

Title: Improving Math Learning with Executive Function Skills and Inclusive R&D
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Every student is a powerful learner capable of succeeding in mathematics. The EF+Math Program aims to dramatically improve math outcomes for Black and Latinx students and students of all races experiencing poverty. We are a community of researchers, developers, educators, and students who are developing research-informed mathematics learning approaches for grades 3-8 that combine executive function (EF) skills, conceptual understanding and multi-step problem solving, and equity. Our Inclusive Research and Development (R&D) model places an intentional focus on equity throughout the R&D process and centers educators and students as crucial partners from the start. It is essential that mathematics education research and product development is connected to the realities of our education system and leverages the expertise of educators and students; we must continue to develop understanding of how to effectively link research and practice towards impact for students.

Our program is exploring two research questions: (1) In what ways does the simultaneous development of executive function skills with conceptual understanding and multi-step problem solving skills, with an explicit focus on equity, improve student learning outcomes? (2) How does the process of Inclusive R&D impact the research and practice outcomes? After the first three years of our Inclusive R&D cycle, preliminary data from small-scale studies suggest many of our approaches are improving mathematics learning, and simultaneously we are increasing our knowledge of the relationship between mathematics learning and EF skills. The attention to equity and educator voice in every stage of the R&D process is producing mathematics learning approaches that are aligned with classroom practice.

This session will engage participants in examining the findings from a portfolio thematic analysis, with perspectives from various teams, including both educators and researchers. We will then discuss the implications and applications of this work with all session participants, focusing on promising opportunities for integrating EF and equity within math learning experiences, and ways researchers and educators can collaborate together to do so.

Brief Literature Review and Theoretical Framework

Executive Function Skills, Mathematics, and Equity

We ground our work in answering the first research question in existing research on the mathematical development of EF skills, conceptual understanding and multi-step problem solving as critical components of mathematics learning, and equitable teaching and learning strategies. While existing mathematics programs and tools use some of these principles, we are unique in creating learning approaches and research methods that combine all three.

EF skills are the core capacities that allow us to manage our attention, thoughts, emotions, and behavior. EF skills include three separate and interacting processes: cognitive flexibility, working memory, and inhibitory control (Miyake et al., 2000). Strong EF skills can support students' actions to set and achieve their goals. Research suggests that we can strengthen EF skills through contextualized development opportunities (Clements et al., 2016; Diamond & Ling, 2019; Strobach & Karbach, 2016). Our work builds on existing research to emphasize an asset-based lens—in both awareness-building and in skill-building—so that EFs can be leveraged to support students' agency.

EF skills are associated with mathematics learning outcomes. Prior research shows that not only can strong EF skills support increased mathematics learning, but strong mathematical understanding can also support the increased development of EF skills (Bull & Lee, 2014; Merkley et al., 2018; Miller-Cotto & Byrnes, 2020). Additional research suggests that building EF skills may improve mathematics learning opportunities for all students. One study found that for students with high EF skills, there is a smaller gap in mathematics scores between students from low income and high income households (U.S. Department of Education, 2019). The association between EF skills and math learning outcomes and the need for in context development of EF skills informs our work of directly integrating EF strengthening opportunities within mathematics learning approaches will dramatically improve student outcomes in mathematics.

Conceptual understanding and multi-step problem solving skills are essential for students' mathematics learning (National Council of Teachers of Mathematics, 2014). However, studies show that Black and Latinx students and students of all races experiencing poverty are less likely to have access to educational opportunities that foster conceptual understanding and problem solving in mathematics (e.g. Berry, 2008). The EF+Math Program approaches embed EF learning opportunities within rigorous mathematics curricula that simultaneously support students' development of conceptual understanding and problem solving skills.

Further, studies suggest that instructional practices that give every student a chance to participate in mathematical discussions, foster their sense of belonging in mathematics classrooms, and develop their identity as mathematics learners may particularly benefit Black and Latinx students and students of all races experiencing poverty (e.g. Aguirre, Mayfield-Ingram, & Martin, 2013). The EF+Math Program mathematics learning approaches build upon the work of scholars who center Black and Latinx students and students of all races experiencing poverty to drive instructional approaches which attend to culture, power, and privilege (e.g. Gutiérrez, Goffney, & Boston, 2018; Martin, 2012; Martin, Gholson, & Leonard, 2011). Further, the community commitment to understanding EFs through an asset-based approach posits that developing and supporting EFs can lead to increased student empowerment and agency in learning.

Inclusive R&D and Our Community

To answer our second research question, we look to research on research-practice partnerships and inclusive and equitable research and design. The field of education research is increasingly incorporating perspectives of educators through research practice partnerships, research alliances, design-based implementation research, and networked improvement communities (Vetter et al., 2022). As Coburn et al. (2021) point out, all types of education research require collaboration with educators, but many new models pair teachers and researchers as collaborative partners. Understanding how research partnerships function to disrupt barriers to equity and invite disruption of power dynamics is essential for the future of education research and development (Coburn & Penuel, 2016; Vetter, et al., 2022). Inclusive R&D also draws from the fields of ed tech development and inclusive design models such as participatory design (DiSalvo et al., 2017), Inclusive Innovation (Angevine et al., 2019), and equityXdesign (Hill et al., 2016).

Additionally, Inclusive R&D is an example of how equity can be embedded in all stages of math education research, the importance of which has been articulated by Aguirre et al. (2017). The teams in our community are committed to developing their critical racial equity knowledge and cultural fluency; this work is ongoing, and includes creating equity surveys for internal reflection,

guidelines and tools for reflecting on their products and materials, and engaging in trainings on equity principles. The teams are composed of educators, students, researchers, and developers who collaboratively design, develop, and research equity-oriented mathematics learning approaches and assessments. The EF+Math Program intentionally structures and supports team dynamics and partner interactions to deconstruct hierarchies of power that arise implicitly throughout traditional R&D processes. Educators and students are involved in design, decision making, application, and research. The EF+Math Program also intentionally created this portfolio of teams working towards the same goals with different strategies to increase impact. The “power of the portfolio” —the benefits gained from this design—can be seen both in the way all teams contribute to the set of knowledge about EF, math, and equity, and in the development of collaborations across teams.

Methods

After many iterations of R&D in co-leadership with educators and students, the EF+Math Program teams have developed mathematics learning approaches that integrate executive function skills, conceptual understanding and multi-step problem solving skills, and equity using an Inclusive R&D process. They have begun testing their scientific hypotheses about the relationship between EF and mathematics through pilot studies in classrooms across the country. To our research questions, we conducted a thematic synthesis analysis (Braun & Clarke, 2006) of our portfolio of ten project teams’ work.

Data sources for the analysis included published results in journals and conference presentations, quantitative and qualitative work-in-progress findings, and qualitative and quantitative analysis of bi-annual surveys and interviews with community members. Participants included researchers, developers, educators, and advisors, providing holistic representation and varied perspectives from the different groups in the EF+Math Program community. In total, we analyzed 90 publications and conference proceedings, more than 60 in-progress analyses, and over 180 surveys and interviews. Surveys and interviews were structured to elicit participants’ perspectives regarding their ongoing work and impact, successes and challenges, and beliefs about Inclusive R&D.

Thematic codes of overarching constructs (EF, mathematics, and equity) and finer-grained sub-constructs were applied to each data source. Additional codes denoted whether data referred to learnings about the Inclusive R&D process or the learning approaches. Sample size, effect size, and individual study methods were also evaluated where appropriate to contextualize the data. Once codes were applied to all data, thematic analyses were conducted to identify consistent themes across the portfolio and uncover areas of intersection. Descriptions were created for each of the identified themes using the data sources and codes; these themes were shared back to participants across the community for member-checking. Here we present these themes or “insights,” representing the portfolio-level progress of our teams and community members.

Evidence of Promise and Contribution to the Field

Our first set of insights demonstrates how simultaneous development of executive function skills with conceptual understanding and multi-step problem solving and equity show promise for improving student learning. Evidence from teams who have conducted early implementation studies shows the positive impact of these approaches for Black and Latinx students and students of all races experiencing poverty. Additionally, teams’ research is revealing new insights about the relationship between EF skills and mathematics learning, which point to opportunities for better and

more tailored support for students. Specifically, student mathematics learning outcomes are improved when executive function skills are strengthened alongside positive student beliefs. In these efforts, we have also found that effectively building students' executive function skills during mathematics learning requires new instructional strategies, tools, and assessments. Our teams are building such adaptive assessments and tools alongside their learning approaches, which contributes to their dynamic understandings of student learning and drives iterative, continuous improvement of math learning approaches.

Our second set of insights outlines how Inclusive R&D processes can create meaningful impact for research and practice. When educators and students are involved at every stage of the R&D process, learning approaches are more relevant to the classroom. By bringing together educators, students, researchers, and developers, new learning approaches are most effectively integrated into curriculum, designed for straightforward implementation, and are adaptable in response to district, school, and classroom contexts. Further, centering equity from the beginning leads to mindset shifts and a culture of equity and inclusion throughout the process. Over the past three years, teams have demonstrated ways to implement equity-first Inclusive R&D in practice, and they have generated new insights on the promise of this approach. Once an equity-first mindset is established, every aspect of R&D work—including the research and developed approaches—is connected to this early commitment. For example, new student-centered tools and assessments emerge when diverse teams focus on designing for equity. Our teams are creating mathematics learning approaches that use culturally responsive classroom practices like student-centered, culturally inclusive instruction, and that foster collaboration and relationships to best help each student succeed. Teams are also developing and adapting assessments to better center student identities and reinforce asset-based mindsets around learning.

Conclusion

The impact of the EF+Math Program's work is already expanding beyond our community, shifting influential individuals' and organizations' behaviors and actions to be more asset-based and equity-centered. EF+Math Program's intentional emphasis on equitable processes and equity-centered and engaged people is creating a ripple effect that is transformative. With efforts from all of us across multiple sectors and with different areas of expertise, we can collectively transform mathematics education for our students and dramatically improve their mathematics learning outcomes.

Presentation Format & Engagement

This research symposium will invite participants to explore findings collaboratively and apply learnings to their own practices. We also aim for participants to create relationships with other researchers and educators interested in Inclusive R&D and our focal constructs. After a 10-minute introduction, we will lead an interactive exploration of findings related to the first research question (20 minutes). This will include context setting, with both researchers and educators sharing example data and themes. Then, participants will work together to draw conclusions and insights from what they are viewing. This structure will be repeated to address the second research question (20 minutes). After exploring both research questions, participants and presenters will discuss how to apply these insights to their own work (10 minutes), focusing on promising opportunities for integrating EF and equity within math learning experiences and opportunities for Inclusive R&D. The

remaining time (15 minutes) will be used for a group discussion to connect insights and respond to questions. Participants should leave with ideas on how researchers and educators can collaborate together to improve mathematics education, specifically with executive function skills and equity strategies.

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Improving Math Learning with Executive Function Skills and Inclusive R&D

Who We Are

EF+Math is a community of researchers, developers, educators, and students developing research-informed mathematics learning approaches for grades 3-8 that combine executive function (EF) skills, conceptual understanding and multi-step problem solving, and equity through a process called Inclusive R&D. EF+Math is a program of the Advanced Education Research and Development Fund (AERDF).

Problem Space

Improving mathematics learning outcomes is essential for students' success. This involves supporting students' development of conceptual understanding and problem solving skills. One possible lever for improved mathematical learning are **executive function skills**.

We also know that instructional practices that provide students access to mathematical discourse and complex tasks, foster students' sense of belonging, and develop their identity as mathematical learners are particularly important for supporting Black and Latinx students and students of all races experiencing poverty.

EF+Math project teams have engaged in **Inclusive Research and Development (iR&D)** to create math learning approaches that uniquely attend to conceptual understanding, problem solving and executive function skills through an asset-based, approach.

[[link](#) or QR code to primer]
More on our theoretical framework and literature review can be found here:



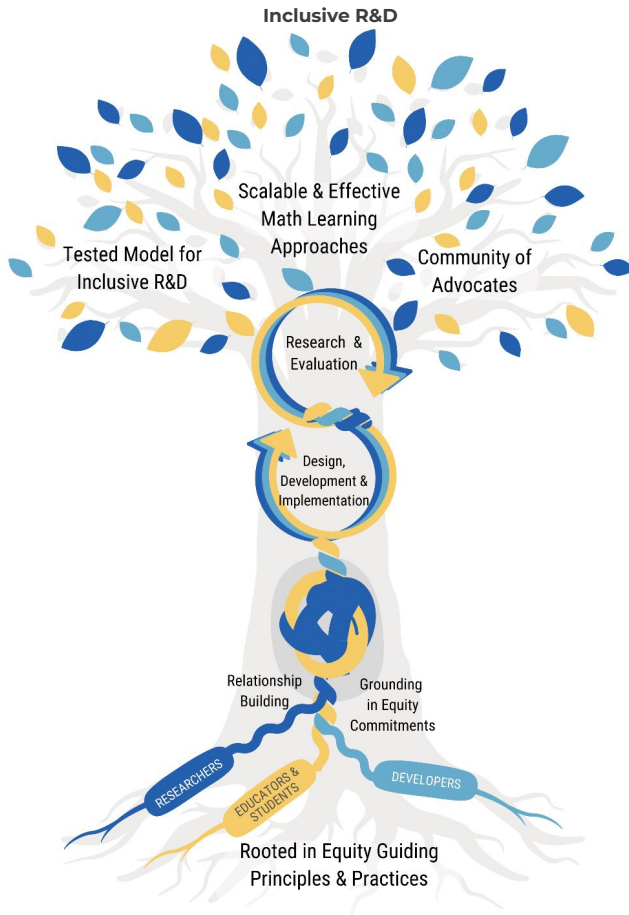
Research Questions

1. In what ways does the simultaneous development of executive function skills with conceptual understanding and multi-step problem solving skills, with an explicit focus on equity, improve student learning outcomes?
2. How does the process of Inclusive R&D impact the research and practice outcomes?

Methods

We engaged in a **portfolio thematic analysis**, where we examined 3 years of data from **preliminary, small scale studies** as well as **perspectives** from ten (10) teams, which included both **educators** and **researchers**. Other data sources included published results in journals and conference presentations, quantitative and qualitative work-in-progress findings, and qualitative and quantitative analysis of bi-annual surveys and interviews with community members.

Thematic codes of **overarching constructs** (EF, mathematics, and equity) and finer-grained sub-constructs were applied to each data source. Additional codes denoted whether data referred to **learnings about the Inclusive R&D process** or the learning approaches. Sample size, effect size, and individual study methods were also evaluated where appropriate to contextualize the data. Once codes were applied to all data, thematic analyses were conducted to **identify consistent themes across the portfolio** and uncover areas of intersection. Descriptions were created for each of the identified themes using the data sources and codes; these themes were shared back to participants across the community for member-checking.



What have we learned about improving student learning outcomes?

Simultaneous development of executive function skills with conceptual understanding and multi-step problem solving and equity show promise for improving student learning. Evidence from teams who have conducted early implementation studies shows the positive impact of these approaches for Black and Latinx students and students of all races experiencing poverty.

- Deeper sense of agency as math learners
- Positive math identities
- Improved outcomes on both internal and external assessments

Additionally, teams' research is revealing new insights about the relationship between EF skills and mathematics learning, which point to opportunities for better and more tailored support for students.

- Explicit attention to and development of EF skills increases students' metacognitive awareness, allowing them to be better agents of their learning
- Providing choice around how to enact problem-solving strategies enables teachers to understand areas of success and growth for students, allowing them to tailor supports in intentional and meaningful ways

What have we learned about the process of iR&D?

Inclusive R&D processes can create meaningful impact for research and practice. Research-informed learning approaches are

- More relevant to the classroom
- More effectively integrated into curriculum
- Designed for straightforward implementation
- Adaptable to district, school, and classroom contexts

Equity-based mindsets and processes from the beginning lead to

- New student-centered tools and assessments
- Embedded culturally inclusive instructional methods
- A focus on student identities

What's Next?

EF+Math's intentional emphasis on equitable processes and equity-centered and engaged people is creating a ripple effect that is transformative. Our work is continuing! Here is what is next for us in the next couple years.

- Full evaluation of math learning approaches developed through Inclusive R&D
- Opportunities for educators to learn about executive function skills in mathematics
- Codifying our learnings from implementing our Inclusive R&D model
- Constructing an "Inclusive R&D Toolkit" for educators and other partners who are interested in bringing the Inclusive R&D model to their own systems

District Opportunity:



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