# Teacher Participation in an Improvement Network: A Working Paper on Developmental Trajectories

March 2022


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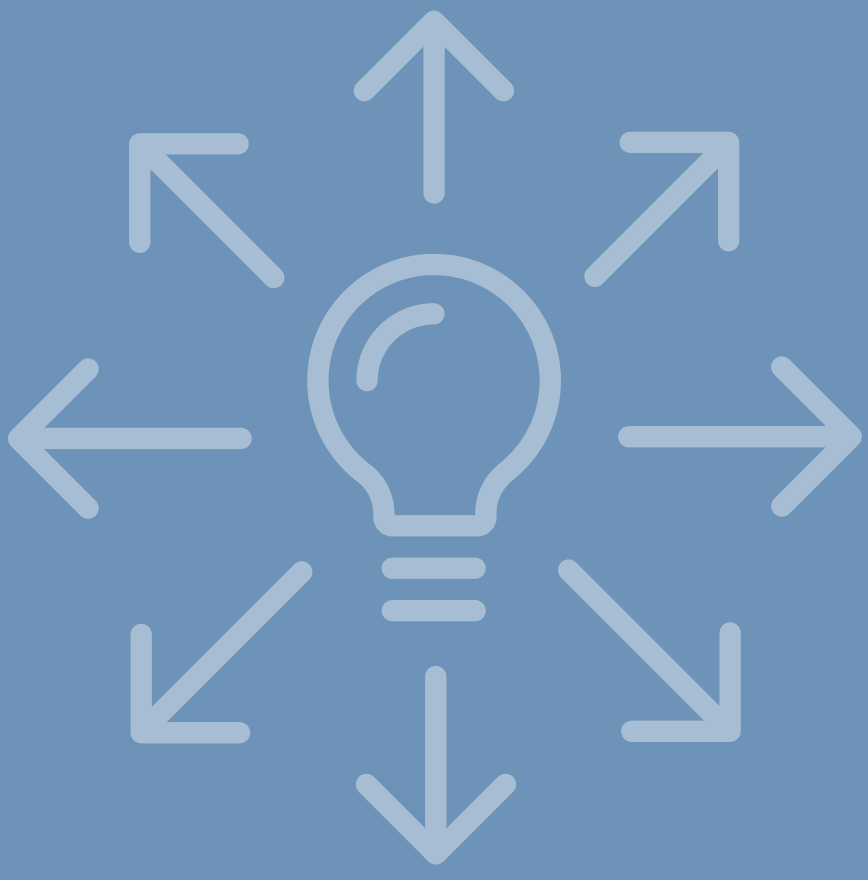

# Partners for Network Improvement

**Research, Strategy, & Evaluation**

Partners for Network Improvement (PNI) is a research and evaluation group based at the University of Pittsburgh's Learning Research and Development Center. Led by Jennifer Russell, one of the key developers of the Network Improvement Community Development Framework, PNI both leads networks and supports network leaders in their work to design, implement, and adapt improvement networks. Developmental evaluation is one tool PNI uses to help network leaders develop strong improvement networks.

## Developmental Evaluation

Although industries such as healthcare have used improvement science for decades, the use of improvement science and networked improvement communities is relatively new in education. Because this work is complex and innovative, and because improvement science by nature requires rapid tests of change, adaptation to context, and systems thinking, the Nellie Mae Education Foundation invested in an intensive developmental evaluation of the Better Math Teaching Network (BMTN). PNI conducted a developmental evaluation that studied and supported the networked improvement community's (NIC) initiation, development, outcomes, and dissemination of lessons learned.

PNI's developmental evaluation of BMTN aimed to:

- Infuse an evidence-based critical friend/thought partner perspective into the network development process
- Track growth and the development of the NIC as a learning organization
- Produce useable knowledge for the education field and specifically for other educators, policymakers, funders, and researchers interested in the NIC model as a way to organize for improvement and address high-leverage practical problems
- Advance the evaluation field by testing and refining models for evaluating improvement processes and NICs in education contexts


## Acknowledgements

We would like to thank the BMTN hub leaders and the 62 teachers who opened their practice and their learning space, and welcomed us in. We are inspired by their love of math, passion for students, and desire to never stop improving. We would especially like to thank the BMTN teachers who worked with us in 2020 to better understand their experience, over time, in the network.

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# The Better Math Teaching Network

From 2016 to 2021, the Better Math Teaching Network (BMTN) aimed to transform high school mathematics teaching in New England. Researchers and teachers worked together to make high school Algebra I classes more student centered. Launched by researchers at the American Institutes for Research (AIR), with support from the Nellie Mae Education Foundation (NMEF), the network was grounded in the following five core principles:

1. **Teachers are central to change.** Teachers shape students' learning experiences and beliefs about math. It is possible to create classrooms that are more strongly student centered—classrooms in which all students are actively and meaningfully engaged in learning math.
2. **Student-centered teaching is complex and almost impossible to do in isolation.** Teaching to maximize student engagement and understanding is complex. One way to deal with this complexity is for teachers to participate in structured, collaborative learning with other teachers and researchers.
3. **Teaching can be continuously improved.** Teaching is a craft to continuously hone. Teachers use practices daily that lend themselves to ongoing, incremental improvement. Continuous improvement methods from industry and healthcare hold promise for education.
4. **Quick-cycle improvement methods provide opportunities to study and improve teaching.** Many of the practices teachers want to improve on can be studied with quick-cycle research and development methods. Teachers can test and refine strategies within and across lessons, realizing improvements every few weeks, rather than waiting until summer break.
5. **Research and practice should be seamlessly integrated.** Too often, research and practice fail to inform each other. The BMTN included researchers and practitioners who worked arm-in-arm to test and refine improvement strategies in real classroom settings. Mutual respect fueled the work.

Network leaders organized the BMTN as a networked improvement community (NIC) to address a common problem of practice using improvement science. They drew on research to define three principles for Deep Engagement in Algebra (DEA), which anchored teachers' work as they strove to make their practice more student centered:

**Connect:** Make connections among mathematical procedures, concepts, and application to real-world contexts, where appropriate.

**Justify:** Communicate and justify mathematical thinking as well as critique the reasoning of others.

**Solve:** Make sense of and solve challenging problems that extend beyond rote application of procedures.

The BMTN was piloted with a group of nine teachers during the 2015–2016 school year and added teachers the following three years. In all, a total of 63 teachers engaged in the BMTN. Selected from a pool of volunteers that applied to join the network, participating teachers worked in urban, suburban, and rural contexts and taught at least one Algebra I course to ninth-grade students. They engaged collaboratively to continuously improve their teaching, enhancing learning for thousands of high school math students throughout New England.

Changing classroom instruction is a high-leverage opportunity for improving education at scale. For this reason, educators across the United States are engaged in networks that aim to improve teaching and learning. In networked improvement communities (NICs), educators work collectively to improve learning opportunities for students using improvement science methods (Bryk, Gomez, Grunow & LeMahieu, 2015; Gomez, Russell, Bryk, LeMahieu, & Mejia, 2016; Russell, Bryk, Dolle, Gomez, LeMahieu, & Grunow, 2017; Russell, Bryk, Peurach, Sherer, LeMahieu, Khachatryan, Sherer, & Hannan, 2019). NICs go beyond the typical workshop-based professional development to support collective learning in which educators:

- Commit to a shared goal that is tied to a measurable outcome
- Use disciplined inquiry methods anchored in concrete data to enact high-leverage instructional routines
- Experiment to find which practices work under which conditions

The NIC model for improvement in education has been in use for a little more than a decade. Instructionally focused NICs are temporary organizations that seek to improve classroom instruction and student outcomes. They typically depend on a finite funding stream and are run by hub leaders who have little to no authority over network members. Designing improvement networks is complex work, and how members engage in the work varies. Improvement networks are developmental in nature (Russell et al., 2019) in that some functions are more pressing in earlier years than in later years. For example, in the early formation of a NIC, hubs attend to the establishment of trust among members. As the network matures, and educators in the network have identified promising strategies through multiple testing cycles, hubs then shift their focus to the consolidation of learning and knowledge management.

Research identifies developmental processes for the formation and maturation of NICs (Russell, et al., 2017; Russell et al., 2019). We hypothesize that the educators who participate in NICs also experience developmental trajectories. We asked: What are teachers' experiences at different points in their participation in a NIC? How might they experience change as they remain in the NIC for several years? We explore these questions empirically through a case study of an instructionally focused NIC: the Better Math Teaching Network (BMTN).[1]

In order to better understand teachers' participation trajectories, we identified three different forms of learning we hypothesize are necessary to engage in an instructionally focused NIC:

1. Learning how to engage in a network (the social aspect)
2. Learning to use the tools of improvement science (the continuous improvement aspect)
3. Learning how to solve the focal problem of practice (the theory of improvement aspect—in the case of the BMTN, fostering deep student engagement in algebra)

To do this, we compared teachers' responses when they were in their first, second, third, and fourth years of network participation, regardless of how mature the network was at the time the individual joined.

1 See Appendix: Trajectory Methodology.

Given that there was some attrition and new teachers joined each year, we had more survey responses from teachers who had first- and second-year participation than we did for teachers who had third- and fourth-year participation:

| Participation years | Count |
|---|---|
| 1 | 53 |
| 2 | 54 |
| 3 | 32 |
| 4 | 12 |

We speculated that certain teacher characteristics might influence the trajectory of their participation experience. To describe this variation, we considered a set of teacher characteristics related to teacher tenure, their self-report on how student centered their instructional practice was when they entered the network, the quality of their improvement work, their prior connection to BMTN colleagues, and their school context. We report on some preliminary, data-based hypotheses about how teachers' experiences with network participation change over time. Specifically, we present mean responses to survey measures for each year of participants' engagement with the network (e.g., first year, second year) to show participation trajectories. In each section, we include vignettes from our analysis of five years of qualitative data.[2]

In the sections that follow, we present a set of preliminary hypotheses. The patterns we highlight serve as possible differences in how teachers with different characteristics experienced one instructionally focused NIC: the BMTN.

2 See Appendix: Trajectory Methodology.

# Learning How to Engage in a Network—The Social Aspect

Learning is accelerated in instructionally focused NICs as teachers share promising strategies with others in the network. In order to benefit from engagement in a NIC, members must understand how to participate in and learn within a network. Hub leaders explicitly structure ways to create these connections, such as designing routines for small improvement teams to meet regularly, and ways for ideas to be shared across teams or within the broader network.

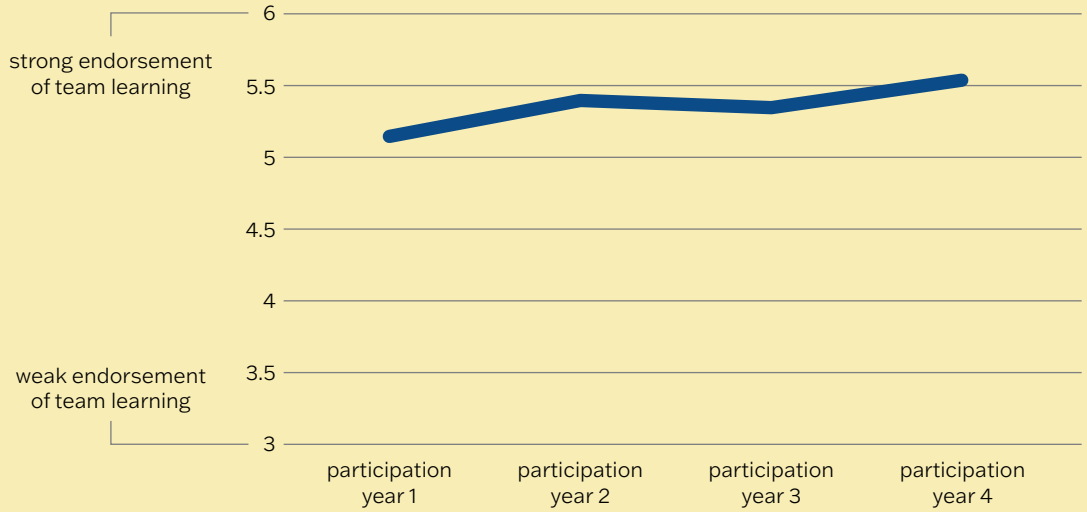
In the BMTN, hub leaders organized teachers into small teams (team learning) around one of the guiding mathematics core ideas: connect, justify, or solve (see definitions on page 4). The BMTN hub also structured ways for the individual and team learning to be shared across the network through whole network meeting presentations and by the use of tools such as annual change idea summary booklets.

# Team learning

The longer teachers stayed in the network, the more they came to appreciate opportunities for learning with a team of colleagues who were testing similar instructional changes, as shown in **Figure 1**.[3]

**The value of team learning increased each year, suggesting that team learning may be developmental.**

**Figure 1. Team learning trajectory**




Some preliminary developmental trends in team learning include:

- More experienced teachers tended to be less positive about their team learning experience during early engagement in the network, yet had the most growth over time.
- Teachers who had high-quality engagement in inquiry cycle work in their first year of network engagement were more positive about team learning than teachers whose inquiry cycle quality was in the mid/lower ranges. The high-quality engagement group's estimation of the value of team learning grew each year.
- Teachers who stayed in the network for four years and never knew any of the other BMTN teachers prior to joining the network were the most positive about team learning.
- Teachers who knew a colleague in the network in their first year of participation had higher appreciation for team learning experiences in their first year than those who did not.
- Teachers in rural schools had the most growth in appreciation for team learning over time.

3 Teacher responses to the network health survey tended to skew positive, so we have adjusted the x-axis on our graphics to reflect that trend.

## Casey

As a third-year teacher, Casey joined the network with her math coach in the network's pilot year. She appreciated having that connection:

> *I think at first, knowing [my math coach] helped me—as a newer teacher—not feel so shy. I was honestly a little bit intimidated. Having someone who knew me, and my classroom, and my teaching helped bridge the gap and build up my confidence a little bit in terms of the work that we were doing [in the network].*

In their third year of network participation, one of her pilot year BMTN colleagues moved to her urban school to teach in the classroom next door to hers. Casey enjoyed having a school-based buddy in the network:

> *The fact that we're teaching the same population of students really helped because we talk so often about how important it is to consider the context when you're thinking about change ideas. When we have the same population, we can be more aligned on our context. Just having people in your same district helps. Then, of course, when [network colleague] came to my school, it was even better because we were literally talking about the same students.*

Although she had curricular freedom to enact student-centered teaching strategies, inconsistent student attendance served as a barrier to her data collection efforts during inquiry cycles. Casey appreciated the participation structure and the cadence of the small group meetings. She learned the most from her small group colleagues (e.g., tweaking instructional changes, helping students connect ideas, using mechanisms for data collection). In her third year in the network, Casey found learning first-hand from other teachers invaluable (e.g., how they implemented lessons, what resources they used, specifics of classroom interactions that made it more student centered). As the network grew larger, she experienced a loss of intimacy and found the small group work enabled the deep sharing and development of stronger relationships she encountered in the network's early years. In her fourth year of participation, Casey reported:

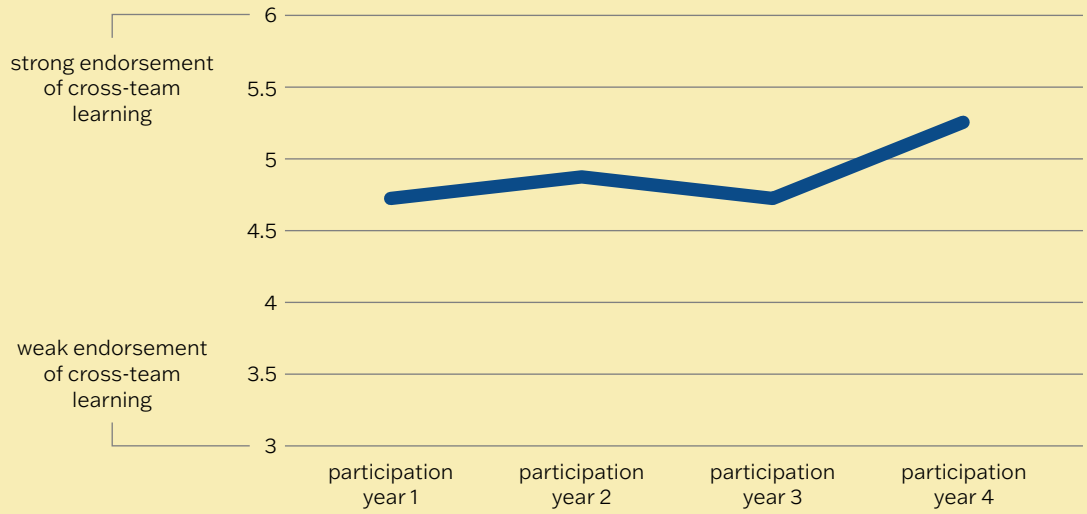
> *The benefit of engaging in this network is to be intentional about changing a part of your practice, as well as sharing ideas with colleagues from different districts and schools. I love hearing about other curricular resources people use and other strategies that teachers are using in their classroom. So often it is hard to find new ideas, and the network meetings provide a great space to share those ideas.*

# Cross-team learning

Building opportunities for network members to learn from colleagues beyond their improvement teams is one of the biggest challenges hub leaders face. In the BMTN, this challenge was magnified by the variation in contexts, teacher characteristics, and the vast number of instructional changes teachers were testing. For these reasons, cross-team learning was consistently valued for the first three years of participation and then became even more useful in teachers' fourth year of network participation, as shown in **Figure 2**.

**There may be a developmental aspect to cross-team learning in which participants experience the real benefits in later years of participation.**

**Figure 2. Cross-team learning**




Some preliminary trends in developmental patterns of cross-team learning include:

- Novice teachers were initially less positive about cross-team opportunities, but by their third year of participation, there was no difference between more or less experienced teachers in their enthusiasm for cross-team learning.
- Teachers who entered the network with low self-ratings on student-centeredness initially found cross-team learning more valuable. By their third year of participation, there was no difference between teachers who started more or less student centered.
- Teachers who had a buddy from their school in the network found higher value in cross-team learning in their first year. Teachers who knew someone in their first year of participation reported higher value in cross-team learning for their first two years. However, over time, the value of cross-team learning goes up for people without a buddy and goes down for people with a buddy. This may suggest that having a buddy reduces early anxiety about participating in the network but may constrict their outreach in later years.
- Teachers in schools with high proportions of students growing up in poverty and teachers in schools with high proportions of minoritized students initially find more value in cross-team learning, which later declines.

# Janet

Janet joined the network in her second year of teaching and identified herself as a student-centered teacher. As the only algebra teacher in her rural school, she craved collaboration with other algebra teachers and appreciated learning from the network teachers who were highly student centered. From the start, she found the small group work (team learning) useful, particularly in coming up to speed with measuring the impact of her instructional changes in the inquiry cycle process. In her first year of participation, she sought support for measuring the impact of instructional changes—collecting data was initially a challenge for Janet.

> *The biggest challenge for me comes when we do the PDSA [Plan-Do-Study-Act] cycle because I know what it looks like to collect the data, but sometimes it's hard because I'm trying to change too much at once. . . . It's a small thing that we're really focusing on changing or tying into our lesson, but sometimes the school day can be so unpredictable. I'll teach a lesson and then I'll realize, oh, we need more time on a specific topic. I don't necessarily feel like I can work on that same change idea consistently in every class, so sometimes that throws me off a little bit when I do my PDSA cycle.*

Working with her BMTN colleagues, Janet cultivated her skills in selecting appropriate measures and collecting meaningful data.

> *Brainstorming with my small group has been helpful. As time goes on, the [inquiry] process gets easier, but it's still that measures piece that's challenging. How do I know that I'm really engaging [the students] with depth? We talk about it in our small group.*

In later years, she sought out support to address issues in her own classroom practice. The collaborative aspect was critical to Janet across all four years of network participation. She appreciated the diversity of experiences network teachers brought to the work, as well as the range of school contexts among participating teachers. Janet placed high value on the ideas and resources other teachers brought to the network from which she learned.

> *I find it really helpful to have other people to communicate with in the network and bounce ideas off of. This is my second year teaching algebra, so I'm still a new teacher finding resources. Sometimes even those informal sharing moments give me ideas about how I can make algebra easier for my students. That colleagueship—being able to collaborate with others, the resources and learning that I take away from that—I see what it really looks like to learn algebra.*

Ultimately, the collaborative aspects of the network helped Janet to engage with colleagues in her own district:

> *The BMTN has made me more comfortable having those conversations with colleagues. I now represent the math department on the leadership team at our school, so I feel like I'm more comfortable in that role because I've been able to engage in some professional development related to math teaching.*

# Learning How to Use the Tools of Improvement Science— The Continuous Improvement Aspect

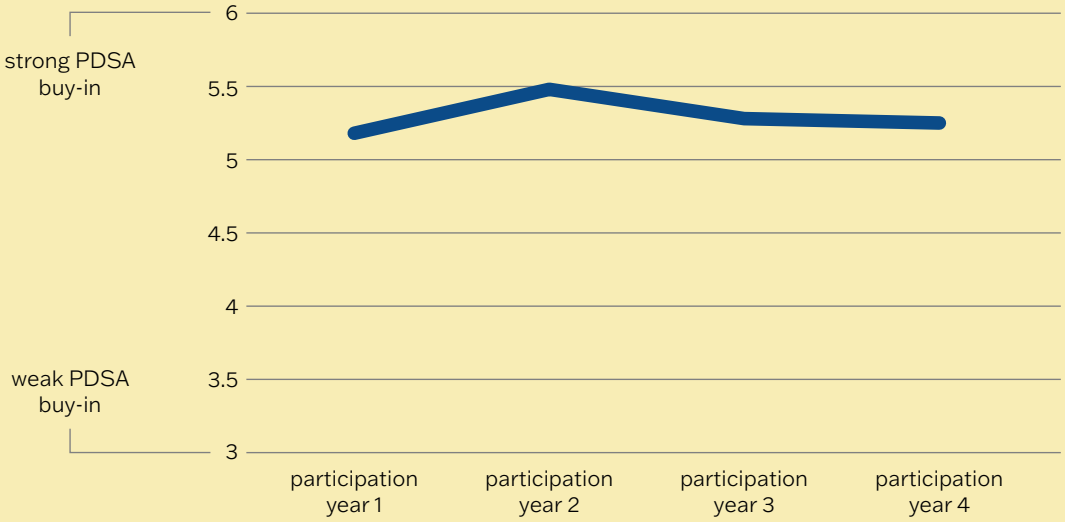
Improvement networks are different from other networks typically found in education in that they use a disciplined approach to organize improvement work. Tools and routines from improvement science structure the work in these networks. In the BMTN, teachers engaged in Plan-Do-Study-Act (PDSA) cycles as they sought to make their algebra classes more student centered. Learning how to use these tools and routines was new for all of the teachers who joined the network.

# Buy-in for PDSA cycles

Buying into PDSA cycles as a useful strategy for improvement is crucial to moving the needle on a network's aim. Overall, teachers' buy-in was highest in the second year of participation but declined in their third and fourth years, as shown in **Figure 3**.

**This suggests that enthusiasm for using PDSA cycles may grow in early years but levels off in subsequent years.**

**Figure 3. PDSA buy-in**




Some preliminary trends in buy-in for PDSA cycles include:

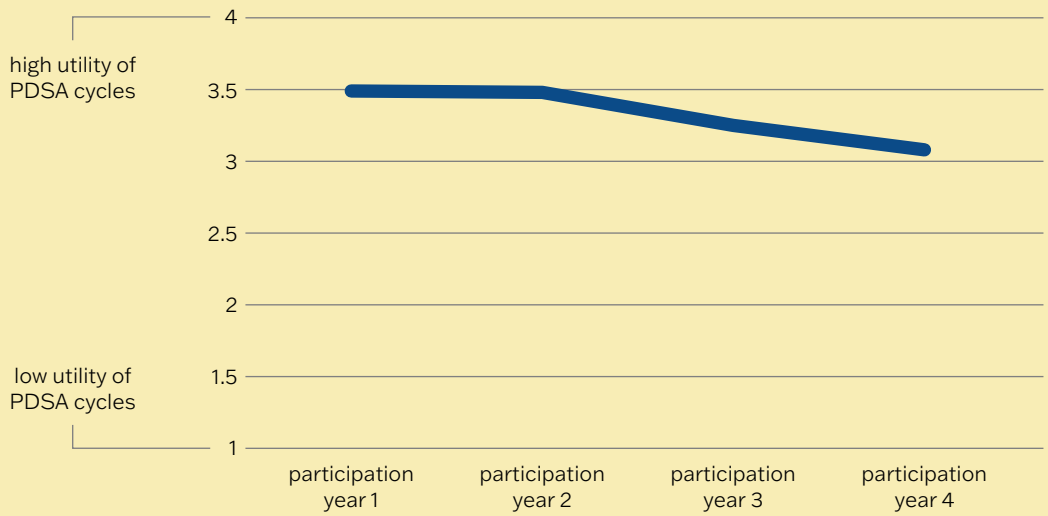
- Teachers who had higher-quality PDSA cycles in their first year had higher buy-in for the first and second years of network participation. This suggests that teachers who deeply engaged in the inquiry cycle process found value in it more quickly.
- Teachers who had a BMTN colleague in their school had more growth in their levels of PDSA buy-in from their first year of participation to their second year. Teachers who knew someone when they joined the network had higher buy-in in their first two years of network participation.
- Urban teachers had the highest drop in PDSA buy-in from their second year to their third year. This may suggest that urban teachers faced more contextual challenges in sustaining the use of PDSA cycles. This is confirmed in our qualitative data, as teachers in urban settings noted common challenges including student absenteeism and mobility.

# Utility of using PDSA cycles to test change ideas

The first year of engaging in PDSA cycles to test new instructional strategies tends to be quite difficult. After this initial learning curve eases, some teachers find inquiry tools highly useful while others experience less utility. In the BMTN, teachers had to create their own change ideas to test, which put pressure on them to both identify a high-leverage strategy and design practical measures that would tell them if their change was leading to improvement. Overall, BMTN teachers found the PDSA cycle to be less useful after their second year of network participation, as shown in **Figure 4**.

**Early perceptions of the utility of PDSA cycles are tempered somewhat over successive years of network participation.**

**Figure 4. Utility of PDSA cycles to test change ideas**




Some preliminary trends in the developmental nature of PDSA cycle utility include:

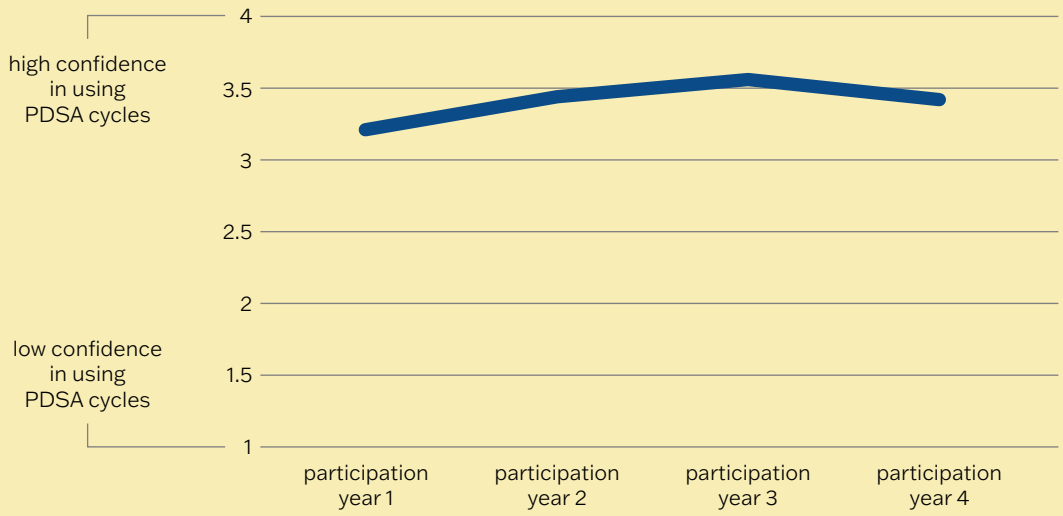
- Teachers who entered the network with low self-ratings on student-centeredness found PDSA cycles to be more useful after their first year in the network, but that utility fell again in their third year of participation.
- Teachers who entered the network with high self-ratings on student-centeredness found PDSA cycles to be less useful after their second year in the network.
- Teachers who had high-quality PDSA cycles in their first two years of participation identified PDSA cycles to be more useful. This suggests that early support for rigorous, high-leverage PDSAs may be important in later perceptions of utility.
- Teachers who knew someone when they joined the network found PDSA cycles to be more useful across all years of participation.
- Teachers in rural schools consistently found PDSA cycles to be useful. Teachers in suburban schools found the PDSA cycles to be less and increasingly less useful over time. Teachers in urban schools found the PDSA cycles to be less useful after their second year of participation in the network.

# Confidence in using PDSA cycles

The longer a teacher was in the BMTN, the more confident they became in using PDSA cycles. While the number of teachers who participated is small for the fourth year, there appears to be a small drop in confidence, as shown in **Figure 5**.

**Teachers' confidence in using PDSA cycles generally increases over time.**

**Figure 5. Confidence in using PDSA cycles**




Some preliminary developmental trends in confidence in using PDSA cycles include:

- Novice teachers had the biggest growth in confidence after their first year in the network.
- Teachers who entered the network with lowest and highest self-ratings on student-centeredness had larger growth in confidence in using PDSA cycles after their first year in the network. Teachers who rated themselves as more moderately student centered had slow and consistent growth in confidence across three years of participation.
- Teachers who knew someone in the network at some point had the highest growth in confidence, which was steady across three years of network participation. Teachers who knew someone when they arrived in the network had particularly high growth in confidence between their first and second year of network participation.
- Teachers in schools with high proportions of students growing up in poverty and teachers in schools with high proportions of minoritized students had the most growth in confidence after the first year of network participation.

# Amanda

Amanda was an experienced, student-centered teacher when she joined the network in its pilot year. She taught in an urban, alternative school. As the only math teacher in her school, she craved the collaboration that the network offered. Committed to evidence-based strategies, she was very reflective about how her practices influenced and engaged students. Despite constraints in amassing substantial data sets given her small class sizes, high student turnover, and absence rates, Amanda believed in the PDSA process as a strategy for changing practice:

> *[Rather than] totally turning practice upside down . . . the beauty of improvement science is that you are trying out little by little something that's manageable. You choose the idea, and you choose the data that you're going to collect. I think that is a more authentic way to work on change in practice, and hopefully it leads to more opportunities for students to be at the center of the process.*

She appreciated the PDSA inquiry cycle and the process mapping tools, pointing to them as both useful for continuous improvement as well as accountability:

> *What I really appreciate about the PDSA cycle is that it brings attention to something that you know you need to work on—or you really want to work on—but you don't usually have time. . . . I think the actual act of looking at the data gives you so much insight into what's happening in the classroom.*

Over time, Amanda grew confident in her use of continuous improvement as she tested out each DEA.

> *I got better at figuring out what data to collect. It got easier to find the measures that would fit best with, 'Will students do it with depth?' It got easier as time went on, because I think for a lot of people, myself included, finding the right measure was the hardest piece.*

# Ellen

Ellen was a veteran teacher who came to the BMTN in the first full year of the network, with her school-based colleague, Julie, who was a less-experienced teacher. They both had room to grow as student-centered teachers. Ellen welcomed the collegiality offered by teachers in the network, appreciating the common challenges they faced despite their different contexts. The collaboration with Julie strengthened the quality of her inquiry cycle work as well as her confidence. In their first year of participation, their PDSA work was shared with the rest of the teachers to serve as a model of what high-quality documentation looked like. They often chose to test out the same strategy, sharing tasks and ideas for measures, working through challenges, and supporting each other through the process. In their third year of participation, they had another school colleague join the network. Ellen shared:

> *I talk with Julie and Kaitlyn because it can be aggravating to pick what I think is a perfect task, set everything up, and then discover that my students have gone in a completely different direction than anticipated. This leads me to feel frustrated, and I wonder what to do with all the data that I collected. It happens to all of us. I find it encouraging to have conversations with others who understand my struggles.*

Ellen notes that learning how to implement the PDSA is not a game of mastery—some challenges recur, dependent on mathematical content focus, student population, and local context.

# Learning How to Foster High School Students' Deep Engagement in Algebra—The Theory of Improvement Aspect

Instructionally focused NICs seek to improve a shared outcome. Collectively, they build a theory of improvement—a roadmap for how to improve teaching in support of more powerful student learning. In the BMTN, math teachers from all over New England worked to increase the number of high school students who were deeply engaged in algebra. The network's theory of improvement was to increase student engagement in high school math by focusing their improvement work on three principles for Deep Engagement in Algebra (DEA):

- **Connect:** Make connections among mathematical procedures, concepts, and application to real-world contexts, where appropriate.
- **Justify:** Communicate and justify mathematical thinking as well as critique the reasoning of others.
- **Solve:** Make sense of and solve challenging problems that extend beyond rote application of procedures.

These three DEA principles guided the design of instructional changes that teachers tested in their classrooms.

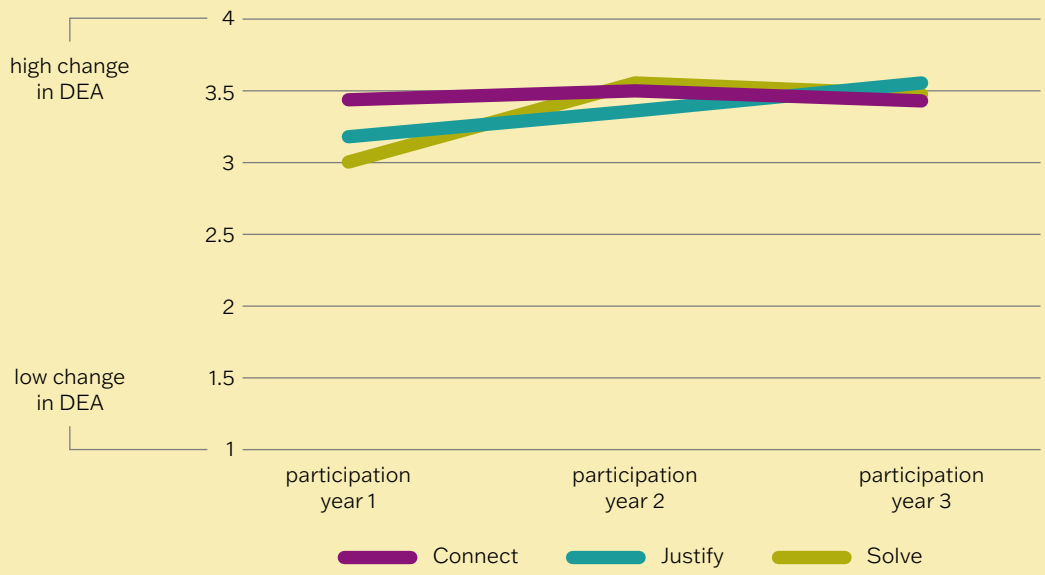
We examined teachers' self-report of changes in their practice for each of the DEA principles, as well as changes in their confidence for engaging students to connect, justify, and solve. We consider DEA-related changes in instructional practice as an indicator of teachers' growth in alignment with the network's theory of improvement and explore whether there is a developmental pattern aligned to participation years.

# Practice change: DEA

Most teachers reported consistent instructional improvement each year related to the DEA principle on which they focused. Rather than steep increases, teachers reported slow, steady progress improving student-centered math instruction that focused on the DEA principles. As shown in **Figure 6**, teachers consistently reported change in their instructional practices each year for each DEA area of focus. However, patterns in the scope of change vary by DEA principle. Greater proportions of teachers who focused on **solve** accelerated the scope of their instructional change from their first year to their second year. Teachers who focused on **justify** showed evidence of gradually increasing instructional changes from their first year to their third year of participation. Acceleration in change was less evident for teachers who focused on **connect**, who tended to report consistent change in their uptake of DEA-related practices.

**This suggests that network members' experience around practice change connected to the NIC's theory of improvement is likely incremental.**

**Figure 6. Change in practice in *connect*, *justify*, and *solve* by area of focus**




Some preliminary trends in growth in engaging students in **connect**, **justify**, and **solve** with quality include:

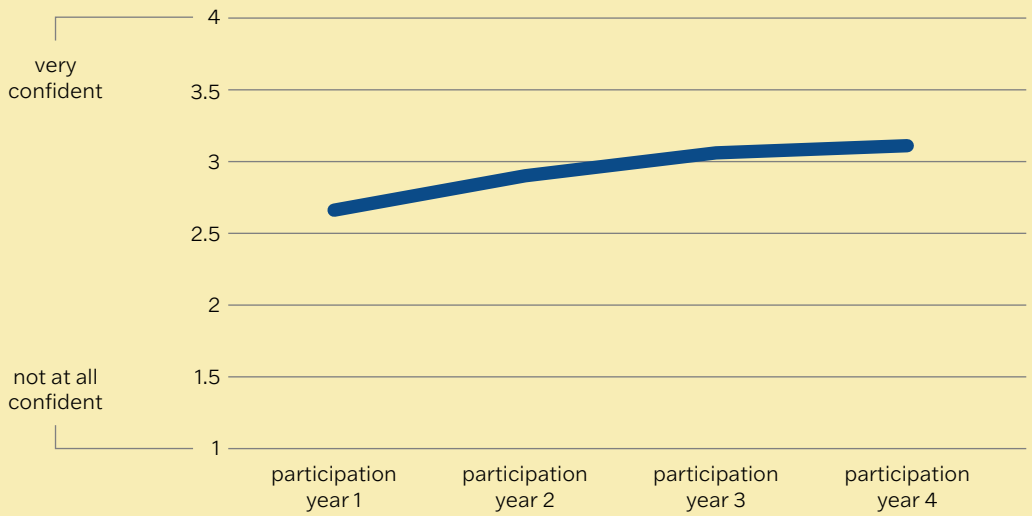
- Teachers who had between 0 and 10 years of teaching experience reported the most instructional growth over time. Experienced teachers (20+ years) had the most growth in **connect-** and **justify-**related instructional changes.
- Teachers who entered the network with high self-ratings on student-centeredness had the most growth in instructional changes over time. They reported the most growth in **solve**.
- Teachers in schools with high proportions of students growing up in poverty and schools with high proportions of minoritized students, as well as those teaching in urban schools, reported more instructional change than teachers who taught in other contexts.

# Confidence in DEA

Each year, network members became more fluent in the theory of improvement and more confident in implementing the theory in their classrooms, as shown in **Figure 7**. The longer teachers participated in the network, the more their confidence engaging students in **connect**, **justify**, and **solve** with quality grew.

**For NICs more broadly, this may suggest that network members become more confident with the network's theory of improvement in each subsequent year of participation, with the most growth in early years.**

**Figure 7. Confidence engaging students in the DEA principles with quality**




Some preliminary developmental trends in teachers' confidence in engaging students in **connect**, **justify**, and **solve** with quality include:

- The more student-centered teachers were when they joined the network, the more their confidence engaging students in **connect**, **justify**, and **solve** with quality grew.
- Teachers who knew someone in the network reported more growth in their confidence engaging students in **connect**, **justify**, and **solve** with quality after their first year of participation.
- Teachers in schools with high proportions of students growing up in poverty and schools with high proportions of minoritized students reported more growth in confidence engaging students in **connect**, **justify**, and **solve** with quality over time.

# Monique

Monique joined the BMTN in the third year of the network as a previously highly student-centered teacher from an urban school. When she moved from teaching upperclassmen to ninth grade before joining the network, she shifted her instructional practices to a more teacher-centered approach—she did not perceive ninth graders to be mature enough to engage in a student-centered learning environment. The network changed her approach:

> *When I abandoned (student-centered teaching), I arranged my students in rows again. I was teaching. I was modeling. Students were doing what I was suggesting. It was the old teacher talk / teacher teach kind of thing. Two years in, I found the network. Through the network and by hearing what other teachers were doing with ninth graders, I returned to a student-centered dynamic. I gave it a try and never looked back. Now, students are seated in small groups. Our routines include individual, partner, small, and whole group dynamics. Students are collaborating. Students are thinking. Students are problem solving. They make choices about learning partners, tasks, and their process. Within the framework of our routines, there is different work every day to keep students on their toes and improving. It is a lively, noisy, dynamic classroom again; and students are learning Algebra 1 concepts with depth as opposed to that cursory, procedural-type learning.*

Monique valued the inquiry process and documentation, viewing the PDSA as a tool for reflection and accountability. Trying out each DEA principle, she gained confidence in using PDSA cycles to test ways to make her algebra classes more student centered. She reported tremendous growth in learning—her own learning in terms of her pedagogy and professional practices as well as increased learning evidenced among her students.

# Mary

Mary had just moved from middle school to high school algebra when she joined the network. She did not have a toolbox of student-centered strategies for her new role, and she relied on a few veteran teachers in the network to help her identify promising strategies to test. The PDSA process opened her eyes to her own teaching practices and their influence on her students, and she became more confident in her ability to engage her students. Mary made great strides in improving deep engagement in **solve** in her classroom, finding a tried-and-true routine to use regularly.

> *My planning changed because I knew—whether I'm teaching new content or previously reinforced content—this would be the structure. I realized that this routine is solid. It works for most tasks. By using this routine regularly, kids get used to it. They get more familiar with being an independent learner, and it helps them deal with any math anxiety.*

Mary came to strongly believe that small change yields big improvements:

> *I used to think that systematic change within my classroom was too overwhelming and too challenging, and I'd stick to what I was doing. For example, if engagement was low in my classroom, I would think, 'Well, those were just external factors that impact students, and I really can't change that.' Now, I think that obviously I can change that. If there is an inequity in my class, an inequity of voice, if students are not talking as much—all of those things I can change.*

As her confidence in using continuous improvement grew, so too did Mary's ability to deeply engage her students in **solve**.

# Conclusion

In this analysis, we use the case of the BMTN to explore whether individuals participating in a NIC experienced common developmental trajectories on known dimensions of engagement. Our analysis included quantitative data from annual network member surveys and qualitative data from annual member interviews. We find evidence that suggests potential developmental trajectories on three key dimensions of network participation:

1. **Learning how to engage in a network**
   - Team learning may be developmental in that with each subsequent participation year, the value of team learning increases.
   - There may be a developmental aspect to cross-team learning in which participants experience the real benefits in later years of participation.
2. **Learning to use the tools of improvement science**
   - Enthusiasm for PDSA cycles may build from year 1 to year 2 but then level off in subsequent years.
   - Early perceptions of the utility of PDSA cycles may be tempered somewhat over successive years of network participation.
   - Confidence in using PDSA cycles to improve increases with each year of network participation.
3. **Learning to take up the theory of improvement**
   - Network members' experience around practice change connected to the NIC's theory of improvement is likely incremental.
   - Network members become more confident with the network's theory of improvement in each subsequent year of participation, with the most growth in years 1 through 3.

In addition, we found preliminary variations based on participant characteristics such as teaching tenure, whether they participated in the network with a colleague they knew prior to joining the network or with a school-based colleague, the context of their school, and how student centered they were at the outset of their participation.

Together, we think that these early findings of potential patterns would benefit from further exploration across networks and with larger numbers of participants to empirically validate whether these are case-specific patterns or more universal participation trajectories. Should developmental trends in NIC participation be validated, network leaders could draw on these to provide timely and tailored supports to network members.

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# Appendix: Trajectory Methodology

## Methodology description for quantitative analyses of trajectory study

The quantitative findings of this report were drawn from four years of network participant survey data. Network participants completed surveys via Qualtrics twice a year over four years. Network participant responses were exported as a csv file for each survey.

To conduct the trajectory analyses, we generated a time-series dataset consisting of row-level data for each teacher at every survey time point. This dataset was constructed by merging each csv file using unique identifiers for both participants and survey time points. Survey responses were then aggregated for each point in time.

The complex design of the study did not allow for experimental or quasi-experimental analyses. However, the survey data coupled with observational and interview data allowed for a descriptive assessment of constructs related to network improvement. We assessed change over time using summary statistics (i.e., means, standard deviations, etc.) for each survey time point. Subgroup analyses were conducted using attribute variables associated with each teacher participant. Subgroup analyses included teacher length of tenure, a binary variable for teachers in schools with high proportions of students growing up in poverty (schools in which at least half of the students receive free/reduced priced lunches), a binary variable for teachers in schools with high proportions of minoritized students (at least 50% of students in the school are minoritized), and school location (urban vs. rural vs. suburban). Subgroup analyses were also conducted using constructs and codes assigned by qualitative researchers. These variables included whether a network participant had a friend and/or colleague in the network, PDSA quality indicators, and network engagement codes. We also drew on participant responses from surveys to explore correlational patterns across teacher self-assessments (e.g., the extent to which they perceived their instruction as student centered prior to network participation).

Data cleaning, structuring, and analyses for this report were conducted using open-source statistical software. Data analyses were conducted using pandas (version 1.2.4) data analysis packages in Python (version 3.8.8).

## Methodology description for qualitative analyses of trajectory study

Analyses of survey data from the initial two years of the BMTN suggest that several variables appear to influence teachers' experience within the network, including teachers' professional tenure, school context, existence of connections at the onset of joining BMTN, and familiarity and practical experience with student-centered instruction. To explore these preliminary findings, we selected 13 BMTN teachers in year 3 of the developmental evaluation for in-depth study to explore teachers' developmental trajectories across their participation years in the BMTN. Specifically, we designed this qualitative study to enable greater exploration of and corroboration with the preliminary themes emerging from these trajectory analyses of survey data, as well as to identify additional themes emerging from teachers' participation in the BMTN over successive years. Selected teachers represent a mix of cohorts, school contexts, and familiarity and experience with student-centered instruction.

## Table 1. Characteristics of trajectory case study teachers

| COHORT (N) | TENURE (N)<br>Veteran (17+ years)<br>Novice (<7 years)<br>Neither Novice nor Veteran (7–17 years) | SCHOOL CONTEXT (N) | Self-report of student-centered EXPERIENCE upon joining the network (N) |
|---|---|---|---|
| Cohort 1: 5 | Veteran: 5 | Urban: 6 | Seasoned: 4 |
| Cohort 2: 4 | Neither Veteran/Novice: 5 | Suburban: 4 | Room to Grow: 6 |
| Cohort 3: 4 | Novice: 3 | Rural: 2 | Not Student Centered: 3 |
| | | Public Charter: 1 | |

We examined qualitative data across all years of participation for each of the 13 teachers comprising the trajectory study sample. For each selected case, we examined interview transcriptions by program year along several key dimensions to glean developmental trajectories. These dimensions and overarching questions included:

- **Benefits** (In what ways, if at all, do the perceived benefits of network participation change over time?)
- **Challenges** (In what ways, if at all, do the challenges to participation change over time? To what extent is there change over time in whether/what ways challenges are mitigated?)
- **Quality of PDSA** (Does/how does the quality of teachers' PDSA change as they become more experienced in the network?)
- **View of the network** (In what ways do teacher perceptions of how the network design serves their needs change over time?)
- **Key learnings** (In what ways do teachers' key learnings shift over time in terms of domain of learning [IS, NIC content, being in network] and source of learning?)
- **Room to grow** (Upon entry into the network, how much room did each teacher have to grow on student-centeredness, improvement science, math content?)
- **Local context** (How did their local context shape their engagement in the work?)
- **Impact** (How does teacher report of impact on practice and student engagement change over time? To what extent does practice change sustain over time as a result of engaging in PDSA cycles? Are teachers using PDSA cycles in their practice?)
- **Spread** (What are the various profiles of spread?)

The primary data source was teacher interviews conducted biannually each program year as part of the developmental evaluation. Additional data sources included case study profiles of those teachers featured as part of the developmental evaluation's case studies of select teachers, and survey data illuminating additional insights into dimensions analyzed.

## Table 2. Data sources for trajectory study qualitative analyses

| Data sources | Data collected |
|---|---|
| Teacher interviews | Year 1: December 2016 (9), June 2017 (9)<br>Year 2: December 2017 (13), June 2018 (13)<br>Year 3: March 2019 (12), May 2019 (11)<br>Year 4: March 2020* (12), May 2020* (2) |
| Network health survey | Year 1: December 2016, June 2017<br>Year 2: December 2017, May 2018<br>Year 3: January 2019, June 2019<br>Year 4: February 2020, May 2020<br>Final reflection survey: April 2021 |
| Case study profiles | 13 teachers |
| PDSA documentation | Between 2 and 4 cycles for each year of participation:<br>Cohort 1 and 2 teachers: 9<br>Cohort 3 teachers: 4 |

* Included high-level theme questions pertaining to program experiences over course of teachers' multi-year participation.

Following the creation of a matrix for each individual teacher that highlighted and summarized development along these key dimensions across multiple years, the evaluation team compared individual teacher trajectories against the dimensions and key themes emanating from the trajectory analyses of survey data, including:

- Benefits of BMTN participation
- Network value
- Challenges
- Confidence in using improvement science
- Utility of improvement science
- Value of social resources
- Network culture
- Quality of PDSA documentation

Themes emanating from the trajectory analyses of qualitative data include:

- Teachers' appreciation and value for social resources afforded by the network grow over time.
- Teachers' confidence in using improvement science techniques increases with time and experience.
- Knowing someone in the network at the onset of joining accelerates perceived benefits of the network.

Vignettes included in the body of this report highlight these themes in individual profiles.

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