Carnegie Math Pathways

FRIENDS OF EVIDENCE

CASE STUDY

This is one of a series of illustrative case studies, under the auspices of the Friends of Evidence, describing powerful approaches to evidence being taken by initiatives currently engaged in efforts to improve outcomes among disadvantaged children, families, youth and neighborhoods.

"Developmental math is where aspirations go to die." This observation by Uri Treisman, a professor of mathematics at the University of Texas at Austin, reflects the extraordinarily high failure rates among the half-million community college students annually assigned to developmental (remedial) math instruction as a pre-requisite to taking college-level courses. About 80 percent of students enrolled in these courses never complete or pass them. For these students, developmental math is a formidable barrier to higher education.

The Carnegie Foundation for the Advancement of Teaching created the Carnegie Math Pathways (Pathways) to tackle this problem through a network of college faculty, administrators, researchers and program designers who are working together to address a specific problem of practice. Pathways has dramatically increased the success rates of community college students in remedial math courses while also shortening the time spent doing so—compared to students enrolled in traditional developmental options. Specifically, among the 27[1] participating colleges in the 2013-2014 school year the results were as follows:

- Of the 2,831community college students who enrolled in the Pathways one year-course approach (Statway) in the fall of 2015, 1,582 (56 percent) passed the full course and earned college credit. By contrast, only 6 percent of a baseline group of similar remedial math students successfully earned college credit in one year and only 15 percent did so in two years.

- Of the 2,547 students who enrolled in the Pathways one-semester course approach (Quantway 1) in 2015-2016, 1,720 (62 percent) successfully completed remedial math in one semester, whereas only 21 percent of a baseline group of similar students completed remedial math in one year.

Thus, in both approaches, Pathways students achieved about triple the success of comparable students in half the time. Moreover, these improvements have occurred for every racial, ethnic and gender subgroup and at virtually every college participating in Pathways, despite the varying conditions and resources across these schools. The achievement of such dramatic and consistent results at scale is rare in the education field.

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[1]Since 2013-14, the number of participating community colleges in the initiative has grown to 50.

The vehicle Carnegie used to produce these results is "Improvement Science,"[2] an approach to generating and using evidence to drive continuous improvement in practice.[3] Carnegie created Pathways not only to change the life trajectories of struggling community college students, but also as a test case to demonstrate the potential of Improvement Science to transform the education sector.

The remarkable accomplishments of Pathways demonstrate not only the progress that can be made in higher education, but in the public sector more generally when a broad spectrum of evidence is brought together within a continuous improvement approach to make progress on a difficult-to-achieve result. Specifically, Pathways demonstrates the usefulness of pulling together multiple sources of evidence and evaluation to design test and improve new interventions. Pathways also provides a powerful example of how networks can be leveraged to accelerate learning and scale innovation and quality improvement. Finally, Pathways illustrates that to achieve big results, reliably and at scale, programs need to build a substantial infrastructure to support quality improvement and embed quality improvement into the culture, norms, and practices of an initiative's staff and partners.

This case study looks at Pathways through the lens of how the initiative uses and generates evidence in order to achieve its goals. Our analysis is organized around characteristics of a more inclusive approach to evidence that CSSP and the Friends of Evidence group have identified as frequently encountered in initiatives that can be considered "evidence innovators." We examine each of these characteristics in turn.

[2]As stated by the Improvement Science Research Network active in the healthcare field, "Improvement science emerged to provide a framework for research focused on healthcare improvement… The primary goal of this scientific field is to determine which improvement strategies work as (researchers and health care providers) strive to assure effective and safe patient care. The conceptual frame of reference for improvement science allows a broad scope of scientific study about which improvement strategies work best in the complex adaptive system of the acute care organizational system in different ways." (http://isrn.net/about/improvement_science.asp)
[3]The core principles of improvement that specifically guide Carnegie's work can be retrieved from http://www.carnegiefoundation.org/our-ideas/six-core-principles-improvement/.

Figure 1.

Carnegie Math Pathways Goals

Pathways aim to "achieve big results, reliably and at scale" for community college students who struggle with remedial math. This means that the Pathway goals are to:

1. dramatically **improve the success rates** of community college students in remedial math courses;
2. do so "reliably" by not only increasing the success rate of students on average, but also by ensuring that that this **rate is achieved or exceeded by every single participating community college**; and
3. **reach a total of at least 50,000 students** at schools across the country by School Year 2017–2018.

1. Results Shape Intervention Design and Implementation

Figure 1 enumerates the ambitious Pathways goals. To accomplish these goals, Pathways is designed to enable students to earn college math credit in one year instead of requiring them to take the typical two-year (or more) sequence of remedial courses prior to taking a college credit bearing course such as pre-calculus or college algebra. Currently, Pathways is implementing two different approaches to achieve this goal: Statway and Quantway. Statway is a two-semester course that embeds remedial math within college-level statistics. It awards students college credits for the college-level material they learn in the course. Quantway is a more sequential approach, consisting of two separate semester courses: Quantway 1 focuses on accelerating what would normally be two terms of remedial math into one term, and Quantway 2, the subsequent semester course, allows students to obtain college math credit.

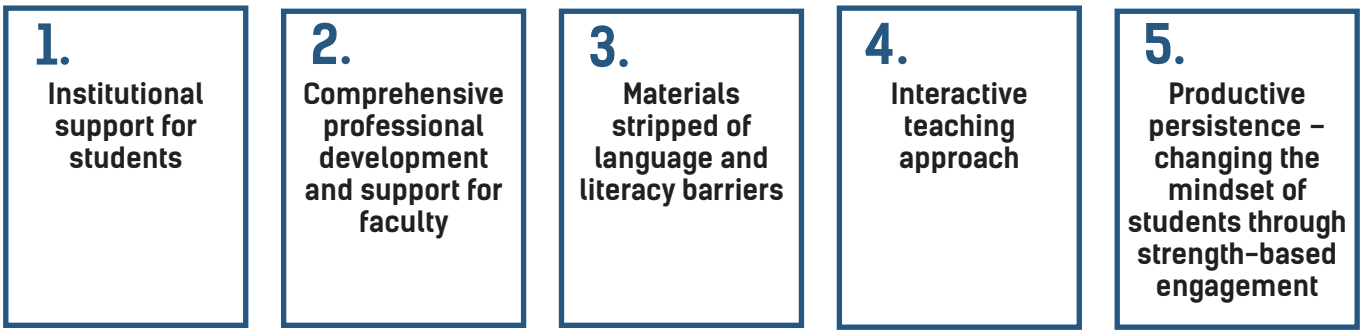
There are several key features that distinguish courses in both approaches from typical math courses at community colleges. First, the Pathways require that institutions examine institutional structures —including the ability to offer a multi-term cohort-model course. Other institutional changes include developing placement and counseling policies that guide students into remediation pathways that reflect their academic and career goals. Second, since the changes being designed would require substantial changes in practice on the part of instructors, the Pathways needed to deliver a comprehensive professional learning solution to support adopting faculty. Third, the Pathways team reviews all materials to eliminate language and literacy barriers that might disadvantage students with other developmental needs. Fourth, Pathways courses rely on a different type of pedagogy. If you were to walk into a typical math class at a community college, you would see an instructor standing in front of a room delivering a lecture to a large group of students. By contrast, in a Pathways class, you would typically see small groups of students spread throughout a classroom working together on real, high-interest math problems as an instructor walks from group to group to guide their work. You would also see the instructor engaging the whole class by highlighting the various strategies that were used by particular groups to solve math problems and asking the class questions about those strategies.

Fifth, Pathways courses focus not only on academic instruction, but also on the non-academic skills and attitudes that help or hinder the ability of students to learn, such as students' sense of belonging in their classes and their beliefs about whether they are capable of learning math. Carnegie calls this set of skills and attitudes "productive persistence." Pathways instructors use a variety of research-based exercises to increase their students' productive persistence. For example, as discussed in greater detail below, instructors in Pathways classes direct their students to read an article that has been shown to change students' attitudes about their ability to learn math.

One can dig into the design challenges by examining the work done to develop the two of the features described above. In designing the features of the Pathways course, the Pathways team combined and adapted research-based methods on a variety of subjects to suit its community college context. For example, they drew on research by James W. Stigler, Professor of Psychology at UCLA, who examined the performance of various countries on the TIMMS

Figure 2.

Key Features of the Carnegie Math Pathway Approaches



exam, an international math and science assessment of fourth and eighth graders, in order to develop more effective methods for teaching math. Carnegie worked with Professor Stigler to adapt these methods for community college students and faculty.

Similarly, to increase their students' productive persistence, Pathways learned from and adapted research-based ideas and techniques developed by several psychology researchers. For example, Pathways drew on psychology research showing the importance of developing social ties within the first weeks of a course, and more specifically that early engagement with informal student networks is highly predictive of student learning over time.[4] Pathways faculty and researchers then worked together to translate these ideas into practices for encouraging a sense of "belonging" among community college students in the math courses. One faculty member developed a "group noticing routine".

The "group noticing routine" was designed to build a sense of belonging by making students responsible for each other's presence in class. The routine consisted of three distinct stages. In the first stage, the faculty member placed students in groups and encouraged them to get to know each other outside of the immediate math context.

In the next stage, the groups were asked to report who was absent each day at the beginning of class. In the final stage, the groups were asked to take responsibility for contacting students who skip a class in order to encourage them to attend future classes and give them any materials or information that they missed in class. The first test of this routine in one classroom resulted in strong attendance across the semester, with an 85 percent median attendance rate—a far better result than the past experience with similar student groups. After the initial test, Pathways then tested the routine in a few classrooms in diverse settings, adapting it as needed to integrate into local context. They continued to use disciplined methods to generate evidence about how these routines were adapted and what results were achieved in different settings. Student attendance and retention continued to show substantial improvement. Spurred by these results, they extended the test to 25 more classrooms in different community colleges and, after observing similar levels of success, asked all of the instructors in the 50-institution Pathways network to adopt it. This work followed the same developmental path employed for all Pathways innovations and adaptations—producing evidence at each level of testing before being incorporated into the core instructional system.

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[4] See Cook, J. E., Purdie-Vaughns, V., Garcia, J., & Cohen, G. L. (2012). Chronic threat and contingent belonging: Protective benefits of values affirmation on identity development. Journal of Personality and Social Psychology, 102(3), 479-496; Garcia, J., & Cohen, G. L. (2012). A social-psychological approach to educational intervention. In E. Shafir (Ed.), Behavioral foundations of policy; and Vaquero, L.M., & Cebrian M. (2013). The rich club phenomenon in the classroom. Nature: 3, 1174.

2. Pathways Uses Results and Networked Learning to Guide Continuous Improvement and Demonstrate Accountability

To pursue the established goals as summarized in Figure 1, Pathways uses a "networked improvement community" (NIC) approach that consists of Pathways' full network of community colleges, which currently includes 50 schools with smaller networks of stakeholders such as subgroups of math faculty mentors and community college administrators. The network members work together to innovate and solve common problems. One of the defining features of a NIC is a shared belief in a common set of key drivers that, taken together, will allow the network to achieve a shared aim. For Pathways' NIC, such drivers include increasing students' productive persistence, improving remedial math curricula and instruction, and improving the professional development of math instructors. A NIC also agrees on a common set of measures to assess the extent to which they are making progress in relation to each of their drivers. For example, Pathways collects data on students' scores on math assessments and on surveys measuring several

dimensions of students' productive persistence. Pathways shares this data with its NIC, and the NIC members then use the data to inform their collective efforts to continuously improve.

Pathways' NIC allows its members to increase the power and speed of their continuous improvement efforts in a number of ways. First, Pathways encourages schools and stakeholders throughout its network to conduct small experiments to develop solutions to a wide range of challenges. As illustrated in the example described above, network members are encouraged to experiment with processes and curriculum to find new ways to improve student engagement and performance. Solutions that prove successful in these experiments are then tested in a larger number of schools, and if they prove effective in these larger experiments, Pathways spreads the practices to all of the colleges in the network just as they did with the "group noticing routines". This process enables Pathways to rapidly innovate and scale solutions that address a broad array of challenges, and Pathways' large and organized network makes this process possible.

Second, working with a large network allows Pathways to identify and learn from both the highest and lowest performing schools and classrooms. Pathways uses a variety of strategies to leverage these data to help all of its schools achieve a high level of performance. It has paired low performing schools with high performing schools in the same state to help the low performers learn from the high performers in order to improve. It has also spread the useful practices of its highest performing schools and instructors to the rest of the schools in its network.

Third, Pathways uses its network to diffuse expertise and leadership responsibilities from the Carnegie Foundation, which serves as the hub of the network,[5] to members throughout the network. For example, Pathways trains faculty for leadership roles in the network, such as for roles as faculty instructional coaches, curricula and assessment developers, and improvement facilitators, who guide faculty across the network on how to develop and test new ideas in their classrooms. This diffusion of expertise and leadership responsibilities increases the number of improvements Pathways can tackle at any given time, and it deepens the engagement of all participating colleges.

Figure 3.

Accelerated Continuous Learning

1. **Conduct small experiments**
2. **Learn from variation**
3. **Diffuse expertise and leadership**
4. **Multiple forums for shared learning**

Pathway provides a number of forums for network members to share data, and collectively identify and solve problems. These include:

(1) An annual in-person meeting (the Carnegie Math Pathways Forum) each summer for both new and experienced faculty and administrators in all Pathways schools. At this meeting, experienced faculty (all NIC members) introduce new Pathways members to the initiative's teaching methods by simulating a Pathways classroom and teaching the new members a course module that they would normally teach their students. Experienced faculty and administrators also attend meetings around common interests, such as writing assessment items and mentor training. In addition, experienced faculty participate in a series of panels and presentations at the annual meeting on the results of small experiments they have run in their classrooms to test solutions to common challenges.

(2) Monthly calls for community college administrators, where they discuss common administrative challenges and share solutions. For example, administrators on these calls might share strategies for negotiating articulation agreements with four-year colleges to ensure that their students can transfer their math credits to these four-year schools. Institutional researchers from the colleges also participate in these calls on a regular basis as results of their studies and other analyses become available.

(3) Monthly faculty mentors calls, where the faculty members who mentor other Pathways instructors on their campuses discuss and solve common challenges related to course instruction.

(4) Weekly to monthly productive persistence calls, where faculty and researchers interested in this topic identify challenges related to students' productive persistence skills, devise solutions based on both faculty observations and available research, choose the schools where they will test the solutions, and then report back to the group on the results of their experiments before deciding whether to apply the solutions to all Pathways schools. As an example, the group noticing routine described earlier was discussed on a call before experimenting with it. The successful results were then shared on a subsequent call. Afterwards, the group on the call further tested the interventions in more schools, and, when it continued to prove effective, spread it to the entire Pathways network at the annual summer meeting.

(5) Weekly to monthly curriculum calls, where faculty and researchers interested in improving Pathways curricula engage in a similar process to develop and test new curricula materials.

(6) Weekly to monthly[6] assessment calls, where faculty and researchers interested in this topic also engage in a similar process to develop and test new assessment items.

While the primary purpose of the data Pathways collects is to arm its networks with information they can use to continually improve, it also uses this data for accountability purposes with funders. Pathways' progress in tripling the success rates of remedial math students and consistently outperforming comparison group students across a large and diverse set of schools has shown funders that what Pathways is doing is working. As Pathways has demonstrated its worth, its funders have shifted from holding the program accountable for whether it works to holding it accountable for scaling to more schools without compromising its results.

3. Pathways Uses Multiple Evaluation Methods for Diverse Purposes

Pathways uses several evaluation methods to assess different aspects of its work ranging from developmental evaluations to experimental designs.

Pathways uses developmental evaluations to assess and improve its work. For example, Pathways uses developmental evaluations to track and communicate the thoughts, feelings, and experiences of frontline workers. With a network as large as Pathways, it is easy for network managers and leaders to become disconnected from the faculty who teach and the students who enroll in the program. To bridge this gap, evaluators periodically interview faculty and students, participate in faculty phone calls, observe classes, and survey network members. This "sensing" function helps ensure that problems encountered in the network are identified and addressed quickly. Pathways also uses developmental evaluations to learn from and improve new initiatives. For example, when Pathways first developed a faculty support program, they assigned a developmental evaluator to the undertaking to provide additional capacity to learn quickly what was and was not working for new faculty and their mentors and to provide recommendations for improvement.

As previously discussed, Pathways collects a wide variety of data to inform its efforts to continually improve and demonstrate the overall impact of the initiative. This includes data on the math common assessment scores and college credits obtained by Pathways students.

Pathways regularly uses randomized control trials to test discreet interventions that Pathways members are considering adding to the initiative. For example, social psychology researchers Carol Dweck, Lisa Blackwell, and Kali Trzesniewksi created an intervention to help students develop a growth mindset—the belief that they are not born with a fixed quantity of talent in a specific content area, but that they can improve their skills acquire new talents through learning and practice. They demonstrated the effectiveness of this intervention through an experiment with seventh grade students. Pathways then adapted this research-based intervention for its community college students. The modified version of the intervention consists of a persuasive reading and writing exercise that aims to "shift students away from the idea that 'I am just not good at math' (i.e. a fixed mindset about math) toward a view that math ability can be grown and developed."[7] In collaboration with several psychology researchers including Carol Dweck and David Yeager, Pathways tested this intervention with community college students through a randomized control trial, and based on the positive

[5] The network members are supported by core expertise groups that develop and promotes an infrastructure that allows the network to cull and synthesize the best of what is known from scholarship and practice, rapidly develop and test prospective improvements, deploy learning about what works , and to add to the knowledge base to continuously improve the performance of the educational system. More information can be found at http://www.carnegiefoundation.org/in-action/core-expertise-groups/.

[6] The productive persistence, curricula and assessment calls each occur on a weekly to monthly basis, depending on the time of the year and the needs of each group.

results of the experiment, Pathways spread the intervention to all of the colleges in its network.

Some researchers are troubled by the fact that Pathways has not used a randomized control trial to study the overall effect of its initiative. However, Pathways leaders believe that this is not only unnecessary, but might interfere with the very qualities that are producing their success. To conduct a randomized control, for example, Pathways' leaders would have to freeze the initiative in its current form instead of continuing their process of constant experimentation and improvement. They do not think this trade-off is worthwhile because they believe their data demonstrating that they have achieved dramatic results across a large number and variety of contexts are proof enough that their initiative works.[8] Moreover, they believe "the replicability of quality outcomes reliably at scale (rather than causal attribution) is the appropriate gold standard for improvement research."[9]

4. Pathways has Built the Infrastructure, Practices and Culture to Support the Use of Evidence for Continuous Improvement

Pathways is now in its sixth year of operation and has spread to over 50 colleges with 300 participating math instructors. To facilitate the efforts of this large network to continually improve and scale, Carnegie employs a large team of full-time staff located at the Foundation and network faculty members who serve as part-time staff, whose total hours are roughly equal to the hours of 27 full-time employees. This group includes:

- Program administrators,
- Technology experts,
- Data analysts,
- Faculty facilitators who facilitate the network calls and faculty mentors who coach new faculty,
- Improvement science coaches, and
- Researchers

As Chris Thorn, Carnegie's Director of Knowledge Management observed, it is not enough to build a strong infrastructure by hiring the right staff. To develop the capacity of an initiative like Pathways to achieve "big results, reliably and at scale," you also need to establish a "set of roles, norms and supporting practices that leverage the infrastructure to support the work." For example, Carnegie has developed a variety of roles for stakeholders in its network to support its work, such as contributing to the development of the Pathways curricula or experimenting with productive persistence interventions. It has also established practices and structures, such as networked improvement communities, that enable stakeholders to work collectively on these issues.

Furthermore, Carnegie has established a strong culture of collaboration and improvement across its network. One way it has done this is by focusing on a unifying, ambitious and inspiring goal that motivates its members to contribute to the network: "reclaiming one hundred thousand students' mathematical lives."[10] To further support its culture of improvement, Carnegie also encourages instructors in the Pathways network to embrace the use of data. In doing so, it clearly and regularly communicates to them that the purpose of the data is not to blame individual instructors, but rather to use the data to identify systemic challenges and collectively solve them.

[7] Bryk, A., Gomez, L., Grunow, A., and LeMahieu, P. (2015). Learning to Improve: How America's Schools Can Get Better at Getting Better. Cambridge, MA: Harvard Education Press.

[8, 9, 10] Pathways' leaders are considering hiring an external evaluation organization to conduct an audit of the initiative's research and results. This organization would review Pathways' compliance with data security and privacy protection policies. It would also review Pathways' measurement models, means of capturing data and analytical models and research data sets. In addition, it would randomly select a set of Pathways findings and audit the trail of evidence and analysis that produced the finding. The purpose of the audit would be twofold—it would strengthen Pathways' accountability through the inclusion of independent perspective and it would provide them an opportunity to learn from and fix any problems the auditor identifies. The auditors would, in effect, independently warrant the verity of the internal evaluative analytics as based on valid evidence, resultant of rigorous and appropriate analyses, and replicable through independent testing. It is important for there to be a mechanism independent of the program designers to do this. This is the point and power of an external audit.

5. Conclusion

Pathways illustrates the power of using a broad evidentiary base—the experiences of students struggling in developmental math programs, identity development research and evaluations of teaching methods and curriculum content—and robust continuous learning to achieve system reform at scale. Pathways is clear about the results it seeks. Participating leaders and instructors maintain an unwavering focus on results, systematically measuring progress while remaining open to new ideas and devoting time and energy to testing and documenting innovations. Learning is not dependent on one methodology, one administrative environment or one implementation team. Different aspects of Pathways' work are evaluated in different ways, ranging from RCTs to process documentation of the way that work is done. The learning is amassed and shared across a growing network of diverse community college settings, faculty and student bodies. Many people have a stake in learning from and sharing their successes and failures and thus accelerating progress for more and more students.

For more information about the Carnegie Math Pathways, Improvement Science and the tools available for building similar initiatives, please go to http://www.carnegiefoundation.org/in-action/pathways-improvement-communities/.

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