at Oregon schools, districts, colleges, and universities to replicate our study and explore differences across a variety of groupings and contexts.

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[28] Gebauer et al. (2020); Klassen (2004); Lewis et al. (2012); Manzano-Sanchez et al. (2018).

Supplemental Information

Table 1

Direct associations between formative instructional practices, math self-efficacy, and math achievement

Paths	Direct Associations
Math Achievement	
Math Self-Efficacy	0.553 (0.006)***
Students Experiencing Poverty	-0.234 (0.008)***
IEP Status	-0.189 (0.006)***
English Learner Status	-0.267 (0.007)***
Mobility	-0.032 (0.007)***
Attendance	0.160 (0.007)***
Math Self-Efficacy	
Opportunities for Math Feedback and Help	0.049 (0.024)*
Opportunities for Math Discussion	0.350 (0.025)***

Note. Direct associations are standardized regression coefficients. They represent the change in standard deviations in the outcome (i.e., *Math Achievement* or *Math Self-Efficacy*) associated with a one standard deviation increase in the covariates (i.e., formative instructional practices and student background characteristics). We use the WLSMV estimator in *lavaan* (Rosseel, 2012) with robust standard errors to estimate the structural and measurement models. Model fit includes $\chi^2(176, N = 16{,}563) = 11{,}111.510$, $p < .001$, CFI = .963, TLI = .975, SRMR = .039, RMSEA = 0.061. * is $p \leq .05$, ** is $p \leq .01$, and *** is $p \leq .001$.

Table 2

Indirect associations between formative instructional practices and math achievement

Paths	Indirect Associations
Opportunities for Math Feedback and Help → Math Self-Efficacy → Math Achievement	0.027 (0.013)*
Opportunities for Math Discussion → Math Self-Efficacy → Math Achievement	0.194 (0.014)***

Note. The indirect associations are the product of standardized regression coefficients (i.e., the product of two associations: covariate and mediator, and mediator and outcome). Specifically, they represent the change in standard deviations in *Math Achievement* associated with a one standard deviation increase in the covariate (i.e., *Opportunities for Math Feedback and Help* or *Opportunities for Math Discussion*) through a mediator (i.e., *Math Self-Efficacy*). We use the delta method to estimate the standard errors for the indirect associations (MacKinnon et al., 2002). * is $p \leq .05$, ** is $p \leq .01$, and *** is $p \leq .001$.

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